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14 June, 2007

The Secretary
Senate Rural and Regional Affairs and Transport
Parliament House
Canberra ACT 2600

Dear Senators,

ADDITIONAL REPORTS FOR TRAVESTON DAM SENATE INQUIRY

Thank you for the opportunity to present to you last Monday.

As mentioned at the hearing, ACF has commissioned research into the potential for the roll out of rainwater tanks in South East Queensland that is relevant to your inquiry but was not completed in time for the original submission date. This research includes an analysis of the potential water savings, the energy savings from avoiding dams and desalination plants, and the costs of rolling out rainwater tanks on a massive scale.

I would also like to bring to the Committee's attention the recent report by Rob Hales into the implications of the SMEC proposal for a dam on the Clarence River in Northern NSW. This report includes important data on the actual river flows in the Clarence and related rivers and how these have been reduced in recent years. This data was not available to SMEC when conducting their research.

I have attached both of these reports for your information and hope that they are helpful in your considerations.

For further information please don't hesitate to contact me on (03) 9345 1134 or k.noble@acfonline.org.au .

Yours sincerely

Kate Noble
Sustainable Cities Campaigner

The economics of rainwater tanks and alternative water supply options

A report prepared for Australian Conservation Foundation, Nature Conservation Council (NSW) and Environment Victoria

11 April, 2007

Marsden Jacob Associates

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Marsden Jacob Associates

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Executive Summary

Marsden Jacob Associates (MJA) has been commissioned by the Nature Conservation Council of NSW, Environment Victoria and the Australian Conservation Foundation to conduct research into the impact of a targeted rainwater tank roll-out in Sydney, Melbourne and South East Queensland (SEQ).

For individual property owners, the cost effectiveness of rainwater tanks is typically determined by comparing the cost of installing and operating a rainwater tank against savings from household water bills plus the impact of garden water restrictions. However, considering the benefits only from the perspective of the property owner does not recognise the broader cost savings to the community such as deferred water infrastructure, savings to stormwater infrastructure, and environmental externalities such as the cost of greenhouse gas emissions.

The present study compares the yield and levelised cost (i.e. the cost per kilolitre supplied) of various long term water source options in Sydney, Melbourne and SEQ against the potential yield and cost of rainwater tanks. Previous research by MJA for the National Water Commission indicates that both the yield and the cost of tanks varies significantly based on individual household variables – in particular the size of the roof collection area.

This study compares the cost of rainwater tanks with other water infrastructure such as dams and desalination plants. Levelised cost (the cost per kilolitre of water supplied) is a factor of water yield from a particular technology and the cost of supplying it. Yield from a 5 kilolitre tank for a small ($50m^2$) and large ($200m^2$) roof collection area was shown to vary from around 47 kL to 105 kL in Sydney, 24 kL to 86 kL in Melbourne and 41 kL to 99 kL per year in Brisbane (airport sites only).

Table 1 summarises the potential annual yield and levelised cost of rainwater tanks and other alternative water sources. The levelised costs in Table 1 are provided to illustrate the relative cost of each option under specific conditions, however caution must be applied in comparing results because:

- levelised cost indicates the direct cost of each option only and does not account for social, environmental or "flow-on" economic impacts;
- levelised cost assumes that water sources will be utilised at their maximum capacity from the first day of commissioning. In practice, many options may be underutilised in early years, resulting in a higher unit cost;
- different options have different levels of water supply reliability and may not be appropriate for all purposes (such as emergency drought situations). Ideally, a full portfolio analysis should incorporate an analysis of the relative supply risks of each water supply option.

Table 1: Levelised cost of alternative sources – Sydney and SEQ

Water Source	Total annual yield (GL/a)	Levelised cost ($/kl)
Sydney		
Rainwater tank (additional 10% take up)[1]	8-17	2.15-5.41
Rainwater tank (additional 65% take up)[1]	49-110	2.15-5.41+
Desalination (125 ML/day)	up to 46	2.70-3.50
Desalination (500 ML/day)	up to 182	1.80
Melbourne		
Rainwater tank (additional 10% take up)[1]	3-12	2.67-10.92
Rainwater tank (additional 72% take up)[1]	24-88	2.67-10.92+
Desalination	50?	Not avail.
South East Queensland		
Rainwater tank (additional 10% take up)[1]	5-11	2.22-6.22
Rainwater tank (additional 73% take up)[1]	33-80	2.22-6.22+
Traveston Dam	70-150	2.00+ (Traveston Dam, Wyaralong Dam, SEQ (Gold Coast) Desalination, Western Corridor Recycled Water Scheme)
Wyaralong Dam	18	
SEQ (Gold Coast) Desalination	45	
Western Corridor Recycled Water Scheme	Up to 77	

Notes:

1: Lower bound and upper bound scenarios for rainwater tank take up from additional inducement policies (see Section 4, excludes houses with an existing tank installed). Maximum take up rate may be lower due to houses with difficult or inaccessible plumbing. Based on expected yield from a "typical" 5 kL tank plumbed for both indoor and outdoor use.

In addition, the key findings of this report include:

- rainwater tanks will be widely installed in new housing developments due to regulations imposed by both the Queensland and NSW governments. While new dwellings can be designed to be 'rainwater tank-friendly', a growing proportion of future dwellings are expected to be in high density unit blocks which are mostly unsuitable for rainwater tanks (although the majority of new dwellings since 2001 have been detached 'rainwater tank-friendly' dwellings). However there is also significant potential for take-up of rainwater tanks in existing dwellings. The majority of existing dwellings, particularly in SEQ, are detached houses, making them suitable in theory for rainwater tanks. Many may not accommodate a tank due to limited land area or plumbing constraints. There are currently around 1.1 million houses potentially suitable for rainwater tanks (i.e. detached and semi-detached houses)[1] in Sydney and 0.9 million in SEQ.

[1] The ABS identifies 'semi-detached' houses (11% and 6.6% of total houses in Sydney and SEQ respectively in 2001) as including some row, terrace and town houses, which may be less suitable for rainwater tanks. However, MJA notes that Gold Coast City Council includes as mandatory rainwater tanks on all new

- MJA understands that it is unlikely that rainwater tanks could be installed in time, or provide sufficient security, to offset emergency water sources such as the SEQ Western Corridor Recycled Water Scheme. However, rainwater tanks can act to 'free up' existing water supplies and may therefore defer the need for future water sources required to cater for growth;

- in most cases, the precise timing of future water sources is unknown. In the case of Sydney, a review of the existing Metropolitan Water Plan indicates that a major new water source may not be required for 10 years or more if adequate demand management and recycling initiatives are in place. However the NSW government has indicated that a desalination plant will act as a contingency measure if water supplies fall below certain critical levels. While the exact timing of new sources is unknown, MJA has illustrated the impact of rolling out rainwater tanks to 5% of households each year, assuming that Sydney demand were 40% less than "Business As Usual" (due to demand management initiatives such as BASIX) and the SEQ demand scenario adopted by the Queensland Government. In these scenarios, expenditure in 2010 that was required to cater for demand growth across the system (excluding emergency supply options) could potentially be delayed:

  - past 2026 in Sydney or to around 2019 in SEQ if all potential housing (i.e. detached and semi-detached houses – 70 per cent of Sydney dwellings and 78 per cent of SEQ dwellings) could install a rainwater tank;

  - to around 2022 in Sydney or 2018 in SEQ if only 50% of total dwellings could install a rainwater tank;

  - to around 2012 in Sydney or 2013 in SEQ if only 10% of total dwellings could install a rainwater tank.

  Water sources could potentially be deferred by more than the indicated time if demand management initiatives reduce future demand, or may be deferred by less than the time indicated due to other factors such as the need for emergency water supplies or specific regional growth requirements. The deferral of water sources will be cost effective only to the extent that rainwater tanks are less expensive than alternative water sources (refer Table 1).

  Similar results would be expected for Melbourne depending on the growth in the number of dwellings and the impact of demand management initiatives.

  Additional demand management initiatives could potentially defer the need for water infrastructure even further.

- for houses with large roof collection areas and average to high water use, rainwater tanks are similar in cost to other forms of water infrastructure such as dams and desalination plants (refer Table 1) in Sydney and SEQ. Dwellings with smaller roof areas typically have a low yield and therefore a significantly higher unit cost;

'...such dwellings as stand alone single dwellings, duplexes, row houses, terrace houses, town houses and villa units'. (Gold Coast City Council, 2007: p1).

- research indicates that rainwater tanks are more than five times as energy efficient as desalination plants per kilolitre of water produced (rainwater tanks requiring around 1 MWh/ML compared with a typical desalination plant requirement of 5 MWh/ML);
- the cost of rolling out rainwater tanks to existing properties will depend on specific household attributes and will be affected by plumbing and site constraints. For many houses, internal plumbing difficulties may preclude the use of rainwater inside the house. For those existing houses that are capable of installing a tank, a "typical" 5,000 litre rainwater tank could cost in the order of $2,500 to $3,500 fully installed. A preliminary estimate of the cost to roll out rainwater tanks to 5% of households would therefore be approximately $200-$280 million per annum in Sydney, $180-$250 million per annum in Melbourne and $140-$200 million per annum in SEQ;
- as part of this exercise, the levelised cost of greenhouse gas emissions were investigated for inclusion in the levelised cost. However there is significant scope for further research in incorporating other externalities such as stormwater infrastructure savings into cost comparisons of water infrastructure. We also recognise that broader environmental and social factors must be included in comparisons of the costs and benefits of particular water infrastructure proposals.

1. Introduction

Rainwater tanks have been a familiar water supply solution in rural Australia for many years. Recently, with the impact of droughts stretching to our cities, urban Australians are now also increasingly turning to rainwater tanks as an alternative to our rapidly depleting dams.

Currently, some 17% of Australian households have installed rainwater tanks.[2] Rainwater tanks offer a number of advantages over conventional water sources, including:

- collectively, rainwater tanks may offer a smaller environmental footprint than dams or desalination plants;
- property owners may be able to avoid the consequences of city-wide water restrictions;
- property owners may partially offset their annual water bill;
- in some areas, rainwater may offer a better aesthetic (in particular better tasting water) than the city drinking water supply; and
- tank yield is relatively directly related to rainfall and, although day to day fluctuations may be significant, the yield over a year may be less volatile than dam supplies, which require significant rainfall to saturate catchments and begin the run-off process.

Marsden Jacob Associates has been commissioned by the Nature Conservation Council of NSW, Environment Victoria and the Australian Conservation Foundation to conduct research into the impact of targeted rainwater tank roll-out in Sydney, Melbourne and South East Queensland (SEQ). In particular, the research has been directed at four specific questions:

1. What is the cost of providing rainwater tanks (cost per kilolitre) compared to desalination plants and dams?
2. What are the additional costs and benefits of environmental externalities - in particular the impact of reducing greenhouse gas emissions and the costs of carbon abatement?
3. How many rainwater tanks would be required to avoid dams and desalination plants such as those proposed for Sydney, Melbourne and South East Queensland?
4. What would be the cost to Government of a targeted program to roll out rainwater tanks to 5% of households each year in high rainfall cities such as Sydney, Melbourne and Brisbane?

[2] Australian Bureau of Statistics (2006)

2. The relative cost of rainwater tanks

Question One: What is the cost of providing rainwater tanks (cost per kilolitre) compared to desalination plants and dams?

The relative cost of water supplied by rainwater tanks depends on a number of factors, including average yield from tanks, and capital and on-going costs relative to other sources. These factors vary significantly between geographical location (and therefore weather patterns) and even between particular facilities.

This section explores the elements affecting the cost of rainwater tank yield, relative to publicly available information on other water sources.

Cost efficiency of Rainwater tanks

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.

2.1. Rainwater Tank yields

Marsden Jacob Associates (MJA) recently completed a major study on the cost effectiveness of rainwater tanks for the National Water Commission, including a detailed examination of costs and annual yield. The study found that:

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.*

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:

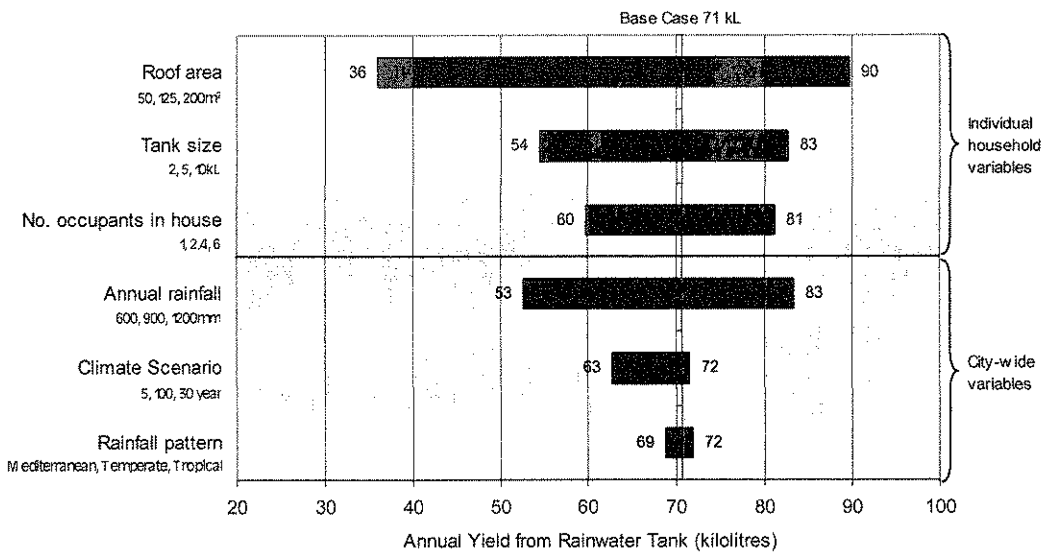
- *the heavy tropical rains of Queensland and the Northern Territory;*
- *the relatively consistent year round rainfall of New South Wales, Victoria and Tasmania; or*

- *the Mediterranean climates of South West Western Australia and southern South Australia, characterised by significant rainfall during winter and relatively dry summers.*

To determine the 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 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 or area. 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.

The relative impact of the key characteristics affecting yield are shown in Figure 1.

Figure 1: 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 125m² 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: *MJA MART model*

MJA'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.*[3]

As indicated above, the yield of a rainwater tank is sensitive to the precise rainfall for the area. Providing one representative site for rainfall for any city is a difficult task, particularly for an area the size of South East Queensland (SEQ). In modelling for rainwater tank yield, MJA has used the airport site in each case, but notes the potential for variation by suburb. For example, since 1976 the Brisbane airport site has recorded more rainfall than inland sites such as Indooroopilly (10 per cent), similar rainfall to the Bureau of Meteorology's previous regional office station (within one per cent, station located in the Brisbane central business district), and 20-30 per cent *less* rainfall than the Sunshine and Gold Coasts sites (established in 1994).[4] MJA notes that the three major population centres in SEQ (Brisbane, the Sunshine and Gold Coasts) are all located close to the coastline.

2.2. Cost of rainwater tanks

Use of levelised cost

One method of comparing the value of different water sources is to compare levelised cost. Levelised cost estimates the cost per kilolitre of water supplies, dividing the annualised capital and operating costs by expected annual yield.

Levelised cost is a useful tool for comparing the cost of options with very different annual yields, such as small scale water tanks compared with large scale desalination. We apply levelised cost throughout this study as an indicative guide to the relative magnitude of costs, but we note that the approach is a simplification of the analysis of water supply options. Water supply planning is a complex process that needs to include consideration of environmental, social and economic factors. The economic analysis is complicated by the need to consider supply reliability objectives and to consider strategic aspects related to contingency supplies.

While some environmental factors can be quantified (such as greenhouse gas emissions – see Section 3.1), this is not always possible. Thus, levelised cost should not be used as an isolated decision-making tool.

[3] Marsden Jacob (2007), pp. ES iii - v

[4] Maroochydore Airport (30% more rainfall than Brisbane airport) and Gold Coast Seaway (20% more rainfall) between 1994 (beginning of time series) and 2006.

Due to the lack of publicly available information, another simplification required for this exercise is that the annual yield/usage from each water source will equal the maximum capacity of that source. The actual usage of large infrastructure will typically be below maximum capacity for a number of years and therefore the levelised cost may be understated in some cases depending on the actual take up rate.

A full analysis is beyond the scope of this study and therefore the levelised cost results are provided for indicative purposes only.

2.2.1. Rainwater tank costs

Research by MJA, conducted on behalf of the National Water Commission, indicates that the cost to the community of rainwater tanks with mixed indoor/outdoor use can range from $2.15/kL to $12.30/kL depending on the exact location, tank size and roof collection area (Table 2).

Table 2: Levelised cost of rainwater tanks to community – combined indoor and outdoor use

Tank Size	2 kL		10 kL	
Roof Area	50m^2	200m^2	50m^2	200m^2
Levelised Cost ($/kL) [1,2]				
Brisbane	6.14	3.16	6.22	2.22
Sydney	5.34	2.79	5.41	2.15
Melbourne	8.75	2.98	10.92	2.67
Adelaide	9.76	3.77	12.30	3.32
Perth	7.39	3.71	8.85	3.25

Note: 1. Based on a standard above ground tank, plumbed for both indoor and outdoor use. Melbourne cost includes an offset for reduced stormwater treatment costs due to nitrogen removal in Melbourne.

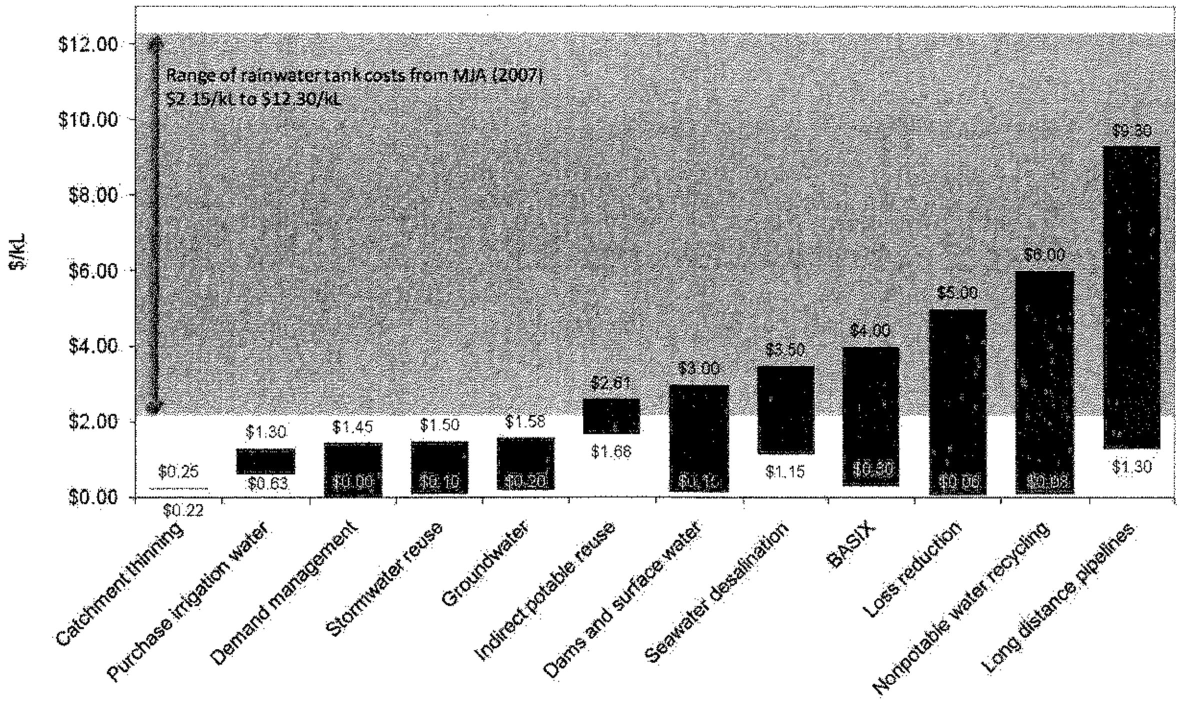
2. Yield based on daily time step data from BoM sites (typically the airport). Substantial variation across cities may exist (for example, the old Brisbane regional office station shows total rainfall since 1976 to be within 1% of the total airport rainfall, however the rainfall at the Brisbane showgrounds was 10% lower for the same period).

Source: Marsden Jacob Associates (2007)

2.3. Cost of alternative water sources

The cost of alternative water sources has been estimated in planning documents produced for each Australian capital city. A summary of the available results is shown in Figure 2.

Figure 2: Direct Costs of Water Supply/Demand Options– Sydney, Adelaide, Perth, Newcastle



Source: MJA analysis based on water supply plans for Sydney, Adelaide, Perth, Newcastle (originally produced for MJA (2006)) and recent NSW Treasury cost estimates. Lower bound of indirect potable reuse estimate based on Toowoomba.

As indicated by the chart above, the cost of water sources varies significantly according to the specific circumstances of each city. The cost of some options, such as demand management, can be negligible in some cases, while the costs for options such as desalination, dams and recycling can potentially be as high as $3.00/kL or more. The highest cost options include plans to pipe water significant distances for consumption by our major cities. By comparison, the unit cost of rainwater tanks that are plumbed into the house can range from $2.15/kL to $12.30/kL[5]. At the lower end of the range (typically reflecting the unit cost of properties with large roof collection areas), the cost of rainwater tanks is comparable to, or lower than, the cost of many water source options being examined around the country. At the higher end of the range, the cost of rainwater tanks could be as high as $12.30/kL, significantly above the cost of most alternative water supplies.

As indicated earlier, levelised cost is a useful tool for comparing the cost of different water sources, however a full assessment of the benefits of any particular water source should take into account all of the social, environmental and economic factors, including the relative reliability of each source.

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

[5] Cost is lower if the tank does not require a water pump. See Marsden Jacob (2007) for more information.

savings will typically 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 research by Coombes and Kuzcera (2003) are achievable in other areas, 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. (For a more detailed discussion of the potential for stormwater savings see MJA (2007)).

2.3.1. Case Studies: Sydney and SEQ

Below we examine the major water supply options for two specific case studies – Sydney and South East Queensland.

Sydney: One of the major water supply options for Sydney is a desalination plant of between 125 ML per day and 500 ML per day capacity. The capital expenditure of the full scale (500 ML per day) desalination plant and associated infrastructure has been estimated to be in the order of $2.5 billion, with operating expenditure of $165 million per year,[6] while a 125 ML per day option would cost $1.3 - $1.9 billion[7]. These estimates indicate a levelised cost of around $1.80/kL for the largest plant (assuming that it is used at maximum capacity) and $2.70 - $3.50/kL for the smaller plant (assuming the same operating cost per kilolitre as the larger plant).

Queensland: A number of options are available to increase the water supply to South East Queensland, including desalination, the Western Corridor Recycled Water Scheme and dams at Traveston Crossing and Wyaralong. Full financial details have not yet been released by the Queensland Government, however estimates provided by the Department of Natural Resources, Mines and Water (DNRMW) show the following estimates of capital cost:

	Prudent Yield (GL)	Capital Cost ($m)
Traveston Dam Stage 1	70	1,400 to 1,700
Traveston Dam Stage 1 plus Borumba	110	1,650 to 1,950
Traveston Stages 1 and 2 (incl Borumba)	150	2,000 to 2,500
Wyaralong Dam	18	500
SEQ (Gold Coast) Desalination	45	850
Western Corridor Recycled Water Scheme:		
Stage 1	30	641
Stage 2 (includes Stage 1)	Up to 77	1,784

Source: DNRMW, *Water for South East Queensland: A long term solution*

6 Sydney Water fact sheet, *Indirect potable recycling and desalination - a cost comparison*

7 $1.3 billion based on previous Sydney Water estimates. $1.9 billion based on NSW Treasury costing estimates that allow for a 125 ML/d plant that "could be quickly scaled up to 500 million litres a day if necessary". www.treasury.nsw.gov.au/promises/pdf/cost_42.pdf

Other information required for a levelised cost calculation, including operating costs and interconnection costs, have not yet been publicly released. Due to siting constraints, it is expected that the cost of connecting both desalination plants and dams into the proposed SEQ "water grid" will add significantly to both the capital and operating cost of supply.

In addition, MJA understand that cost and yield estimates are currently being refined by the Queensland Government. Therefore any attempt to estimate the levelised cost with precision could be misleading before final estimates are released.

MJA has therefore not attempted to quantify levelised costs particular to SEQ, but we note that costs for comparable desalination plants and dams are at least $2.00/kL, and will potentially be significantly higher in SEQ due to the substantial siting constraints. This estimate is provided for order of magnitude comparison only and MJA recommend that a site specific analysis is conducted once more detailed cost information is released.

2.3.2. Summary

Table 3 summarises the comparative levelised costs of alternative water sources for Sydney and South East Queensland, including rainwater tanks. As can be seen, the levelised cost per kilolitre of some rainwater tanks will, *prima facie*, be cost competitive against desalination and the South East Queensland dams. Rainwater tanks with higher unit costs, typically those associated with small roof collection areas, will not be cost competitive against alternative water sources.

Estimates are provided for indicative purposes only. As noted earlier, caution should be applied when comparing these estimates, as costs do not include externalities such as the impact on stormwater systems, avoided environmental costs of inundation for dams and greenhouse gas emissions (see Section 3.1 for inclusion of greenhouse abatement costs).[8] In addition, a full assessment of the relative cost of each water source would require a careful review of the relative reliability of dams, desalination plants and rainwater tanks to establish the degree to which each provided a secure long term source of water. We note that dams and rainwater tanks each have features that promote different aspects of reliability – for example, while dams can smooth out rainfall variability over a number of years (due to their significant capacity), rainwater tanks are less dramatically impacted by extended or severe droughts (tanks have a relatively direct relationship to rainfall, while dam catchments require significant initial rainfall to begin the run-off process). See MJA (2007) for a more detailed discussion on the relative reliability of dams compared with rainwater tanks.

8 It should be noted that Sydney Water has announced that all energy costs associated with a desalination plant will be 'carbon neutral', presumably through an exclusive arrangement with a renewable energy supplier.

Table 3: Levelised cost of alternative sources – Sydney and SEQ

Water Source	*Total annual yield (GL/a)*	*Levelised cost ($/kl)*
Sydney		
Rainwater tank (additional 10% take up)[1]	8-17	2.15-5.41
Rainwater tank (additional 65% take up)[1]	49-110	2.15-5.41+
Desalination (125 ML/day)	up to 46	2.70-3.50
Desalination (500 ML/day)	up to 182	1.80
Melbourne		
Rainwater tank (additional 10% take up)[1]	3-12	2.67-10.92
Rainwater tank (additional 72% take up)[1]	24-88	2.67-10.92+
Desalination	50?	Not avail.
South East Queensland		
Rainwater tank (additional 10% take up)[1]	5-11	2.22-6.22
Rainwater tank (additional 73% take up)[1]	33-80	2.22-6.22+
Traveston Dam	70-150	2.00+ (Traveston Dam, Wyaralong Dam, SEQ (Gold Coast) Desalination, Western Corridor Recycled Water Scheme)
Wyaralong Dam	18	
SEQ (Gold Coast) Desalination	45	
Western Corridor Recycled Water Scheme	Up to 77	

Notes:

1: Lower bound and upper bound scenarios for rainwater tank take up from additional inducement policies (see Section 4, excludes houses with an existing tank installed). Maximum take up rate may be lower due to houses with difficult or inaccessible plumbing. Based on expected yield from a "typical" 5 kL tank plumbed for both indoor and outdoor use.

2.4. Other potential impacts

Two key additional areas for indirect cost savings are local water mains and stormwater infrastructure.

2.4.1. Water mains

In greenfield sites there is some potential to reduce the size of water mains if rainwater tanks are widely installed and will be used during peak water usage periods. Smaller mains are often sized to meet minimum fire-fighting requirements, however augmentation of larger distribution and trunk mains could potentially be deferred or avoided if peak water usage is reduced through the installation of rainwater tanks. There has been little work done 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 is likely 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 because of significant fixed costs associated with water mains. 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.

2.4.2. Stormwater systems

There have also been few studies on the impact of reduced demand on the size of stormwater infrastructure. The capital cost of established sites will be unlikely to change if rainwater tanks are introduced (some replacement costs may be reduced but stormwater assets are mostly long-lived). MJA (2007) noted that:

For greenfield sites or established areas requiring augmentation of infrastructure, the size of stormwater infrastructure might be reduced if run-off from roofs is diverted by rainwater tanks. However, most stormwater infrastructure is designed for probable peak events, and the size of the infrastructure may have to be maintained if peak events occur when rainwater tanks are already full.[9]

Modelling indicates that the amount of water diverted into rainwater tanks in Sydney during the top 10 peak rainfall events in the last 100 years varies greatly, from 1-3% for some roof area/tank size combinations up to 50% for large tanks connected to smaller roof areas. Results for other cities are also varied.

MJA (2007) also noted that:

If significant volumes of rainfall could be diverted from the stormwater system, local drains in greenfield sites could potentially be reduced in size, however larger drains and drains capturing significant road or other run-off would be affected to a lesser degree.

The potential impact on the stormwater system will be greatest in greenfield sites and will vary significantly amongst 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 reveals a lack of published information on the marginal cost of stormwater systems. One paper by Coombes and Kuzcera (2003) 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 another development, savings were estimated at from $210 to $511 per lot, however it is unclear from the paper how the figures were derived.

Another impact on stormwater infrastructure will be the reduction of nutrients in the system, which will have the greatest impact when water drains into environmentally sensitive areas. Melbourne Water estimates that rainwater tanks reduce the flow of nitrogen into waterways by around 0.2 kg per year for a 150m^2 roof. Developers are currently levied a one-off offset charge of $800/kg of nitrogen, who can therefore save around $160/house by installing

[9] MJA (2007), pp. 31-32

rainwater tanks. This saving should probably be regarded as cost reflective and applied to developers as a broader infrastructure saving for Melbourne residents.[10]

[10] MJA (2007), pp. 32-33

3. Adding environmental costs to levelised costs

Question Two: What are the additional costs and benefits of environmental externalities - in particular the impact of reducing greenhouse gas emissions and the costs of carbon abatement?

The cost comparison of the previous section compares the financial costs of different water source options in high rainfall capital cities, levelised per unit of water produced. However, a full economic analysis would take account of the relative environmental impacts of differing water source options, such as:

- ecosystem impacts of inundation associated with dam construction;
- the environmental impact of materials used in construction and installation (including the materials used to manufacture rainwater tanks);
- environmental impacts of hyper-saline outflows caused by desalinating sea water; and
- greenhouse gas impacts of all water source options, as they all involve some energy use (except gravity fed outdoor garden use of rainwater tanks).

In many cases, demand-management (reduction in the water used per capita) has a very low environmental impact and in some cases can also reduce energy use. For example, water-efficient showerheads not only reduce water consumption but also reduce the energy used to produce hot water, so in turn reduce greenhouse gas emissions. However, initiatives such as high-level water restrictions can cause amenity costs to gardeners, which can have real flow-on effects (for example, on health impacts).[11]

Dam construction is associated with inundation of large tracts of land, with the most suitable sites for dam construction usually chosen first. Historically, the most suitable sites have been determined by geography, prioritising high yield, and low construction and delivery cost. More recently, environmental and social impacts form part of the decision-making process, however in many cases, large-scale inundation will continue to have substantial environmental impacts through alteration of the natural landscape. While noting this, measurement of these impacts is beyond the scope of this study.

Desalination of seawater is the most energy-intensive of the water source options explored here and involves the release of hyper-saline water as a by-product. Environmental impacts are assessed as part of the water source planning process, however MJA is unaware of any attempt to measure this impact in cost/benefit terms in the Australian context.

Rainwater tanks do not have notable environmental impacts associated with their ongoing use, however they do consume energy associated with pumping for internal use. Given the

[11] Gardening being a favoured physical activity of older Australians, for example.

much smaller distances the water is moved, energy costs per kilolitre are typically lower than other source options, except where water is gravity fed throughout the system.

While measurement in dollar terms of the environmental impacts described above is beyond the scope of this study, recent initiatives to put a price to greenhouse gas emissions allows us to factor this environmental impact into our cost analysis.

3.1. The cost of carbon

The European Union has established a trading market in carbon emissions, providing a cap in total emissions and allowing trading within that total. The price of carbon in the European Union Emission Trading Scheme (EU ETS) was 0.98 Euro per tonne (AUD $1.65)[12] as at 27 February 2007, down from over 30 Euros in April 2006.

While Australia currently does not have a national carbon trading market, New South Wales has the Greenhouse Gas Abatement Scheme (GGAS), imposing mandatory greenhouse gas benchmarks on all NSW electricity retailers and certain other parties (referred to as benchmark participants) to abate the emission of greenhouse gases from the consumption of electricity in NSW. The price of NSW Greenhouse Gas Abatement Certificates (NGACs) is not publicly released, however MJA understands that the average price in June 2005 was $12.65 per tonne (1 certificate being equal to one tonne of carbon).[13] In the National Electricity Market, one tonne of carbon emissions is roughly equal to one megawatt hour of electricity.[14]

Sydney Water has announced that its planned desalination plant will be 'effectively' powered using renewable energy.[15] Using Sydney Water estimations of energy use (900 GWh annually) and estimated cost of 'greenhouse gas offsets' ($35m annually), this results in an estimated cost per tonne of carbon of $37.18/t. This estimate is greater than the NGAC price quoted above, and more likely reflects the price of purchasing renewable energy (through Renewable Energy Certificates) rather than offsetting carbon emissions (for example, producing wind energy as opposed to investing in carbon sinks).

Again, the spot price of Renewable Energy Certificates is not publicly released, however reports have noted an oversupply in 2006 and a subsequent decrease in price to around $23/t.[16] Table 4 below models the water source options from Table 3 with publicly available estimates of energy use, carbon emissions and abatement costs per ML at different carbon prices. As can be seen from the table, rainwater tanks have the lowest abatement costs of the sources explored.

12 Exchange rate of AUD$1 = 0.593 Euro (13 March 2007)

13 http://www.edl.com.au/PublicDocuments/20050825_ENEJune2005FinRes&BusUpdate_254303.pdf

14 1.03t CO_2e/MWH as at February 2007.

15 http://www.sydneywater.com.au/EnsuringTheFuture/Desalination/pdf/ProjectReportOperation.pdf#Page=1

16 http://www.renewableenergyaccess.com/rea/news/story?id=47634&src=rss

Table 4: Costs of abatement of alternative sources – Sydney and SEQ

Water Source	*Annual yield (ML/a)*	*Energy use (MWh/a)*	*Energy efficiency (MWh/ML)*	*CO^2 emissions (t)*	*Abatement costs $/ML*		
					NGAC $12.65/t	REC low $23/t	REC high $37.18/t
Rainwater tank	0.07	0.067	0.956	0.07	12	22	36
Sydney							
Desalination (125 ML/day)	45,625	225,000	4.932	235,350	62	113	183
Desalination (500 ML/day)	182,500	900,000	4.932	941,399	62	113	183
South East Queensland							
Traveston Dam Stage 1	70,000	137,480	1.964	143,804	25	45	73
Traveston Dam Stage 2	40,000	52,920	1.323	55,354	17	30	49
Traveston Dam Stage 3	40,000	52,920	1.323	55,354	17	30	49
Tugan Desalination	45,000	225,000	5.000	235,350	63	115	186

Source: MJA analysis, energy estimates from ISF/Cardno 2007.

Table 5 explores the impact of carbon abatement on the relative levelised costs for different water sources. While the impact on rainwater tanks is the lowest of all options, in no cases do the relative levelised costs change due to carbon abatement. The overall small impact on levelised cost of abating the carbon released through water production, or purchasing carbon neutral energy for this production, suggests that this is an affordable option to water suppliers.

Table 5: Carbon impacts on levelised costs of alternative sources – NSW and QLD

Water Source	*Original levelised cost ($/kl)*	*Change in levelised cost*		
		NGAC $12.65/t	*REC low $23/t*	*REC high $37.18/t*
Sydney				
Rainwater tank	2.15-5.41	0.01	0.02	0.04
Desalination (125 ML/day)	1.80 +	-0.13	-0.07	-
Desalination (500 ML/day)	1.80 +	-0.13	-0.07	-
South East Queensland				
Rainwater tank	2.22-6.22	0.01	0.02	0.04
Traveston Stage 1	} 2.00+	0.03	0.05	0.07
SEQ Desalination		0.06	0.12	0.19

Source: MJA analysis.

Carbon abatement has the highest impact on desalination, which is the most energy intensive. It should be noted that Sydney Water's levelised cost estimates factored in carbon abatement at the highest estimated cost of our analysis ($37.18/t), so cheaper abatement would decrease their levelised cost.

4. Deferring alternative water sources with rainwater tanks

Question Three: How many rainwater tanks would be required to avoid or defer dams and desalination plants such as those proposed for Sydney and South East Queensland?

As noted in the previous sections, the annual yield of rainwater tanks varies according to a number of elements. Estimates of average yield in different cities are therefore heavily dependent on assumptions about these elements, especially rainfall and average roof collection area. In this section, we first consider the potential yield from a rainwater tank roll-out programme compared with the yield from other proposed dams and desalination plants, and then discuss the potential impact on the timing of future water sources.

Potential Yield from Rainwater Tank roll-out

MJA analysis of ABS Census and housing approvals data reveals that the maximum number of houses currently suitable for rainwater tank use (i.e. detached and semi-detached houses)[17] in South East Queensland is around 859,900 and in Sydney is 1,127,500.[18] The actual number of properties suitable for installing a tank could be substantially below this maximum once site specific factors such as available land area and plumbing constraints are taken into account. The maximum number of houses that are 'in-scope' in Sydney is around 70 per cent, and in SEQ more broadly it is 78 per cent of total housing stock (Table 6). The ABS reports that the uptake of rainwater tanks in capital cities, is small, with 4.9 per cent in Sydney, 4.8 per cent in Brisbane and 6 per cent in Melbourne. This contrasts with Adelaide where 37.8 per cent of households had a rainwater tank in 2004.[19]

17 The ABS identifies 'semi-detached' houses (11% and 6.6% of total houses in Sydney and SEQ respectively in 2001) as including some row, terrace and town houses, which may be less suitable for rainwater tanks. However, MJA notes that Gold Coast City Council includes as mandatory rainwater tanks on all new '...such dwellings as stand alone single dwellings, duplexes, row houses, terrace houses, town houses and villa units'. (Gold Coast City Council, 2007: p1).

18 Based on census data for 2001 and building approvals data to 2006 (Cat 8731.0, 3236.0).

19 ABS. 2004. Environmental Issues: People's Views and Practices. Cat 4602.0.

Table 6: Potential rainwater tank households 2006 – Sydney and SEQ

Water Source	*Sydney*	*SEQ*
Total households 2006	1,610,800	1,104,647
Total potential RWT households 2006	1,127,519	859,907
Ratio of potential RWT households to total households 2006	70%	78%

Source : ABS, Qld Govt, MJA analysis[20]

The yield from a rainwater tank roll-out programme will be constrained by the number of suitable sites. Given the broad band of yield per rainwater tank found in Figure 1, MJA does not consider a point estimate of yield to be a realistic approach without modelling based on multiple weather stations and detailed information on roof collection areas. As such, when estimating the potential yield from rainwater tanks, MJA provides a number of alternatives relative to yield assumptions. These assumptions are found in Table 7.

The equivalent number of rainwater tanks for the full capacity yield of a 500ML/day desalination plant in Sydney would be 3.65 million at a yield of 50kL/a, 2.6 million at 70kL/a, and 1.8 million at 100kl/day.

Stage 1 of Traveston Dam at sustainable yield would require 1.4 million rainwater tanks at 50kL/a, 1 million at 70kL/a, or 700,000 at 100kL/a.

Results are summarised in Table 7.

Table 7: Alternative Sources: Number of rainwater tanks for equivalent yield, Sydney and SEQ

Water Source	*Total annual yield (ML/a)*	*Number of rainwater tanks for equivalent yield*		
		50kL/a	70kL/a	100kL/a
Sydney Desalination (125 ML/day)	45,625	912,500	651,786	456,250
Sydney Desalination (500 ML/day)	182,500	3,650,000	2,607,143	1,825,000
Traveston Dam Stage 1	70,000	1,400,000	1,000,000	700,000
Wyaralong Dam	18,000	360,000	257,143	180,000
Gold Coast Desalination	45,000	900,000	642,857	450,000
Max number of houses 'in scope' SYD - 2006			1,127,519	
Max number of houses 'in scope' SEQ - 2006			859,907	

Source : MJA analysis

[20] 2001 data from ABS Census, household growth 2001-06 from ABS Cat 8731.0, SEQ total household data from Qld Govt 2007. See Table 8 for detailed analysis

Take-up scenarios

The analysis of the previous section identified the equivalent yield of various dams and desalination plants compared with rainwater tanks. In some cases, the number of tanks is in excess of the number of 'in scope' properties. However, rainwater tanks effectively defer the need for new water sources by reducing the demand on existing water supplies and 'freeing up' capacity that can then be used to supply growth rather than constructing new water sources.

MJA understands that it is unlikely that rainwater tanks would be capable of being installed within the required timeframe, or provide sufficient security, to avoid the immediate drought response needs of South East Queensland (such as the construction of the Western Corridor Recycled Water Scheme). However, longer term water supply solutions targeting future growth could potentially be deferred if rainwater tanks adequately reduce the draw on existing water sources.

Contrary to expectations, existing houses in Sydney and especially in SEQ have large potential for take-up of rainwater tanks when compared with future growth in dwellings in greenfields sites. While new dwellings can be designed to be 'rainwater tank-friendly', a growing proportion of future dwellings are expected to be in high density unit blocks which are mostly unsuitable for rainwater tanks (although the majority of new dwellings since 2001 have been detached 'rainwater tank-friendly' dwellings).

The majority of existing dwellings in Sydney and especially SEQ are detached houses, making them suitable in theory for rainwater tanks. While there has been a trend in recent years for larger houses on smaller blocks, these do not constitute the majority of houses in SEQ. Indeed, older houses are more likely to sit on a property with a larger backyard with available space for a rainwater tank. Furthermore, the classic 'Queenslander' house sits on stilts and typically has more space underneath to sit a rainwater tank.

However, existing dwellings are likely to prove more expensive to connect to rainwater tanks (especially when plumbed for internal use), and the roofing may be designed awkwardly for rainwater capture. It is clear that not every detached or semi-detached house is suited for tank capture, and it is likely that connection will be more costly for these houses than in greenfields sites.

Regardless, the generous rebates being offered in SEQ (up to $1,700 per tank with $100 more if plumbed internally) are clearly motivating many homeowners to purchase a tank, with 500 rebates a week being granted by Brisbane City Council at the time of writing (which is an annual rate of 26,000) and reports of waiting periods of 6 months for some tanks.[21] The small rebate for plumbing costs may account for the small proportion of rebates going to tanks being plumbed internally (around 5 per cent). Also, tightening water restrictions are clearly motivating homeowners to use rainwater on their gardens.

MJA has seen no study into the potential for rainwater tank take-up in SEQ or Sydney and makes no claim to this in this paper. However, there appears no major physical impediment for take-up in the majority of existing dwellings, and a number of policy options exist should

[21] Pers comm. Brisbane City Council, 23 March 2007.

this be deemed an economically viable objective, from larger rebates to more compulsory policies.[22] Where internal plumbing is impractical, external use is clearly attractive in SEQ (with 95 per cent of rebates going to external use). SEQ also has high outdoor water use compared with other capital cities and therefore limiting rainwater tanks to outdoor use reduces annual yield by only around 15% (compared with tanks plumbed for both indoor and outdoor use, based on a 5kL tank and $125m^2$ roof collection area).

MJA provides a number of illustrative scenarios for take up, found in Figure 3 and Figure 4. These scenarios demonstrate the impact on expected annual demand of a take-up of rainwater tanks of 5 per cent of houses per year, up to different threshold points. A maximum of 10 per cent is considered by industry to be substantial, however MJA have modelled a number of scenarios between this figure and the maximum conceivable take-up ('Max take-up').

For Sydney, 'BAU less 40%' models 'business as usual' demand based on ABS household projections, less an assumed 40 per cent reflecting the maximum impact of BASIX water savings targets on new dwellings.[23] All lines below this demonstrate take-up of rainwater tanks in existing homes at 5 per cent per year, to thresholds at 10 per cent, 25 per cent, 50 per cent, and the maximum potential take-up.

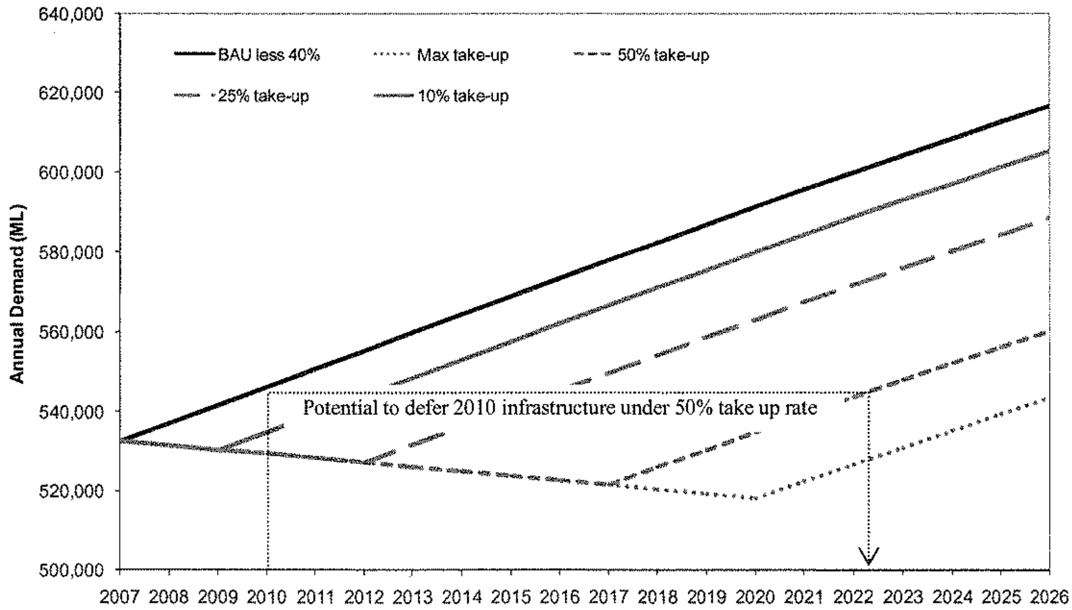
As we concern ourselves with the potential for rainwater tank rollout on *existing* dwellings, and the 'BAU less 40%' assumes a reduction of 40 per cent of demand from *future* dwellings, there is no double-counting in this analysis.

The overlaid arrow demonstrates the potential to defer expenditure on water source infrastructure that would otherwise have been constructed in 2010 (for illustration only). Water sources could potentially be deferred by more than the indicated time if demand management initiatives reduce future demand, or may be deferred by less than the time indicated due to other factors such as the need for emergency water supplies or specific regional growth requirements.

22 Regarding the potential for mandating rainwater tanks on all suitable houses, MJA notes that both NSW and QLD currently mandate rainwater tanks for all suitable new houses.

23 BASIX is described in more detail below

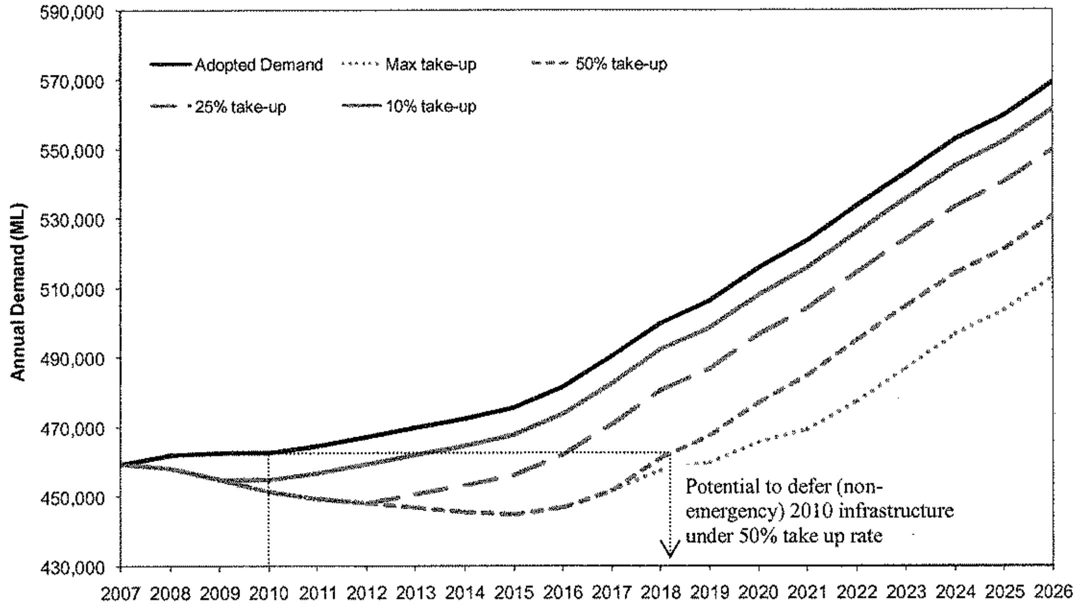
Figure 3: Annual demand impact of different rainwater tank take-up schedules - Sydney



Source: MJA analysis

Figure 4 reflects these same take-up scenarios in SEQ, using the 'adopted demand' scenario from the Queensland Government's paper 'Water for South East Queensland: A long term solution'. This is based on a medium savings scenario which assumes rainwater tanks on all new developments, but an 'ultimate penetration of 5% of existing accounts' (Qld Govt, 2006: p16). As current penetration is already at 5 per cent, MJA identifies no double-counting, and regardless provides a number of take-up scenarios.

Figure 4: Annual demand impact of different rainwater tank take-up schedules - SEQ



Source: MJA analysis, DNRMW (2006)

Future housing growth to 2026 is expected to be associated with a higher proportion of rainwater tanks than there are currently, given new regulations in NSW and QLD.

Based on the estimates of demand shown in the charts above, the impact of rainwater tank take up on new water infrastructure can also be estimated. In most cases, the precise timing of future water sources is unknown. In the case of Sydney, the existing metropolitan Water Plan estimates that a major new water source may not be required for 10 years or more if adequate demand management and recycling initiatives are in place. However the NSW government has indicated that a desalination plant will act as a contingency measure if water supplies fall below certain critical levels.

While the exact timing of new sources is unknown, MJA has illustrated the impact of rolling out rainwater tanks to 5% of households each year, assuming that Sydney demand were 40% less than "Business As Usual" (due to demand management, as above) and the SEQ demand matched the case adopted by the Queensland Government. In this scenario, expenditure in 2010 that was required to cater for demand growth across the system (excluding emergency supply options) could potentially be delayed:

- past 2026 in Sydney or to 2019 in SEQ if all potential housing (i.e. detached or semi-detached houses – 70 per cent of Sydney dwellings and 78 per cent of SEQ dwellings) could install a rainwater tank;
- to 2022 in Sydney or to 2018 in SEQ if only 50% of total dwellings could install a rainwater tank;
- to 2012 in Sydney or 2013 in SEQ if only 10% of total dwellings could install a rainwater tank;

BASIX requirements in NSW

As of 1 October 2006, all new residential dwellings as well as all residential alterations and additions throughout NSW are required to satisfy BASIX requirements. These requirements relate to energy and water efficiency, and can be met flexibly, including through the optional use of rainwater tanks. However, it appears that rainwater tanks are effectively mandatory because it seems difficult to satisfy the alternative water supply requirements without one, even though different options are available, including the use of groundwater or recycled water.

BASIX sets energy and water reduction targets for new homes and apartments. The Water target ranges from 40% to 0% across NSW, taking into account the significant variances in the climate. Key points are:

- 90% of new residential development will be covered by the 40% water target.
- No new home built in NSW will use more water than the current state average.
- The areas covered by the 40% target represent 98% of the state's population growth.

The BASIX website provides examples of how to meet water targets in different areas of the state.

A BASIX fact sheet states: BASIX is subject to ongoing monitoring: since implementation, the Department has conducted a monitoring program of 100 BASIX-compliant home designs that are now in the development approval and construction process. Items to note:

> *Every home has a rainwater tank, the average size being 4,000 litres and the majority of which will be plumbed to the toilet and laundry, as well as providing water for the garden.*

Building requirements in SE Queensland

New water savings targets set by the Queensland State Government will apply to building development applications lodged for the construction of new houses in South East Queensland from 1 January 2007 and state-wide from 1 July 2007.[24] The new targets can be achieved through a number of options including household rainwater tanks or alternatives such as dual reticulation, communal rainwater tanks or storm water reuse (most of which are less attractive options than rainwater tanks).

There are minimum requirements in place if rainwater tanks are used to meet the water savings targets. These are:

- single detached houses must install a rainwater tank with a minimum 5000L capacity;

[24] http://www.lgp.qld.gov.au/docs/building_codes/housing/water-saving/faq.pdf

- non-detached houses, such as town houses and terrace houses, must install a rainwater tank with a minimum 3000L capacity;

- rainwater tanks must receive rainfall from at least one half of the roof catchment area or 100m2, whichever is the lesser;

- rainwater tanks must supply water for external use and internal use to toilet cisterns and washing machine cold water taps;

- internal fixtures supplied from a rainwater tank must have a continuous supply of water, which may be achieved by an automatic switching device or a trickle top up system.

The potential for future growth in rainwater tanks associated with current building requirements is thus quite strong. It appears that the vast majority of appropriate dwellings in NSW will attach a rainwater tank as part of their BASIX requirements, and the same appears to be true for QLD. In terms of dwelling growth, however, South East Queensland appears to have higher relative potential for rainwater tank growth than Sydney, due to the types of dwellings being constructed there.

MJA is aware of no published projections of dwelling type to 2026 or beyond. However, there has been a trend towards higher density living in recent years, and this trend can be expected to continue in the future as the scope for greenfields developments decreases. This will reduce the potential for rainwater tanks in future housing growth over time, bringing us back to the substantial potential for rainwater tanks in the existing housing stock.

The proportion of recent household growth in Sydney and SEQ which could potentially use a rainwater tank (RWT households) is found in Table 8.[25] For Sydney it is just over 50 per cent, and for Brisbane it is closer to 75 per cent. This reflects the growth in high density housing in Sydney. MJA is unable to predict the housing composition of future growth, however Sydney is expected to grow 450,00 houses to 2026 while SEQ grows almost 600,000. It is likely that the growth in potential RWT households as a proportion of total growth will slow. If, for example, future growth in households is 50 per cent 'rainwater tank-friendly', this will grow 225,000 rainwater tanks in Sydney, and 296,500 in SEQ.

[25] Detached, semi-detached, row, terrace and town house

Table 8: Housing growth 2006-2026, Sydney and SEQ

Water Source	*Sydney*	*SEQ*
Households 2006	1,610,800	1,104,647
Growth in potential RWT households as proportion of total growth 2001-06	52%	74%
Total potential RWT households 2006	1,127,519	859,907
Total household growth 2006-2026	449,500	593,027
Total households 2026	2,060,300	1,697,674
If growth 2006-2026 is 50% potential RWT households	224,750	296,514

Source : ABS, MJA analysis[26]

26 2001 data from ABS Census, household growth 2001-06 from ABS Cat 8731.0, household projections 2006-2026 from ABS Cat 3236.0, SEQ growth data based on medium population growth projections from Qld Govt and average household size estimations. Rainwater tank projections for SEQ based on Brisbane housing approvals data 2001-06 (ABS Cat 8731.0)

5. Cost of rolling out rainwater tanks

Question Four: What would be the cost to Government of a targeted program to roll out rainwater tanks to 5% of households each year in high rainfall cities such as Sydney and Brisbane?

As outlined above, State Governments across Australia have legislation and regulation focussing on attaching rainwater tanks to new housing and renovations. However, MJA has identified that a significant proportion of existing households could make use of rainwater tanks, but currently do not and will be largely untouched by existing policy. As such, there is scope to expand the number of existing households with rainwater tanks.

Table 9: Cost of rolling out rainwater tanks, Sydney and SEQ

	Sydney	*SEQ*
Total households 2006	1,610,800	1,104,647
5% of households	80,540	55,232
'In scope' RWT households 2006	1,127,519	859,907
Proportion of current households with rainwater tanks	5%	5%
Proportion of 'in scope' RWT households but without RWTs	65%	73%
Number of 'in scope' RWT households but without RWTs	1,046,979	804,675
Max years available for excess take-up of rainwater tanks	13.0	14.6
Approx ave cost of 5kL rainwater tanks	$2,500-$3,500	$2,500-$3,500
Total annual capital cost of 5% roll-out of rainwater tanks ($m)	$200-280	$140-200
Annual water savings (low)ML / RWT / a	3,800	2,300
Annual water savings (high) ML / RWT / a	8,500	5,500

Source : ABS, MJA analysis[27]

Given the scope for potential take-up of rainwater tanks in existing households, MJA estimates that if rolled out to 5 per cent of total households per year and *all* potential households were capable of installing tanks, households without a tank would be exhausted in 13 to 15 years. Table 9 shows that, assuming a capital cost of $2,500-3,500 per rainwater tank and an average yield of 70kL/a, roll-out would extend annually to:

[27] 2001 data from ABS Census, household growth 2001-06 from ABS Cat 8731.0, household projections 2006-2026 from ABS Cat 3236.0, SEQ growth data based on medium population growth projections from Qld Govt and average household size estimations. Rainwater tank projections for SEQ based on Brisbane housing approvals data 2001-06 (ABS Cat 8731.0)

- over 80,540 households in Sydney at an annual capital cost of $200-$280 million, saving 3.8-8.5 GL/year per 5 per cent of houses; and
- 55,232 households in South East Queensland at an annual capital cost of $140-$200m, saving 2.3-5.5 GL/year per 5 per cent of houses.

The cost of developing and implementing policies to enact this rollout would be in excess of these figures. However, flexibility in application of the policy could see some rainwater tanks being installed externally only, with substantial installation savings (but lower average yields). Any policy installing such a high number of tanks per year would be expected to attract a capital savings through bulk purchase and installation.

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Comment on the SMEC report:

“INTEGRATED WATER SUPPLY OPTIONS FOR NORTH EAST NEW SOUTH WALES AND SOUTH EAST QUEENSLAND”

Snowy Mountains Electricity Commission

Inquiry into Additional Water Supplies for South East Queensland – Traveston Crossing Dam

8 May 2007

Table of Contents

Executive Summary

This report critically evaluates a number of the key assumptions and conclusions put forward in the Snowy Mountains Electricity Report: *Integrated Water Supply Options for North East New South Wales and South East Queensland* (referred to as the SMEC Report in this document). In particular, it raises serious questions about the validity of the Snowy Mountains Electricity Report in its capacity to be used to assess water options for South East QLD.

There are a number of statements made in the SMEC Report that are challenged by the findings in this report. There are also a number of issues that should have been included in the assessment of the viability of the selected preferred options. The major points of contention with the report are as follows:

1) Climate change impacts have not been considered on yield estimates.
2) Climate change has not been factored into environmental flow and regulation issues.
3) Issues with climate change and methods of assessment lead to lower expected yields and therefore increase costs of water.
4) There remain serious questions over the methods of assessment of storage sizes, yields and regulation of all the selected preferred options.
5) The preferred options impacts on the nationally listed endangered Eastern River Cod and other fauna.
6) The preferred options will significantly impact National Parks.
7) It fails to acknowledge Indigenous Land Use Agreements.

A more comprehensive assessment is needed before any conclusions can be drawn concerning the viability of any of the options listed in the SMEC report.

1.0 INTRODUCTION

A number of concerns have been noted regarding the outcomes of the Snowy Mountains Electricity Report: *Integrated Water Supply Options for North East New South Wales and South East Queensland* (the SMEC Report) and this document explores those concerns in more detail. Analysis by hydrographers, environmental planners, ecologists and financial analysts has revealed that there are significant assumptions and limitations in the SMEC Report that need re-examination.

1.1 Overview and Purpose

This report evaluates the following aspects:

- the impacts of climate change on the SMEC Report conclusions;
- reassessment of water availability based on local water arrangements and environmental assessments critical to the viability of the selected preferred options;
- Indigenous land management issues - included because of recent changes in land use agreements in Northern NSW, and
- re-assessment of the cost estimates (in consideration of the points above).

This report acknowledges that the SMEC report recommended further work be conducted to determine the hydrological, environmental and socioeconomic aspects of the potential for water supply options from Northern NSW. Not withstanding this recommendation this report presents evidence that seriously questions the conclusions of the SMEC report.

1.2 Summary of SMEC Report: Selected Preferred Options

The following excerpts are taken from the *Forward* of the SMEC report. These are given here to give a background to this document. It is important to acknowledge that the critique of the SMEC report acknowledges that the scope and purpose of the SMEC report did not include detailed environmental, economic and social assessment. Additionally, it is also acknowledged that it was a desktop study with major limitations. However, the purpose of this report is to critique the SMEC report in light of the possibility that the SMEC report is used to make policy decisions on the alternative water supplies for NSW and SEQLD. For background purposes the most salient section of the SMEC Forward has been given below.

> "The review recommends five options for further investigation. Four of the five options are based on storage and transfer from the Clarence River whilst the fifth (and cheapest) is based on storage and transfer from the Tweed River catchment. A dam on the Clarence River upstream of Duck Creek with a pipeline to the Logan River could provide up to 100,000 Megalitres (ML) per annum at a price of around $1.73 per kL. This proposal stands out as the best value for money with the capacity to effectively serve both SEQ and NE NSW in the medium to longer term. It is dependant however on construction of a large storage and will require detailed environmental scrutiny.
>
> The review recommends five options for further investigation. Four of the five options are based on storage and transfer from the Clarence River whilst the fifth (and cheapest) is based on storage and transfer from the Tweed River catchment."

Table 1 Selected Preferred Options – SMEC Report Executive Summary Table p2.

Option	River	Description	Estimated Yield	Unit Cost Bulk Water($/KL)

TW7	Tweed Dam on Oxley River. Pipeline from	Brays Park Weir to Nerang River	20,000	$1.42
CL3b	Clarence Dam on Clarence Upstream of Duck	Creek. Pipeline to Logan River	100,000	$1.73
CL5b	Clarence Dam on Tooloom Creek.	Pipeline/tunnel to Logan River	20,000	$1.65
MA1	Clarence Weir on Mann River. Pipeline to	Logan River	50,000	$2.12
MA2	Clarence Dam on Mann River. Pipeline to	Logan River	100,000	$2.04

1.3 Points of contention with the SMEC Report

There are a number of statements made in the SMEC Report that are challenged by the findings in this report. There are also a number of issues that should have been included in the assessment of the viability of the selected preferred options. The major points of contention with the report are as follows:

i) Climate change was not discussed in the report.

ii) Decreases in potential yields resulting from climate change were not considered.

iii) Climate change and subsequent decreased flows predicted for the region will exacerbate all environmental issues.

iv) Climate change and subsequent decreased flows predicted for the region will exacerbate river regulation issues.

v) The approach to the storage-yield assessment is not aligned with a typical hydrological assessment. There appears to be no information in the report on the hydrological efficiency of the proposed storages. It appears that a desired yield has been identified and then a storage size has been determined to provide this yield.

vi) Regulation and the ratio of storage capacity to annual inflow for the selected preferred options of CL3b, MA2 and TW7 exceeded the SMEC Reports own targets. The regulation targets of 15% and low ratios of storage capacity to annual inflow were set to ensure environmental and riverine ecology health and ensure the viability of storages.

vii) Failure to identify present regulation in the Mann/Nymboida system that impact on potential yield, river regulation and environmental flows.

viii) Serious questions over the actual data presented at the Upper Clarence above Duck Creek selected Preferred option (CL3b). The SMEC data presented in the report overestimates the yield from this site. A more realistic lower yield has been recalculated based on SMEC's own data.

ix) Points raised in vi) and vii) means that the regulation issues of environmental and riverine ecology health are exacerbated.

x) The questioned flow estimates coupled with stream flow reductions due to climate mean that yield will be considerable lower than reported at the upper Clarence above duck creek dam site option and highly likely in the Mann River (MA2) option.

xi) A more realistic, decreased yield in the Mann River and Upper Clarence options will increase costs estimates significantly.

xii) Impacts on species and communities will become more acute with decreasing flows caused by climate change. All rivers at the selected preferred option sites were identified as experiencing high environmental stress.

xiii) Impacts on National Parks will occur in all selected preferred options tabled in the SMEC report. Some parks will have severe and adverse impacts on the integrity park features.

xiv) There are a number of threatened species listed under NSW legislation that will be affected by the proposed selected preferred options.

xv) The selected preferred options of on the Mann River (MA2) and the Upper Clarence (CL3b) will impact on the critically endangered eastern freshwater cod (*Mucculochella ikei*).

xvi) Federal assessment under the EPBC Act (Environment Biodiversity Conservation Act) will most likely occur if the CL3b and the MA2 options are to proceed.

xvii) Recent Indigenous Land Use Agreements involving the Yabbra National Park and Tooloom National Park will mean that potential dam construction is subject to consultation with the Githabul People.

1.4 Scope and Limitations

This report was written in response to the extended deadline to examine the SMEC report within the Senate Inquiry into Additional Water Supplies for South East Queensland – Traveston Crossing Dam. As such further work needs to be conducted to a examine many of the issues raised in this report.

This review of water availability and storage assessments of the SMEC report have been undertaken using the SMEC data itself, additional local information and stream flow data from the Dept. of Land and Water NSW. It is acknowledged that issues identified in this report needs to be verified by more extensive modelling work. However, the conclusions made in this report indicate that the outcomes of further extensive modelling will most likely result in seriously questioning the viability of the preferred selected options outlined in the SMEC report.

The water Issues of the Tweed River have not been examined in detail. The Tweed River Water Strategy outlines how future water issues should be addressed that balance increasing water extraction demands with environmental flow requirements (and other social and environmental issues). The SMEC Report outcomes are not in alignment with that strategy. Further assessment and consultation should be undertaken before judging the viability of the options for water transfer to South East QLD from that system.

2.0 CLIMATE CHANGE

2.1 Failure to Account for Existing Decreased Rainfall and Flow

The SMEC report has not acknowledged the impact of climate changes on storage size and yield calculations. There is strong evidence indicating significant decreases in rainfall and runoff in Northern NSW. The SMEC report does not consider this evidence. In NSW

> NSW annual total rainfall has decreased 14.3mm/decade since 1950, dominated by high year-to year variability. Temperature increases in NSW mean that there is a tendency for more recent dry periods to be accompanied by warmer temperatures than in the past. Decreases in the annual intensity and frequency of extreme daily rainfall events in NSW are consistent with the decline in annual mean rainfall since 1950, with strongest decreases at coastal locations.
> NSW Government P1

This conclusion is evidenced later in this report after assessment of stream flows in the Upper Clarence was conducted. That assessment showed that annual average runoff has been decreasing since 1965 in the Upper Clarence.

2.2 Climate Change Projections

The findings and conclusions of the report fail to account for future impacts climate change. There is considerable evidence to suggest that there will be a decrease in annual rainfall and subsequent decrease in runoff in the catchments of the selected preferred options in the SMEC Report

A report by the CSIRO indicates significant changes are likely in the region.

> Over NSW, average decreases in annual moisture balance are largest in the north and smallest along the coast. By 2030, annual average decreases range from 0 to 195 mm along the

> coast and 20 to 325 mm in the north, relative to 1990.
> (Hennessy etal. 2004, p9)

The Clarence and the Mann river systems whilst may be considered coastal are about 100km inland. These catchments will be more impacted upon by climate change when compared to the Tweed system. Thus reduced rainfall is expected in these systems.

Additionally the likelihood of increases in drought frequency is high.

> The projections indicate that increases and decreases in drought frequency are possible, but there is a tendency toward increases, especially in winter and spring.
> (Projected changes in climate extremes NSW Gov P19)

This will mean that the yields for the run of river options identified in the SMEC report will be lower than reported. Implications for expected yields from storages are that the size of storage will generally need to be larger to capture expected yields. This has major implications for environmental flows and regulation issues.

A general estimate of the likely decrease in runoff is given below. It is relevant to Northern NSW because the rainfall patterns are similar to South East Queensland, particularly the Upper Clarence catchment. The implication for runoff is outlined in the Queensland Government's submission to the senate inquiry

> A preliminary assessment of the impact of climate change on inflows into SEQ storages has been conducted using the outputs from a range of general circulation models and an approximate method of down-scaling the climate information to the catchment scale. The results show average annual inflows tending to decrease by up to -16%. The impact on yields is similar but may further reduce yields if future down-scaling work reveals longer embedded dry periods.
> (QLD Government senate inquiry submission 2007, p.87)

Based on this information presented above, a decrease in runoff should have been factored into the yield estimates, environmental flow requirements, and future local water regulation. Not doing so overestimates the available water for delivery to South East Queensland. It should also be stated that the16% decrease in average annual inflows is considered as conservative.

Assuming normal conditions will continue is not appropriate. The yield estimates for all selected preferred options listed in the SMEC report will not be achievable with the same environmental flow and regulation requirements. Additionally, some selected preferred options will be affected more than others because of the differences in catchment locations relative to the coast and latitude. This will have an impact of bulk untreated costs estimates. The cost of bulk untreated water will increase because of falling yield. Changes to water availability and cost estimates as a result of climate change are given in those sections later in this report.

2.2 Climate Change and Stressed Rivers

Overall, climate change will have a negative affect on biodiversity, as it will exacerbate existing stresses on ecosystems, as well as creating new ones (CSIRO 2003). Therefore, with increasing human demands for water it is paramount that environmental needs are adequately represented and catered for in management decisions. (Climate Action Network Australia. retrieved April, 2007).

The SMEC report has identified the Upper Richmond River as a ‘highly stressed river’ but fails to acknowledge that the Clarence and the Mann Rivers at the position of selected preferred options have been assessed as having high environmental stress characteristics. Mann and Clarence have not been identified as hydrologically stressed in SMEC report. This is an oversight in process for the Mann River (MA1 and MA2) assessment.

Specific recommendations exist regarding the water regulation of river systems. For example, the Nymboida River, upstream of its confluence with the Mann, is already subjected to high levels of extraction. It is classified by the

NSW Stressed Rivers Assessment as having high hydrologic stress. Furthermore, the Healthy Rivers Commission of New South Wales (1999) identified that there was a “pressing need to contain further growth in water extractions (under most flow conditions) from the Nymboida River, both to protect the river itself and to protect those existing users who have already made investments in water using activity.”

Decreased runoff under climate change scenarios will exacerbate the stress in these all river systems assessed in the SMEC Report. This is a significant issue because all of these the rivers have already been rated as having high environmental stress.

3.0 WATER AVAILABILITY

There are a number of issues with the way SMEC Report has assessed water availability. The specific issues are detailed in each section below.

3.1 Methods of Assessment

The SMEC Report does not explain its method of assessing the selected preferred option . It can only be assumed that the methods used to determine the yields reported in the SMEC Report are adequate and the yields reported are reasonably reliable. This is a considerable assumption given the gravity of the potential impact this report could have on the future development of northern NSW and climate change.

From the brief description of the conceptual methodology for this assessment it seems that the approach to the assessment is not aligned with a typical hydrological assessment. It also appears that a desired yield has been identified and then a storage size has been determined to provide this yield. Normally a storage site would be identified and then this site would be analysed to determine the most efficient size of storage for that site.

A storage site would usually have a hydrological point of inflection up to which point an increase in storage size will produce an increase in yield but after which point an increase in storage size would only produce a very small increase in yield. An economic assessment of such a site would normally determine that a storage size around this hydrological point of inflection will be the most economical. There appears to be no information in the SMEC Report on the hydrological efficiency of the proposed storages.

3.2 Critique of Upper Clarence Options

There are two main concerns associated with the assessment of the yields and flow regime impacts for the upper Clarence River storage options. Firstly, there seems to be a disparity with the figures presented that were used for storage inflows and secondly, it appears the impacts of climate change on potential yields were not considered.

3.2.1 Disparities with Data presented for the Upper Clarence

A number of the tables included in the SMEC Report contain conflicting data with regard to the inflow estimates. It appears this has led to an over estimation of the historic annual yield and therefore seriously compromises the reported outcomes. This questions the ability for the system to provide maintenance of environmental flows and allocations downstream from the storage.

Table 4.1 "Estimated annual natural runoff at selected diversion points" (p40) and Table 4.5 "Potential dam sites details" (p48) cite the flow for the dam site upstream from Duck Creek as 400,000ML/yr. However, this contradicts the information presented in Table 3.3 and 3.4 (p28-29) where the annual average flow rate for the dam site upstream from Duck Creek is cited as 650,000ML/yr. It can only be assumed that the figures calculated for this site and presented in Tables 3.3 and 3.4 have been based on the larger and incorrect figure of 650,000 ML/yr. It is therefore likely that the stated yield would not be able to be secured. If this yield could not be secured the following implications would result.

Assuming a yield of 100,000 ML/yr, the ratio of storage capacity to storage yield and the ratio of average annual inflow to storage capacity will be affected considerably. In short, the ratios will increase markedly as will the percentage of regulation at the dam site.

This strongly suggests that the yield is inaccurate and the impact on downstream flows is underestimated. The dam is unlikely to be efficient as it has to be very large to account for the fact that it is in a smaller than assumed catchment and its failure rate is likely to be considerably higher than reported. The following tables outline some likely alterations to the reported figures as a result of this discrepancy. It should be noted that as there was very little information provided on the method of assessment it is difficult to accurately determine the implications of these discrepancies.

It should also be noted that the storage size ratio is:

> "a relationship between the average annual inflow to a dam and its storage capacity is a good index for sizing storages. The ratios give an indication of the hydrologic limits. High ratios point towards difficulties in filling the storage." SMEC. 2007,p29)

Table 2. Recalculation of Ratios of Average Annual Inflows to Storage Capacities for the Storage Site on the Upper Clarence upstream of Duck Creek (CL3b).

Time Period	**Flow at Tabulam (ML/yr)**	**Flow at Dam Site (ML/yr)**	**Ratio of storage size to average inflow at dam site** (Assuming 250,000 ML storage)
1909 To date (SMEC report)	756,000	650,000	38%[1]
1909 To date (recalculated)	**756,000**	**400,000** [2]	**63%**

1 It is proposed this figure is incorrect based on a discrepancy in the inflows adopted in the SMEC report.
2 This is the (correct) annual average flow at the proposed dam site as quoted in table 4.1 and 4.5 in the SMEC document.

3.2.2 Contemporary Trends – Reduced Annual Inflow

There is evidence to suggest the runoff in the catchments of the Upper Clarence is decreasing and has been decreasing for some time. An investigation into how the ratio of storage size to average inflow has been changing over time suggests issues such as climate change are already affecting system flows. Table 3 presents the change in this parameter over time. It should be noted that the period from 1909 to date includes the significant drought at the beginning of the century so the data is not necessarily skewed by the recent drought.

This shows that the figures presented in the SMEC Report are potentially misleading and if the figures shown here are considered correct, the viability of a dam at this site is reduced. These revised figures show quite clearly that a storage at this location would have too much impact on downstream flows and the yields and corresponding reliabilities expressed in the SMEC Report would be unachievable.

Table 3. Contemporary Trends in Ratios of Storage Capacity to Average Annual Inflow for the Storage Site: Upper Clarence upstream of Duck Creek (CL3b).

Time Period	Flow at Tabulam (ML/yr)	Flow at Dam Site (ML/yr)	Ratio of storage size to average inflow at dam site*
1909 To date	756,000	400,000	63%
Aug 1965 to date (40.6Years)	676,921	351,999	71%
1987-to date (20 years)	514,502	272,686	91%
1997 to date (10 years)	317,763	168,414	148%

Assuming 250,000 ML storage and that the ratio of dam site flow to flow at tabulam can be used to infer stream flow data.
Source: NSW Gov, Provisional River Data

3.2.3 Climate Change and New Calculations of Storage In-Flow

It is generally accepted that all contemporary yield assessment should be done with consideration for climate change as has been discussed in Section 2 of this report. If this consideration is included into the assessment the impacts on yields and flow related impacts will be further exacerbated.

Tables 4 and 5 present the impact climate change would have on storage capacity and regulation issues. The issues are highlighted through assuming two scenarios. The first is the climate change scenario indicating a general decrease of 16% in flows of the period from 1909 to date. The second is that there will be a decrease in flows based on contemporary flow regimes. Despite the fact that further rainfall runoff modelling needs to be undertaken, the results broadly identify the yield, storage and regulation issues of decreased rainfall and runoff in the catchment. Table 4 illustrates two climate change scenarios in ratios of average annual inflows to storage capacity of the

250 000ML dam site at Upper Clarence, upstream of Duck Creek.

Table 4. Climate Change Scenarios in Ratios of Average Annual Inflows to Storage Capacities (Upper Clarence, upstream of Duck Creek option (CL3b))

Scenario	**Annual Average Flow** ML/Yr at Dam Site	**Ratio of storage size to average inflow at dam site** (Assuming 250 000 meg storage)
Climate change 1 (16% decrease runoff using data:1909 to date)	336 000	74%
Climate change 2 (16% decrease runoff using data:1965 to date flow)	295 679	85%

Source: NSW Gov, Provisional River Data

Table 4 shows that there are high ratios of storage size to average inflow at the upper Clarence above Duck Creek dam site given climate change scenarios. The large percentage ratios indicate that under the climate change scenarios the storage performs poorly. This has implications for the possibility of realising 100 000ML flow yield at this site for all years as stated in the SMEC Report. The economic implications will be discussed in the relevant section below. This has implications for downstream effects if the proposed 100 000 ML/yr yield is be realised in all years. Table 5 shows the percentage of flow regulated given the climate change scenarios.

Table 5. Percentage of flow regulated (Dam Size 250 000ML)

Dam Site	**Yield**	**Ratio of storage size to average inflow at dam site**	**Annual Average Flow**	**Percentage of flow regulated**
Upstream Tabulam - Upstream Duck Creek	100,000	38%*	400,000	25%
Climate change 1 (16% decrease runoff 1909 to date)*	100 000	63%	336 000*	29%
Climate change 2 (16% decrease runoff on 1965 to date flow)*	100 000	85%	295 679*	33%

Under the guidelines set down in the SMEC Report the proposed storage in the upper Clarence, upstream of Duck Creek, exceeds the regulation limits. In the SMEC Report the following limit on regulations of stream flow exists.

> "Limits on levels of regulation and adoption of the NSW's stressed rivers policies of providing minimum flows from dams formed an important consideration of this study in sizing storages. Regulation of rivers was limited to around fifteen percent as a basis for environmental and riverine ecology health. The ratio of storage capacity to annual inflow was also generally kept below unity to ensure the viability of the storages" (SMEC 2007 p.3)."

The proposed storage after the revised calculations and especially after factoring climate change does not fit the SMEC Report criteria regarding minimum flows from dams and the viability of the storages.

3.3 Critique of Selected Preferred Mann River Options

The options listed for the Mann River have not taken into account existing water availability and allocations. The following points indicate that the Mann River weir is not viable and the dam option seriously undermines water availability and environmental flow characteristics of the Mann/Nymboida/Clarence catchment.

3.3.1 Clarification of Flow Regimes

The authors of the SMEC Report have obviously not been aware of existing flow diversion and water use activities upstream of the Mann River options (MA1, MA2). This has resulted in the use of incorrect flow gauge information to estimate water available to satisfy NSW environmental flow requirements and for dam yield. The use of the Mann river flow data has not recognised cumulative impacts of upstream extraction and as such has underestimated the environmental flow requirement, the percent regulation at the dam site, and overestimated the dam yield. It also has major negative implications for flow regimes if the weir at Jackadgery is built.

3.3.2 Mann River Data Does Not Reflect Natural Flow Regimes.

The Mann River has three major tributaries upstream of the Jackadgery stream gauge: the Nymboida, Boyd and Mann rivers. The Nymboida River provides the largest contribution to low and medium flows recorded in the Mann River at Jackadgery (refer flow data file :Nymboida and Mann daily flows for 2001 and 2002).

Significant volumes of water (up to 860 ML/day) have been extracted from the Nymboida Weir since 1924, which is almost the entire period for which flow records exist at the Mann River Jackadgery (since 1910). It is expected that the Mann River 80thpercentile flow (250 ML/D) estimated from Jackadgery stream gauge data would more closely reflect less than the 95th percentile of natural flow, assuming that the remaining tributaries (Boyd and Mann) collectively contribute more than 25 ML/D during these periods. An assumption supported by flow data collected on the Mann River at Mitchell and Boyd River at Broadmeadows.

3.3.3 Regulation and Environmental Flows Upstream on the Nymboida

Water is extracted from a weir pool on the Nymboida River for hydroelectricity power generation and to provide town water supply for the communities of the Lower Clarence Valley and Coffs Harbour. A new storage is being constructed for water supply to Coffs Harbour. It is expected that the 30 000ML Shannon Creek Dam will come online by mid-2008.

Following the Healthy Rivers Commission Inquiry environmental flow rules were introduced downstream of the weir to protect:

- 100% of the instantaneous natural flows when these are less than the 95th percentile (at Nymboida Weir) and
- 30% of instantaneous natural flows (at Nymboida Weir).

Nymboida water extraction has significantly decreased the low and medium flows recorded on the Mann River at Jackadgery. Annual 80th percentile flow recorded for the Nymboida River upstream of the extraction weir pool is 400 ML/D, significantly greater than that recorded downstream on the Mann River at Jackadgery (250 ML/D) (Table 6).

Table 6. Difference in percentile Flow at Mann River and Nymboida

Annual percentile flow	Nymboida at Nymboida 204001	Mann at Jackadgery 204004
95th	225 ML/D	70 ML/D
80th	400 ML/D	250 ML/D

Thus, Mann River flow data (Jackadgery) cannot be accurately used to:

- determine downstream minimum environmental flow requirements (80thpercentile, 95thpercentile) and
- assess the water availability for weir and dam yields.

The SMEC Report needs to examine data from a period that is more reflective of contemporary flow regimes.

3.4 Storage Management Approach – MA2, CL3b and CL5b.

In addition to the above issues about the viability of the sites, the approach to storage management, mentioned in the SMEC report (p1), is contentious. Below is an approach outlined to decrease the impact of such large storages on the Mann River and Upper Clarence.

> Under normal weather conditions, these storages would remain full and all inflows would be passed through the dam, minimising impacts on downstream users and ecology. Operational modeling will be required to offer confirmation on the potential yield increases whilst minimising environmental and social impacts. (SMEC 2007 p.1)

Whilst acknowledgement that this approach to environmental and regulation is a positive one, based on the amended storage-inflow ratios and percentage regulation figures presented above, the likelihood of these storages remaining full and all inflows would be passed through the dam is lessened dramatically. The point of contention lies with the assumption that stream flows will be normal in the future and that the SMEC data correctly estimates the inflow.

3.5 Tweed Catchment Selected Options

The selected preferred option for the Tweed River system is a dam on its major tributary at Rocky Cutting near Mt Warning National Park – just downstream from the town of Tabulam. The 25 000-45 000 ML proposed storage would inundate farmland, riparian rainforest and possibly impact on the township of Tyalgum (no maps supplied in the SMEC Report). Potential impacts include reduction in stream flows, possible resumption of national park (Wollumbin National Park) significant socio-economic impact of relocating affected residents.

The impact of the dam at Rocky Cutting would have adverse impacts on an already stressed river system.

> "In terms of overall condition, most north coast river catchments are in 'better than average' condition compared to other NSW coastal river catchments. However, the Richmond, Tweed and Brunswick are in worse than average condition. Half of the 159 north coast sub catchments are under high environmental stress, while one in six have been identified as having high conservation values." (Healthy Rivers Commission. March 2003 p.36)

Regulation of the Oxley River for diversion to Queensland is a significant issue for the Tweed Shire. The levels of regulation below the Rocky Cutting option on the Oxley River is 26% (for a Queensland diversion limit of 20,000 ML/yr)

The SMEC Report also adds

> "If the measurement location were to be Brays Park Weir (356,000 megalitres per year), with Tweed's future demand of 28,0000 megalitres per year, the levels of regulation from the Rocky Cutting option would be about 11% and 13.5% for diversion limits of 10,000 and 20,000 megalitres per year respectively."

However, this does not change the fact that at the Rocky Cutting dam site there will be 26% regulation of flow (it is acknowledged that water is released downstream of the proposed dam to flow to Bray Park Weir for subsequent diversion to QLD).

4.0 REVISED COST IMPLICATIONS

Before discussing the costs section of the SMEC Report it should be noted that its authors noted that

> "The results of the financial analysis demonstrate the viability of the options developed although they were based on a number of sweeping assumptions due to the restricted time frame, the nature of the study and the lack of access to recent financial data."

It is from this position that the following discussion is based. Notwithstanding this disclaimer, there appears to be certain assumptions that need to be considered before this document can be used to evaluate the relative merits of the selected preferred options proposed.

4.1 Clarification of SMEC Methodology

The variable that can have a large impact on the cost per ML/yr is yield. It appears that an economic assessment of sites have not determined the storage size around the hydrological point of inflection that dictates the most economical size. Abstraction of annual yields seems to be the approach to determine storage size. Further work is needed to determine site specific storage yield parameters. This is critical for an accurate cost of water from each site.

4.2 Realistic Assumptions in Costing Selected Preferred Options

The costing of different dam and weir options were outlined in section 6 of the SMEC Report. The assumptions underlying the option costing were also outlined. One of the foci of this report has been to examine the assumptions and methods of the SMEC Report. Based on the findings presented so far in this report there is sufficient evidence to strongly recommend that the SMEC Report costings should be re-evaluated. Additionally, in this section further assumptions of the SEMC Report are challenged. This casts doubt over the usefulness of the SMEC Report for valid comparison between options in Northern NSW as well as the comparison between of the relative water costs from Northern New South Wales and Queensland.

Two major issues cast doubt over the costing options of the SMEC Report:

- A precautionary approach using a climate change scenario should be the baseline from which to calculate yield and option costs. Sensitivity analysis should be undertaken centred on these costs.

- Annual average yields are questionable based on the high likelihood that supply yields will not be fully utilised in all years at the Upper Clarence and the Mann river sites. Therefore, bulk untreated water unit costs will increase differentially for each site because of decreased yields unaccounted for by the SMEC Report.

Additional to these issues there are concerns regarding costing assumptions. These concerns have a high likelihood of raising the bulk untreated water unit costs uniformly and differentially across all options.

The assumptions that need to be factored into the bulk untreated water unit costs before sensitivity analysis are:

- Assumptions of land resumption costs are equal across all options. The dam options of the Oxley River, Upper Clarence and Mann river have significant land acquisition costs. Not factoring these into the bulk untreated underestimates the costs of these options and makes comparison with other options questionable.

- It was assumed in the SMEC Report that the NSW Natural Resource Management bulk water charges should be ignored. This was done on the basis that the charge is less than 0.5c/kl (SMEC 2007, p 58). However, it cannot be assumed that NSW will be prepared to sell their water for this price given: increasing water demands because of growth in the region; increased pressure of regulated and stressed river systems; and opportunity costs associated with pricing water at this level.

- The economic risks associated with dams on the Upper Clarence, above duck Creek (Cl3b) and the Mann River at Jackadgery (MA2) is substantial. The estimated cost for each option is approximately 1 320 million and 1 500 million respectively. Sensitivity analysis can assess this risk. However failing to factor climate change, inclusion of local flow regulation, inclusions realistic flow data and other assumptions outlined in this section increase the likelihood costs would be prohibitively high.

4.3 Climate Change and Costings- Upper Clarence Dam Option (CL3b)

To illustrate the significance of not including a climate change scenario into yield estimation and subsequent costs the Upper Clarence Dam Option (CL3b) is recalculated. The costings are assumed as constant. The only difference is the reduced yield because of a reduction in 16% of average annual flows. See Table 7 for the increased cost.

Table 7. Revised Bulk Untreated Cost Given Climate Change

	Annual Cost ($m)	Projected Yield (ML/yr)	Projected $/KL	Revised Yield -16% (Climate change)	Revised $/KL -16% (Climate change)
TW7	28.3	20	1.42	16.8	1.68
CL3b	173.2	100	1.73	84	2.06
CL5b	33.1	20	1.66	16.8	1.97
MA1	106.1	50	2.12	42	2.53
MA2	203.6	100	2.04	84	2.42

The results in Table 7 show that for CL3b an increase to $2.06KL will occur based on the revised flow rate under climate change of a 16% decrease in stream flows.

A further scenario is then added. In Table 8 a decrease of 20% in annual yield will be assumed. This scenario is a more realistic estimate of potential annual average yield from this site given the corrections in section 3.21. Although it is an abstraction, it will serve to illustrate the point how much bulk untreated cost increase if yield decreases. The following scenarios are presented below in Table 8.

Table 8. Revised Bulk Untreated Cost Given Decreased Yield

Dam Site	Revised Projected Yield -36% (20% decrease plus 16% climate change)	Revised $/KL -36% (20% decrease plus 16% climate change)
CL3b	64 000 ML/yr	2.706

The implications of the decreased yield caused by climate change and a more realistic annual average flow is an increase in bulk untreated cost. Undertaking sensitivity analysis would show the economic risks associated with this option are high. This is especially so because of the large outlay for capital works.

5.0 ENVIRONMENTAL ISSUES

Environmental issues are outlined for the Clarence and Mann River preferred selected options below. Further assessment of environmental issues are needed for the Tweed options.

5.1 Endangered and Threatened Species

Two sites were examined for the presence of threatened species. The two sites were dams on the Clarence River upstream of Duck CK Option (Cl3b) and the Mann River near Jackadgery (MA2). The Oxley River dam site was not assessed for endangered species. Further evaluation of this option is needed.

5.1.1 Clarence River upstream of Duck CK Option (Cl3b)

The proposed section of dam on the Clarence River, upstream of Duck Creek, falls within the Woodenbong Catchment Authority (WCA). The NSW threatened species website, identifies 101 endangered or vulnerable fauna species (*Appendix 4A*) for this area. Using an approximate radius of 50km surrounding Duck Ck, encompassing numerous National Parks (NP), State Forests (SF) Timber Reserves (TR) and freehold lands, the NSW National Parks and Wildlife Service, Atlas of NSW Wildlife (NSW Wildlife Atlas), identifies 40 vulnerable or endangered species (*Appendix 4B*). The Department of Environment and Water Resources, Protected Matters Search (DEW Search) identifies 109 threatened species, 3 threatened communities and 17 migratory species for a similar search area (*Appendix 4C*).

Of the many endangered and vulnerable species identified, 4 that have the potential to be affected by any change in hydrological conditions for the area, include the frog species:

- Litoria brevipalmata, the Green-thighed Frog, status Vulnerable;
- Mixophyes fleayi, Fleay's Barred Frog, status Class 1 Endangered;
- Philoria loveridgei, Loveridge's Frog status Class 1 Endangered; and
- Philoria richmondensis, status Class 1 Endangered.

5.1.2 Clarence River downstream of Duck CK

This proposed section for dam construction also falls largely within the threatened species search conducted for the above Duck Creek section. Therefore the species can be assumed to exist in both areas with reasonable degree of confidence.

5.1.3 Mann River near Jackadgery MA2

The proposed section of dam / weir on the Mann River, near Jackadgery, falls within the Dalmorton Catchment Authority (DCA). The NSW threatened species website, identifies 95 endangered or vulnerable species (*Appendix 4A*) for this area. Using an approximate radius of 50km surrounding Jackadgery, encompassing numerous National Parks (NP), State Forests (SF), Timber Reserves (TR) and freehold lands, the NSW Wildlife Atlas, identifies 28 vulnerable or endangered species (*Appendix 4B*). The DEW Search identifies 81 threatened species, 2 threatened communities and 15 migratory species for a similar search area (*Appendix 4C*).

Of the many endangered and vulnerable species identified, 2 that have the potential to be affected by any change in hydrological conditions for the area, include the frog species:

- Litoria aurea Green and Golden Bell Frog, status Class 1 Endangered; and
- Mixophyes balbus, Stuttering Frog, status Class 1 Endangered.

5.2 Threatened Species and Key Threatening Processes

Schedule 3 Section 8 of the NSW Threatened Species Conservation Act 1995, Key Threatening Processes (*Appendix 4D*), identifies two key threatening processes directly associated with the construction of dams for potable water use, they include:

- Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands; and
- Clearing of native vegetation

Key threatening processes, threatened or endangered frogs within the proposed Dam sites have in common, are:

- Modification and loss of habitat; and
- Changes in water quality and water flow patterns either increase or decrease.

5.3 The Environment Biodiversity Conservation Act

Federal assessment under the Environment Biodiversity Conservation Act (EPBC Act) will most likely occur through the EIS process if the proposal the selected preferred options on the Upper Clarence and the Mann River were to proceed. The Nymboida, Mann and Clarence Rivers contain part of the only remaining wild breeding population of the critically endangered eastern freshwater cod (*Mucullochella ikei*). Also found in the locality of the dam sites are other critically endangered flora that are included under this legislation.

6.0 IMPACT ON NATIONAL PARKS

The preferred options outlined in the SMEC Report (2007: 2) involve significant impacts to established national parks in the northern NSW region including the Nymboida NP on the Mann River; Yabbra NP on the Clarence River and Wollumbin NP on the Oxley. These areas are covered by the *National Parks and Wildlife Act 1974* and in some sections (e.g. Nymboida NP), the *Wilderness Act 1987*.

National parks, according to the *National Parks and Wildlife Act 1974:*

> "…protect and conserve areas containing outstanding or representative ecosystems, natural or cultural features or landscapes or phenomena that provide opportunities for public appreciation and inspiration and sustainable visitor use"

As collective public goods national parks provide important direct and indirect public benefits that are greatly valued by the community at a local, national and international scale. These include: protecting the integrity of the environment and wildlife; ensuring the purity of water supplies to nearby communities; cultural heritage; scenic amenity; recreation and tourism opportunities and education.

6.1 The Nymboida NP on the Mann (options MA1 & MA2)

The Nymboida National Park that lies on the Clarence River is part of the Gibraltar Range Group of Parks. This park will be adversely affected by construction and inundation of MA2 (Dam on Mann River).

According to the management plan this park "encompasses some of the most diverse and least disturbed forested country in New South Wales. The Parks contain a stunning landscape of granite boulders, expansive rainforests, tall trees, steep gorges, clear waters and magnificent scenery over wilderness forests" (2005, pii).

The area proposed by the SMEC Report for the Nymboida National Park is also covered in the *Wilderness Act 1987*. In accordance with section 9 of the Wilderness Act, wilderness areas must managed according to the following wilderness management principles: to restore (if applicable) and to protect the unmodified state of the area and its plant and animal communities; to preserve the capacity of the area to evolve in the absence of significant human interference; and to permit opportunities for solitude and appropriate self-reliant recreation.

6.2 Yabbra NP on the Clarence (option CL3b)

Yabbra National Park was added to the Parks and Reserves of NSW in 1999. It covers an area of 8,890 hectares. The Upper Clarence above Duck Creek option (CL3b) will impact on the southern edge of the park. The Upper Clarence, Tooloom creek option (CL5b) will most likely impact on Yabbra State Forest. However site analysis using maps displaying inundation areas (not shown in SMEC appendices) are needed to verify this impact.

6.3 Wollumbin NP on the Oxley (option TW7)

Wollumbin National Park and Wollumbin State Conservation Area are the latest addition to the Parks and Reserves of the Tweed Caldera established in 2003 under the *National Parks Estate (Reservations) Act 2002*. Whilst not a designated World Heritage Area, Wollumbin National Park directly adjoins the western side of Mt Warning NP which is an area of international significance recognized by inclusion in the Central Eastern Rainforest Reserves (Australia) World Heritage Property (World Heritage CERRA).

The area as a whole represents natural heritage of international significance with high biodiversity and unique geological landforms. This is an area of international significance and recognized under the World Heritage Convention for being outstanding examples of ongoing ecological processes.

The Rocky Cutting Dam on the Oxley River (Tweed Dam at rocky cutting TW7) am will most likely impact a small section of the northern edge of the park where it borders the Oxley River.

7.0 INDIGENOUS ISSUES

The proposed Dams on the Upper Clarence (CL3b, CL5b) will impact on national parks that have a new indigenous land use agreement in operation. The largest indigenous land use agreement (ILUA) ever made in NSW was made on the 27th of February 2007. This is the first step towards a consent determination that will recognise the Githabul People's native title rights and interests to this land tenue and other tenue in the region. Under such agreements the Githabul people must be consulted on any contracts or tendering processes and must be given opportunity to comment on the preparation, implementation and amendment of the plan of management, the construction of public works, infrastructure, facilities or repair or demolition work on the parks.

The Clarence River Dam, upstream of Duck Creek (CL3b) will impact on Yabbra National Park and the other dam option in the Clarence system on Yabbra State Forest. The extent of the impacts of the dams on these parks is unclear, as the SMEC Report did not supply maps of dam sites and inundation zones. However, the dam sites were ascertained from the satellite maps of the SMEC Report used to show delivery routes from the dam sites. Based on this and the assumptions about dam wall heights it can be assumed that significant sections of the riverine landscapes and lower slopes of the of the southern section Yabbra National Park and the southern section of the Tooloom National Park would be inundated.

Dam and pipeline construction work will also impact on other national parks of the region. These national parks also are covered by the same indigenous land use agreement (ILUA).

8.0 CONCLUSION

This document has explored a number of concerns regarding the outcomes of the Snowy Mountains Electricity Report: Integrated Water Supply Options for North East NSW and South East Queensland (the SMEC Report). The inclusion of climate change and the inclusion of water availability based on local water arrangements were seen to be lacking. This had an impact on expected yield from all selected preferred options. This resulted in more cost per KL from all options.

Significance of environmental impacts should have been included in preliminary assessment of selecting preferred options. This is also the case for national park impacts. Indigenous land management issues should also have been included into initial assessments.

This report has raised serious questions about the validity of the Snowy Mountains Electricity Report in its capacity to be used to assess water options for South East QLD.

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