ECONOMIC MODELLING OF BENEFITS OF TRANSFORMATIVE WATER GOVERNANCE APPROACHES IN REMOTE INDIGENOUS COMMUNITIES

Draft final report

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Working together to meet the needs of remote and isolated communities sustainably for the long-term page left deliberately blank

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Executive Summary

1. Introduction

1.1 Stated requirements and objective

The requirements of this assessment are to, where practical, quantify and appraise potential financial and social economic benefits associated with water demand efficiencies that will accrue from a rollout of a transformative water governance approach (TWGA) for remote essential services management across Queensland's remote Indigenous communities.

1.2 Scope and Focus

The scope of the analysis of this report focusses on Queensland remote communities and is based on Torres Strait Island community (Masig [Yorke] Island) and one Aboriginal mainland community (Mapoon) as representative of the 33 mainland and Torres Strait Islander and Aboriginal communities.

The focus of this report is estimating financial and economic gains that will potentially accrue to both the Queensland Government and the above communities from a combination of technical and infrastructure changes, real-time monitoring and feedback and Indigenous informed collaborative activities to support community demand and engagement.

1.3 Structure of report

The remainder of this report is organised into four sections as follows:

- Section 2 briefly describes the nature of financial and social economic benefits that are expected to accrue from the TWGA project.
- Section 3 sets out the methodology that has been employed in this analysis.
- Section 4 reports the results of a financial analysis of capital and operational savings related to more appropriate water use.
- Section 5 outlines the estimates costs of the TWGA program and integrates these with benefits to present the results of the benefit cost analysis.
- Section 6 present further benefits of the programme by way of quantification of the social economic benefits of the project.
- Appendixes A and B detail the process and associated limitations of the results presented in Sections 4 and 6.

2. Background

2.1 Business as usual is simply not working!

The current business as usual delivery of essential services in remote and isolated communities (RICs) including provision of drinking water, energy, liquid and solid waste management, environmental health and transport is not socially, environmentally or economically sustainable.

With the impacts of climate change as a multiplier to existing challenges in delivery of RIC essential services, health, well-being and overall resilience of the communities themselves are under threat in the long-term.

2.2 A strategic approach

Issues are complex and problems and solutions interlinked across sectors, technologies and cultural backgrounds. Many good projects and approaches have been deployed to directly tackle these challenges. However, reliance on discrete funding and short timelines and agencies working in isolation have constrained strategic outcomes.

A focus on technical solutions and spending on capital infrastructure often excludes the social and environmental considerations critical to the long-term sustainability of essential service supply and use in RIC contexts.

> "A TWGA will allow room for innovation, learning and progress in moving toward evidenced-based, genuinely sustainable and resilient essential services"

2.3 Ensure money and effort is not wasted

To generate outcomes that are fit for purpose, fit for people and fit for place, the TWGA initiative outlines a platform for collaboration across key industry stakeholders, applied researchers and communities. Skills and knowledge sharing across disciplines and sectors including civil and environmental engineering, environmental health, climate science, community development , energy and, transport planning and WASH (water, sanitation, hygiene) can all work towards a shared vision for sustainable and resilient remote communities.

3. Financial and social economic benefits

3.1 Financial benefits

The provision of secure and safe drinking water to remote Aboriginal and Torres Strait Island communities is inherently energy and capital intensive and expensive (Beal et al., 2016). Reductions in water demand can prolong the expected asset life of water-related plant and equipment and reduce operational costs such as repairs, maintenance and energy (Beal et al., 2016).

3.2 Health benefits

The link between poor quality water and associated poor health outcomes is well established (Productivity Commission, 2020). Amongst other diseases, diarrhoea due to waterborne infections associated with untreated water kills almost one million people globally per annum (Levallois & Villanueva, 2019). In industrialised nations, water contaminated with chemical pollution can lead to a variety of chronic diseases including cancer and cardiovascular disease and amongst other health impacts, adversely affect reproductive outcomes and children's health (Levallois & Villanueva, 2019). Significant reductions in poor health outcomes can be realised where water quality issues are addressed (World Health Organization, 2014).

In Australia, research by Hall et al. (2020) concluded that microbial contamination of drinking water represents a risk to remote Indigenous communities and that there is evidence that bore water may be polluted with high levels of chemical contaminants. For example, work undertaken by the Office of the Auditor General (OAG, 2015) that indicates that the quality of drinking water supplied to Indigenous communities in Western Australia fails Australian standards approximately 30% of the time. For Australia's remote Indigenous communities, high costs associated with supply and maintenance coupled with sparse populations means they may lack the infrastructure required to ensure safe drinking water (Fien & Charlesworth, 2012; Beal et al., 2019). This can create a reliance on unreliable and lower quality sources of water such as bores and rainwater tanks (Jackson et al., 2019). This is particularly the case in Torres Strait Island communities where concerns have been expressed by the Queensland Health Department about the number and duration of "boil water alerts" due to detection of *Escherichia coli* (*E. coli*) in routine treated drinking water samples (Hall et al., 2021) and in mainland communities where bore water potentially contains high level of chemical contaminants (Hall et al., 2020). More appropriate water demand management and use can improve health outcomes by ensuring that appropriate sources are applied to appropriate uses e.g. high-quality water for drinking and lower quality water for the garden.

4. Methodology

The approach taken in this economic assessment is the use of a benefit cost analysis. This type of assessment weighs-up the costs and benefits of a project over the period of the project's life. Costs typically include capital and operational expenditure, whilst benefits might include extended capital asset life and reductions in repairs and maintenance.

Over the period of a project, the differential between the total present value (PV) benefit and present value costs is called the benefit-cost ratio. If the benefit cost ratio is greater than 1, then from an economic perspective, at least, the project should be supported. If the benefit cost ratio is less than 1, the project is not supported.

However, it is important to remember a benefit cost analysis does not provide a definite 'answer' as to whether a project should proceed or not; but merely provides the decision maker with economic information on which to make a decision - the scope of the line items that are 'costs' and 'benefits' are always contested. A narrow benefit cost analysis might only include financial costs and benefits; but a broader analysis might also include quantification of social costs and benefits, such as health impacts and improvements.

In the absence of differentiated cashflows discounting and an inflationary factor has not been applied. It is considered that both of these would have immaterial impact on these results. Rather an internal rate of return (IRR) has been calculated. The IRR indicates the funding rate at which benefits would equate to costs. The higher the rate the more compelling the project.

Given the tangibility of the benefits the benefit cost analysis centres on the capital and operational cost savings estimated due to the program. Aggregate benefits and costs are compared in accordance with the ten-year expected duration of the project. Health benefits are not incorporated in this analysis. Rather they are presented as an additional indication of the value of the TWGA program.

5. Capital and operational cost savings

Due to availability of differing data sets, capital and operational cost savings due to a reduction in demand were undertaken separately. This section presents the results and caveats of this analysis. Details of each calculation process are presented in Appendix A.

5.1 Water efficiency savings

Water efficiency savings are drawn from water demand management analysis presented in Beal et al. (2016). Specifically, the results for case study Site 1 (Masig Island) and Site 2 (Mapoon) replicated in Table 1 below.

Table 1 Modelled end-use demands for BAU and retrofit scenarios in the three study areas (source: (Beal et al., 2016: Table 2))

		BAU (L/p/d)		Retrofit (L/p/d)		
	Indoor use(%)	Site1 (Masig Island)	Site3 (Mapoon)	Assumed Savings (%)	Site1 (Masig Island)	Site3 (Mapoon)
Shower	35	67.5	209.7	40	40.5	125.8
Tap	16	30.8	95.9	20	24.7	76.7
Bath	2	3.9	12.0	0	3.9	12.0
Toilet	19	36.6	113.9	20	29.3	91.1
Clothes washer	23	44.3	137.8	50	22.2	68.9
Leakage	5	9.6	30.0	50	4.8	15.0
Outdoor	NA	94.4	611.9	31-58	39.6	422.2
TOTAL		**287.1**	**1,211.2**		**165.0**	**811.7**
Average reduction					**42.53%**	**32.98%**

Savings equate to an average of 42.53% reduction in water usage for Masig Island and 32.98% for Mapoon. These savings form the basis of the estimates of cost savings for Island and mainland communities presented below.

5.1.1 Island communities

Table 2 shows that the estimated annual cost savings from more efficient use of water, attributable to the TWGA program, are in the vicinity of $9 to 18 million per annum dependent on the extent of diffusion of the TWGA program across the full island population.

The savings represent reductions in operational and capital expenditure due to a reduction in water demand. They are based on an annual average cost per kilolitre of water consumed of $26.00 calculated by ARUP (2019b) as part of an economic analysis of a Torres Strait Island Regional Council (TSIRC) Sustainable Water and Wastewater Management Plan. The figure represents a business-as-usual scenario whereby capital equipment is replaced across a 25-year period but, importantly not enhanced or improved. As such it provides an indication of the costs required to maintain water delivery at a status quo. The largest component (56%[1]) of the investment upon which the above cost per kilolitre is based on renewals – capital expenditure required to replace aging and non-productive water

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[1] (ARUP, 2019b, p. 12) attributed 40% of total investment to water-related operational expenditure.

production assets. Savings accrue due to increases in the useful life of assets as a result of reduction of throughput and associated reductions in plant depreciation.

There are a number of reasons to assume that the savings calculated above are conservative:

- As noted in Appendix A, although a growth factor applied in the calculation of cost per kilolitre of water consumed may overstate costs, it's expected that exclusion of consumer service obligation[2] (CSO) tariffs could significantly understate costs.
- ARUP explicitly note that the average annual cost does "*not represent a service price similar to the charges applied by metropolitan utilities and should not be interpreted as such*" (ARUP, 2019b, p. 12). That is to say, that the costs exclude a profit margin, the inclusion of which would obviously increase the amount paid for water consumption.
- A benchmarking exercise noted in ARUP (2019a, p. 8) found that water consumption in similar coastal Indigenous communities, such as Palm Island, consume significantly more water than those administered by TSIRC. This indicates that extrapolation of per person water use of case study site (Masig Island) to non-TSIRC islands (i.e. Palm Island, Horn Island and Thursday Island) is likely to underestimate water consumption and associated cost savings.

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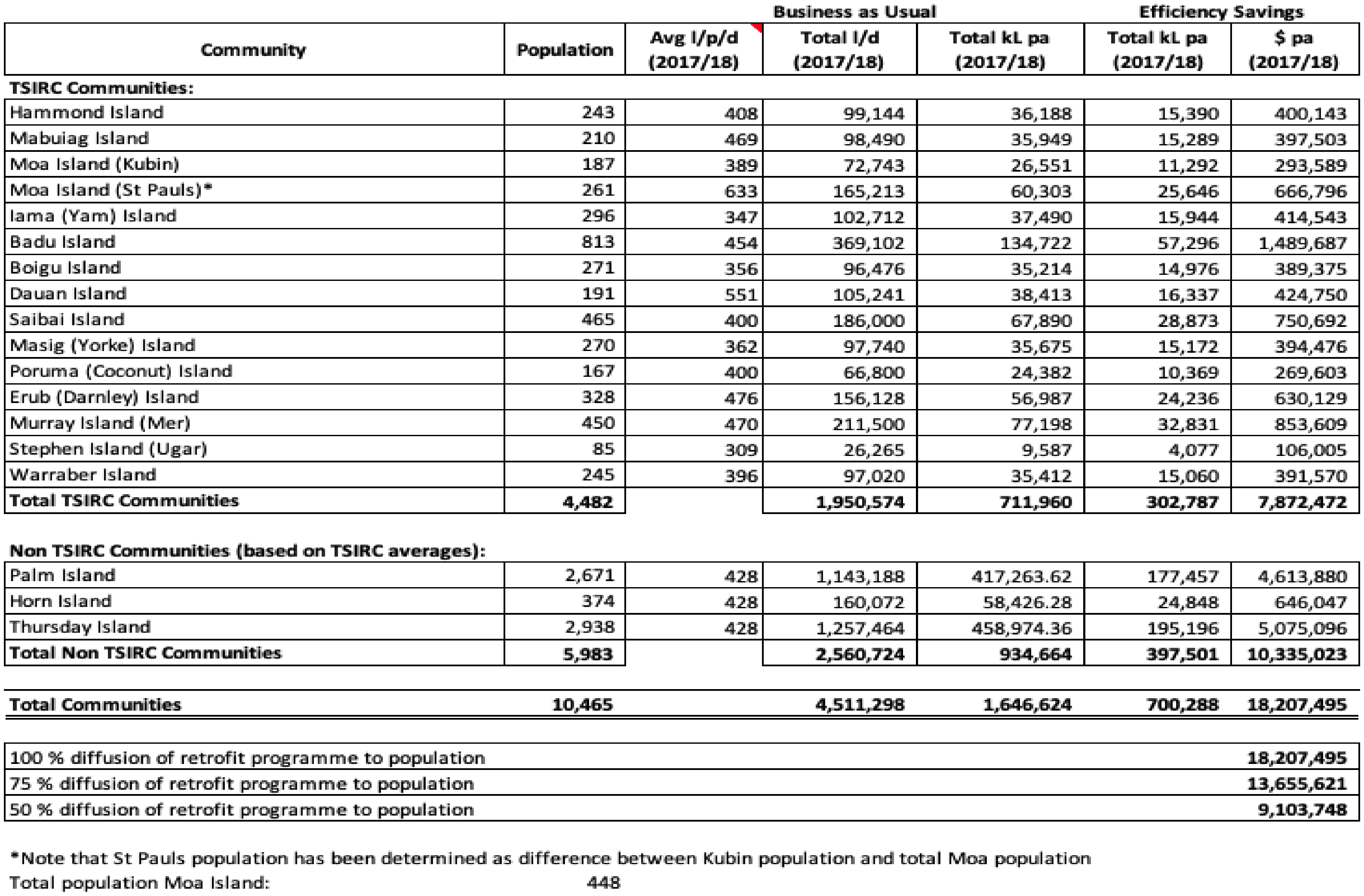
[2] Total electricity network community service obligation costs in 2019-20 were approximately $498 million (Queensland Government, 2021).

Table 2 Estimated water and cost savings for TWGA islands



			Business as Usual		Efficiency Savings	
Community	**Population**	**Avg l/p/d (2017/18)**	**Total l/d (2017/18)**	**Total kL pa (2017/18)**	**Total kL pa (2017/18)**	**$ pa (2017/18)**
TSIRC Communities:						
Hammond Island	243	408	99,144	36,188	15,390	400,143
Mabuiag Island	210	469	98,490	35,949	15,289	397,503
Moa Island (Kubin)	187	389	72,743	26,551	11,292	293,589
Moa Island (St Pauls)*	261	633	165,213	60,303	25,646	666,796
Iama (Yam) Island	296	347	102,712	37,490	15,944	414,543
Badu Island	813	454	369,102	134,722	57,296	1,489,687
Boigu Island	271	356	96,476	35,214	14,976	389,375
Dauan Island	191	551	105,241	38,413	16,337	424,750
Saibai Island	465	400	186,000	67,890	28,873	750,692
Masig (Yorke) Island	270	362	97,740	35,675	15,172	394,476
Poruma (Coconut) Island	167	400	66,800	24,382	10,369	269,603
Erub (Darnley) Island	328	476	156,128	56,987	24,236	630,129
Murray Island (Mer)	450	470	211,500	77,198	32,831	853,609
Stephen Island (Ugar)	85	309	26,265	9,587	4,077	106,005
Warraber Island	245	396	97,020	35,412	15,060	391,570
Total TSIRC Communities	**4,482**		**1,950,574**	**711,960**	**302,787**	**7,872,472**
Non TSIRC Communities (based on TSIRC averages):						
Palm Island	2,671	428	1,143,188	417,263.62	177,457	4,613,880
Horn Island	374	428	160,072	58,426.28	24,848	646,047
Thursday Island	2,938	428	1,257,464	458,974.36	195,196	5,075,096
Total Non TSIRC Communities	**5,983**		**2,560,724**	**934,664**	**397,501**	**10,335,023**
Total Communities	**10,465**		**4,511,298**	**1,646,624**	**700,288**	**18,207,495**
100 % diffusion of retrofit programme to population						**18,207,495**
75 % diffusion of retrofit programme to population						**13,655,621**
50 % diffusion of retrofit programme to population						**9,103,748**

*Note that St Pauls population has been determined as difference between Kubin population and total Moa population

Total population Moa Island:	448

5.1.2 Mainland communities

Table 3 shows that, dependent on the extent of diffusion of the TWGA program across the full mainland population, that the estimated annual energy cost savings from more efficient use of water, attributable to the TWGA program, are in the vicinity of $2.1 million to $4.1 million.

Table 3 Mapoon energy demand cost savings (source: Beal et al. (2016) updated for diesel costs)

		Energy demand (kWh pa)			**Energy costs ($ pa)**
Community	**Population**	**BAU**	**Retrofit**	**Savings**	**Savings**
Bamaga	1,164	3,638,773	2,724,180	914,593	548,756
Arukun	1,424	4,451,558	3,332,674	1,118,883	671,330
Coen	364	1,137,898	851,891	286,007	171,604
Kowanyama	1,142	3,569,999	2,672,693	897,307	538,384
Lockhart	548	1,713,100	1,282,518	430,582	258,349
Mapoon	294	919,072	688,066	231,005	138,603
Pompuraaw	743	2,322,688	1,738,888	583,799	350,280
Burketown	562	1,756,865	1,315,283	441,582	264,949
Doomadgee	1,399	4,373,405	3,274,165	1,099,240	659,544
Gununa	1,126	3,519,982	2,635,247	884,735	530,841
Total	**8,766**	**27,403,340**	**20,515,607**	**6,887,733**	**4,132,640**
100 % diffusion of retrofit programme to population					**4,132,640**
75 % diffusion of retrofit programme to population					**3,099,480**
50 % diffusion of retrofit programme to population					**2,066,320**

As a proxy of total savings these figures are conservative given that they only include energy costs savings. Unlike, the analysis presented for island communities above these estimates do not include capital-related cost savings due to extension of plant and equipment life expectancies. Additionally, they do not include operational expenditure such as repairs and maintenance, consumables and staffing. The energy costs included are also estimated exclusive of any CSO: an uplift factor, consistent with island communities, that has the potential to raise energy costs significantly.

5.2 Caveats

The above results should be interpreted as a high-level, first pass assessment of potential financial savings for Torres Strait and Aboriginal communities and the Queensland Government through more efficient use of water. The analysis has been hindered by a lack of information, and where available, granularity that hinders more focused interpretation. Assumptions applied and relied upon are considered in Appendix A. The main assumption underlying this analysis is that the mix of water-related infrastructure type and use are consistent between mainland and island communities and their respective representative communities. For a detailed view of assumptions applied to this analysis the reader is also directed to the reports upon which this analysis relies, i.e. Beal et al. (2016) and specific to the islands: ARUP (2019a) and ARUP (2019b).

6. TWGA costs and Benefit Cost Analysis

6.1 TWGA project costs

Total estimated TWGA project and ongoing costs across a ten-year period are provided in Table 4.

Table 4 TWGA setup and ongoing costs

	Year		1	2	3	4-10	**Total**
	Annual communities program rolled out to (total = 27)		9	9	9	27	
	Cumulative communities program rolled out to		9	18	27	27	
Costs ($'000)	TWGA setup and establishment	Griffith University travel, salaries, training materials, digital and website development and maintenance, community engagement, knowledge and learning activities software and hardware expenses for digital tools	234	233	233		**700**
	TWGA ongoing	Griffith University ongoing monitoring, training and evaluation				50	**350**
	Sustainability officer at each of the 27 communities (2 days per week)	Maintain demand management equipment, community engagement	252	252	252	756	**6,048**
	Annual cost		486	485	485	806	**7,098**
	Accumulated costs to end of period		**486**	**971**	**1,456**	**7,098**	

Project disbursements have been allocated on the basis of an equally apportioned rollout to nine communities per year (for a total of 27). It is assumed that sustainability officers are engaged for each community as the program is rolled out. It is also assumed that officers are engaged for two days a week (0.4 full time equivalent) at an annual cost (wage plus associated costs) of $14,000 per day.

Undiscounted and un-adjusted for inflation these costs equate to a total of $7.1 million for the whole ten-year period. Total TWGA setup and ongoing costs are estimated at $1.05 million across the period with the bulk budgeted in the first three years. Overall the majority of costs ($6 million) are attributable to sustainability officers.

6.2 Capital and operational benefits

Table 5 presents the total capital and operational savings from the TWGA program across a ten-year period. Consistent with costs, benefits have been accrued to an annual basis as the program is rolled out across the 27 island and mainland communities.

Table 5 Benefits of TWGA program from capital and operational cost savings

Year	**1**	**2**	**3**	**4-10**	**Total Years**
Annual communities program rolled out to (total = 27)	9	9	9	27	
Cumulative communities program rolled out to	9	18	27	27	
Cost savings by community geography					
Islands (CAPEX and OPEX) ($'000)	6,069	12,138	18,207	18,207	163,867
Mainland (electricity only) ($'000)	1,378	2,755	4,133	4,133	37,194
Total cost savings ($'000)	**7,447**	**14,893**	**22,340**	**22,340**	**201,061**
100% diffusion ($'000)	7,447	14,893	22,340	22,340	201,061
75% diffusion ($'000)	5,585	11,170	16,755	16,755	150,796
50% diffusion ($'000)	3,723	7,447	11,170	11,170	100,531

Total cost savings across the ten-year period are estimated at approximately $100 million.

6.3 Benefit cost and internal rate of return analysis

The results of a benefit cost ratio (BCR) analysis based on comparison of an aggregation of the above quantified capital and operational cost savings compared to budgeted TWGA costs is presented in Table 6. For all diffusion scenarios the BCR significantly exceeds one and as such supports the implementation of the TWGA project.

Table 6 Benefit cost results

	Total costs	**Benefits (proportion diffused)**		
		100%	**75%**	**50%**
Costs and benefits ($'000)	7,098	201,061	150,796	100,531
Benefit Cost Ratio (BCR)		**28.33**	**21.24**	**14.16**
Internal rate of return (see assumption in Caveats section below)		45%	40%	34%

The BCR calculations are conservative given the assumptions applied to timing of cost and benefit disbursement. For example, there is potential that prioritisation of high population communities (eg Thursday Island) earlier in the program would bring greater ongoing benefits forward. This would increase the total benefits over the program.

The estimated internal rate of return (IRR) across a ten-year period ranges from 34% to 45%. This significantly exceeds Infrastructure Australia's highest recommended discount rate of 10% (Infrastructure Australia, 2018, p. 104) and the Australian dollar ten-year benchmark bond coupon rate of 1.75%[3]. As such it also supports application of the TWGA program. These calculations are prefaced on an extremely conservative assumption of all program outlays at year one with no benefits accrued until year ten.

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[3] Based on ISIN AU3SG0001993 with maturity of 21 August 2031 sourced on October 15 2021 from https://www.qtc.com.au/institutional-investors/aud-benchmark-bonds/

6.4 Caveats

As noted in the Methodologies section, benefits and costs have not been discounted in this analysis. In lieu of actual cash flows and given that cost savings have been estimated on an average per annum basis, application of a discount factor would provide immaterial differences to the results presented above. The bottom row of Table 6 above illustrates this immateriality through the magnitude of internal rates of return calculated for each diffusion rate.

7. Health Benefits and Costs

7.1 Overview

Funding of Aboriginal and Torres Strait Islander health services constitutes a large part of Australia's and Queensland's total health expenditure. In 2015-16 expenditure directed to Indigenous health services comprised 4.4% of the nation's total health cost and 1.3 dollars was spent per Indigenous person compared to non-Indigenous (Australian Institute of Health and Welfare, 2016a). This was significantly more in remote and very remote communities however where it was estimated that the cost per Indigenous person was $9,000 compared to $4,810 for a non-Indigenous person[4]. In Queensland, funding of specific Indigenous health services comprised 23% of total direct expenditure and 19% of the state's direct expenditure with the remainder expended by mainstream services (Queensland Health, 2020).

Although no data was identified that attributes national and state health costs to poor water quality, burden of disease analysis indicates that these costs could be significant. For example, the Australian Institute of Health and Welfare (2016b) estimated that gastrointestinal infections, conditions often associated with unsafe drinking water, contributed approximately 3.6% of total Indigenous physical health loss in 2011.

For the developing world, it has been estimated that poor sanitation and water quality generate economic losses of US$260 billion per year (Hutton, 2013). Additionally, investments to address poor water quality and sanitation return $4.30 for every dollar spent (Hutton, 2013). Whilst Australia is not part of the developing world these figures provide an indication of the scale of the cost that lack of access to safe drinking water generates and the significant benefits that can accrue from investing to address them.

In the absence of detailed health expenditure data this report estimated an economic cost of burden of disease attributable to poor water quality as a proxy of economic health costs.

7.2 Economic cost of Burden of Disease

Table 7 presents the economic cost of burden attributed in this study to unsafe drinking water. The calculations are prefaced on the key concepts of "burden of disease" and "value of statistical life year" described in Box 1. As a risk reduction cost they are arguably perpetual and should be interpreted as such.

Table 7 Economic cost of burden of disease due to unimproved sanitation

Measure	Per 1000 population	Island communities (10,465)	Mainland communities (9,947)	Total (20,412)
Disability-adjusted life year (DALY)	0.0471	0.4930	0.4130	0.9060
Value of a statistical life year (VSY)	$10,223	$106,984	$89,615	$196,599
100 % diffusion of TWGA programme to population	$10,223	$106,984	$89,615	$196,599
75 % diffusion of TWGA programme to population	$7,667	$80,238	$67,211	$147,449
50 % diffusion of TWGA programme to population	$5,112	$53,492	$44,807	$98,299

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[4] Figures extracted from Spending by remoteness graph available at https://www.aihw.gov.au/reports/Indigenous-australians/Indigenous-health-expenditure-estimates/contents/spending-by-remoteness

The table indicates that unimproved sanitation is responsible for the loss of approximately 0.0471 healthy years for every 1000 Indigenous persons living in remote communities such as the focus of this analysis. This equates to a societal loss of value of $10,223 for every 1000 Indigenous people. Improvements in sanitation due to more appropriate and healthier use of water due to the TWGA program have the potential to reduce these costs. As displayed, economic health benefits from the program are estimated between approximately $98,000 and $197,000 dependent on the uptake within the communities.

On a per person basis the VSY represents barely 0.1%[5] of the total health costs attributed per remote Indigenous person. As such and as a proxy of economic benefits by way of reduced health costs and improved health outcomes the above estimates appear extremely conservative.

Box 1. Key Concepts

Burden of disease (from Australian Institute of Health and Welfare (2016b, p. 2))

Burden of disease analysis is a way of measuring, comparing and combining the impact of different diseases, conditions or injuries (often referred to in this report as 'diseases' for simplicity) and risk factors on a population. It uses information from a range of sources to quantify the fatal (for example, dying from cancer) and non-fatal (for example, living with cancer) effects of these diseases in a consistent manner so that they can then be combined into a summary measure of health called the DALY—a disability-adjusted life year. A DALY combines estimates of years of life lost due to premature death (YLL) and years lived with ill health or disability (YLD) to count the total years of healthy life lost from disease and injury. The health loss that the DALY measures represents the difference between the current health status of the population and the ideal situation where everyone lived a long life, free of disease. Burden of disease estimates capture both the quantity and quality of life, and reflect the magnitude, severity and impact of disease and injury within a population. The analysis also estimates the contribution of various risk factors to health loss, known as the attributable burden.

Value of statistical life year

The value of a statistical life year (VLY) is an estimate of the value society places on a year of life. It is closely associated with the value of a statistical life (VSL) which is an estimate of the value society places on reducing the risk of dying. It is a useful measure in health-related evaluations because in many cases health interventions lead to small increments in life years as opposed to full life expectancy (Ananthapavan et al., 2021). By convention the life is assumed to be the life of a young adult with at least 40 years of life ahead. It is a statistical life because it is not the life of any particular person. The VLY applied in this study of $217,000 is denominated in 2020 dollars and has been sourced from the Commonwealth Government's most recent "Best Practice Regulation Note" (see Office of Best Practice Regulation (2020)). It has been applied here as a proxy of the economic value of life.

7.3 Caveats

It should be noted that the determination of social and health system costs was hindered by a lack of relevant data and focused academic research. Where available the dataset is also over ten years old and as such may not represent current health conditions and issues. Due to a failure to identify and source relevant health expense and attribution data this study has not been able to estimate the financial impact of poor water quality on health services provided to Torres Strait Islanders and aboriginal communities. It also has not been able to attribute economic benefits from improved water quality. The DALY derived for poor quality water is guesstimate at best and does not appear reasonable when compared to the range of disease associated with lack of access to safe drinking water. At worst these results indicate a topic in need of further and more detailed research and at best a system that is extremely cumbersome to interrogate.

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[5] Per person VSY of $10.22 is 0.114% of the $9,000 attributed to each remote Indigenous person per year.

8. Conclusion

The above benefit cost analysis and economic health analysis indicates that the benefits of the TWGA program significantly exceed associated costs. While data availability has hindered analysis, the nature of missing data and that applied tends to indicate an underestimation of benefits, providing further support for the program.

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Appendix A. Capital and operational cost saving calculations

Due to differing data availability the cost estimation process for island and mainland communities differed and each is explained separately below. However, each set of cost estimates was based on a consistent set of water demand saving estimations.

A.1 Water savings due to the TWGA project

As noted in Section 0 water efficiency savings are drawn from water demand management analysis presented in Beal et al. (2016). Specifically, the results for case study Site 1 (Masig Island) and Site 2 (Mapoon) replicated in Table 1 below.

A.1.1 Island communities

The modelling undertaken for water demand savings for the islands followed a four-step process:

- Step 1: For each island community in scope of the project calculated total water consumption on a kilolitre per annum basis.
- Step 2: estimates of water demand savings from Beal et al. (2016) were then applied to that of Step 2 to estimate kilolitres saved for each of, and aggregate of the island communities.
- Step 3: estimate the average annual cost per kilolitre of water consumed.
- Step 4: the total water savings across all of the islands was calculated by applying the cost per kilolitre from Step 4 to the aggregate water savings estimated in Step 3.

Step 1: Water consumption per community

The total annual water consumption per community was estimated in two tranches:

- TSIRC communities: this was calculated as the population of each community according to the 2016 census multiplied by average annual water consumption per community person based on average daily per person consumption sourced from ARUP (2019a, p. 44: Figure 10). The average daily per person water consumption represents total community daily demand between April 2017 and April 2018, i.e. residential use, all commercial use and all leaks for the community divided by the community population (Harrington, 2021).
- Non-TSIRC communities: as average water consumption was not available for non-TSIRC communities (Thursday Island, Horn Island and Palm Island) the average daily consumption per person of all TSIRC islands was applied to each community's population.

Step 2. Total water savings

This was simply 25% of the total consumption for each community. The results of water savings across all communities was summed as the total estimate.

Step 3. Average annual cost per kilolitre of water consumed

An average annual cost per kilolitre of water consumed of $26.00 was sourced from ARUP (2019b, p. 12: Table 1). The report states that this represents an indicative annual operating and capital cost per kilolitre based on ongoing investment in the operation, maintenance and renewal/replacement of existing water assets only (i.e. Scenario 1: Business as Usual). The report further notes that cost has been calculated from a cashflow projection of operational and capital costs across a projected 25-year project period. These projections assume, amongst other things, annual cost growth of 3%. They have not been discounted.

Item	Description	Beal et al (2016)	Updated diesel costs	Unit
	Water savings—total demand			
	Annual BAU water demand	180,839		kL/y
A	Post-retrofit demand	141,477		kL/y
B	**Total water savings from retrofit (100 % diffusion)**	39,362		kL/y
C	**Water-related savings in energy (diesel and power grid)**			
	BAU energy required for bore pumps	65,102		kWh/y
	Post-retrofit energy required for bore pumps	50,932		kWh/y
	Savings in energy for bore pumps	14,170		kWh/y
	Cost savings for energy	4,634	8,502	$/y
D	**Savings in water treatment (diesel)**			
	BAU estimated energy demand for treatment	27,126		kWh/y
	Post retrofit energy required for treatment	21,222		kWh/y
	Savings in energy for treatment	5,904		kWh/y
	Cost savings for energy	1,931	3,543	$/y
E	**Savings in transfer/recirculation pumps energy (diesel)**			
	BAU pumping energy required for transfer/recirc. Pumps	546,135		kWh/y
	Post-retrofit energy required for transfer/recirc. Pumps	427,262		kWh/y
	Savings in energy for transfer/recirc. Pumps	118,873		kWh/y
	Cost savings for energy	38,871	71,324	$/y
F	**Hot water savings in energy (diesel and power grid)**			
	Annual BAU hot water demand	19,045		kL/y
	Annual post-retrofit hot water demand	12,269		kL/y
	Reduction in hot water demand	6,777		kL/y
	Savings in energy for reduced hot water required	73,187		kWh/y
	Cost savings for energy	23,932	43,920	$/y
G	**Total energy savings from retrofit (100 % diffusion)**	212,161		
H	**Total energy costs**			
	BAU costs	225,158	506,427	$/y
	Retrofitted costs	167,202	379,139	$/y
I	**Total monetary savings**			
	100 % diffusion of retrofit programme to population	69,368	127,289	$/y
	75 % diffusion of retrofit programme to population	52,026	95,467	$/y
	50 % diffusion of retrofit programme to population	34,684	63,644	$/y

A detailed analysis of how the cost figure has been derived has not been undertaken as part of this project and as such as it is adopted, as given. ARUP (2019b) do note however that the cost does not represent a service price similar to that that would be charged by a metropolitan utility. Additionally, a high-level analysis of inputs to the costing model identified that energy costs (i.e. electricity and diesel) were applied at subsidised rates[6]. Whilst the growth factor noted above may inflate costs somewhat it is fair to assume that both exclusion of margins typical of utility service charges and exclusion of an energy consumer service obligation tariff would push them down. Thus, the cost is potentially conservatively low (an assertion supported by discussion with TSIRC staff).

Step 4: Total water savings

Total annual cost savings of approximately $10.5 million was calculated as the product of annual cost per kilolitre and total water savings.

A. 1.2 Mainland communities

The modelling undertaken to calculate annual water demand savings for the mainland followed a three-step process:

- Step 1. For the representative site, Mapoon, total energy demand savings calculated in Beal et al. (2019) were with updated diesel fuel costs based on those applied in ARUP (2019b), ie change from $1.09 to $2.00 per litre.
- Step 2. Total energy demand savings for Mapoon were resolved to a per person saving for the community.
- Step 3. Mapoon per person savings were extrapolated to the full mainland community by population.

Step 1: Update Beal et al. (2019) energy savings

Table 8 replicates Table 4 of Beal et al. (2019) with original figures attributed to the study (column: Beal et al (2016)) and updated estimates based on an updated diesel price from ARUP (2019b) (column: Updated diesel costs).

Table 8 Estimated annual savings in water, energy and cost from the retrofitting project with updated diesel costs (source: Beal et al. (2016: Table 4)

The newly calculated total monetary savings of $127,289 are consistent with $2.00/$1.09 multiplied by the initial savings of $69,368.

Step 2. Resolve total savings to saving per person

Mapoon savings per person were calculated by dividing total savings calculated in Step 1 by the population of Mapoon (270) applied in Beal et al. (2019: Table 1) as:

Monetary savings per person	= Total monetary savings/population
	= $127,289/270
	= $471.44

Step 3. Total annual water energy cost savings

This was calculated by multiplying the total population of each community according to the 2016 census by annual savings per person estimated in Step 2 (Table 9).

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[6] Based on subsidised electricity supply costs of $0.30/kWH and subsidised diesel costs of $2.00/litre provided in ARUP's MCA Unit Cost Rates Database.

Table 9 Total energy cost savings by mainland community

Community	Population	Total savings
Bamaga	1,164	548,756
Arukun	1,424	671,330
Coen	364	171,604
Kowanyama	1,142	538,384
Lockhart	548	258,349
Mapoon	294	138,603
Pompuraaw	743	350,280
Burketown	562	264,949
Doomadgee	1,399	659,544
Gununa	1,126	530,841
Total	**8,766**	**4,132,640**

Appendix B Burden of disease calculation process

A.2. Overview

The modelling undertaken for this project adopted the concepts of burden of disease, DALYs, and attributable factors that have been used in similar studies (e.g. see Deloitte Access Economics (2016)).

The approach was limited by a paucity of data and information to the following five steps:

- Step 1: Risk factors associated with unsafe drinking water and unsanitary conditions were identified.
- Step 2: Identify the total DALY associated with conditions and attribution factors that arise due to the risk factors identified in Step 1 for very remote locations[7].
- Step 3: Application of attribution factors were then applied to total DALY to calculate a portion of burden of disease due to the risk factor.
- Step 4: The DALY figure calculated in Step 2 was then divided by the total population of Aboriginal and Torres Strait Islanders located in very remote locations to generate a DALY at individual level.
- Step 5: This number was then multiplied by value of a statistical life year (VSL) to estimate VSL attributable to unsafe drinking water.

Data was predominantly drawn from the "Australian Burden of Disease Study Impact and causes of illness and death in Aboriginal and Torres Strait Islander people 2011" study undertaken by the Australian Institute of Health and Welfare (2016b). This study which explored the impact and cause of death in Aboriginal and Torres Strait Islander people, contains the most recent available dataset available, i.e. from 2011 (Queensland Health, 2020).

Step 1: Risk factor associated with unsafe drinking water

The coarseness of data available from AIHW represented a limited risk factors to a list of 29 (see Table 10). Of these, the mostly closely aligned to unsafe drinking water was unimproved sanitation.

Table 10 Risk factors (Source: Australian Institute of Health and Welfare (2016b, p. 105: Table 8.4))

Tobacco use; High body mass; High blood plasma glucose; Physical inactivity; High blood pressure; Alcohol use; Diet high in processed meats; Diet low in fruit; Drug use; Diet low in whole grains; Diet low in nuts and seeds; High cholesterol; Diet high in sweetened beverages; Diet low in vegetables; Childhood sexual abuse; Diet low in omega 3 fatty acids; Intimate partner violence; Diet low in fibre; Diet high in saturated fat; Unsafe sex; Occupational exposures; Ambient particulate matter pollution; Diet high in sodium; Iron deficiency; Diet high in red meat; Low bone mineral density; Diet low in milk; Diet low in calcium; Unimproved sanitation

Step 2: Total DALY associated with unimproved sanitation

Infectious disease was the only burden associated with unimproved sanitation identified with three percent of that burden attributed. Total DALY associated with infectious diseases of Indigenous communities in very remote locations of 1,439.20 was sourced from Supplementary data tables: S12.2.5 (non-fatal burden: 650.20)

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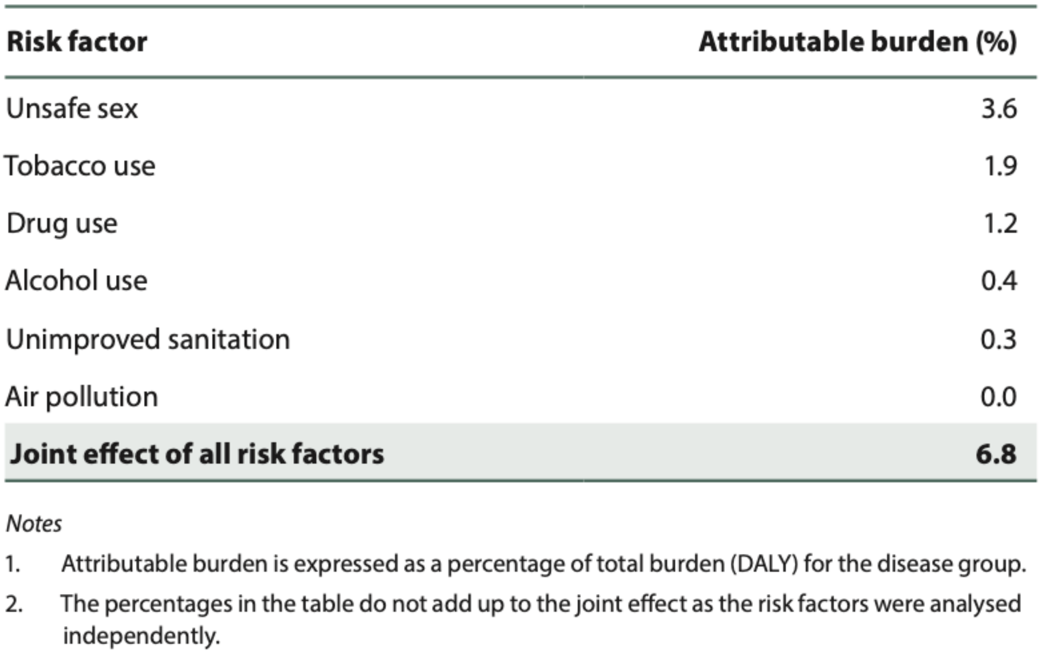
[7] The location of communities analysed in this study was consistent with "very remote" as depicted in the Australian Remoteness Index of Areas (see https://www1.health.gov.au/internet/publications/publishing.nsf/Content/ARIA-Review-Report-2011~ARIA-Review-Report-2011-2~ARIA-Review-Report-2011-2-2-3)

and S12.2.6 (fatal burden: 789.00). A DALY attributable to unimproved sanitation of 4.32 was derived as 0.30% of 1,439.20.

Table 11 Proportion (%) of burden attributable to risk factors for infectious diseases, Indigenous Australians, 2011 (Source: Australian Institute of Health and Welfare (2016b, p. 200: Table 10.11.1))



Risk factor	Attributable burden (%)
Unsafe sex	3.6
Tobacco use	1.9
Drug use	1.2
Alcohol use	0.4
Unimproved sanitation	0.3
Air pollution	0.0
Joint effect of all risk factors	**6.8**

Notes

1. Attributable burden is expressed as a percentage of total burden (DALY) for the disease group.
2. The percentages in the table do not add up to the joint effect as the risk factors were analysed independently.

Steps 3, 4 and 5: A DALY attributable to unimproved sanitation per person

Table 12 depicts the process, sources and values applied in Steps 3, 4 and 5 to calculate a DALY and VSY attributable to infectious disease from unimproved sanitation.

Table 12 Calculation of economic cost of burden of disease (i.e. VSY per 1000)

Step	Measure	Value	Source*
2	Total DALY attributable to infectious disease	1,439.20	
3	**Proportion (%) of burden attributable to risk factors for infectious diseases**		
	Unimproved sanitation attribution factor	0.30%	Table 10.11.1
	Total DALY attributable to unimproved sanitation	4.32	
4	Very remote population	91,648	Table 12.2.1
	DALY per 1000	0.0471	
5	VSY	$217,000	Office of Best Practice Regulation (2020)
	VSY per 1000	$10,223	

*Note that "Table" refers to tables sourced from AIHW (2016)