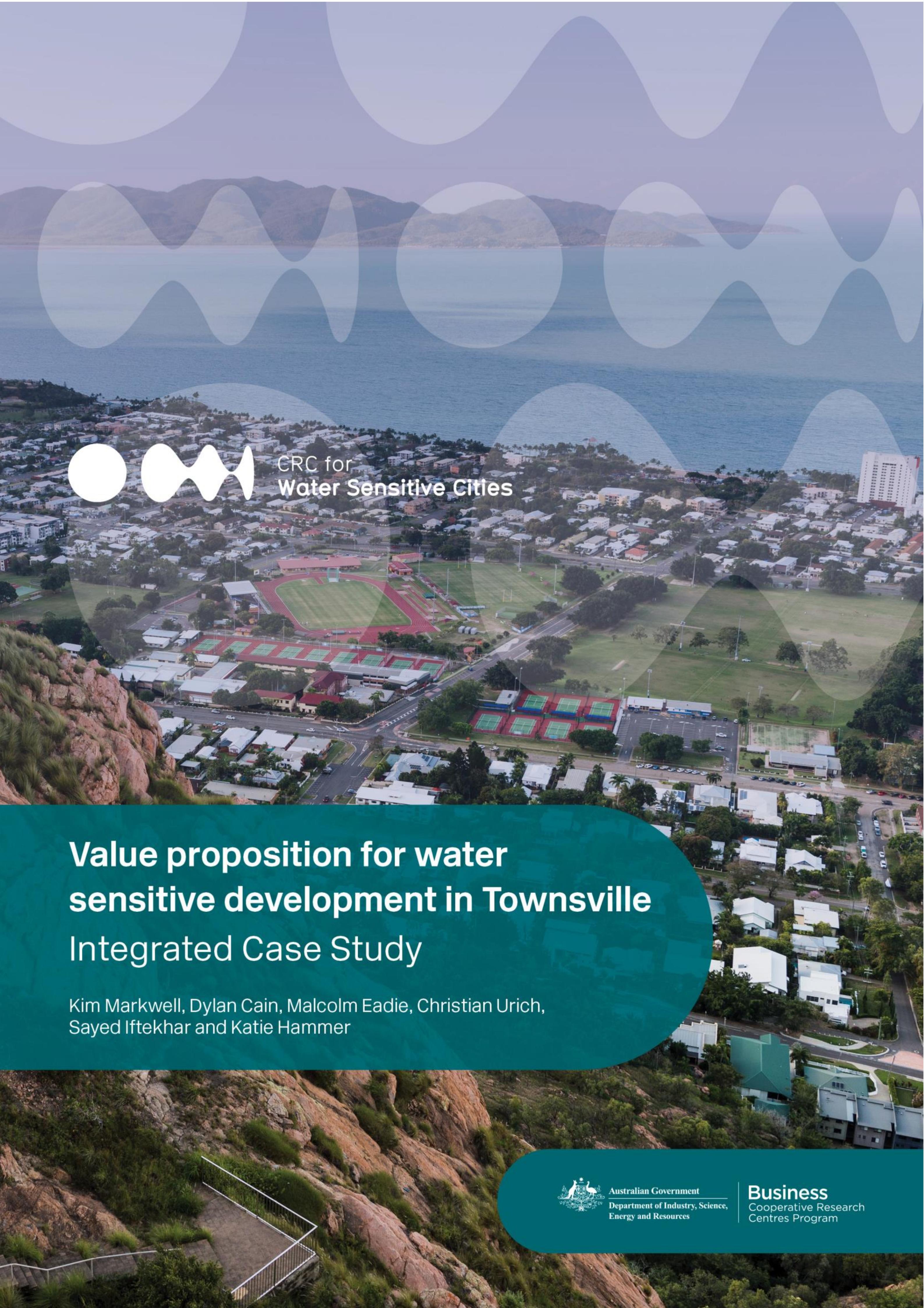

CRC for
Water Sensitive Cities

Value proposition for water sensitive development in Townsville

Integrated Case Study

Kim Markwell, Dylan Cain, Malcolm Eadie, Christian Urich,
Sayed Iftekhar and Katie Hammer

Australian Government
Department of Industry, Science, Energy and Resources

Business
Cooperative Research
Centres Program

Value proposition for water sensitive development in Townsville
Townsville Integrated Case Study

Contributors
Kim Markwell (E2Designlab)
Dylan Cain (E2Designlab)
Malcolm Eadie (CRCWSC)
Christian Urich (CRCWSC, Monash University)
Sayed Iftekhar (CRCWSC, Griffith University)
Katie Hammer (CRCWSC, Monash University)

Publisher

Cooperative Research Centre for Water Sensitive Cities
Level 1, 8 Scenic Blvd, Clayton Campus
Monash University
Clayton, VIC 3800

p. +61 3 9902 4985
e. admin@crcwsc.org.au
w. www.watersensitivecities.org.au

Date of publication: August 2021

An appropriate citation for this document is:

Markwell, K., Cain, D., Eadie, M., Urich, C., Iftekhar, S. and Hammer, K. (2021) *Value proposition for water sensitive development in Townsville*. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.

Disclaimer

Table of contents

1. Introduction

1.1 About this report

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC), in collaboration with Townsville City Council (TCC), E2Designlab, and GHD, has developed a business case and value proposition for water sensitive development in Townsville. This value proposition was developed through the CRCWSC's Integrated Case Study Program, which aims to:

- demonstrate an integrated application of CRCWSC tools and how they can be used from vision to implementation of water sensitive cities
- build capacity of local partners to use and apply CRCWSC tools and processes
- generate broad buy-in and commitment for a water sensitive Townsville.

This report documents the Townsville integrated case study process and findings and is intended to be used to inform further communication and engagement pieces for key stakeholders in Townsville, including decision and policymakers, developers and community members.

1.2 Background

The CRCWSC identified several case study sites, reflecting previous projects undertaken in the local area, and willingness and support of local stakeholders: Townsville, QLD; Salisbury, SA; Norman Creek, QLD; and Knutsford, WA. Townsville was selected because of the existing strategic work already done, including:

- development of a vision and transition strategy (2017/2018)
- training and capacity building on the CRCWSC's Scenario Tool and INFFEWS Value Tool (2018)
- research synthesis workshop exploring ideas for greenfield development (2019)
- development of implementation pathways for greenfield development (2019/2020).

Most of the work to date in Townsville has been at a strategic level, and research and industry stakeholders were interested in exploring how this work can be translated into on-ground solutions and demonstrations to generate broad buy-in and commitment for water sensitive development.

To explore this question, the Townsville case study focused on applying the CRCWSC's Scenario Tool and INFFEWS Benefit: Cost Analysis and Value tools to assess the benefits of various water sensitive city interventions. These tools were applied at both the whole-of-city scale, along with the precinct scale, to explore how they add value across different scales and how the outputs can be used for different objectives.

1.3 Methodology

A co-design process was undertaken with Townsville water stakeholders to define and develop the different scenarios to be assessed. The process involved a series of collaborative workshops with participants from TCC and external stakeholders, and facilitated by E2Designlab (Figure 1).

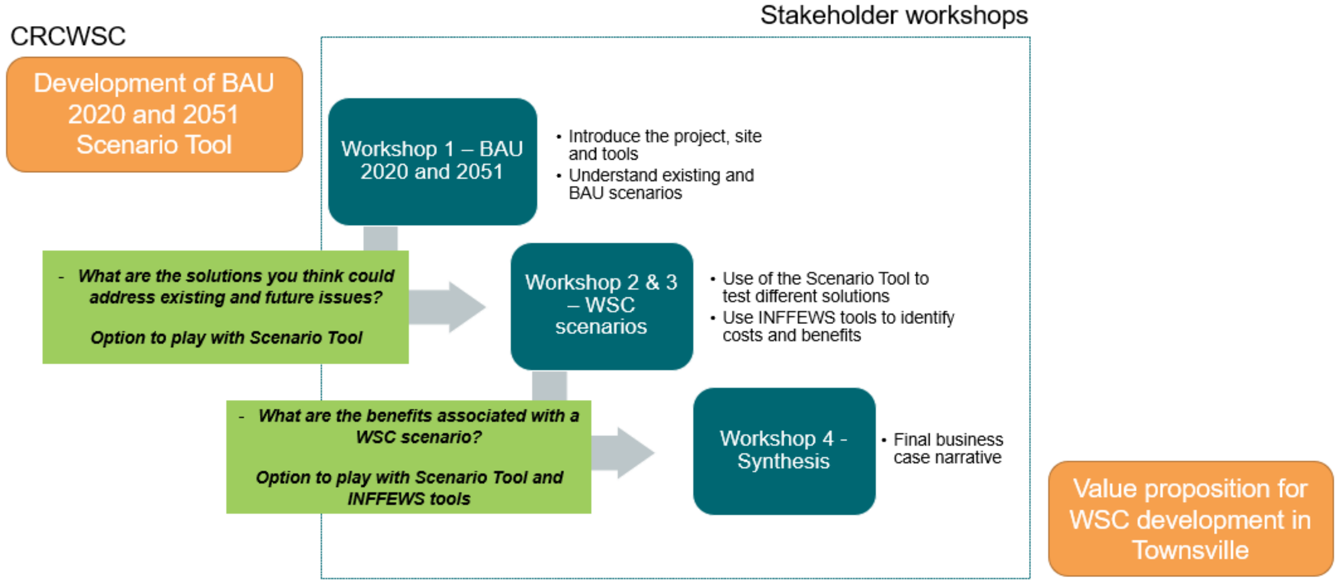

Figure 1: Overview of the co-design process undertaken for the Townville integrated case study

2. Why a water sensitive Townsville?

2.1 Contextual drivers

Townsville is located in the dry tropics of North Queensland, with a population of 190,000 people. It is a city of climatic extremes, with hot, wet summers, and a long, warm dry season. It is subject to drought conditions during the dry season, and extreme flooding and cyclones in the summer. Townsville has several unique drivers that impact how water is managed:

Biophysical drivers

- Townsville experiences water extremes of droughts and floods.
- Water security is a key issue for the region.
- Urban runoff impacts significant marine and coastal environments, including the Great Barrier Reef.

Social drivers

- Townsville has a high potable water demand due to irrigation of private lawns and gardens.
- The community has high expectations for liveability and a green city.

Institutional drivers

- Large-scale water infrastructure and institutions are prevalent, creating a locked-in pathway.
- Townsville experiences ‘boom–bust’ economic cycles.
- There is a disconnect between water servicing and land use planning outcomes.

If we continue taking a business-as-usual (BAU) approach to urban development and water planning in our urban areas, we will miss the opportunity to:

- support healthy and resilient landscapes
- cool our urban areas
- reduce pollutants entering the waterways and the Great Barrier Reef
- reduce the amount of drinking water used
- deliver multiple outcomes from investment.

2.2 Current condition

The CRCWSC Scenario Tool was used to understand Townsville’s current condition in terms of:

- population and land use
- site cover (% impervious, tree cover, irrigated turf)
- land surface temperature, air temperature and Heat Exposure Index
- water balance (water demand, runoff, wastewater, infiltration)
- rainfall and evapotranspiration.

The following information was used to develop this existing WSC scenario:

In-built data:

- Cadastre, building footprints and landcover / vegetation
- Australian census database
- climate (wind, temp, rain etc.)

Additional data:

- potable water / recycled water use
- zoning / planning scheme
- population data.

The images in Figure 2 present some of the outcomes from the WSC scenario model, showing tree cover, impervious cover, air temperature and the Heat Exposure Index. They show the current hotpot areas.

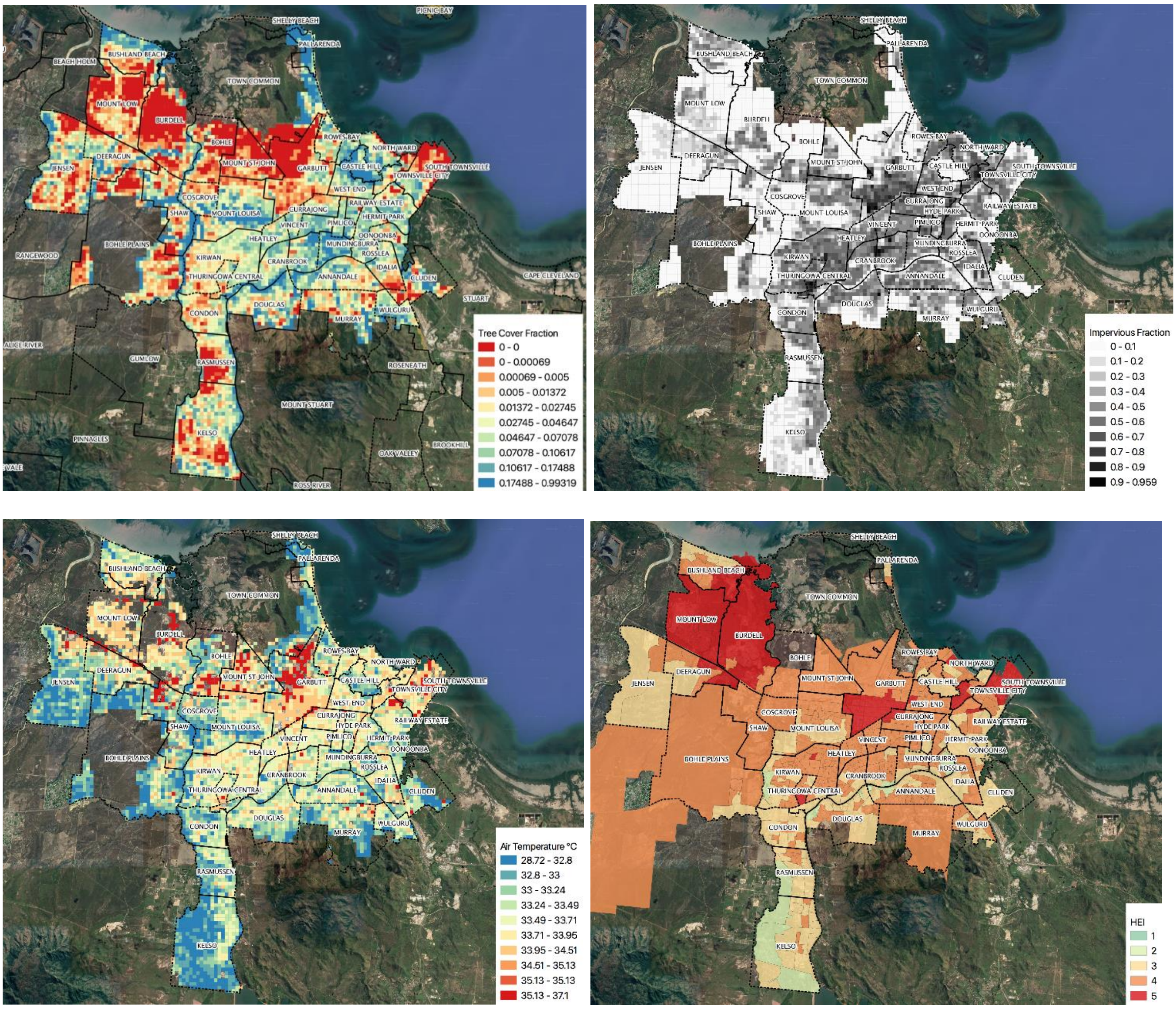

Figure 2: WSC Scenario Tool outputs for the current condition for Townsville, showing tree cover fraction (top left), impervious fraction (top right), air temperature (bottom left) and Heat Exposure Index (bottom right)

Figure 3 shows the current water balance (business as usual 2020):

- Current potable water (imported) demand is 30,517 ML.
- Current recycled water use is 736 ML.
- Current wastewater discharged to receiving environments is only 4,908 ML.
- Current stormwater discharged to receiving environments is 290,216 ML.

These results highlight Townsville's high demand for potable water, largely driven by high outdoor water use. It also highlights that larger volumes of stormwater than wastewater are available as an alternative water source, which could reduce this potable water demand. However, stormwater availability is highly seasonal in Townsville, and the flooding implications of this stormwater must be managed as a priority.

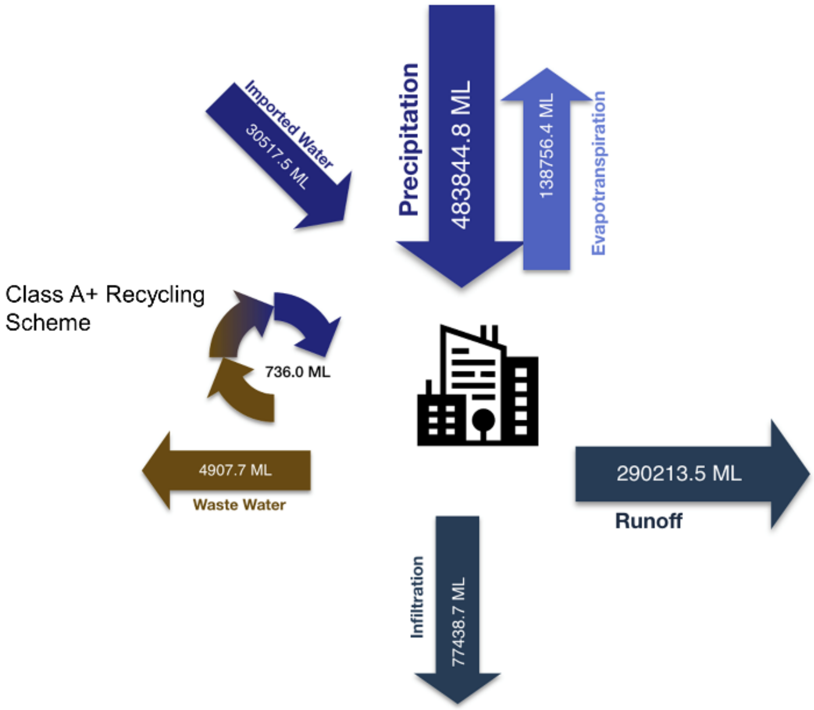

Figure 3: WSC Scenario outputs for the current water balance

2.3 Business-as-usual projections

The business-as-usual approach was determined by applying typical land cover fractions for buildings, concrete, roads and vegetation to land zoned for future development in line with population projections for 2051.

The WSC Scenario Tool showed that taking this BAU approach to development would increase potable water demand, as well as stormwater and wastewater by 2051:

- 1,335 ML of additional wastewater generated
- 1,339 ML of additional stormwater generated
- 3,578 ML of additional potable water demanded.

Project stakeholders were asked to describe Townsville if BAU development continues to occur (Figure 4).

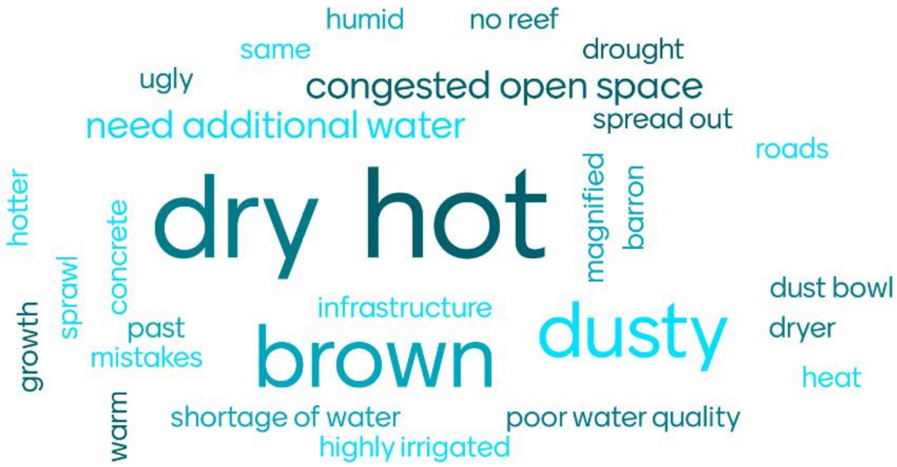

Figure 4: Word cloud showing responses to the question 'How would you describe Townville in 50 years with a business as usual (BAU) approach to development?'

Figure 5 presents WSC Scenario Tool maps that highlight where the changes in impervious fraction and tree cover are likely to occur and how this will influence air temperature. Again, this information is useful for identifying opportunities to integrate WSC solutions that can address these potential changes.

Figure 6 combines the high (5) Heat Exposure Index outcomes from the WSC Scenario Tool with TCC's GIS mapping data of green spaces. Combining these two data sources can help to identify where potential WSC solutions can deliver other benefits such as linking green spaces or creating green grids.

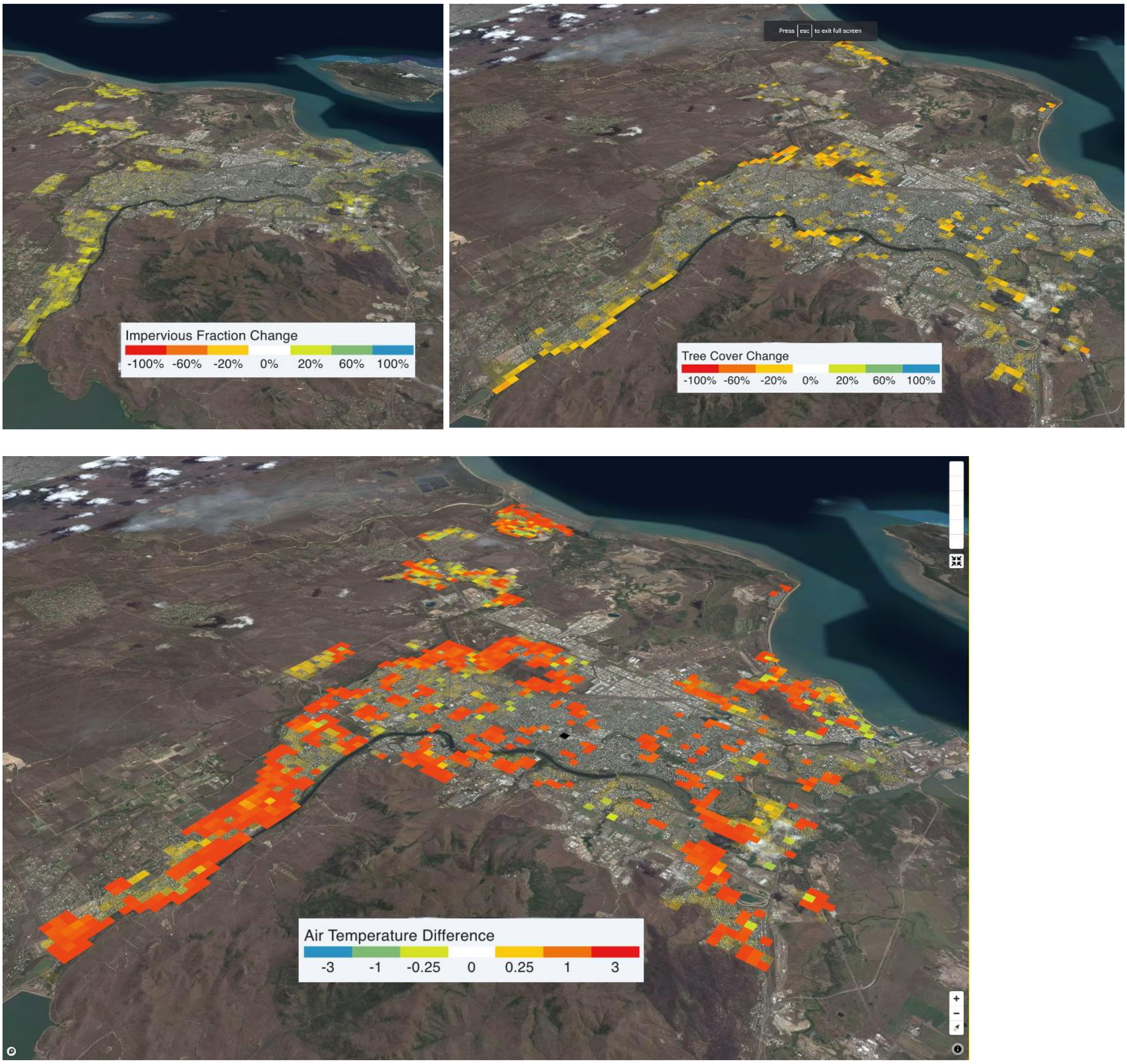

Figure 5: WSC Scenario Tool outputs under BAU, showing change in impervious fraction (top left), tree cover change (top right) and air temperature (bottom)

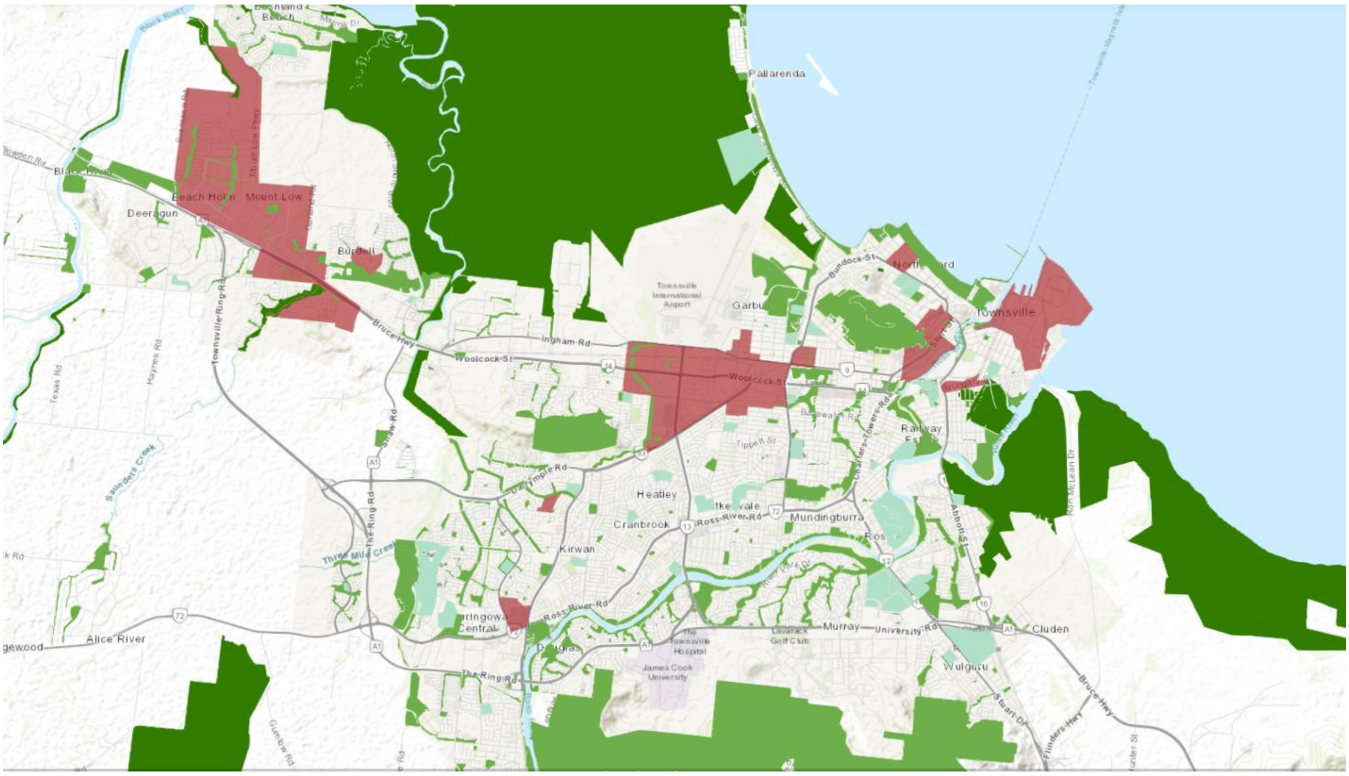

Figure 6: WSC Scenario Tool outputs for High Heat Exposure Index (red areas) overlaid on TCC GIS mapping data for green spaces

3. Townsville as a water sensitive city

3.1 Vision for Townsville as a water sensitive city

A vision for a water sensitive Townsville was developed in 2018 through a collaborative process that brought together stakeholders from across Townsville's water, planning, development, and environment sectors. The vision is presented below, and more information can be found in the *Vision and Transition Strategy for a Water Sensitive Townsville* (Hammer, 2018).

Townsville is an attractive, resilient city that manages water to enhance healthy ecosystems, embrace dramatic natural water cycles, drive world-leading innovation, and support citizens who are proud of their dry tropical identity.

1. Townsville celebrates being an attractive, liveable city with integrated and multi-purpose built and natural environments that feature water, bring people together and showcase the city's dry tropical climate.
2. Water is managed holistically to ensure reliability of Townsville's water system and the long-term sustainability of its resources.
3. Townsville's waterways, wetlands, coastline, and surrounding marine and inland environments are healthy, valued, and continuously enhanced.
4. Townsville people are proud of their connection to water and are empowered to be active and responsible water stewards.
5. Townsville is an international water innovation hub that showcases water sensitive technology, practices and design for the dry tropics.
6. Inclusive water governance in Townsville enables integration, collaboration, innovation and collective leadership.
7. Indigenous water knowledge, values and ways of thinking are valued in the Townsville community and incorporated into water planning, design and management.

3.2 Water sensitive Townsville solutions

A range of WSC solutions were identified and modelled as part of this project, in partnership with TCC. Figure 7 presents an overview of the types of solutions and outcomes TCC staff would like to see in a Water Sensitive Townsville. Table 1 summarises the WSC solutions identified and assessed in this project.

Figure 7: Word cloud showing responses to the question 'What changes would you like to see happen for a WSC future for Townsville?'

Table 1: Summary of water sensitive solutions identified and assessed as part of the Townsville Integrated Case Study

WSC solution	Description	Example image
Passively irrigated street trees	Street trees are irrigated by diverting stormwater flows from the road into the tree pit, resulting in healthy trees and larger canopies	 Image from AECOM (2020) *Design Summary Report: Water Smart Street Trees Standard Drawings*
Increased verge widths	Larger verges where possible to increase the area of vegetation compared with road surface	 Image from *Ideas for Townville*
Optimised irrigation	Reduced amount of water used for irrigation that will still support healthy lawns	 Image from *Ideas for Townville* – Image credit: Townsville Bulletin
Rainwater tanks	5 kL rainwater tanks connected to internal uses (toilets and laundry) and used for irrigation	

3.3 Benefits of a water sensitive approach

The water sensitive city solutions in Table 1 can provide multiple benefits including reduced drinking water use, and greener, cooler and more attractive suburbs. Figure 8 summarises some of the benefits that the WSC approach can provide when compared with the BAU approach, as modelled in the WSC Scenario Tool. These benefits include:

- reduced impervious cover (2.5%)
- increased tree cover (2.6%)
- reduced surface and air temperature and Extreme Heat Stress
- reduced stormwater runoff (8,281 ML) and increased infiltration (2,769 ML)
- reduced water demand (14,466 ML).

Additional benefits derived from these results include higher property values associated with increased tree canopy cover, improved health and productivity associated with reduced temperatures, and reduced nutrients entering waterways and the Great Barrier Reef associated with less stormwater runoff. These quantified benefits are described more in Section 3.4. Other important benefits that could not be quantified include flood mitigation, additional waterway health outcomes and increased recreational activity.

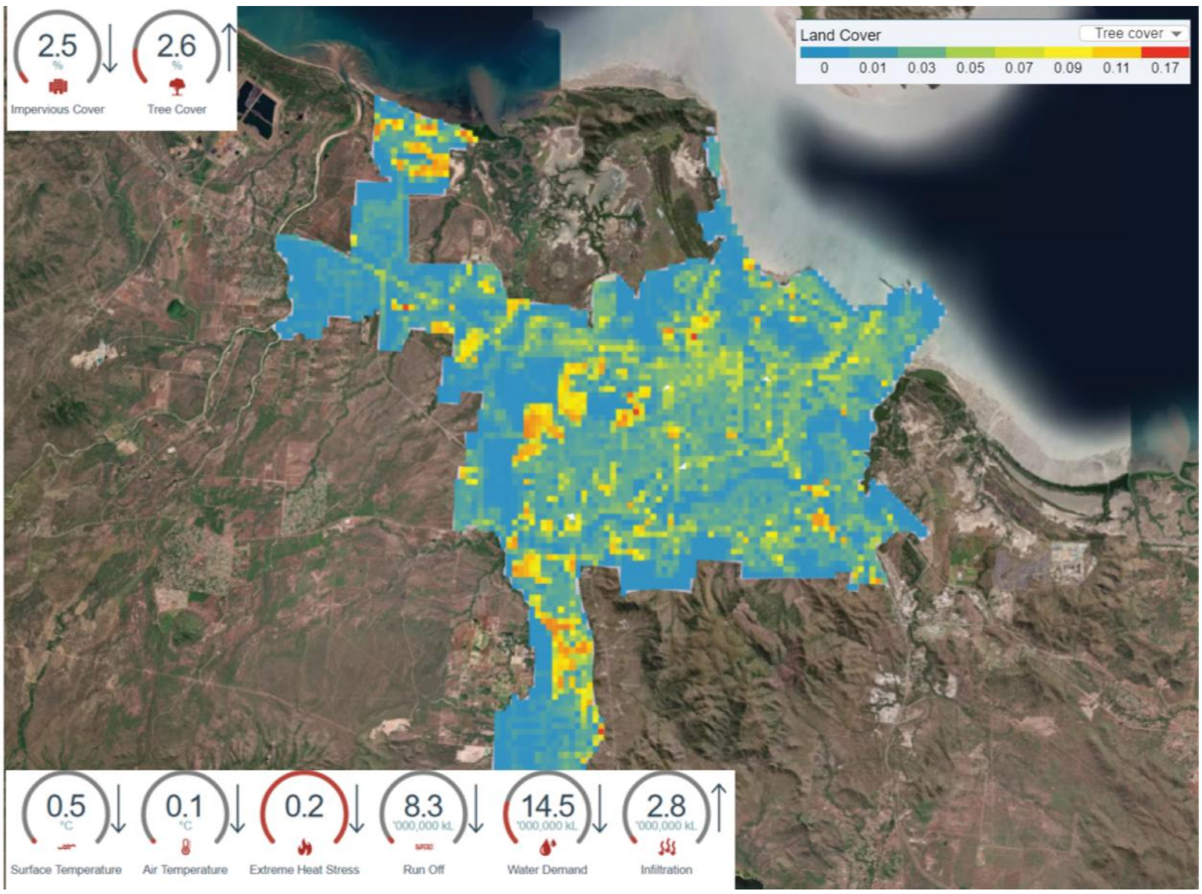

Figure 8: WSC Scenario Tool outputs comparing the WSC approach with the BAU approach as dashboard icons. The base graphic shows the WSC tree cover.

3.4 Costs and benefits of WSC solutions

The following tables summarise the costs and benefits associated with WSC solutions. A benefit–cost analysis was undertaken on the increased greening solutions (passively irrigated trees, increased verge landscapes) and optimised irrigation rates. This analysis considered options with and without rainwater tanks, reflecting the lack of quantifiable benefits that can be attributed to these assets currently (e.g. there is no data about the benefits of rainwater tanks for flooding or waterway stability etc. in Townsville).

Table 2: Summary of costs associated with WSC solutions

Design components	No. of elements	Cost rate – capital	Cost rate – operational	Total cost – capital	Total cost – operational
Additional passive irrigation of trees	16,307 trees	$2,200/tree	$150/tree	$35,875,400	$2,446,050
Optimised irrigation rates	No / marginal cost associated with education program				
Rainwater tanks (5 kL)	55,759	$5,000	$110	$278,795,000	$6,133,490

Table 3: Summary of benefits associated with WSC solutions

Benefit	Benefit value ($2020)	Units	Value type and year
Nitrogen abatement value	$7,000/kg N	19,894 kg/yr TN (with RW tanks) 12,220 kg/yr TN (no RW tanks)	One-off (2021)
Carbon capture from trees – small	$1.39/tree	16,307 trees	Annual – 2021-2030
Carbon capture from trees – mature	$13.69/tree	16,307 trees	Annual – 2031-2051
Potable water reduction – rainwater tanks	$1.51/kL	3,201,888 kL/yr	Annual (starting 2021)
Potable water reduction – optimised irrigation rate	$1.51/kL	11,850,921 kL/yr	Annual (starting 2021)
Cost of tree replacement	$970/tree	1,631 trees	Annual (2021)
Property value – tree canopy increase	$1,059.86/ household	71,698 households	One-off (2031)
Reduced mortality – based on temperature reductions	$1.19/person	213,856 residents	Annual (starting 2031)
Reduced morbidity – based on temperature reductions	$0.16/person	213,856 residents	Annual (starting 2031)
Productivity improvements due to reduced heat	$5.89/workers	19,098 employed workers affected by temperature	Annual (starting 2031)

Note: See Appendix A for additional details on benefit assumptions.

3.5 Value proposition for a water sensitive approach for Townsville

Reflecting the lack of data about rainwater tank benefits, the value proposition is presented with two options:

- Optimised irrigation rate + passively irrigated street trees + rainwater tanks
- Optimised irrigation rate + passively irrigated street trees.

These options are described below.

Option 1: Optimised irrigation rate + passively irrigated street trees + rainwater tanks

Table 4 shows the present value of the benefits and costs associated with the WSC Townsville proposition with all solutions included. For this option, the benefits outweigh the costs, generating an overall benefit cost ratio (BCR) of 1.71. The figure shows the relative frequency of the BCR results.

Table 4: Summary of the overall results for benefit–cost analysis of a water sensitive city Townsville

Benefits (present value)	$504,348,079
Costs (present value)	$448,668,876
Net present value (NPV)	$55,679,203
Benefit cost ratio (BCR)	1.71

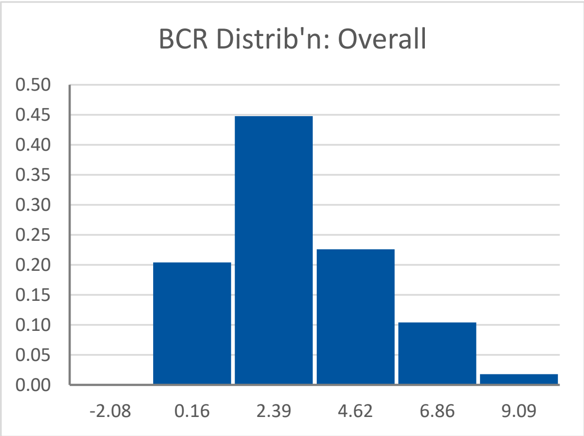

Figure 9 presents the contribution of benefits and costs to this overall outcome. The main cost associated with this option is the rainwater tanks, while the main benefits are attributed to:

- potable water reduction associated with optimised irrigation rates and rainwater tanks
- nutrient removal from increased vegetation cover and rainwater tanks
- property value increase associated with increased canopy cover.

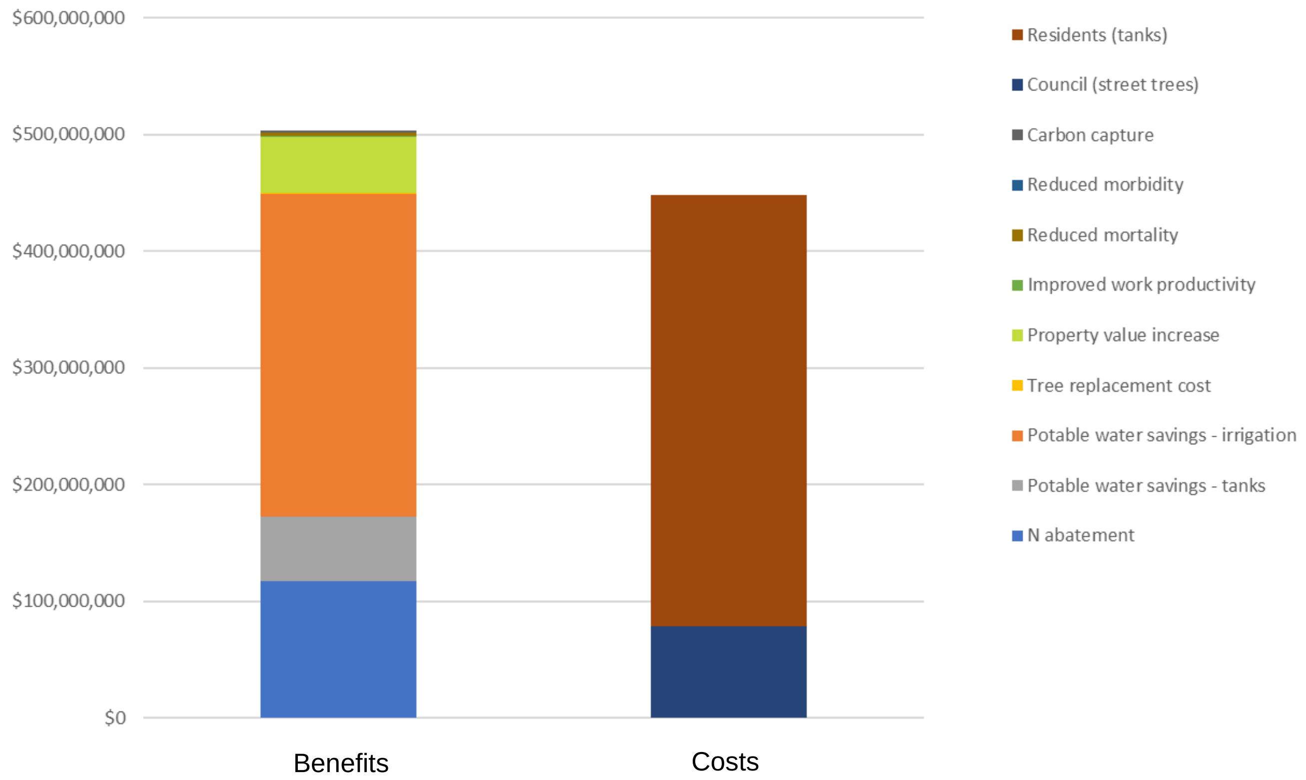

Figure 9: Breakdown of benefits and costs presented as present values (with rainwater tanks included)

While most costs are associated with the rainwater tanks, the only benefits attributed to this cost are the 'potable water savings – tanks' and 40% of the nitrogen removal ('N abatement') shown. Other benefits that rainwater tanks could provide which are not currently monetised include:

- flood mitigation (leaky tanks have been demonstrated to have positive impacts on this in other regions – e.g. Fishermans Bend)
- improved waterway health by disconnecting flows from impervious areas (again this has improved catchments in other areas where current directly connected impervious is relatively low – e.g. Dobsons Creek).

Figure 10 illustrates how the benefits and costs are attributed to project stakeholders:

- Residents – reduced potable water use, reduced mortality and morbidity
- Homeowners – property value increase
- Townsville City Council (TCC) – reduced potable water use (open space), reduced tree replacement
- Broader community – nitrogen removal
- Workers / businesses – improved productivity.

The main cost is the rainwater tanks, which is attributed to homeowners. Depending on if they reside in the house and pay the water bills, they may not be the direct beneficiary of this investment. If the benefits will accrue to others, a different funding model may need to be considered, such as a rebate program or reverse auction (similar to Dobsons Creek) that TCC funds.

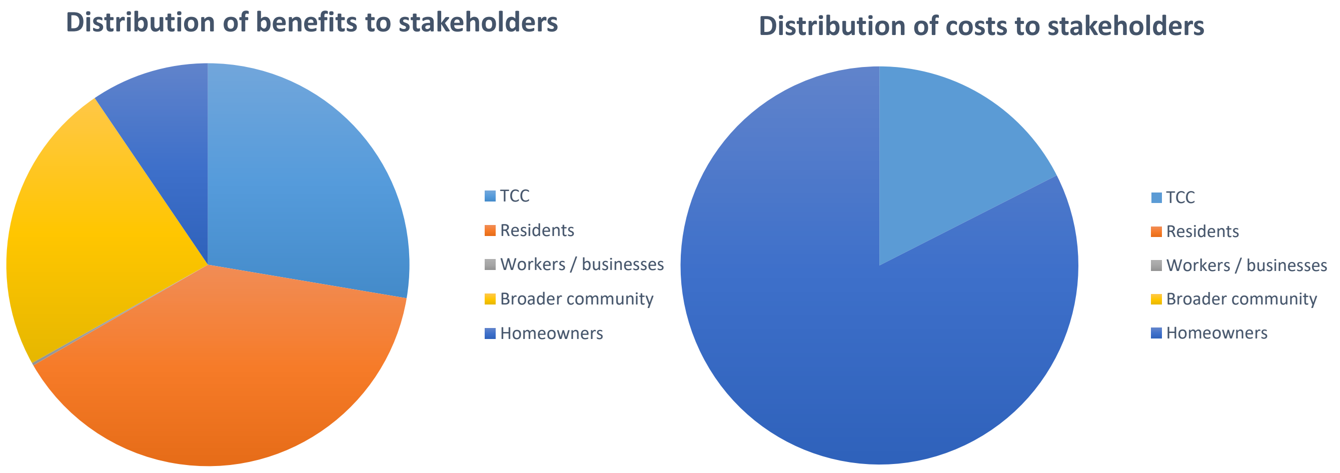

Figure 10: Breakdown of benefits and costs for project stakeholders

Option 2: Optimised irrigation rate + passively irrigated street trees

Table 5 shows the present value of the benefits and costs associated with the WSC Townsville proposition without rainwater tanks. For this option, the benefits outweigh the costs, generating an overall BCR of 5.13.

Table 5: Summary of the overall results for the benefit–cost analysis of a water sensitive city Townsville without rainwater tanks

Benefits (present value)	$403,314,026
Costs (present value)	$78,615,498
Net present value (NPV)	$324,698,528
Benefit cost ratio (BCR)	5.13

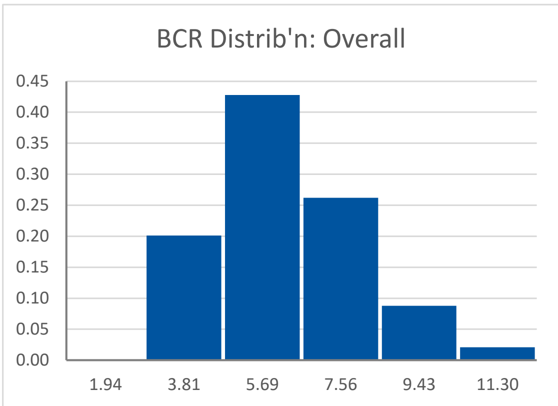

Figure 11 illustrates the contribution of benefits and costs to this overall outcome. The only costs associated with this option are the passively irrigated street trees, while the main benefits remain as:

- potable water reduction associated with optimised irrigation rates
- nutrient removal from increased vegetation cover
- property value increase associated with increased canopy cover.

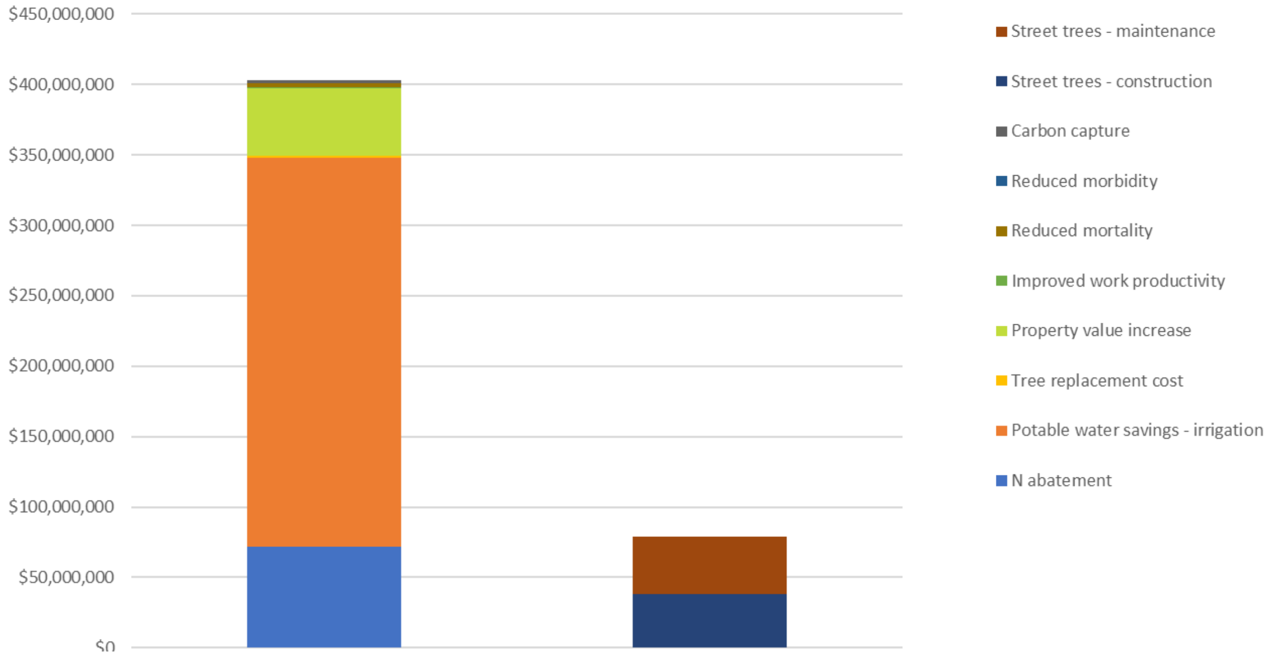

Figure 11: Breakdown of benefits (left) and costs (right) for project stakeholders (without rainwater tanks)

Currently, all costs for this option are attributed to TCC, to deliver and maintain passively irrigated trees. Figure 12 illustrates how the benefits are attributed to stakeholders. This breakdown is very similar to option 1 (with rainwater tanks).

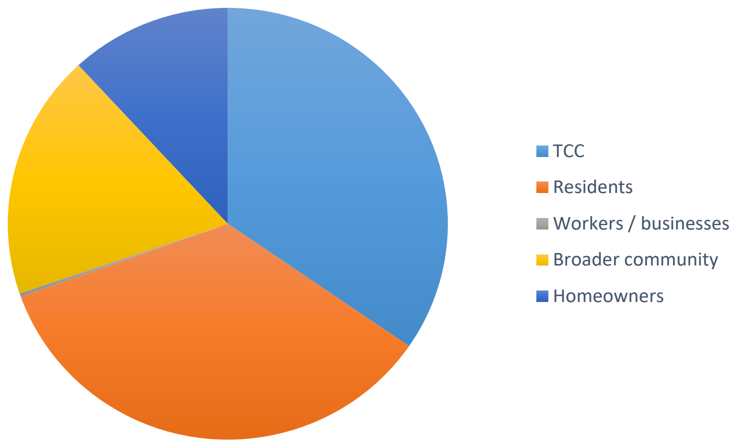

Figure 12: Breakdown of benefits and costs for project stakeholders (no rainwater tanks)

4. Conclusion

This case study demonstrates how the WSC Scenario Tool and the INFFEWS tools can be used to inform the development and assessment of the performance of Water Sensitive City (WSC) solutions when compared with a business as usual approach. For Townsville, this analysis identified that WSC solutions such as passively irrigated trees, optimised irrigation rates and rainwater tanks can provide multiple benefits for the community and the environment. This work also highlighted that using rainwater tanks in this location may require additional data to help justify investment in these assets.

5. References

AECOM (2020). *Design Summary Report: Water Smart Street Trees Standard Drawings.*

CRC for Water Sensitive Cities (2019). *Ideas for Townsville*. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.

E2Designlab (2020*). Water Efficiency Study for Urban Tree Management*.

Hammer K, Rogers BC, Chandler F and Chesterfield C (2018). *Vision and Transition Strategy for a Water Sensitive Townsville*. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.

North Sydney Council (nd). *North Sydney Council carbon calculator.*

Plant L, Rambaldi A and Sipe N. (2017). 'Evaluating revealed preferences for street tree cover targets: A business case for collaborative investment in leafier streetscapes in Brisbane', *Ecological Economics*, 134, pp 238–249.

Rolfe J and Windle J (2012). 'Distance decay functions for iconic assets: assessing national values to protect the health of the Great Barrier Reef in Australia'*.* Environmental and Resource Economics, 53, pp 347–365.

Whiteoak K and Saigar J (2019). *Estimating the economic benefits of urban heat island mitigation – economic analysis*. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.

Appendix A: INFFEWS data and assumptions

This appendix summarises the data and assumptions used for the INFFEWS BCA Tool assessment.

Time-related parameters

Start year for the analysis (year zero in the BCA)
2020

Start year for the project
2021

Length of the analysis (years) (not counting year zero)	
31	Maximum 50

Discount rate (%)

Low (sensitivity analysis)	Default	High (sensitivity analysis)
2%	4%	6%

Costs

Rainwater tanks

The following is an output from Murray Hall (2013) *Review of Rainwater Tank Cost Effectiveness in South East Queensland.* The following table provides the consumer price index-corrected values from this study.

Capital and installation ($AUD2020)	Minimum	Average	Maximum
Rainwater tank	$1,597.14	$1,760.16	$1,888.98
Pump	$823.08	$900.60	$1,096.68
Plumbing	$865.26	$1,026.00	$1,159.38
Tank installation	$380.76	$399.00	$456.00
Laying concrete slab	$680.58	$798.00	$915.42
Pump installation	$228.00	$285.00	$342.00
TOTAL	$4,574.82	$5,168.76	

Costs from Gough Plastics (Townsville supplier) were used to compare some of these costs. The cost of a slimline 5 kL tank was $1,623, compared with the average cost of $1,760 in the table above, and pump cost was $640 compared with $900 in the table above. A capital cost of **$5,000/tank** was therefore adopted for this project.

Passively irrigated street trees

The analysis assumed 30% of the street trees would be designed with underdrainage ($5,000/tree) and 70% could be delivered with infiltration trenches ($1,000/tree). These capital costs and adopted maintenance costs

($150/tree) are consistent with the costs provided in E2Designlab (2020*) Water Efficiency Study for Urban Tree Management* for the NSW Department of Planning, Industry and Environment (DPIE).

Benefits

Water quality improvements

OPTION 1 – N abatement (adopted)

Nitrogen abatement rates adopted are based on Melbourne Water Stormwater offsets charge ($6,645/kg N + 8.9% administration fee. This is also consistent with the recommended offset cost for another SEQ local Council which was $7,143/kg.

OPTION 2 – Household willingness to pay (not adopted)

Rolfe and Windle (2012) was used to identify benefit values households were willing to pay across Australia for a 1% improvement in the Great Barrier Reef condition. The analysis assumed improving the health of the Great Barrier Reef required achieving the load reductions identified for the Burdekin in the *Reef 2050 Water Quality Improvement Plan*. The data below summarises how this assessment was undertaken.

Burdekin water quality reef target	From Reef 2050 WQ improvement plan
DIN	820

DIN Ratio in urban stormwater

DIN = nitrate, nitrite + ammonium
Data from Townsville stormwater monitoring data (waterways removed)

ALL SITES	DIN/TN ratio
Average	0.261
Max	0.809
Min	0.000

WSC Townsville	Volume stormwater (kL/year)	Volume TN (ton/year)	DIN removal ton/year	Proportion of DIN removed from Burdekin target
Rainwater tank water capture	3,201,888	0.809	2.01	0.24%
Increased pervious areas	5,098,112	0.000	3.20	0.39%
Total volume of stormwater removed	8,300,000	19.89	5.20	0.63%

The following table summarises the benefit value for each capital city that was considered for inclusion.

Benefit	City	Benefit value (/household/ year)	Unit	Benefit type	Assumptions
Household willingness to pay per year for 5 years to have 1% improvement in the Great Barrier Reef condition (current level is 65%)	Townsville	$0.30	65,599 households	Annual for first 5 years and may lag this to start year 3 into project	Assume 0.63% of 1% improvement achieved and using 2016 ABS census data
	Brisbane	$0.20	404,159 households		
	Sydney	$0.15	85,423 households		
	Melbourne	$0.14	57,012 households		
	Adelaide	$0.19	8,678 households		
	Perth	$0.14	9,898 households		

Carbon capture

This benefit was split into two options – first 10 years and last 20 years to account for tree growth. The carbon capture rates were determined using the North Sydney Council carbon calculator and assuming the trees were Scaly Ash (Ganophyllum falcatum) with the following characteristics:

- First 10 years – crown base heigh (CBH) of 20 cm (51 kg $CO_{2\text{-}e}$/year/tree)
- Last 20 years – CBH of 80 cm (502 kg $CO_{2\text{-}e}$/year/tree).

This analysis assumed 16,307 new trees and the price of carbon is the government regulated price of $27.27/ton $CO_{2\text{-}e}$.

Reduced potable use

OPTION 1 – Cost of water use for residents (adopted)

The breakdown of current water plans used by residents highlights that people on the Water Watchers plan currently have up to 772 kL/year available to use. The average household water demand used in the Scenario Tool analysis was only 470 kl/year. Therefore the standard plan rate of $1.51 has been used for this assessment. The majority of people also use this plan.

Cost to residents					
Water plan	Number of residents	% of residents	Upfront / base rate	Additional water	
W2 – Water Watchers	**16,955**	**21%**	$823.00	$3.15	This plan allows 772 kL water so no additional water required
W1 – Standard Plan	**64,538**	**79%**	$376.00	$1.51	This is the adopted rate

OPTION 2 – Cost of water production (not adopted)

The cost of water production ranged from $250 to $350/ML (or $0.25 – $0.35/kL). This span includes annual fixed costs (maintain/operate the treatment plant with minimal yearly capital spend) and variable costs for production that are sensitive to actual water consumption (and therefore production), water restrictions and seasonality.

The cost does not include other large costs essential for treated water production such as:

- Haughton pipeline pumping and maintenance
- staff and operating costs for dams and catchment maintenance teams
- large frequent capital spend items for dams, treatment plants, reticulation networks, tanks etc.

Increased land value

Plant et al. (2017) identified an implicit price for a 1% increase in street tree canopy at frontage within 100 m radius of the frontage (lower limit = $407.64/%/property, upper limit = $513/%/property). This analysis used the lower limit.

The Scenario Tool determined a 2.6% tree cover increase, generating a total value of $1,059.86/household.

Tree replacement reduction

Passively irrigated trees are healthier with longer lifespans than trees without suitable soil volume and access to water. This analysis assumed that using passively irrigated new trees means 10% of trees that would normally die would not need to be replaced. The following table presents costs from a recent Melbourne tree replacement project that were used to inform the benefit value used in this project. The analysis assumed medium sized trees would not need to be replaced, generating a benefit of $970/tree.

Size	Capital expenditure cost / tree	Operating expenditure cost / tree
Small	$355.45	$105.25
Medium	$972.59	$108.12
Large	$1,844.71	$106.29

Improved mortality and morbidity

Whiteoak and Saigar (2019) identified the economic value of improved heat related mortality and morbidity of a person. Morbidity was related to emergency department attendance and presentation. These rates were for persons aged over 64 years/day/1^0C above 30^0C. This analysis assumed five heatwaves/year and a difference in air temperature over the heatwaves of –0.15 degrees compared with BAU. This assumption generated the following benefit values:

- Mortality = –0.15 x 5 x $1.59 = $1.19/person/year
- Morbidity = –0.15 x 5 x $0.21 = $0.16/person/year.

Improved work productivity

Whiteoak and Saigar (2019) identified the economic value of improved work productivity/day for every 1^0C above 30^0C. This analysis assumed five heatwaves/year and a difference in air temperature over the heatwaves of –0.15 degrees compared with BAU. It also assumed 20% of the Townsville workforce was affected by temperature with an assumed average weekly income of $710/week ($141.55 / day).

This resulted in the following benefit values: –0.15 x 5 x $7.85 = $5.89/employee/year.

Population growth assumptions

A number of benefits attributed to tree canopy were included until 2031 (when tree growth is likely to provide some benefits). The following table outlines how the population and household data was modified assuming 1% growth rate to determine an appropriate 2031 dataset.

Benefit	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Property value increase	64,907	65,556	66,212	66,874	67,542	68,218	68,900	69,589	70,285	70,988	71,698
Reduced mortality	193,601	195,537	197,492	199,467	201,462	203,477	205,511	207,566	209,642	211,739	213,856
Reduced morbidity	193,601	195,537	197,492	199,467	201,462	203,477	205,511	207,566	209,642	211,739	213,856
Improved work productivity	17,289	17,462	17,637	17,813	17,991	18,171	18,353	18,536	18,722	18,909	19,098

Adoption and risk

The following table summarises the adoption parameters. It reflects an adoption proportion of 1 for benefits associated with TCC delivered solutions (trees). Reduced adoption proportions were used for benefits associated with solutions that rely on adoption of others (e.g. tanks and irrigation rates of backyards).

Benefit	*Adoption proportion (between zero & 1)*
Property value increase	1
Reduced mortality	1
Reduced morbidity	1
Improved work productivity	1
Carbon capture - small tree	1
Carbon capture - large tree	1
Reduced potable use - rainwater tanks	0.6
Reduced potable use - optimised irrigation	0.8
Reduced tree replacement	1
Nitrogen removal	0.9

The analysis adopted a low project risk (0.03), reflecting that Council will deliver the street trees, and rainwater tanks are a well-known technology.

CRC for
Water Sensitive Cities

Cooperative Research Centre for Water Sensitive Cities

Level 1, 8 Scenic Boulevard
Monash University
Clayton VIC 3800

info@crcwsc.org.au

www.watersensitivecities.org.au