Social and Environmental Economic Values Tool

Economic Values in IWM Evaluation

Projects that provide social, environmental, economic and cultural outcomes to society are commonly evaluated using methods such as cost-benefit analysis. The Social and Environmental Values Tool (SEVT) is a database of common economic values for monetising social and environmental benefits linked to integrated water management and blue-green infrastructure for metropolitan Melbourne, with guidance on how to use them. These values can be used for estimation of the economic value of common non-market benefits using the benefit transfer method in economic evaluation.

The SEVT is intended as a first point of call when searching for common reference values, but as business cases progress more specific economic values may be needed. All evaluations using SEVT values should be reviewed by an experienced economist for quality assurance. The current version, SEVT 5.1, was released in September 2021. It was developed using the best information available at the time, but it is not exhaustive It is a shared resource used by metropolitan water utilities to enable consistency in economic evaluation of IWM projects across Melbourne.

What is the SEVT?

The Social and Environmental Economic Values Tool (SEVT) provides common economic values chosen in consultation with Melbourne's water corporations' planners to support benefit valuation for business cases[1].

The SEVT sourced values from the CRC Water Sensitive Cities INFFEWS Non-Market Values Tool[2] and industry and grey literature relevant to the Melbourne context in 2020.

All references in the SEVT were selected for their relevance to the greater Melbourne context. It is endorsed as a common reference by the Metropolitan Investment Evaluation Group – a collaboration between Melbourne Water, Greater Western Water, South East Water, Yarra Valley Water and Barwon Water – for the economic evaluation of infrastructure projects in Greater Melbourne. This document contains an abridged version of the SEVT.

Use and limitations

The SEVT was designed to be an initial go-to reference for economic values for monetization of common social and economic benefits for use in cost- benefit analysis. Review by a professional economist is required for quality assurance. The SEVT provides planners with simple guidance to increase their understanding of benefit analysis, and to facilitate engagement with economic consultants.

The SEVT does not estimate benefit values, but provides guidance on the estimation method. The SEVT does not include costs nor avoided costs.

The SEVT is based on the best information available at the time, however it has limitations. If a desired value is not available, the user is advised to seek other references[2] or engage a specialist to find or develop fit-for-purpose values.

The SEVT is part of a suite of Melbourne water industry tools, including the MIEG Factsheets on Economic values. It will be updated approximately every 4 years.

Keep up to date with what's happening

For more information please contact your water utility representative

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[1] Social and Economic Value Tool (SEVT) – version 2.4 , March 2021, developed by Marsden Jacob Associates for Melbourne Water.

[2] Iftekhar, M.S, Gunawardena, A., Fogarty, F., Pannell, D. and Rogers, A. (2019). INFFEWS Value tool: Guideline (Version 2): IRP2 Comprehensive Economic Evaluation Framework (2017 – 2019). Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities. See: Tools to assess the value of water sensitive cities principles and practices gaining traction | Water Sensitive Cities Australia (wscaustralia.org.au) for the 2023 update.

Melbourne Water

MARSDEN JACOB ASSOCIATES

Welcome to the Melbourne Water Social and Economic Value Tool (SEVT)

Melbourne's water utilities and stakeholders are developing common and agreed principles and guidelines for economic evaluation of integrated water management (IWM) and green-blue infrastructure projects across Melbourne and surrounds.

The SEVT is one of the tools developed as part of this cross water utility initiative. SEVT is a purpose built collection of economic benefit values that IWM and blue-green infrastrcuture investments can provide. The economic values in the SEVT have been chosen so they are directly relevant to investments in the Greater Melbourne area. You can use the economic benefit values in the SEVT to establish high-level estimates of the potential benefits of proposed IWM and blue-green infrastructure investments. You can then use these high-level benefit estimates in economic analyses, including cost-benefit analysis. Follow with a final review by an economist.

Note that the SEVT is an economic benefit value tool, not a cost-benefit tool. What that means is you take the benefit values from the SEVT and apply them in your own cost-benefit templates. Note also that the SEVT contains economic benefit values for the types of benefits of IWM and blue-green infrastructure widely observed in Greater Melbourne. If you're looking for an economic value that is not in the SEVT you can consult the SEVT database, or contact the authors below, we may have value estimates we can provide, or can provide guidance on how to estimate the benefits you're seeking.

For more information or to provide feedback on this tool, or for guidance on how to apply a particular value please contact:

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New to economic valuation and benefit transfer?

The SEVT tool assumes you have some familiarity with economic valuation and the benefit transfer approach. If you are new to economic valuation and benefit transfer, or are looking for a refresher on these concepts we recommend you review the non-market valuation guidance from the Victorian Department of Economic Development, Jobs, Transport and Resources. This excellent, practical and relatively short resource includes sections on Introductory Concepts, Benefit Transfer, and Step-by-step guidance for addressing non-market impacts in an economic assessment. You can access this free resource through the link below.

DEDJTR Guidance-on-valuing-non-market-impacts

Detailed Benefit Type Guidance

The following pages provide detailed guidance and worked examples on how to use the values provided in the SEVT Lookup tool.

Version 2.4 March 2021

The SEVT database is a development on the INFFEWS non-market values database from the CRC Water Sensitive Cities. The SEVT focuses on values and specific guidance for common IWM and blue-greeen targeted to the Melbourne context.

How to use the SEVT Lookup benefit values

Sensitivity Analysis

Sensitivity analysis examines how changes in the assumptions of an economic model affect its predictions. The unit values in the SEV tool reflect assumptions about the economic values of social and environmental outcomes of green-blue infrastructure based on value transfer literature reviews. They have different levels of confidence in the accuracy of the economic unit value estimates. These levels of confidence reflecting the quality and appropriateness of the studies underpinning them, and their applicability to Greater Melbourne.

We recommend that people apply sensitivity analysis to the economic unit values in the tool. We recommend a simple 'traffic light' basis for sensitivity analysis, based on the quality of the studies underlying the unit values. These traffic light values are found in the yellow detailed guidance tabs. They are organised by benefit type.

Guidance on overlaps in benefit types of risks and double counting

This section provides high-level guidance on how to deal with overlaps in benefit types and risks of double counting. This material is drawn from our own experience and several recent Victorian guidance notes.

The non-market valuation guidance from the Department of Economic Development, Jobs Transport and Resources is particularly good, and recommended reading. It includes comprehensive Q+A on double counting.

What is double counting and why is it an issue?

Double counting occurs when you count the same benefit more than once. For example, an investment in a green parkland may give rise to more enjoyment from active and passive recreation by people living near the park. It might also result in property prices near the park increasing.

The beneficial impacts of more enjoyment from recreation may be captured via a survey or households living near the proposed park site to monetise or quantify the impact. If you include this benefit and the expected rise in property prices from when the park investment occurs in the same benefit calculation, then you are double counting. This is because the benefits to personal wellbeing of having the park measured by this same would overlap with, if not duplicate, the house price impacts.

How to identify double counting risks

To help you with identifying double counting, the benefit rack rate table above identifies where double counting might occur.

Choosing between values to avoid double counting

If the benefits rack rate table highlights a double-counting risk, you need to choose one of the values to include in your benefit assessment, not both or all of them.

There is no standard guidance on the best way to choose the 'right' benefit value to include in your assessment. We recommend three main approaches you can use: (1) the encompassing value method (2) the quality method (3) the subtraction method. Note that these methods are complimentary – for example a benefit value could be higher quality and a more encompassing value. This would simply strengthen the logic for using one benefit value over others.

(1) Encompassing benefit economic value method

An encompassing economic benefit value is a value that likely includes other values that make up the parts of the encompassing value. When you have potential double counting risks, one approach is to select the more encompassing value, because the other values will be included in this encompassing value.

For example, my willingness to pay to live in a house near a parkland with a running trail encompasses (1) my preference for being able to look out a window and see the park from my home (2) the anticipation that I will recreate / run more living near a park, and therefore be fitter and healthier (3) my anticipation that the neighbourhood around my house will be cooler and more resilient to heat impacts than other areas that are just paved (4) my preference for my children to grow up around nature (5) an expectation that properties near parklands will hold up value better than properties not located near parks.

In this example if you are choosing between the property premium for house prices, and the enjoyment benefits from additional recreation, you would choose the house price because the recreation enjoyment benefits are already encompassed within the house price premium.

(2) Quality of study method

A second approach is to use the better-quality study when there are marked differences in the study. We have provided guidance on the quality of the benefit unit values in our detailed guidance on each benefit.

If you have to choose between overlapping values, always look at the quality of the values underpinning them. If one set of values are clearly higher quality or more appropriate for value transfer than the other, then consider using the better quality study.

(3) Substitution value method

Another approach involves using each of the benefit values in the study to see if there is any meaningful difference in results. For example, if you are looking at the economic value of an urban park and having to choose between a recreation benefit value and a house price premium:

- Calculate the benefit value for both approaches separately
- Insert one of the benefit values in the economic analysis to understand the impact
- Substitute the other benefit in the economic analysis to understand if the impact changes much.

If there is little difference in the results when you substitute values, then the choice of which value to use becomes a policy question of which values your audience / decision makers will find more helpful.

Consult the detailed guidance tabs for factors to take into account when making your decision.

One-off vs per period values

For guidance on choosing between one-off or per period SEVT Lookup values please contact Jeremy Cheesman.

Benefit type	Benefit impact	Description	Value to apply (average)	Unit of measure	Base year	Double counting risk	Care needed to avoid double counting with:
Recreation	Visiting an urban park	Value of general recreational visit to urban park	16	$/person/trip	$2018	Yes, see guidance	Property value from proximity to waterways
	Visiting the beach/coast	Value of general recreational visit to beach / coast	31				
	Visiting freshwater/riverside	Value of general recreational visit to freshwater rive	16				
	Recreational fishing	Willingness to pay for one day of fishing	26				
Health	Avoided healthcare costs from urban cooling (over 30 degree days)	Avoided healthcare value from reducing exposure to extreme heat (over 30 degrees) by one day a year	100	$/person	$2019	No	None
	Avoided productivity losses from urban cooling (over 30 degree days)	Avoided productivity loss (presenteeism and absenteeism) from reducing exposure to extreme heat (over 30 degree day) by one day	125				
	Avoided productivity losses from urban cooling (30-35 degree days)	Avoided productivity loss (presenteeism and absenteeism) from reducing exposure to extreme heat (30-35 degree day) by one day	11				
	Avoided productivity losses from urban cooling (35-40 degree days)	Avoided productivity loss (presenteeism and absenteeism) from reducing exposure to extreme heat (35-40 degree day) by one day	65				

Benefit type	Benefit impact	Description	Value to apply (average)	Unit of measure	Base year	Double counting risk	Care needed to avoid double counting with:
Health	Avoided productivity losses from urban cooling (40+ degree days)	Avoided productivity loss (presenteeism and absenteeism) from reducing exposure to extreme heat (40+ degree day) by one day	281	$/person	$2019	No	None
	Avoided productivity losses from increased physical activity (indoors or outdoors)	Workplace production benefit per Victorian adult who becomes physically active (75 minutes per week moderate activity) for remaining lifetime	200	$/person/ one off	$2018	Yes, see guidance	Increased mental health well-being
	Increased mental wellbeing	Workplace production benefit per person who did not recreate outdoors and now recreates outdoors (75 minutes per week passive recreation activity) for remaining lifetime	200	$/person/ one off	$2019	Yes, see guidance	Increased physical health well-being
	Avoided healthcare costs from increased physical activity	Avoided healthcare cost benefit per Victorian adult who becomes physically active (75 minutes per week moderate activity) for remaining lifetime	100	$/person/ one off	$2018	Yes, see guidance	Increased physical health well-being
Air quality and pollution	Air pollution removed by trees	Air pollution removed by medium tree of ozone, sulphur dioxide, nitrogen dioxide, carbon monoxide and particulate matter (<10 microns)	6.51	$/tree/year	$2019	Yes, see guidance	Property values from proximity to urban forests/street trees
	NO2 removed by trees	Average annual pollutant uptake and pollutant removal by medium trees of NO2	651	$/tonnes			

Benefit type	Benefit impact	Description	Value to apply (average)	Unit of measure	Base year	Double counting risk	Care needed to avoid double counting with:
	SO2 removed by trees	Average annual pollutant uptake and pollutant removal by medium trees of SO2	451				
	PM-10 removed by trees	Average annual pollutant uptake and pollutant removal by medium trees of PM-10	150				
	CO2 emission removal	Average cost of emission removal of CO2 per tonne	40				
Property values	Proximity to urban wetland (marginal impact)	Increased property value for each additional % closer to the asset, up to 300 metres	-0.2	% property	N/A	Yes, see guidance	Health benefits
	Prevalence of street trees (marginal impact)	WTP for 1% increase in footpath tree cover within 100 m	0.1				Urban cooling benefits
	Proximity to community and cultural park (marginal impact)	Increased property value from medium house distance to first percentile distance from Park	-0.006				Health benefits
	Proximity to urban wetland (average impact)	Average impact on properties up to 300 metres	1				
	Proximity to metropolitan park (marginal impact)	Increased property value from medium house distance to first percentile distance from Park	-0.4				

Benefit type	Benefit impact	Description	Value to apply (average)	Unit of measure	Base year	Double counting risk	Care needed to avoid double counting with:
	Proximity to sport and recreation park (marginal impact)		-0.012				
	Proximity to national and state park (marginal impact)		-0.013				
	Prevalence of street trees (average impact)	Average impact on properties up to 300 metres	3.5	% property	N/A	Yes, see guidance	Health benefits
	Household connection to recycled water supply (non-drinking)	Increased property value from having connection to recycled water supply for non-drinking use (houses and townhouses only, not apartments)	0.7	% property	N/A	Yes, see guidance	Benefits of avoiding water restrictions
Biodiversity and ecology	Willingness to Pay for wetlands	Willingness to pay per hectare of wetlands	0.0015	$/ha/hh/one-off	$2017	Yes, see guidance	Property values from proximity to waterways; change in recreation benefit from improved waterway condition.

Benefit type	Benefit impact	Description	Value to apply (average)	Unit of measure	Base year	Double counting risk	Care needed to avoid double counting with:
	Port Philip and Westernport Bay water quality condition	Cost to maintain Bay and beach water quality condition	6645 (2250-11,000)	$/kg/once-off	$2021	Yes, see guidance	Property values from proximity to waterways and Bay; waterway condition improvements; recreation values from improved Bay condition
	Willingness to Pay for environmental water release	WTP for a 1GL change in Environmental Water release into significant urban, peri-urban and rural waterways (like Yarra, Tarago)	1.244	$/GL/once-off	$2017	Yes, see guidance	Property values from proximity to waterways; change in recreation benefit from improved waterway condition.
	Willingness to Pay for Grasslands	Willingness to pay for healthy grasslands per hectare per household	0.001	$/ha/hh/one-off	$2017	Yes, see guidance	
	Urban Waterway - Amenity improvement	WTP for a 1 km Shift in Urban Waterway from Highly Modified (low amenity and low ecological value) to Sustainable Amenity (high amenity and low ecological value)	0.0043	$/km/hh/once-off	$2015	Yes, see guidance	
	Urban Waterway - ecological improvement	WTP for a 1 km Shift in Urban Waterway from Highly Modified to Near Natural (low amenity and high ecological value)	0.1826				

Benefit type	Benefit impact	Description	Value to apply (average)	Unit of measure	Base year	Double counting risk	Care needed to avoid double counting with:
	Urban Waterway - Amenity and ecological improvement	WTP for a 1 km Shift in Urban Waterway from Highly Modified to Ecologically Healthy (high amenity and high ecological value)	0.0726				Property values from proximity to waterways; change in recreation benefit from improved waterway condition
	Urban Waterway - Switch from amenity to ecological	WTP for a 1 km Shift in Urban Waterway from Sustainable Amenity to Ecologically Healthy	0.1826				
	Urban Waterway - switch from amenity to near natural	WTP for a 1 km Shift in Urban Waterway from Sustainable Amenity to Near Natural	0.0726				
	Urban Waterway - switch from ecological to near natural	WTP for a 1 km Shift in Urban Waterway from Ecologically Healthy to Near Natural	0.0363	$/km/hh/once-off	$2015	Yes, see guidance	
Flooding	Reduced flooding impacts	Refer detailed guidance for stage damage functions in Appendix A2.6	See guidance notes	Blank	Blank	No	Refer guidance notes

Guidance and worked example for Benefit Type 1. Recreation	
Benefit impacts	1.2 Recreational fishing 1.3 Visiting an urban park 1.4 Visiting freshwater / riverside 1.5 Visiting the beach / coast
Description	The economic value of general recreational visits including but not limited to recreational fishing, boating, visiting an urban park, waterside activities, and beach activities.
Traffic Light Quality score:	Orange. Based on a small number of recent Australian studies evaluating the economic value of recreation to recreators. Recreation economic values are based on observed trip behaviour. The economic valuation approach is well established. Per trip values have been relatively stable over the last decade, showing consensus in estimates.
Recommended sensitivity analysis	+ / - 30%
Unit of measure	$ person / daytrip
Form of quantitative estimate needed	Number of trips new trips attributable to the investment.
Care to avoid double counting with	• Amenity values from – hedonic pricing. If you are estimating the benefit of urban space in greenfield or other developments using hedonic pricing (discussed below) then the consumer surplus from park visits is already priced into the house price premium. You cannot claim the house price premium as a benefit and the urban park trip visitation as a benefit for residents in the same evaluation. This is double counting. • Health benefits – in some cases health benefits from recreation are included in recreation values. This is not the case with the recreation values we have recommended. However, if you are using other recreation benefit figures, make sure they do not include health benefits as well. If they do, do not claim recreation health benefits separately, as this is double counting.
Discussion	We have recommended the recreation benefits based on a review of multiple studies. The unit values are average values for the Greater Melbourne population. There is good evidence that people obtain benefits from outdoor activity in parks, public open space, near and on waterways, and beaches and Bays over and above how much they pay to do these activities. Economists call the difference between the maximum amount that consumers are willing to pay for outdoor activities and what they actually pay consumer surplus. Consumer surplus is a direct measure of welfare contribution.

For example, if the maximum amount a Victorian is willing to pay for an outdoor activity is $80 per day including all trip and equipment expenditure and they only actually pay $50, then the person gets a consumer surplus of $30. Even though this $30 consumer surplus does not get exchanged through any marketplace transaction, the existence of the consumer surplus is a benefit that should be counted in economic analysis and is also central to the individual's decision to do the recreation activity.

For the purposes of this analysis, we have developed conservative estimates to reflect the benefits that near or on-water recreation visitation combines active and passive recreation. The recreation consumer surplus values recommended are based on a $50 per day equivalent, reflecting the consistent outcome of a range of earlier analyses. The unit values recommended reflect that most of the on and near water activities last for less than a day, typically a couple of hours. Key points here are:

• **There are not many Australian studies that have measured the value of recreation at urban rivers and waterways.** Australian recreational values for rivers focus on boating or fishing and other activities, and on 'larger' regional rivers (such as the Murray and the Fitzroy Rivers).

• **The travel cost – contingent behaviour (TCM-CB) study for sites on the Hawkesbury-Nepean River by Gillespie *et al* [35] is a key relevant study** for Melbourne Water. The TCM-CB questionnaire was administered onsite using face-to-face interviews, over a 10-day period in 2013. The survey provided 952 completed questionnaires, achieved with a 78 per cent response rate. Around 200 questionnaires were completed at each of the four most popular sites. The surveys identified if the main purpose of visit was swimming. The CB question asked how recreation at the site would change for increasing the percentage of days per year that river condition is good for natural river swimming.

Gillespie *et al* [35] estimated the recreational value of a trip at round $15 per trip ($2016), with trips lasting for several hours. Note that these recreational values are for all activities (land and water). Separate models could be estimated for respondents who participate in water activities if the authors would agree to doing these runs or providing the data for evaluation.

• **The recreational values of Gillespie *et al*** [35] **are likely conservative.** This is because (1) they only include trip costs (car, public transport, bike) to calculate the TC (i.e. they exclude other costs such as drinks, food etc that people may expend as part of the trip) and (2) they calculate the opportunity cost of time for adults at 35% of the average wage rate for the Outer Western Sydney Statistical Subdivision. Other Australian recreation value studies have assumed higher opportunity costs.

• **The recommended values of around $15 per trip are in line with Parks Victoria [38] w**ho estimated the value per trip to metropolitan parks at around $10 per trip and reservoir parks at around $16 per trip ($2018). They are also consistent with Lansdell and Gangadharan (2003) who estimated values per trip values to Maroondah Reservoir and Albert Park at $20 and $15 per trip respectively ($2018).

• **Note that there will be variation in recreation values depending on whether the site is a 'major site' or a 'minor site'.** A major site is a site that attracts a lot of visitors, but is visited less frequently, such as for a special family outing. A minor site would be a local swim site that perhaps has less use but is visited frequently, such as for weekday swims or walking. For 'major' sites, consider using estimates closer to the upper bound values. For minor sites (such as pocket parks) use the lower bound values.

	• **Note also that the $15 per day estimate is an estimate of total recreation value.** What this means is that if the recreation is transferred to another site, or substituted with another recreation activity, then there is no new recreation value created, and you cannot claim the recreation value as a new benefit. This is because the benefit is not created by the new park visitation, it is simply transferred from another site or recreation activity. • **There are no studies that have valued recreation at Victorian beaches or the coast directly that we are aware of.** Other Australian studies have valued beach trips in the order of $20 per trip ($2014) [39] • **If recreation activities are substituted then you may claim a percentage of the recreation benefit.** How much benefit you can claim will depend on what activities are being transferred from and to. For very similar activities (such as recreating in the new park compared to an otherwise similar existing park) then the benefit is any difference in the costs of getting to the park (i.e. consumer surplus is probably the same, but costs are less). For activities such as recreating in a park instead of a gym, then a lower bound per trip $5 could be used. This would imply there is a preference for recreating in a park instead of indoors.
General guidance	Use the per trip estimate for urban park visitation, including on- and near- water activities.
How to apply the values	• Estimate the number of trips you expect to the site (park, waterway etcetera) in a year because of the new investment. • Estimate how many of these trips are **new (induced)** activities, not substitutes from existing sites. • Estimate the value of total trips per year for new activities as the consumer surplus $ value x trips. For substitution from existing sites, estimate the values using the lower bound per trip estimates (or $nil if they are near perfect substitutes).
Worked example	

Assumptions	Value	Unit of measure
Number of trips expected to the site in a year because of the new investment [A]	10,000	People
% of trips that are new (induced) trips, i.e. not substituting recreation from another site [B]	20%	%
Recreation value per trip [$2016] [C]	$16	$ per person per trip
Inflation adjusted willingness to pay – difference in the value of money (inflation) since the study was completed in 2018 and now [D]	https://www.rba.gov.au/calculator/	Index

Calculation

Economic value of induced recreation = Number of trips expected to the site in a year because of the new investment [A] * % of trips that are new (induced) trips, i.e. not substituting recreation from another site [B] *

Recreation value per trip [C] * Inflation [D]

Economic value of induced recreation = 10,000 * 20% * $16 * 1.06 = $33,920

Scaling / transformation required	None

Guidance and worked example for Benefit Type 2. health	
Benefit impacts	2.1 Avoided healthcare costs from urban cooling 2.2 - 2.5 Avoided productivity losses from urban cooling 2.6 Avoided productivity losses from increased physical activity (indoors or outdoors) 2.7 Increased mental wellbeing 2.8 Avoided healthcare costs from increased physical activity
Description	The economic value of urban cooling.
Unit of measure	$ person
Traffic Light Quality score:	Green. Based on recent Australian studies evaluating the impacts of urban heat on Sydney and Melbourne populations.
Recommended sensitivity analysis	+ / - 10%
Form of quantitative estimate needed	• Number of people benefiting from reduced heat incidence • Reduction in number of extreme heat days (defined below) each year.
Care to avoid double counting with	None. If you are using this approach, do not also claim urban heat mitigation benefits using other tools such as the WSAA health benefits from liveable cities ready reckoner.
Discussion	We have recommended the urban cooling benefits based on two recent studies. We have measured economic values for the following urban cooling benefits: Health and productivity impacts of urban cooling measured as the economic value of change in the incidence of morbidity and mortality from heat stress. **Health and productivity impacts of urban cooling measured as the economic value of change in the incidence of morbidity and mortality from heat stress.** Our review of contemporary literature on urban heat impacts focusses on recent high-quality empirical studies that are directly relevant to Greater Melbourne and Greater Sydney. Key summary points from this literature are: • The urban heat island effect creates real economic costs. In Australia, heat waves claim more human lives than any other natural hazard [24]. • Greater Melbourne is likely to experience extreme weather that may be exacerbated by a more urbanised environment in the future [25].

- There is evidence that the addition of trees and other vegetation to the built environment provides benefit in mitigating the urban heat island effect in Australia [25-29]. The mitigating impact of trees differs at micro, local and macro scales. Greenery selection, plant configuration and urban morphology also impact on tree's mitigating impact [29]. Cooling by evapotranspiration varies by climate, canopy physical and geometrical properties and season but is typically up to 2–3 °C, sometimes higher. In summer, this mechanism produces generally larger cooling (>2.0 °C). Cooling from vegetation is larger if canopies and ground cover are implemented in targeted configurations, e.g., urban parks, rather than spread out over large areas [29].

- Evidence shows that the extent of benefits due to evapotranspiration and local shading is location specific and (1) related to particular meteorological conditions and (2) the greenery maintenance regime and configuration [29]. Both these variables can compromise urban greenery mitigation effects at both local and mesoscale, in terms of pedestrians' thermal comfort.

- Generally, combining urban greening (large scale mature tree plantings) and urban blueing (use of evaporative cooling techniques by installing water fountains across a region) can provide greater urban cooling benefits than separately. The benefits are not additive however, and the additional benefit (measured in terms of cooling degree days (CDD)) is typically marginal [8]. Greenery selection, plant and open water body configuration and urban morphology will clearly impact on outcomes.
- The current evidence suggests the impact of greening alone on human thermal comfort, and any associated heat stress, may be negligible cases. These studies evaluate how human thermal comfort, and associated heat stress, is determined by a combination of temperature, humidity, wind, and radiation.

- [27] found that cooling via reducing net radiation or increasing irrigated vegetation in parks or on green roofs did reduce ambient air temperature in Greater Sydney. Irrigated gardens and parks generated cooling but by a comparatively small amount (<0.5°C). Irrigation also caused a decrease in wind speed and a significant increase in the amount of water in the atmosphere (0.1–2.4hPa). The combined impact of lower air temperature, lower wind speed and higher humidity means that the impact of increasing greening with irrigation on heat stress was negligible for Greater Sydney.

- Lower air temperature did not lead to less heat stress because both temperature and humidity are important factors in determining human thermal comfort. Specifically, cooling the surface via evaporation through the use of irrigation increased humidity—consequently, the net impact on human comfort of any cooling was negligible. This result suggests that urban cooling strategies for Greater Melbourne must aim to reduce ambient air temperatures without increasing humidity. This may be achieved for example via the deployment of solar panels over roofs or via cool roofs utilizing high albedos in order to combat human heat stress in the urban environment.
- To date, economic evaluations of add UHI Definition (UHI) impacts have not considered how populations could respond to urban warming, and how this would change health costs of urban heat. In short, analyses to date have assumed that people do not learn over time how to cope with heat, and that they do not acclimatise. There is evidence that people do learn over time how to cope with heat stress, and Australians can heat-acclimatise [30]. Structural, behavioural and acclimatisation changes may reduce morbidity and mortality, and associated costs, potentially substantially.

- To date, economic evaluations of urban greening or blueing on heat stress have not acknowledged that urban greening and blueing could increase the rates of heat related morbidity and mortality. This however is a possibility. For example, if urban greening and blueing induces outdoor participation, particularly active recreation, during extreme heat events (35 degrees+), then there is a possibility that we will see more heat related impacts, not less. Urban blueing and greening could generate unintended outcomes and increase rates of heat related illness.

	• To date, most economic evaluations have not considered how sequences of 'hot days' impact on productivity and health outcomes. Economic studies assume the 'hot day' impacts are additive – i.e. the economic impact of two hot days back to back are the same as two hot days separated by a month. Current evidence suggests that hot day sequences may have greater economic impacts than single hot days [31]. • WSAA [32] estimates the economic relationship between the number of hot days and economic costs based on a combination of hospitalisation from heat stress, lost productivity and mortality. They note that the estimates will mainly apply in larger precinct scale studies, and in lower socioeconomic classes. They estimate a relationship based on an assumed relationship between ambient temperature (number of hot days) and heat-related deaths. While they do not define what they mean by 'hot days', we assume this is days of 30+ degrees average temperature, based on the study they base their estimates on [25]. • WSAA estimates a broad relationship between reduced number of hot days, health care and productivity costs. They estimate reducing one 'hot day' will result in a benefit of around $100 per person in reduced morbidity and mortality cost, and $125 in productivity benefits from reducing absenteeism and presenteeism ($2019). Productivity estimates are based on a 'human capital approach'. This provides a higher estimate of productivity cost than the alternative approach, which is known as the "friction cost approach" [33]. The WSAA approach also applies the productivity benefit to the whole population. More correctly it should only be applied to the working population. • Marsden Jacob [31] estimated the health benefits of urban cooling in work for Sydney Water's Western Sydney Masterplan. We used a similar approach to WSAA (2019). Our approach segmented extreme heat days into three categories (1) 30-35 degree days (2) 35-40 degree days and (3) 40+ degree days. We estimated the total cost of heat stress as (1) costs to employers and workers (lost production and compensation costs) and (2) the community (health and medical and transfer costs). Lagged impacts of heat stress were included in these costs. We used costs from [34]. We use the friction-cost approach [33] to value the productivity impacts of heat stress on the workforce. The friction-cost method calculates the economic cost of heat stress as the as hours not worked. Our approach adjusts for 'make up' hours worked by workers who have suffered heat stress based on evidence in [24]. Our approach assumes that workers return to work, and that the primary impact of absenteeism for workers and employers is lost productivity, net of make up time. We extend the workforce heat stress estimates to the rest of the population by assuming (1) that non-workforce participants have similar heat stress and heat stress day incidence as the workforce incidence and (2) that the opportunity cost of time for non-workforce participants is 35% of the average wage rate. Our approach for calculating opportunity costs is consistent with recent economic analyses for Sydney Water [35]. • We assumed that workplace heat stress incidence increases broadly in line with Ambulance call outs. We calculate how mortality costs increase when average daily temperatures increase, using the value of statistical life (VSL) approach [36]. Using this approach we estimated that (1) reducing one 30-35 degree day will result in a benefit of around $11 ($2018) per 18+ person in productivity benefits from reducing absenteeism and presenteeism (2) reducing one 35-40 degree day will result in a benefit of around $65 ($2018) per 18+ person in productivity benefits from reducing absenteeism and presenteeism (3) reducing one 40+ degree day will result in a benefit of around $280 ($2018) per 18+ person in productivity benefits from reducing absenteeism and presenteeism. These estimates are consistent with WSAA.
General guidance	• Care should be taken when claiming urban heat benefits. Benefits should only be applied to precinct scale projects with meso scale cooling impacts [32]. UHI benefits may be greater in locations where there is lower humidity, and greater wind speed, and when investments maintain this balance. This is because the current evidence suggests the impact of greening alone on human thermal comfort, and any associated heat stress, may be negligible when lower temperature achieved from urban greening also increases humidity and reduces wind speed.

	• Estimation needs defensible estimates of urban heat changes from the project. Defensible quantification of these impacts will require drawing on location-specific studies/modelling, rather than simply applying values from studies in other locations [32]. • Care should be taken not to overstate impacts of urban heat. Urban cooling benefits attribution will be greater generally when urban greening is combined with urban blueing and cool building technologies. The costs of all these investments need to be accounted for. • Care should be taken not to overstate impacts of urban heat. When thinking about avoided health impact costs (1) consider whether urban greening could actually create negative health outcomes by encouraging more people to be outside on hot days and (2) potential for acclimatisation. • Productivity estimates set out below are based on a 'human capital approach'. This provides a higher estimate of productivity cost than the alternative approach, which is known as the "friction cost approach" [33].
How to apply the values	• Determine if the project can create meso scale cooling impacts [32]. If not, do not use the values, urban heat benefits are likely to be small relative to other benefits. • Establish defensible estimates of urban heat changes with and without the project for each year of the project life. Defensible quantification of these impacts will require drawing on location-specific studies/modelling, rather than simply applying values from studies in other locations [32]. • Establish the population who will experience the meso scale change in temperature attributable to the project for each year of the project life. • To calculate the impact multiply the impacted population in each year by the number of days of heat reduction. • Because of the uncertainty of the estimates, conduct sensitivity analyses to see how estimates change. • Productivity estimates set out below are based on a 'human capital approach'. This approach provides higher cost estimates than the "friction cost approach". Consult [33] to see how you can calculate the friction cost approach.
Worked example	

Assumptions	Value	Unit of measure
Population who will experience a meso scale change in temperature attributable to the project in a year of the project life [A]	10,000	People
Working population who will experience a meso scale change in temperature attributable to the project in a year of the project life [B]	5,000	People
Number of days per person of reduced exposure to extreme heat (over 30 degree day) in the year [C]	1	Days
Avoided productivity loss (presenteeism and absenteeism) from reducing exposure to extreme heat (over 30 degree day) by one day ($2019) [D]	$125	$ per person
Avoided morbidity and mortality cost from reducing exposure to extreme heat (over 30 degree day) by one day [E]	$100	$ per person

	Inflation adjusted willingness to pay – difference in the value of money (inflation) since the study was completed in 2019 and now [F]	https://www.rba.gov.au/calculator/	Index
	Calculation Economic value of reducing exposure to extreme heat (over 30 degree day) by one day, morbidity and mortality cost = Population who will experience a meso scale change in temperature attributable to the project in a year of the project life [A] * Number of days per person of reduced exposure to extreme heat (over 30 degree day) [C] * Avoided morbidity and mortality cost from reducing exposure to extreme heat (over 30 degree day) by one day * Inflation Economic value of reducing exposure to extreme heat (over 30 degree day) by one day, avoided morbidity and mortality cost = 10,000 * 1 * $100 *1.0 = $1,000,000 Economic value of reducing exposure to extreme heat (over 30 degree day) by one day, avoided productivity loss = Working population who will experience a meso scale change in temperature attributable to the project in a year of the project life [A] * Number of days per person of reduced exposure to extreme heat (over 30 degree day) [C] * Avoided productivity cost from reducing exposure to extreme heat (over 30 degree day) by one day * Inflation Economic value of reducing exposure to extreme heat (over 30 degree day) by one day, avoided productivity cost = 5,000 * 1 * $125 *1.0 = $625,000		
Scaling / transformation required	• Consider using lower bound UHI benefits in locations where there is lower humidity, and greater wind speed, and when investments maintain this balance. This is because the current evidence suggests the impact of greening alone on human thermal comfort, and any associated heat stress, may be negligible when lower temperature achieved from urban greening also increases humidity and reduces wind speed.		

Guidance and worked example for Benefit Type 3. Air Quality and Pollution	
Benefit impacts	3.1 Air pollution removed by trees 3.2 NO2 removed by trees 3.3 SO2 removed by trees 3.4 PM-10 removed by trees 3.5 CO2 emission removal
Description	These values measure the economic benefit of pollution removed by mature urban forest per tree of ozone, sulphur dioxide, nitrogen dioxide, carbon monoxide and particulate matter (<10 microns). Economic benefit is measured as adverse health effects avoided by improving air quality. More information is provided below.

Unit of measure	$/tree/year
Traffic Light Quality score:	Green. Economic values are based on a peer reviewed model developed by US EPA and parameterised for Victoria. Economic values are based on observed market prices (for carbon credits) and / or peer reviewed estimates of the social costs of carbon and air pollution for Australia.
Recommended sensitivity analysis	+ / - 10%
Form of quantitative estimate needed	Number mature trees planted, plus assumptions around survival and growth rates.
Care to avoid double counting with	☐ Amenity values from urban forests
Discussion	We have recommended air quality (ozone, sulphur dioxide, nitrogen dioxide, carbon monoxide) and carbon sequestration values based on i-Tree eco estimates. i-Tree measures the functional structural value of the tree and the economic value of the environmental services it provides. Assuming these values are strictly separate, they can be added without double counting (i.e. it is assumed that an individual's amenity values are separate from the from functional services provided). I-Tree has been parameterised for Victoria and uses Victorian data. You can read more about the Victorian model here https://www.itreetools.org/eco/international.php. The Victorian model of the human health impacts of air pollution removal are based on BenMAP a US specific model created by the Environmental Protection Agency, parameterised for Australia (read more here). i-Tree Eco (Australia) is currently designed to provide accurate estimates in Victoria of: • Urban forest structure (e.g. species composition, number of trees, tree density, tree health etc.) analysed by land-use type. • Hourly amount of pollution removed by the urban forest, and associated percent air quality improvement throughout a year. Pollution removal is calculated for ozone, sulphur dioxide, nitrogen dioxide, carbon monoxide and particulate matter (<10 microns). • Hourly urban forest volatile organic compound emissions and the relative impact of tree species on net ozone and carbon monoxide formation throughout the year. • Public health incidence reduction and economic benefit based on the effect of trees on air quality improvement. • Total carbon stored and net carbon annually sequestered within the urban forest. • Yearly tree canopy rainfall interception summarized by tree species or land use. • Compensatory (amenity) value of the forest, as well as the value of air pollution removal and carbon storage and sequestration. Calculation methods for functional structure and ecosystem services are detailed in [8]. **What the economic benefit values are based on.**

	Different trees remove different amounts of air pollution and sequester different amounts of carbon. As a result, different trees have different economic benefits of air pollution removal and carbon sequestration. For the SEVT, the $/tree/year values are the average pollution removal and carbon sequestration economic value based on a representative mix of tree species that would perform well in Melbourne. Pollution data is referenced on RAAF-Laverton weather station. The representative sample of trees used to obtain unit values is calculated from sample species include Yellow and Red Box, Pink Flowering and Yellow Gum, and Smooth-barked Apple Myrtle, with the balance of the tree species being less typical, including a mix of native and exotic species. Examples include English Oak, Golden-rain Tree, Judas Tree and Kanooka. These species have been selected to meet desired outcomes of improved liveability by increasing shade canopy, leaf area and biomass, evapotranspiration, and amenity etc. **Carbon economic values** Carbon dioxide sequestration values are derived from species-based biomass equations. Carbon dioxide avoided values are estimated by converting the savings to tonne of avoided carbon emissions. Values (kWh and Mbtu) are converted to carbon dioxide using state-based EPA E-grid conversion values. The low-end carbon sequestration dollar value is $17 per metric ton. This per tonne value is the current Australian Carbon Credit Unit price, as at December 2020. It is the price someone seeking to offset carbon emissions would pay to offset under the Australian Carbon Credit scheme. Carbon Credits have traded in the $15-18 range per metric tonne since 2015. The high-end carbon sequestration value reflects the potential social cost of carbon, based on avoided health costs and morbidity. The social cost of carbon is based on [insert ref] **Air pollution economic values** Air pollutant deposition resource unit values are based on methods and models derived from the i-Tree Streets application. Air pollutant removal resource units and monetary values for air quality benefits are estimated based on avoided health costs and morbidity. We use the following parameters based on Australian estimates and previous work by Marsden Jacob Associates: NO2 $673 per metric ton; PM10 $185 per metric ton; SO2 $471 per metric ton ($2019).
General guidance	Use the per tree value to estimate the air quality and carbon sequestration benefits of mature tree canopy.
How to apply the values to air pollution	• Estimate the number of trees planted, and their age at maturity. • The $/tree/year estimate is for air pollution removed by mature urban forest. To calculate the annual benefit estimate as the tree grows, we need to adjust for the tree biomass. You can estimate the relationship between growth, pollution removal and age at maturity by assuming a growth pattern - such as sigmoid or linear. Note that these simplifying assumptions are unlikely to have material impact on your benefit assessments unless urban forest is the main benefit in your analysis. • Make a realistic assumption about tree survival – i.e. what % of trees will reach maturity. 75% survival is assumed as normal in i-Tree Australia. • Estimate the annual air pollution reduction economic benefit, calculated as for year (i): $APB_i = \$/tree/year * trees_i * \%\ full\ growth_i * (survival\%_i)$ • Discount the annual cashflows back to obtain the total air pollution and carbon sequestration benefit over the evaluation timeframe.

Worked example (linear growth and pollution removal)	Assumptions	Value	Unit of measure
	Pollution removal economic value $ per year (per medium sized tree) [A]	$6.50	$ per year per tree
	Number of years to maturity [B]	30	Per tree
	Annual growth rate [C]	3.33%	Per year (linear growth)
	Number of trees being planted [D]	1,000	Trees
	Survival rate [E]	75%	%
	Calculation Air Pollution Removal benefit in year $_i$ = $/tree/year [A] * trees $_i$ [C] * % full growth $_i$ [D] * survival % $_i$ [E] Air Pollution Removal benefit in year 1 = $6.50 * 1,000 * 3.33% * 75% = $163 Air Pollution Removal benefit in year 10 = $6.50 * 1,000 * 33.3% * 75% = $1,625 Air Pollution Removal benefit in year 20= $6.50 * 1,000 * 66.66% * 75% = $3,250 Air Pollution Removal benefit in year 30 (full maturity) = $6.50 * 1,000 * 3.33% * 75% = $4,875 Air Pollution Removal benefit in years 30+ until trees die off (full maturity) = $6.50 * 1,000 * 3.33% * 75% = $4,875		
Scaling / transformation	Sigmoid or linear transformation to get annual estimates of the air quality benefit of the tree as it grows to maturity, as discussed above.		

Guidance and worked example for Benefit Type 3. Property Value	
Benefit impacts	4.1 - 4.10 Proximity to blue and green infrastructure. 4.11 Household connection to recycled water supply
Description	The economic value of amenity from properties being located near urban parks, wetlands, and recreational lakes, or from having recycled water supply to the household.
Unit of measure	$ per property (one off benefit capitalised in property value)
Traffic Light Quality score:	Green for (4.1-4.10). Based on recent high-quality Australian studies evaluating the impacts of green and blue infrastructure on property prices in Greater Melbourne.
Recommended sensitivity analysis	+ / - 10%
Traffic Light Quality score:	Orange for 4.11. Based on 2014 study from Sydney for a single greenfield residential site.
Recommended sensitivity analysis	+ / - 30%
Form of quantitative estimate needed	Number of properties, dwelling type, and distance from amenity asset being valued.
Care to avoid double counting with	Recreation values (4.1-4.10). If you are estimating the benefit of urban space in greenfield or other developments using recreation values (discussed above) then the consumer surplus from park visits is already priced into the house price premium. You cannot claim the house price premium as a benefit and the urban park trip visitation as a benefit for residents in the same evaluation. This is double counting. Household costs of water restrictions (4.11). If you are estimating the benefit of having recycled water supply, large scale supply may reduce the risks of (potable) water supply restrictions. Water restrictions impose costs on households, because they restrict how and when potable water can be used. There is a risk of double counting if you count the benefit of reduced risk of water restrictions and the premium from having third pipe connections.
Discussion	We have recommended benefit values based on a review of multiple studies. The unit values are average values for the Greater Melbourne region. They apply to high, mixed and low-density residential developments. Non-market valuation studies have established a clear link between the 'greenness' and 'blueness' of a suburb and property prices in that suburb. The 'green and blue premium' can be interpreted as an indication of home-owners' willingness to pay for the amenity, recreational and other benefits of a relatively green landscape in their neighbourhood, or for wetlands, lakes and other open water. This willingness to pay is a direct measure of economic benefit (consumer surplus) of these things. Several Australian studies have also calculated premiums associated with having alternative water supplies at the home, including recycled water supply and rainwater tanks. The analytical technique employed in studies valuing green and blue amenity and calculating the value of alternative water supply is called Hedonic Pricing. Hedonic pricing has a long history of use in economic studies as an avenue to estimate willingness to pay (WTP) for a range of non-market goods and services.

Hedonic pricing assessments, including meta-analyses, have reported implicit property premiums associated with green infrastructure and urban amenity and alternative water supply to the household in the range of 0-10 percent. Caution needs to be used for the higher range estimates, unless they are located right next to the asset. Key points are:

- **Australian and international studies show wide divergence in property premiums for proximity to green and blue amenity**, despite generally controlling for the spatial location of a wide range of other influences on property price (e.g. access to schools, parks and gardens, house and lot size, year and month of sale etcetera). Higher premiums are typically associated with areas where there are mature slow growing broadleaf trees and other extensive established greenness. Premiums are typically lower for greenness during the establishment phase.

- **Hedonic pricing models can suffer from under-specification.** This can inflate the green price premium and the premiums associated with alternative water supply. This can result in price premiums being overstated. Under-specification occurs when things that impact on prices, and are correlated with increasing greenness or the households with alternative water supplies, are left out of the hedonic price model. This can result in the price premium being attributed to greenness or the alternative water supply incorrectly.

For example, lot size will impact on property prices, and larger lots could have more trees on them. If lot size is excluded from the hedonic model but tree index value is included then the price premium attributable to lot size may be incorrectly attributed to trees, and this will overstate the economic value of trees. Good model specification can address these design issues. The studies we have based our recommended values on have good model specification.

Similarly, if most households that have alternative water supply (recycled water connected or rainwater tanks) also have higher energy ratings, but household energy ratings are not included in the model specification, then the price premium attributable to higher energy ratings will incorrectly be attributed to having recycled water connected or rainwater tanks).

The recommended values for green infrastructure in this database are from primary sources, all directly relevant to Melbourne Water:

- **Recommended values for urban wetlands and recreational lakes are based on work by Marsden Jacob in 2017 [40]**. In the 2017 work we used house price observations from the Caroline Springs and Lakeside Park. An advantage of these sites is that they each have similar characteristics – i.e. both are greenfield sites with a large recreational lake, multiple wetlands, a shopping centres adjacent to the recreational lake, and freeway exits/entrances to the developments. Following the approach in earlier studies, (Polyakov, Fogarty, Zhang, Ram, & Pannell, 2016), we recorded key characteristics known to impact on house prices: construction year, land size, number of bedrooms, number of bathrooms, townhouse or freestanding, number of garage spaces, construction material, and whether the building is one or two stories. For each house we also measured their distance to key green and grey infrastructure within the development: the distance to the recreational lake within the development, the distance to the nearest large wetland, distance to the nearest sporting oval, distance to the neighbourhood shopping centre, and distance to the freeway entrance / exit. We also measured distances to key dis-amenities. For each house we also obtained latitude and longitude coordinates.

Using the dataset we then estimated the property price premium for properties located near wetlands, recreational lakes, urban parks and other green and blue assets. Our work shows there is a significant price premium for houses being located near recreational lakes and wetlands: for every one percent a house is further away from a recreational lake, the house price declines by around 0.4 percent, on average. For every one percent a house is further away from a wetland, the house price declines by around 0.2 percent, on average.

Figure 1 shows this result in easier to understand terms – i.e. how house prices decline as properties move further away from the recreational lake or wetland. The results show that a property around 10 metres from a recreational lake (i.e. on the lake front) is valued at $705,000 ($2017) on average. At 20 metres away, the identical property would be worth $675,000, and at 150 metres away it would be worth around $620,000. This result shows that there is a $85,000 price premium from living on a lakefront compared to living in an otherwise identical property 150 metres away from it.

For a wetland, the results show that a property around 10 metres from a wetland (i.e. on the wetland front) is valued at $660,000 ($2017) on average. At 20 metres away, the identical property would be worth $645,000, and at 150 metres away it would be worth around $620,000, i.e. the same as the lake. This result shows that there is a $40,000 price premium from living on a wetland front compared to living in an otherwise identical property 150 metres away from it.

Note that these results show there is no statistically significant difference between recreational lakes and wetlands. While the results above suggest that a recreational lake is 'worth' more than a wetland measured in terms of house prices, statistical analysis shows that the value is statistically the same.

The proximity premium for recreational lakes and wetlands last around 300 metres. Figure 1 highlights this result. Within around 300 metres of proximity to the lake or wetland, most of the price premium largely disappears. This result is consistent with intuition and earlier studies (Polyakov, Fogarty, Zhang, Ram, & Pannell, 2016). In simple terms, people value living very close to these assets.

- **Recommended amenity values for proximity to urban parks is based on recent work by Infrastructure Victoria** [41]. This paper provides the first estimates of the effects of parks on house prices within Victoria, and in Greater Melbourne specifically. They estimate hedonic regressions of house prices on the distance to six types of parks as well as a wide range of other amenities that may impact on house prices. IV finds that moving from the median to the first percentile of distances from a park is associated with increased property prices of up to $86,000 ($2018). The property price premium lasts for around 300 meters.

- **Recommended amenity values for proximity to street trees is based on [42].** This study used spatial hedonic price modelling of 2,300 house sales across 80 sample sites in 52 residential Brisbane suburbs, to reveal home-buyers willingness to pay 3.73% more for houses in streets with target levels of footpath tree cover (50% tree canopy coverage of the footpath zone by 2031) nearby (within 100m). In our assessment, this is the best available study on the amenity value of urban street trees for footpath tree cover currently available.

	Ÿ **Recommended values for recycled water supply is based on a 2014 evaluluation of property premiums from recycled water supply in Rouse Hill, Sydney.** This study uses the Hedonic Pricing method to compare properties with and without recycled water access sold in and around the Rouse Hill recycled water plant, to establish whether a value for recycled water access can be identified, by isolating property attributes which contribute to the property's sale price. The study finds a relatively small but statistically significant price premium associated with recycled water infrastructure in the Rouse Hill area, increasing property values by 0.72%. Note here that this value is only applicable to homes and townhouses, given there were no apartment or commercial developments included in the hedonic price dataset.
General guidance	Use per property, based on proximity to asset.
How to apply the values	• Estimate the number of dwellings that are within the zone where premiums occur. This is 100 meters for street trees and 300 meters for wetlands, recreational lakes, and parks. For new developments you should estimate the number of dwellings at the end of the analysis period (typically 30 years). • Estimate the unit value (sale price) of dwellings without the amenity asset – i.e. what is the likely sale value of the property without the park, lake or wetland near it? Do this for each dwelling type (low, medium, high density). • For the number of dwellings apply the premium based on the distance of the dwellings to the asset. You can do this either by applying premiums using the distance function. Or you can take the average distance point and use this. • What you have calculated is the capitalised amenity value of the property that results from it being close to the amenity asset. This is a one off benefit. That means you do not get the benefit each year or when the property is sold and transferred to new owners. You can obtain the present value of the capitalised value by discounting the capitalised value of the asset back to present day values. Use the time of the asset at maturity as the capitalised asset date, then discount back to present values.
Worked example (average premium)	

Assumptions	Value	Unit of measure
Properties within 300 meters of new green infrastructure (such as public open space) [A]	500	Properties
Average property price of properties within 300 metres without the green infrastructure [B]	$600,000	Per property
Average price premium for properties within the 300 metres [C]	1%	Index
Inflation adjusted willingness to pay – difference in the value of money (inflation) since the study was completed in 2018 and now [D]	https://www.rba.gov.au/calculator/	Index

Calculation

Economic value embedded in property premium = Number of properties within 300 meters [A] * Average property price [B] * property price premium [C] * Inflation [D]

Economic value embedded in property price premium = 500 * 600,000 * 1% * 1.06 = $3,180,000

Scaling / transformation required	• Consider scaling for the size of the green infrastructure asset. Larger assets (e.g.) larger parks and wetlands, generally have larger price premiums associated with them. We suggest you obtain specialist advice for these calculations, or you can use the WSCA Value Tool calculators to calculate scale effects for wetlands and bushlands. The scaling of amenity impacts is calculated within the % price change (which is an elasticity estimate).

Guidance and worked example for Benefit Type 5. Biodiversity and Ecology	
Benefit impacts	**5.1 Willingness to Pay for wetlands**
Description	Willingness to pay for additional area of healthy urban wetlands.
Unit of measure	$/ha/household/one-off
Traffic Light Quality score:	Red. Economic values are lower confidence. They should be treated as highly indicative estimates. Values are based on benefit transfer measuring the economic value of larger regional wetlands, and wetlands of significance such as RAMSAR sites, not urban wetlands.
Recommended sensitivity analysis	+ / - 50%
Form of quantitative estimate needed	Area of healthy urban wetlands
Care to avoid double counting with	• Amenity values from urban wetlands • Biodiversity and ecology benefits of urban waterways (that rely on wetlands)
Discussion	We have recommended the biodiversity and ecology unit values for urban wetlands based on review of multiple studies. The unit values are average values for the Greater Melbourne population as a whole. There is good evidence that Australian households are willing to pay biodiversity and ecology for wetlands and wetland rehabilitation and maintenance programs when these are large regional programs and wetlands, and they deliver regional ecology and biodiversity outcomes. There is little evidence that suggests households are willing to pay for additional biodiversity and ecology benefits provided by urban wetland. Note here that there is good evidence that households are willing to pay for urban wetlands as amenity assets, irrespective of size. Note also that the benefits of improved waterway condition (biodiversity and ecology) attributable to wetlands are included in waterway values, to the extent that wetlands feed into waterways. This means the wetland biodiversity and ecology values are already partially reflected in waterway values.

	Key points here are: • Brander, Gómez-Baggethun et al. [9] undertook a meta-analysis study of international wetlands estuaries. They estimated the average value of wetlands to be approx. $6,000 (A$) per hectare ($7,400 2017). This would equate to approximately $0.0035 per hectare per Victorian household in $2019. These wetlands were typically larger regional wetlands providing significant regional biodiversity and ecology functions. • WorleyParsons (2013) estimated the annual economic value of ecosystem services provided by Victorian wetlands to be in the range of AU$4,500 per hectare, based on Australian and international studies ($5,175 2017). This would equate to approximately $0.0023 per hectare per Victorian household in $2019. The range was AUD500-23,000 per hectare. These wetlands were also typically larger regional wetlands providing significant regional biodiversity and ecology functions. • The Rolfe, Brouwer et al. [10] meta-analysis Australian wetlands, estuaries and rivers estimated the average household WTP was in the order of AU$9.80 as a one-off payment (2017) which is the equivalent of a conservative willingness to pay (WTP) estimate of AU$88 million ($2017) for Australian healthy wetland when extrapolated to the Australian population as a whole. • The 2015 SIMALTO survey commissioned by Melbourne Water to support the waterways and drainage charge price submission [11] found that (1) Melbourne Water residential customers preferred to keep their Waterway and Drainage charges at around $95. The current charge is $100.72 per household. (2) Residential customers did not support Melbourne Water investing in more wetlands. Most wanted Melbourne Water to cut back on urban wetland investments, even though this would result in more pollution reaching waterways and the Bay. This implies a low willingness to pay for urban wetlands for biodiversity and ecology purposes alone.
General guidance	Use the per hectare of wetland value to estimate the biodiversity and ecology benefits of established healthy wetlands.
How to apply the values	• Estimate the area of additional urban wetlands. • Make a realistic assumption about asset performance – i.e. what % of the urban wetlands will be healthy and providing biodiversity and ecology services. • Estimate the population impacted in the future – this is the number of households in Greater Melbourne when the wetlands are established (approximately 1,832,000 households as at 2016 census) • Estimate the per household economic value, calculated as: $/ha/household/one-off *additional wetland ha * (1-not healthy%) • Estimate the total Greater Melbourne economic value. This is done by multiplying the per household value by the number of new households in each year in the evaluation. Each household is only counted once, as the payment is once off.

Worked example	Assumptions	Value	Unit of measure

	Economic value of urban wetland, healthy and providing biodiversity and ecology services [A]	$0.00	$ per hectare per household, as a one-time payment.
	Number of wetland hectares [B]	1,000	Hectares
	Healthy rate - % of the urban wetlands that will be healthy and providing biodiversity and ecology services [C]	75%	%
	Population – number of households receiving the benefit of the urban wetlands that will be healthy and providing biodiversity and ecology services [D]	1,832,000	Number of households
	Calculation Per household economic value of biodiversity and ecology services provided by wetlands: $/ha/household/one-off [A] *additional wetland hectares [B] * Healthy % [C] Per household economic value of biodiversity and ecology services provided by wetlands: $0.0015* 1,000 * 75% = $1.125 Greater Melbourne household economic value of biodiversity and ecology services provided by wetlands: $0.0015* 1,000 * 75% * 1,832,000 = $2,061,000.		
Scaling / transformation required	If you are estimating benefits for a population smaller than Greater Melbourne then use of distance decay functions could be appropriate following the approach in Hanley et. al. [12]. This reflects that households are typically more likely to place higher values on wetlands that they will get direct benefit from because they live near them.		

Benefit impacts	5.2 Willingness to Pay for Grasslands
Description	Willingness to pay for additional area of healthy grasslands.
Unit of measure	$/ha/household/one-off
Traffic Light Quality score:	Red. Economic values are lower confidence. They should be treated as highly indicative estimates. Values are based on sparse literature and benefit transfer measuring the economic value of larger regional grasslands outside the metropolitan area.
Recommended sensitivity analysis	+ / - 50%
Form of quantitative estimate needed	Area of healthy urban grasslands.
Care to avoid double counting with	☐ Amenity values from urban grasslands ☐ Biodiversity and ecology benefits of urban waterways (that rely on grasslands)
Discussion	The recommended biodiversity and ecology of grasslands is based on limited studies. The recommended values are based on an evaluation of predominantly international studies. They should be treated as highly indicative estimates. Note that a higher estimate per hectare may be expected if significant protection of threatened species is being provided. Literature on the economic value of grasslands is sparse for Australia. • WorleyParsons (2013) estimated the annual value of ecosystem services of grasslands / heathlands to be in the order of AU$390-510 per hectare per annum in 2017 dollar terms. • This equates to a capitalised value of services of in the order $5,750-7,500 per hectare ($2,350-3,050 per acre) in $2017.
General guidance	Use the per hectare of grassland value to estimate the biodiversity and ecology benefits of grasslands.
How to apply the values	• Estimate the area of additional urban grasslands. • Make a realistic assumption about asset performance – i.e. what % of the urban grasslands will be healthy and providing biodiversity and ecology services. • Estimate the population impacted in the future – this is the number of households in Greater Melbourne when the grasslands are established (approximately 1,832,000 households as at 2016 census) • Estimate the per household economic value, calculated as: $/ha/household/one-off *additional grassland ha * (1-not healthy%)

	• Estimate the total Greater Melbourne economic value. This is done by multiplying the per household value by the number of new households in each year in the evaluation. Each household is only counted once, as the payment is once off.	
Worked example	Assumptions	Value
	Economic value of urban wetland, healthy and providing biodiversity and ecology services [A]	0.0015
	Number of wetland hectares [B]	1000
	Healthy rate - % of the urban wetlands that will be healthy and providing biodiversity and ecology services [C]	0.75
	Population – number of households receiving the benefit of the urban wetlands that will be healthy and providing biodiversity and ecology services [D]	183200 0
	Calculation Per household economic value of biodiversity and ecology services provided by wetlands: $/ha/household/one-off [A] *additional wetland hectares [B] * Healthy % [C] Per household economic value of biodiversity and ecology services provided by wetlands: $0.0015* 1,000 * 75% = $1.125 Greater Melbourne household economic value of biodiversity and ecology services provided by wetlands: $0.0015* 1,000 * 75% * 1,832,000 = $2,061,000.	
Scaling / transformation required	□ If you are estimating benefits for a population smaller than Greater Melbourne then use of distance decay functions could be appropriate following the approach in Hanley et. al. [12]. This reflects that households are typically more likely to place higher values on grasslands that they will get direct benefit from because they live near them.	

Benefit impacts	5.3 - 5.8 Biodiversity and ecology of urban waterways
Description	Willingness to pay for additional kilometres of waterway.
Unit of measure	$/km/household/one-off
Traffic Light Quality score:	Green. Overall, a high-quality economic valuation study. Economic values are based on a peer reviewed willingness to pay survey of 1,000+ Greater Melbourne households commissioned by Melbourne Water to assess community preferences for maintaining or improving urban waterway condition in Greater Melbourne. The study was completed in 2015. Results are calibrated to be representative of the Greater Melbourne household population. However, the study did have design limitations that mean results may underestimate Melbourne Water customers' values for waterways. We discuss these below.
Recommended sensitivity analysis	+ / - 10%
Form of quantitative estimate needed	Kilometres of waterway shifting from: ☐ Highly Modified (low amenity and low ecological value) to Sustainable Amenity (high amenity and low ecological value) ☐ Highly Modified to Near Natural (low amenity and high ecological value) ☐ Highly Modified to Ecologically Healthy (high amenity and high ecological value) ☐ Sustainable Amenity to Ecologically Healthy ☐ Sustainable Amenity to Near Natural ☐ Ecologically Healthy to Near Natural
Care to avoid double counting with	☐ Amenity values from urban waterways
Discussion	The recommended unit values are based on a choice modelling study commissioned by Melbourne Water in 2015 to evaluate Melbourne Water customers' willingness to pay for improving waterway outcomes in Greater Melbourne [13]. The willingness to pay estimates are for the 8,400 kilometres of waterways that Melbourne Water manages. Respondents were provided with information on stream condition by classification. Ecological values were based on 2010 ISC scores. Respondents were told it would take at least 10 years to shift between condition categories. Around 700 Melbourne Water customers completed the survey. Results showed in $2015 : • On average respondents are willing to pay $1.54 for a 1 per cent increase in the Near Natural (high ecological value and low amenity) waterways in Melbourne (from a base of 2,270 kms of Near Natural waterways) • On average respondents are willing to pay $1.29 for a 1 per cent increase in the Ecologically Healthy (high ecological value and high amenity) waterways in Melbourne (from a base of 760 kms of Ecologically Healthy waterways

	• On average respondents have no significant willingness to pay for any increase in Sustainable Amenity (low ecological value and high amenity) waterways. However, those with more positive attitudes to the environment are willing to pay $0.80 for a 1 per cent increase in these waterways in addition to the payment of $0.10 at the average. These results are broadly similar with the results of the SIMALTO survey commissioned by Melbourne Water. The SIMALTO results showed that Melbourne Water customers are willing to allocate some more of the Waterways and Drainage Charge to improving ecological values in around 300 kilometres of Melbourne waterways. However, the additional investment that customers supported in SIMALTO was smaller than other investments they were asked about. We used the results from Cooper, Crase et al. 2017 to calculate a per kilometre willingness to pay per household in the benefits table. We have also used the estimates to calculate willingness to pay per kilometre to shift in the benefits table from: - Highly Modified (low amenity and low ecological value) to Sustainable Amenity (high amenity and low ecological value) - Highly Modified to Near Natural (low amenity and high ecological value) - Highly Modified to Ecologically Healthy (high amenity and high ecological value) - Sustainable Amenity to Ecologically Healthy - Sustainable Amenity to Near Natural - Ecologically Healthy to Near Natural **The estimates for the shifts in Sustainable Amenity to Near Natural and Ecologically Healthy to Near Natural are the 'best available' estimates of willingness to pay for improved ecological values.** This is because the shifts measure the value of ecological value as the difference between having amenity and not having amenity at the waterway. The values are average values across all of the Melbourne Water residential customer base. **There are limitations to the Cooper, Crase et al. 2017 study that mean the waterway values may undervalue Melbourne Water customer willingness to pay for biodiversity and ecology of waterways**. These limitations include but are not limited to (1) that the payment was for one year only. This may enforce budget constraints compared to multiple year payments and result in people understating their willingness to pay [14] (2) protest rate was high (25%) compared to similar studies. This may suggest survey design issues (3) we understand the survey drop-out rate was high compared to similar studies. This may also suggest survey design issues. These limitations should be kept in mind when using the results of the study.
General guidance	Use the per kilometre unit values to estimate the economic value of waterway health improvement. If you want to exclude amenity values, use the unit values for shifting between categories where amenity value remains constant. This will give a proxy for willingness to pay for change in ecological condition only.
How to apply the values	• Estimate the kilometres of waterway condition that will be changed by the investment. Note that this could be an improvement from current condition, or a prevention of decline to a lower condition. • Identify the change value – i.e. what condition is the waterway moving from and to and how much a household is willing to pay. Waterway condition investment outcomes can take 10+ years to eventuate. • Estimate the economic value of the shift to the household, calculated as: $/ha/household/one-off *kilometres changing condition

- Estimate the total willingness to pay of Melbourne households as: per household WTP * number of households (approximately 1,832,000 households as at 2016 census)
- Adjust for the survey protest rate. Protest rates are the % of population who said they didn't want to pay anything because they didn't agree with something about the survey. To be conservative, assume these respondents are not willing to pay for waterway improvement. The base assumption is 25% of households have protest votes and a zero WTP, based on the survey results.
- Calculate lower and upper bound estimates using the lower and upper bound willingness to pay estimates. The true willingness to pay falls somewhere between these values.

Worked example

Assumptions	Value	Unit of measure
Number of kilometres of waterway that will be changed by the investment [A]	300	Kilometres of waterway
WTP for a 1 km Shift in Urban Waterway from Highly Modified to Ecologically Healthy (low amenity and high ecological value) [B]	$0.18	$/ per km/ per Greater Melbourne household / once-off payment
Greater Melbourne households [C]	1,832,000	number of households
Protest rate [D]	25%	%, based on the Cooper 2017 survey results.
Inflation – difference in the value of money (inflation) since the study was completed in 2015 and now [E]	https://www.rba.gov.au/calculator/	%

Calculation

Benefit of waterway improvement for all Greater Melbourne households = Number of kilometres of waterway that will be changed by the investment [A] * WTP for a 1 km Shift in Urban Waterway from Highly Modified (low ecological value and low amenity) to Ecologically Healthy (low amenity and high ecological value) [B] * Greater Melbourne households [C] * (1 - Protest rate [D]) * Inflation [E].

Benefit of waterway improvement for all Greater Melbourne households = 300 * $0.18 * 1,832,000 * (1-0.25) * 1.07 = $83,800,260

Scaling / transformation required (more complex benefit transfer steps)	Consider calibrating for one lump sum payment. There is good evidence [14, 15] that people are willing to pay more for goods and services when they can pay over several years rather than a single year. One reason for this is that people may be budget constrained – for example, people may not want to pay $1,000 in a year, but would be willing to pay the equivalent of $1,000 in today's money over several years. You can calculate the calibrated willingness to pay as: Where LS is the lump sum payment AWTP is the average annual WTP, is the implicit discount rate and t is the number of annual payments. We suggest using a discount rate of around 15% [14]. We suggest setting n as the life of the asset, to a maximum of 30 years. Consider adjusting the % of respondents that are protestors who have a zero WTP. A reasonable assumption is around 40% of protestors may have a positive willingness to pay [16]. Consider if you need to adjust willingness to pay for when the benefits are likely to happen. The Cooper and Crase study told respondents that it would take at least 10 years to shift between waterway condition categories. If it will take less than 10 years to get the waterway improvement, then people are probably going to be willing to pay more. You can estimate the amount that people would be willing to pay for the outcome now versus in the future using a standard discount rate. The maximum number of kilometres estimates can be applied to is 8,600. The study is constrained to Greater Melbourne. a higher estimate per kilometre value may be expected if the kilometres are side by side / connected.

Benefit	5.10 Port Philip and Westernport Bay water quality condition
Description	Replacement cost to maintain condition of Port Philip and Westernport Bays.
Units of measure	$/per person/per year $/kg TN/ once-off
Traffic Light Quality score:	Red. There are no directly relevant robust studies that can be used to estimate the economic value of maintaining, improving or preventing degradation of biodiversity and ecology of Port Philip and Westernport Bays. The unit values we provide are best available estimates based on recent work in Sydney.
Recommended sensitivity analysis	+ / - 50%
Form of quantitative estimate needed	Population data Kilograms of nitrogen reduction to Bay achieved by project
Care to avoid double counting with	Recreation values for Bay use. Property price premiums for properties benefiting from improved Bay condition (for example if they are located on the shorefront).

Discussion	There are no directly relevant robust studies that can be used to estimate the economic value of maintaining, improving, or preventing degradation of biodiversity and ecology of Port Philip and Westernport Bays. The unit values we provide are values recommended by . Recent reviews on economic values for charactering stormwater management have established a lack of relevant economic data for valuing the ecological health of PPB and Westernport Bay. The INFFEWS value database conducted a comprehensive analysis of Australian data relevant to blue-green infrastructure and the MW Social and Environmental economic value guidance (Marsden Jacob Associates 2020) expanded the search for Melbourne specific references. The consolidated findings from all three economic references are: • The Melbourne Water nitrogen offset value is not a proxy value for Bay condition and has no relevant economic nor investment meaning. • Costs for stormwater treatment vary: $2245 - $11,000 per kg N. • No robust economic studies exist that address the value community places on health of bay • An economic valuation study should be commissioned to close this important knowledge gap. • To set an economic value for N as a proxy to the health of the bay, either a replacement service cost or an estimate of the willingness to pay to preserve bay water quality using benefit transfer can be used. As an interim position, MWC recommends: • No value for nitrogen should be used, as the economic value is very small because of the good bay health. Instead invest to achieve the target and show benefits for other effects (plus there are other benefits not assessed) until the stormwater flow regulation comes into effect. • Focus on target and least cost option to achieve that target. • Use replacement cost based on a range of cost options due to uncertainty. PPB is in good condition now, but condition in future is unknown. If we set a value now it will have a long life. Better to have a conservative approach as other states will be looking at Vic to copy what happens with the nitrogen. We also need to consider intergenerational effects and the risk of catastropic failure (hysteresis of the bay). • If there is are other targets besides N (e.g. for macroinvertebrates), we could also focus on achieving that target. We discuss points supporting this interim position further below. • The 2019 *Assessment of the Values of Victoria's Marine Environment* report [18], the 2016 *Marine and Coastal Ecosystem Accounting: Port Phillip Bay* report [19] and the 2017 *Port Phillip Bay Environmental Management Plan 2017–2027* [20] highlight that Victoria's marine environment supports biodiversity and ecological functions and services that create economic value for many Victorians. These values include recreational water use, commercial fishing, tourism, and other things that create value for Victorians. The *Port Phillip Bay Environmental Management Plan 2017–2027* reports that recreational fishing contributes around $420 million per year to economic activity in Victoria and that Bay tourism and associated businesses contribute more than $320 million per year to the economy. • Current assessments show Port Phillip Bay and Westernport are generally healthy systems with good to very good water quality except in locations like Hobsons Bay [18, 19]. The denitrification efficiency process maintains the nutrients in Port Phillip Bay at an optimal level for biodiversity. A denitrification efficiency (DE) lower than 60% in Port Phillip Bay (40% for Hobsons Bay adjacent to Port Melbourne and Williamstown) indicates the denitrification process is disrupted. No event since 1994 has been large enough to reduce DE for more than a month, and even then only in Hobsons Bay [21].

- Port Philip Bay can process around 5,000 tonnes of nitrogen per year from the catchment before dentification efficiency is disrupted [19]. Currently, less than 3,900 tonnes of nitrogen are being released into the Bay each year on a three-year rolling average.

- There are longer term risks to Port Philip Bay and Westernport, including climate change and population growth. The *2017-27 Port Phillip Bay Environmental Management Plan* concludes that increasing nutrient and pollutants in the Bay may lead to more algal blooms and poor water quality. This would happen particularly during wet periods. It could result in more frequent temporary closures of popular beaches.

- Targets in the Port Phillip Bay Environmental Management Plan (2017) of maintaining loads of total nitrogen (TN) and total suspended solids (TSS) at their current levels. These targets are within the Port Phillip Bay Environmental Management Plan (2017) and draft State Environment Protection Policy (Waters). To achieve these targets improvement works at the Western Treatment Plant are occurring to ensure that nitrogen loads to the Bay do not exceed 3,100 tonnes per year (as a three-year rolling average).

- If no further investments occur, modelling for the Healthy Waterways strategy by Melbourne Water suggests that stormwater runoff could increase from around 1,900 kg TN a year (1.9 tonne) to 2,700 kg TN (2.7 tonne) by 2056 under a most likely population growth scenario.

- The economic value of an environmental good is measured by how much people would be willing to pay to obtain more of the environmental good. Value can also be measured by how much people would be willing to pay to avoid degradation of the resource. In the context of Port Philip Bay and Westernport Bay, the relevant question is how much are people willing to pay to (1) maintain the Bay, or areas of the Bay (such as Hobsons Bay) in the current (good to very good) condition (2) to improve Bay condition above its current good to very good condition. A third question is (3) how much of a reduction (in Waterway and Drainage charges) households would need to get to accept a reduction in the condition of the Bay. To our knowledge, no studies have evaluated this question, nor have Port Philip Bay environmental management plan investments been subject to a rigorous, evidence-based cost-benefit analysis.

- The approach of using the Melbourne Water nitrogen offset rate, or some variant of this rate, is widely used in economic analyses of WSUD investments in Greater Melbourne. The logic is that the cost of nitrogen offsetting somehow reflects the benefit / economic value that Greater Melbourne receives by preventing one kilogram of nitrogen from entering the Bay, or that the nitrogen offset is a cost that would be avoided by making another investment that reduces nitrogen by the same amount.
- However, this thinking is flawed. The Melbourne Water nitrogen offset rate has no economic meaning in cost-benefit analysis. The US EPA *Guidelines for preparing economic analyses* [22] provides clear guidance on why the approach is flawed. The key points here are:

    - The Melbourne Water nitrogen offset rate, or a variant of it, could be a lower bound estimate of the economic benefit of reducing nitrogen in the Bay if, and only if, a cost-benefit study had been done to show that the additional economic benefits of reducing nitrogen in the bay were greater than the additional costs. This would involve looking at the costs and benefits of what will happen to nitrogen loads and economic impacts (algae blooms, beach closures, litter levels) without any future investments to reduce nitrogen, versus investments that do keep nitrogen at current levels. This evaluation has not happened. Without this economic assessment we do not know whether the benefits of investments to keep nitrogen at current levels in the Bay are greater than the costs.

    - Potentially, the economic benefits of nitrogen reduction for things like algae blooms and beach closures are less than the costs of keeping additional nitrogen out of the Bay. This is because:

        (1) the Bay is currently in good to very good condition

	(2) the Bay can process at least 5,000 tonnes of nitrogen per year from the catchment, potentially significantly more [19]. Currently, less than 3,900 tonnes of nitrogen are being released into the Bay each year. This means nitrogen releases could increase with potentially little or no impact on most of the Bay or most beneficial uses and use locations. This implies that the costs of current investments are greater than the benefits. (3) the economic cost of localised algal blooms and localised closures of recreational beaches, such as in Hobsons Bay, are potentially quite small. This is because when a beach is closed because of water quality, people substitute their locations for recreation activities such as swimming and fishing, away from algal bloom affected areas. In simple terms, people could shift their beach activities from Hobsons Bay to St Kilda if there is a temporary beach closure in Hobsons Bay. This means economic losses from nitrogen loads into Hobsons Bay are potentially small. Alternatively, people in the affected regions may simply find a substitute activity to swimming and contribute to the economy through some other recreational pursuit. • Even if we accept that the benefits of reducing nitrogen delivers net benefits, using the Melbourne Water nitrogen offset to measure this benefit is flawed. This is because: (1) The nitrogen offset is not the most cost-effective means of achieving the nitrogen reduction in Port Philip Bay, nor Hobsons Bay. The most appropriate cost-based measure is the least cost approach for reducing nitrogen going to the Bay. (2) The Melbourne Water offset rate, when used, double counts with waterway benefits. I.e. people often use the nitrogen offset rate to calculate the benefit to the Bay, and separate values to capture the value of improved waterway health condition.
General guidance	• Can be used as an interim approach for economic cost in Port Phillip. Westernport should be based on TSS, but can use the same approach to calculate the benefit per year. • A replacement cost method for an equivalent service (i.e. N-removal by other means) ($2,250 -11,000 per kg TN) is the MW interim approach to valuing the denitrification services that PPB (and waterways downstream of the stormwater treatment asset) provide. It assumes that 'the replacement provides the same services, is a realistic least cost option and there is evidence that the service is demanded by society'. The $2,250 represents a lower bound value estimate based on a market value (as estimated by MW). Whilst the range $3,000-11,000 is the cost range for a selection of technologies for N-removal from stormwater (collected by MW). • Because this estimate potentially includes denitrification by waterways (where the stormwater asset is located in waterways providing stormwater treatment functions before waters reach the Bay), waterway health values may or may not result in double counting. Whether this double counting occurs depends on where the stormwater treatment asset is located, and the expected impacts on receiving waterways, and the expected denitrification function of receiving waterways, and whether TN is measured at PPB, or at the stormwater asset treatment site.
How to apply the values	Estimating the interim value of Bay (and potentially waterway) impacts . • Adjust the $2,250 -11,000 per kg TN ($2020) per kilogram TN by CPI to bring it into current day per person per year $. • Preferably, estimate the TN kg reduction entering Port Phillip Bay attributable to the project. Note that this is not the same as TN kg reduction at the project site. The correct approach should account for TN losses between the development site and Port Phillip Bay. For example, all other things equal, one kg TN leaving a site in Port Melbourne will deliver more TN to the Bay than one kg TN leaving a site in Dandenong. The impact of interest is the TN entering the Bay. If you cannot measure the TN kg reduction at PPB, recognise that the TN kg is measured at the treatment site.

	• Calculate the benefit value as TN kg reduction in Port Phillip Bay attributable to the project * $ kg TN.
Worked example (economic value of a healthy bay per $/kg TN/ once-off for Greater Melbourne population)	

Assumptions	Value	Unit of measure
TN kg reduction in Port Phillip Bay (as compared to at the project site) attributable to the project [A]	50	Kg
Economic value per kg TN ($2021) [B]	$6,645	per kg TN once-off
Inflation adjusted willingness to pay – difference in the value of money (inflation) since the study was completed in 2021 and now [C]	https://www.rba.gov.au/calculator/	

Calculation

Economic value of a healthy bay per $/kg TN once-off Greater Melbourne population, based on replacement cost as an interim valuation measure = 50 * $6,645 = $332,250

Scaling / transformation required	☐ None, assume linear relationship between TN and benefits in the absence of better estimates.

Benefit impacts	5.9 Willingness to Pay for environmental water release
Description	Willingness to pay for benefits of additional environmental flows, particularly during drought years.
Unit of measure	$/GL/household/one-off
Traffic Light Quality score:	Green. Overall, a high-quality economic valuation study. Economic values are based on a peer reviewed willingness to pay survey of 700 Greater Melbourne households commissioned by Melbourne Water to assess community preferences for obtaining enhanced environmental outcomes from additional environmental flows in the Yarra, Tarago, and Werribee catchments, during dry years. The study was completed in 2017. Results are calibrated to be representative of the Greater Melbourne household population.
Recommended sensitivity analysis	+ / - 10%
Form of quantitative estimate needed	GL of additional environmental water in the Melbourne Water system.
Care to avoid double counting with	☐ Amenity values from urban waterways
Discussion	Based on Cooper, Crase et al. [17]. This is a recent study commissioned by Melbourne Water to establish the economic value of environmental water entitlements held for the Yarra, Tarago, and Werribee. The Melbourne Water study established the economic value of Melbourne's environmental water entitlements to inform planning and management choices. The approach used an economic non-market technique known as choice modelling. The choice experiment was framed in the context of the ecological improvements that would occur during a dry year, defined as when Melbourne receives below average rainfall. The following points were also presented to respondents in the survey: • The total amount of water held for the environment across Melbourne is approximately 21 gigalitres (Gl), or about 1.2% of the total stored in dams. A Gigalitre (GL) is 1 Billion litres of water, or about the same amount required to fill 400 Olympic size swimming pools. • 21 GL is sufficient to prevent decline in the ecological health of rivers in wet years but not drought years. • The chance of a **drought year** is 20% - or 2 years in 10 we could expect to see drought conditions. • The more water held for the environment the greater the improvement to the population of native species and water quality possible, especially in drought years. The ecological outcomes associated with the additional amount of water allocated to the environment were described in terms of Native Fish population; Frog population; Platypus population; and Water Quality. The timeframe for change in populations was the drought year event. **The results of the choice modelling survey to generate economic value estimates in dollar terms that indicate Melbourne residents' willingness to pay for additional water for the environment.** The Melbourne Water study estimated the value of one GL of additional environmental flows was worth between $0.94 and

	$1.42 per household ($2017) to prevent negative drought year outcomes. The payment was a single year payment (a so-called 'one-off' payment), spread over several payments in a year.
General guidance	☐ Should only be used to value environmental flow releases, and assuming that the changes of a dry year around 1:5. ☐ Should only be used for value transfer to rivers similar to Yarra, Tarago, Werribee
How to apply the values	• Estimate the GL of additional environmental water. Note this is the volume of additional environmental water available in the river each year, not a one-off allocation. Note also that while the environmental water values were estimated for Yarra, Tarago and Werribee, the value could be used for rivers similar to these where environmental waters could be delivered. Note also this is for the water to be transferred to the environmental allocation permanently, not just if a drought year occurs. • Estimate the economic value of the shift to the household, calculated as: $/GL/household/one-off *GL • Estimate the total willingness to pay of Greater Melbourne households as: per household WTP * number of households * (1- protest rate). The base assumption is 14% of households have protest votes and a zero WTP.
Worked example	

Assumptions	Value	Unit of measure
Number of additional GL of environmental water, in addition to 21 GL already allocated [A]	10	GL
WTP for 1 GL of additional environmental water above 21 GL [B]	$1.24	$/ per km/ per Greater Melbourne household / once-off payment
Greater Melbourne households [C]	1,832,000	number of households
Protest rate [D]	14%	%, based on the Cooper 2017 survey results.
Inflation – difference in the value of money (inflation) since the study was completed in 2017 and now [E]	https://www.rba.gov.au/calculator/	%

Calculation

Benefit of waterway improvement for all Greater Melbourne households = Number of additional GL of environmental water, in addition to 21 GL already allocated [A] * WTP for 1 GL of additional environmental water above 21 GL [B] * Greater Melbourne households [C] * (1 - Protest rate [D]) * Inflation [E].

	Benefit of waterway improvement for all Greater Melbourne households = 10 * $1.24 * 1,832,000 * (1-0.14) * 1.036 = $20,240,000
Scaling / transformation required	□ Consider calibrating for one lump sum payment. There is good evidence [14, 15] that people are willing to pay more for goods and services when they are allowed to pay over several years rather than a single year. One reason for this is that people may be budget constrained – for example, people may not want to pay $1,000 in a year, but would be willing to pay the equivalent of $1,000 in today's money over several years. □ Consider adjusting the % of respondents that are protestors who have a zero WTP. A reasonable assumption is around 40% of protestors may have a positive willingness to pay [16]. □ The maximum number of additional GL the values can be applied to is 25GL. This is the difference between current Melbourne Water GL held for the environment and the maximum GL supply respondents were surveyed on. The study is constrained to Greater Melbourne.

Guidance and worked example for Benefit Type 6. Flooding	
Benefit impacts	**6.1 Reduced flooding impacts**
Description	**The economic impact of flooding for residential, commercial, industrial and infrastructure in Greater Melbourne.**
Unit of measure	**$ per property / asset inundation**
Traffic Light Quality score:	**Orange. Based on the flood Rapid Assessment Modelling (RAM) approach. This method is more than a decade old and needs updating with more contemporary evidence.**
Recommended sensitivity analysis	+ / - 30%
Form of quantitative estimate needed	Extent of inundation and depth, overlaid with property types. Estimates of warning times.
Care to avoid double counting with	Hedonic pricing values that take reduced flooding risk into account in commercial, industrial and residential property values.
Discussion	The economic cost of flooding is potentially significant. Recent work by the CRC WSC has estimated the economic consequences and developed recommended approaches [43].

	There are no recommended unit values for flooding impacts. These impacts will vary depending on the depth and duration of flooding, the type of properties and infrastructure impacted, the amount of forewarning time, and the location (LGA) where the flooding occurs. Rather, in this section we recommend a rapid assessment approach to estimating flood damage. Melbourne Water has a flood prioritisation tool. If this tool is used by Melbourne Water to calculate flooding damage, then we recommend that tool is used to assess flooding damages. If the tool is not used, then we recommend that a rapid assessment approach is used, drawing on available LGA data. Key points here are: • Flood damage costs for a range of flood events are established using the rapid appraisal method for Floodplain Management (Flood RAM). Flood RAM is a methodology for the rapid and consistent evaluation of floodplain management measures in a benefit cost analysis framework. Flood RAM enables estimates of flood damages to be made for an area without the need for excessive amounts of detail to be known. It ensures consistency and hence comparability across different evaluations. • When calculating flood damage impacts it is important to distinguish between potential and actual damage when assessing flood damage. Actual damage cost estimates should be used in analyses where there is evidence that property owners will have time to prepare for the flood event. Potential damage is the damage that would occur if no remedial action is undertaken and the exposure to the flood event is not reduced. Actual damage is the damage that occurs after actions have been taken to reduce the exposure to the flood event (e.g. sand bagging, removing valuable items, etc.). • Evidence shows that extended warning times and better preparedness reduce the actual damage costs from flooding, often significantly. DSE (2009) suggests that the actual damage costs for commercial buildings are typically about 45% of potential damage. The ratio of actual to potential damages varies more widely for residential areas and will also vary across different areas and communities. Expert judgement will be required in establishing the ratio of actual to potential damage. • Depth-damage curves available for Australia are coarse [43]. We have taken depth-damage curves for residential, industrial and commercial buildings from [43], which was used for Melbourne. Estimates for roads are based on Flood RAM. • Damage curves for residential commercial and industrial developments are shown in Table 21. • For residential properties, the structural value is calculated as the property value multiplied by the depth damage function, then multiplied by the relevant ratio of actual to potential damage costs. Property values by LGA and development type are available from the Victorian Valuer General website (https://www.propertyandlandtitles.vic.gov.au/property-information/property-prices , all statistics). • For commercial and industrial properties, an absolute value is used per square meter inundation, based on [43]. This includes structural and content damage. • For roads, a damage of $90,000 per km of road flooded above a threshold of 0.3 m is recommended based on [43]. • For motor vehicles, a damage of $12,500 per car impacted above a threshold of 0.5 meters is recommended. Note that increased warning times will reduce the damage costs as cars can be moved.
General guidance	Recall that these estimates are coarse. Apply sensitivity analysis, +/-50%
How to apply the values	• Follow established approaches, detailed in based on [43]. • Estimate the flood inundation depths

	• Estimate the number of residential properties, commercial and industrial indoor floor area, roads and cars impacted by flooding events. This is best estimated using flood hazard simulation modelling. • Calculate the flood damage of each event using the calculations set out above and below. • Because the timing of flood events is not known with certainty, you can calculate an annual average damage (AAD). To calculate the AAD: ○ Estimate the flood damage curve for each design scenario. Sum up the damage costs for each flood event for all buildings and other assets. The flood damage curve (or loss-probability curve) is based on the flood damage cost for a range of flood events / probabilities. Damage costs can be interpolated between known data points (e.g. between the 2 year ARI and 5 year ARI). However, data points outside the range of the data sample should not be extrapolated. ○ The AAD is estimated by integrating the area below the flood damage curve, i.e. calculating the area under the curve. If the damage cost between known data points are interpolated using a linear function.
Worked example	**Calculation** Assume the flood damage function looks like Figure 3. In this case, the AAD is calculated as: $ADD = \sum_{t=1} [damage_{t+1} + (damage_t - damage_{t+1}) * 0.5] * [p_{t+1} - p_t]$ = [\$2,177,000 + (\$2,772,000 − \$2,177,000) ∗ 0.5] ∗ [5% − 1%] + [\$2,174,000 + (\$2,177,000 − \$2,174,000) ∗ 0.5] ∗ [10% − 5%] + [\$2,092,000 + (\$2,174,000 − \$2,092,000) ∗ 0.5] ∗ [20% − 10%] + [\$1,955,000 + (\$2,092,000 − \$1,955,000) ∗ 0.5] ∗ [50% − 20%] = \$98,980 + \$108,775 + \$213,300 + \$607,050 = \$1,028,105
Scaling / transformation required	Remember to adjust for warning times.

References

[1] "Economic Evaluation for Business Cases Technical Guidelines," Victorian Department of Treasury and Finance, Melbourne, 2013.

[2] J. Schirmer and M. Mylek, "Thriving, surviving, or declining communities: socio-economic change in Murray-Darling Basin communities," in Commissioned by the Panel for the Independent Assessment of Social and Economic Conditions in the Murray-Darling Basin., ed. Canberra: University of Canberra, 2020.

[3] R. Baker and B. Ruting, "Environmental Policy Analysis: A Guide to Non-Market Valuation," Productivity Commission Staff Working Paper, Canberra, 2014.

[4] "Research Report: Environmental valuation and uncertainty," OPBR, Department of Prime Minister and Cabinet, Canberra, 2014.

[5] IPART, "Guidelines for Water Agency Pricing Submissions," ed. Sydney, 2018.

[6] D. o. Economic and Development Jobs Transport and Resources, "Guidance on valuing non-market impacts in economic assessments," ed. Melbourne, 2016.

[7] R. Young and J. Loomis, Determining the economic value of water. Concepts and methods. Washington DC: RFF Press, 2014.

[8] D. Nowak, D. Crane, J. Stevens, R. Hoehn, and J. Walton, "A ground-based method of assessing urban forest structure and ecosystem services.," Aboriculture & Urban Forestry, vol. 34(6): 347-358., 2008.

[9] L. Brander, E. Gómez-Baggethun, B. Martín-López, and M. Verma, "Chapter 5: The economics of valuing ecosystem services and biodiversity," in The Economics of Ecosystems and Biodiversity: The Ecological and Economic Foundations, E. b. P. K. TEEB, Ed. London and Washington: Earthscan, 2010.

[10] J. Rolfe, R. Brouwer, and R. J. Johnston, "Meta-analysis: Rationale, Issues and Applications," in Benefit Transfer of Environmental and Resource Values: A Guide for Researchers and Practitioners, R. J. Johnston, J. Rolfe, R. S. Rosenberger, and R. Brouwer Eds. Dordrecht: Springer Netherlands, 2015, pp. 357-381.

[11] Hall & Partners and Open Mind, "Understanding customer value:Key findings from SIMALTO," ed. Melbourne, 2015.

[12] N. Hanley, F. Schläpfer, and J. Spurgeon, "Aggregating the benefits of environmental improvements: distance-decay functions for use and non-use values," Journal of Environmental Management, vol. 68, no. 3, pp. 297-304, 2003/07/01/ 2003, doi: https://doi.org/10.1016/S0301-4797(03)00084-7.

[13] B. Cooper, L. Crase, M. Burton, D. Maybery, and C. Cunningham, "The Value of Melbourne's Waterways: A Report on Preliminary Estimates Using Choice Modelling prepared for Melbourne Water and the Department of Environment Land Water and Planning," ed: University of South Australia, 2017.

[14] K. J. Egan, J. R. Corrigan, and D. F. Dwyer, "Three reasons to use annual payments in contingent valuation surveys: Convergent validity, discount rates, and mental accounting," Journal of Environmental Economics and Management, vol. 72, pp. 123-136, 2015/07/01/ 2015, doi: https://doi.org/10.1016/j.jeem.2015.05.002.

[15] R. J. Johnston et al., "Contemporary Guidance for Stated Preference Studies," Journal of the Association of Environmental and Resource Economists, vol. 4, no. 2, pp. 319-405, 2017, doi: 10.1086/691697.

[16] J. Meyerhoff and U. Liebe, "Determinants of protest responses in environmental valuation: A meta-study," Ecological Economics, vol. 70, no. 2, pp. 366-374, 2010/12/15/ 2010, doi: https://doi.org/10.1016/j.ecolecon.2010.09.008.

[17] B. Cooper, L. Crase, and M. Burton, "The Value of Melbourne's Environmental Water Entitlements: A Report on Preliminary Estimates Using Choice Modelling prepared for Melbourne Water," ed. Melbourne: Melbourne Water, 2017.

[18] Victorian Environmental Assessment Council (VEAC), "Assessment of the Values of Victoria's Marine Environment – Report.," ed. Victorian Environmental Assessment Council, Melbourne, 2019.

[19] M. Eigenraam, F. McCormick, and Z. Contreras, "Marine and Coastal Ecosystem Accounting: Port Phillip Bay," The State of Victoria Department of Environment, Land, Water and Planning, Melbourne, 2016.

[20] The State Government of Victoria Department of Environment Land Water and Planning, "Port Phillip Bay Environmental Management Plan 2017–2027," ed. Melbourne, 2017.

[21] Commissioner for Environmental Sustainability Victoria, "State of the Bays 2016," ed. Melbourne, 2017.

[22] U.S. Environmental Protection Agency, "Guidelines for preparing economic analyses," N. C. f. E. E. O. o. Policy, Ed., ed. Washington DC, 2014.

[23] Deloitte Access Economics, "Economic and social value of improved water quality at Sydney's coastal beaches," ed. Sydney, 2016.

[24] S. E. Perkins-Kirkpatrick et al., "Natural hazards in Australia: heatwaves," Climatic Change, journal article vol. 139, no. 1, pp. 101-114, November 01 2016, doi: 10.1007/s10584-016-1650-0.

[25] Sydney Water Corporation, "Cooling Western Sydney. A strategic study on the role of water in mitigating urban heat Western Sydney.," ed. Sydney, 2017.

[26] A. H. Block, S. J. Livesley, and N. S. G. Williams, "Responding to the Urban Heat Island: A Review of the Potential of Green Infrastructure," ed. Melbourne: Victorian Centre for Climate Change Adaptation, 2015.

[27] S. Ma et al., Evaluating the Effectiveness of Mitigation Options on Heat Stress for Sydney, Australia. 2017.

[28] M. Santamouris et al., Urban Heat Island and Overheating Characteristics in Sydney, Australia. An Analysis of Multiyear Measurements. 2017, p. 712.

[29] M. Santamouris et al., PROGRESS IN URBAN GREENERY MITIGATION SCIENCE – ASSESSMENT METHODOLOGIES ADVANCED TECHNOLOGIES AND IMPACT ON CITIES. 2018, pp. 638-671.

[30] K. K. Zander, S. Mathew, and S. T. Garnett, "Exploring Heat Stress Relief Measures among the Australian Labour Force," International journal of environmental research and public health, vol. 15, no. 3, p. 401, 2018, doi: 10.3390/ijerph15030401.

[31] Marsden Jacob Associates, "Western Sydney Regional Masterplan Stage 2B," ed, 2019.

[32] WSAA, "Quantifying the liveability health benefits of water industry investments in Integrated Water Management," ed. Melbourne, 2019.

[33] W. B. van den Hout, "The value of productivity: human-capital versus friction-cost method," Annals of the Rheumatic Diseases, vol. 69, no. Suppl 1, p. i89, 2010, doi: 10.1136/ard.2009.117150.

[34] Safe Work Australia, "The Cost of Work-related Injury and Illness for Australian Employers, Workers and the Community: 2012–13," ed. Canberra, 2015.

[35] R. Gillespie, D. Collins, and J. Bennett, "Adapting the travel cost method to estimate changes in recreation benefits in the Hawkesbury–Nepean River," Australasian Journal of Environmental Management, vol. 24, no. 4, pp. 375-391, 2017/10/02 2017, doi: 10.1080/14486563.2017.1354236.

[36] Office of Best Practice Management, "Best Practice Regulation Guidance Note Value of statistical life," ed. Canberra: Department of Prime Minister and Cabinet, 2014.

[37] Marsden Jacob Associates, "Economic impacts of active recreation in Victoria," ed. Melbourne, 2018.

[38] T. Varcoe, H. Betts O'Shea, and Z. Contreras, "Valuing Victoria's Parks: Accounting for ecosystems and valuing their benefits," Parks Victoria, Melbourne, 2015.

[39] F. Zhang, X. H. Wang, P. A. L. D. Nunes, and C. Ma, "The recreational value of gold coast beaches, Australia: An application of the travel cost method," Ecosystem Services, vol. 11, pp. 106-114, 2015/02/01/ 2015, doi: https://doi.org/10.1016/j.ecoser.2014.09.001.

[40] Marsden Jacob Associates, "A park, a wetland, a lake or a freeway? Hedonic pricing of green, blue and grey infrastructure in Melbourne greenfield developments.," M. W. a. W. C. Council, Ed., ed. Melbourne, 2017.

[41] R. Evangelio, S. Hone, M. Lee, and D. Prentice, "What makes a locality attractive? Estimates of the amenity value of parks for Victoria," in Infrastructure Victoria Technical Paper No. 4/18, ed, 2018.

[42] L. Plant, A. Rambaldi, and N. Sipe, "Evaluating Revealed Preferences for Street Tree Cover Targets: A Business Case for Collaborative Investment in Leafier Streetscapes in Brisbane, Australia," Ecological Economics, vol. 134, pp. 238-249, 2017/04/01/ 2017, doi: https://doi.org/10.1016/j.ecolecon.2016.12.026.

[43] L. Olesen, R. Löwe, and K. Arnbjerg-Nielsen, "Flood Damage Assessment. Literature review and recommended procedure," ed. Melbourne, 2017.

[44] M. S. Iftekhar, A. Gunawardena, F. Fogarty, D. Pannell, and A. Rogers, "INFFEWS Value tool: Guideline (Version 2): IRP2 Comprehensive Economic Evaluation Framework (2017 – 2019).", ed. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities., 2019.