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Water Sensitive Cities

Assessment of nonmarket benefits of WSUD in a residential development: Belle View case study

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1. Introduction

Water sensitive urban designs, such as rain gardens, constructed wetlands, and living streams, provide multiple ecosystem services, like amenity, recreation and ecological improvements. The benefits of these services are often not considered when making investment decisions due to a lack of monetised values for these services. As a result, intangible benefits are often ignored in the formal investment decision framework (Gunawardena *et al.* 2017).

The CRC for Water Sensitive Cities' (CRCWSC) Integrated Research Project 2 (IRP2) aims to identify and quantify these intangible benefits and produce accepted and well-aligned tools that can be used to inform decision making at multiple levels in public and private sector organisations. One of the key deliverables of IRP2 is to develop and test benefit transfer methods which would allow transferring of exiting nonmarket value information from one location to another. Benefit transfer methods are useful when decision makers face time and resource constraints as such methods allow extrapolation of existing nonmarket values to new contexts (Iftekhar *et al.* 2018).

Benefit Transfer techniques allow one to predict values for an "application site" by extrapolating the results of nonmarket values estimated for original "study sites" (Johnston *et al.* 2015). Two of the most common methods are unit value transfer and benefit function transfer (Boyle *et al.* 2010). In a unit value transfer, point estimates from the study site are applied in the context of application site after appropriate adjustment. On the other hand, a function transfer involves using the benefit function (the relationship between nonmarket value and a set of variables) of the study site and apply it to the application site (Loomis and Rosenberger 2006).

This report describes the application of benefit transfer methods for a specific site, Belle View Estate, in Western Australia. Belle View Estate is a proposed 44 ha residential development located in Bellevue, 16.5 km north-east of Perth. The land is a portion of a larger 99.5 ha landholding comprising Lot 239 Wilkins Street (formerly Goodchild Reserve) and a portion of Lot 799 Katharine Street, Bellevue. The site is transacted by Lot 33 Wilkins Street, a City of Swan owned drainage reserve (Bellevue Drain). The wider landholding is likely to be developed in a number of stages (Coterra Environment 2017).

Figure 1 Location of the site with sites for constructed wetlands and living stream

Source: Own calculation

The water sensitive urban design (WSUD) technologies considered in this development are constructed wetlands and living stream. Constructed wetlands are extensively vegetated water bodies that use sedimentation, filtration and biological uptake processes to remove pollutants from stormwater. A living stream is a constructed or retrofitted stormwater conveyance channel that mimics the characteristics (morphology and vegetation) of natural streams. In addition to providing pollution benefits, both types of systems could generate a range of nonmarket benefits, such as amenity and biodiversity protection (Department of Water 2016). The constructed wetland system will consist of a series of interlinked seasonal (ephemeral) and permanent open water bodies in the Helena River floodplain. The area of permanent open water is approximately 4.5 ha, and the area of seasonal wetlands is approximately 10.4 ha (Figure 1). The area of living stream is approximately 1.7 ha.

The objective of the study is to estimate the nonmarket benefits of constructed wetlands and living streams in a private residential development[1]. In the following sections, we present the methodology used for the transfer of benefits, followed by the results of the assessment and a discussion section.

2. Methodology

In order to assess the benefits from the implementation of WSUD, we have followed a set of steps:

1) Identification of a relevant set of benefits;

2) Review of existing literature to identify a suitable set of studies for assessment;

3) Adjustment of existing estimates to the application site, and;

4) Calculation of the total benefit.

We describe these steps below.

2.1 Selection of benefits

To understand the context and identify the relevant set of benefits related to WSUD extensive consultations with key stakeholders were carried out including with the Strategic Planning Institute P/L, Eastern Metropolitan Regional Council, Shire of Mundaring, Department of Water and Environmental Regulation and Department of Biodiversity, Conservation and Attractions. Further, relevant sets of internal documents were reviewed (e.g., Landvision 2015; Coterra Environment 2017; Coterra Environment 2017; Shire of Mundaring 2017). Based on these activities a preliminary list of potential services or benefits related to WSUD were identified (Table 1). It can be seen that some of the benefits of WSUD are likely to be relevant for private residents of the site, while other potential benefits are more linked with local community benefits.

[1] The study does not discuss the integration of these benefits into a rigorous cost benefit analysis framework. For more information on this see https://watersensitivecities.org.au/research/our-research-focus-2016-2021/integrated-research/irp2-wp3/

Table 1 List of potential benefits

Private	Local
Amenity benefits (from Living stream, Constructed Wetlands and Raingardens)	Amenity Recreation Connectivity (local access) Water quality (nutrient, heavy metal) Mental and physical health (active living and access to nature) Ecological/biodiversity/habitat Indigenous heritage

Source: Own calculation

2.2 Current state of knowledge on the economic value

The second step in quantifying the monetary value of these benefits is to identify the set of studies which provide relevant estimates. The CRCWSC's IRP2 has carried out an extensive review of existing studies that have published estimates of the intangible benefits due to the use of water sensitive systems and practices. The information has been compiled in a Value Tool. A summary of nonmarket value information for the relevant benefits is presented below.

Amenity: There are many nonmarket studies on the amenity benefits of WSUD in Australia. For example, Polyakov *et al.* (2017) found that the price of a house within 200 m of the urban drainage restoration project (Bannister Creek) had increased in value by 4.7% (2.9% - 6.58%) once the restored area became fully established (7-13 years). The increase of house prices is relative to the increase of property values in the neighbouring suburbs outside of the 200 m buffer from the Bannister Creek restoration project. The Bannister Creek restoration project involved work on a 320 m section of the main drain. The restoration work involved giving the creek a more natural shape, with meanders, riffles, fringing sedges, gently sloping banks, and thick vegetation on the banks. The area of the project is about 2 ha. In another study, Plant *et al.* (2017) found that a 1% increase in tree cover along the footpath in Brisbane, within 100 m of a property, increases property values of between 0.08% and 0.1%.

Recreation: The recreation benefit is one of the services most frequently valued in monetary terms. For example, Mahmoudi *et al.* (2013) is a hedonic study that was conducted in the Adelaide metropolitan area using property sales data from 2005 to 2008. The study found that being 1 m closer to a linear park, golf course, green space sports facilities and the coast increased property prices by $0.42, $0.65, $1.91 and $6.05 respectively. In another study, Pandit *et al.* (2014) provided benefit functions to estimate the impact of bushland (which includes local parks) and golf courses on house prices in Perth. The impact depends on the size of the infrastructure and distance. For example, in a location, a 5 ha bushland with an average distance of 400 meters would have a 0.57% increase in the median house price in the vicinity. On the other hand, a park/bushland with 10 ha area and 250-meter average distance would increase the median house price by 1.99%.

Connectivity (local access): Increased access through improved walkability has many direct and indirect benefits (Iftekhar and Tapsuwan 2010). For example, Giles-Corti *et al.* (2008) found that within a WA neighbourhood, recreation and transport are two prominent reasons for walking (52.6% and 36.1%, respectively). More importantly, the respondents identified a new neighbourhood's walkability as a major factor for their choice of housing development. However, they did not provide any estimates of nonmarket values.

Water quality (nutrient and phosphorous): There is some information on the value of removing pollutants from stormwater in Australia. Payne *et al.* (2015) suggested that removal of one kilogram of nitrogen is valued at $6,645 (2014) based on past stormwater treatment works in Melbourne. On the other hand, for Sydney, the Department of Environment and Conservation (2006) provided information on removing pollutants using a hypothetical constructed wetland: Total Suspended Solids ($2.50/kg in 2012 dollars), Total Nitrogen ($625/kg) and Total Phosphorous ($2,501/kg). Polyakov *et al.* (2017) estimated the cost of removing pollutants for different levels of removal targets in Canning catchment, Perth. From the optimisation results, it is possible to calculate the cost of removing pollutants ($/kg). They considered a combination of different actions: infill septic tanks, constructed wetlands, imported fill on new development, behaviour change and application of slow-release fertiliser. Costs of removing pollutants were estimated for three scenarios under emission targets ranging from 20% to 100%: base case scenario where amenity value of a wetland is included, a scenario where banning regular fertiliser is a policy option and a scenario where amenity value of a wetland is not included. Pollutants removal benefit ranged from $206/kg to $1979 for TN and from $2,052/kg to $22,329/kg for TP.

Mental and physical health: There is evidence that physical and mental well-being and community cohesion are inter-linked. For example, Maas *et al.* (2009) found that less green space in people's living environment is positively linked with feelings of loneliness and with a perceived shortage of social support. Lack of social support then leads to deprived mental and physical well-being. Ambrey and Fleming (2014) used self-reported life satisfaction data from the 2005 Household Income and Labour Dynamics in Australia (HILDA) survey to estimate the willingness to pay for urban green space in Australian capital cities. The study found that households in Australian capital cities are willing to pay $1,570 per annum for a one per cent increase (approximately 143 m^2) in open public space in their local area. A study undertaken in Perth, Western Australia from a cross-sectional survey of residents in 2003 and 2005 concluded that residents in neighbourhoods with high quality public open space had, on average, lower levels of psychosocial distress than residents of neighbourhoods with low quality public open space (Francis *et al.* 2012).

Ecological/biodiversity/habitat: Most of the information on nonmarket values of biodiversity and ecology are in relation to the protection of native flora and fauna, endangered species and unique ecosystems. People usually expressed a positive willingness to pay to protect biodiversity and ecology. For example, Rogers *et al.* (2013) found from a choice experiment survey that residents in Perth were willing to pay $65 to reduce an annual fish-kill event from twice a year to once a year in Swan River. It was found in another choice experiment that people in Tasmania were willing to pay, on average, $4.70 for a km increase in native riverside vegetation and $10.00 per species for the protection of rare native plants and animals (Kragt and Bennett 2011). In another study on the valuation of the environmental attributes of NSW rivers, Morrison and Bennett (2004) found that people were willing to pay $11/ household for an additional fish species in the rivers.

Indigenous heritage: There are some nonmarket estimates available on the value of protecting indigenous heritage sites. For example, Rolfe and Windle (2003) reported that indigenous communities were willing to pay $4.80 / annum to protect 1 per cent of Aboriginal cultural sites in Central Queensland. In another study, Zander *et al.* (2010) estimated from a survey in Northern Territory, Western Australia and Queensland that people were willing to pay a one-off payment of $187 to $275 to maintain "ok" and "good" condition waterholes important to aboriginal people respectively compared to maintain "poor" condition of waterholes important to Aboriginal people. The numbers are slightly higher ($206 and $332 respectively) for the respondents' group who evaluated the Fitzroy River in Western Australia. However, due to contextual difference, these numbers would not be suitable to transfer to Belle View Estate site.

In order to estimate the total value of a benefit, we would need to understand the expected changes in the physical condition of the site (i.e., expected physical benefits) due to the implementation of WSUD. A site visit was conducted in June 2018 with representatives from Eastern Metropolitan Regional Council (EMRC), Department of Biodiversity, Conservation and Attractions (DBCA) and University of Western Australia (UWA) to understand the local context better. Based on further follow-up discussions with the developers and key stakeholders, it was identified that the amenity and pollution benefits are likely to be the major benefits of implementing WSUD in this location. Therefore, in the following discussion and analysis, we focus on expected amenity and pollution benefits from living stream and constructed wetlands.

2.3 Estimation of amenity benefit

The benefits for the constructed wetlands are estimated using the estimates of values of urban lakes and wetlands from the study by Pandit, Polyakov et al. (2014). The first step is to compare the characteristics of the study site and Belle View Estate (the application site). It can be seen from Table 2 that there are substantial variations between the two sites. Both sites are urban; however, the study site is established, while the application site is a new development, and the average house price was much higher in the study site.

Table 2 Comparison of the main characteristics of the application site with the study site used

Context	**Study site**	**Application site**
Location	Perth, Western Australia	Perth, Western Australia
Setting	Urban (established)	Urban (new)
Nature of wetlands	A mix of natural, man-made or extensively modified	Man-made or extensively modified
Area of wetlands	5.6% of the study area	5.7% of the study area
Average house price	$ 1,000,000 (2009)	$ 397,000 (2013-2018 in six suburbs area)

Source: Pandit, Polyakov et al. (2014)

To estimate the value of benefits of constructed wetlands and living stream, we first need to know the values of homes without the impact of WSUD. We do this by using a hedonic model of home sale prices. Hedonic modelling is based on the assumption that the price of a good, such as home, traded on the market is a function of prices of its components. The empirical model can be written as:

$$log(p) = F(\boldsymbol{X}, \boldsymbol{\beta}),$$

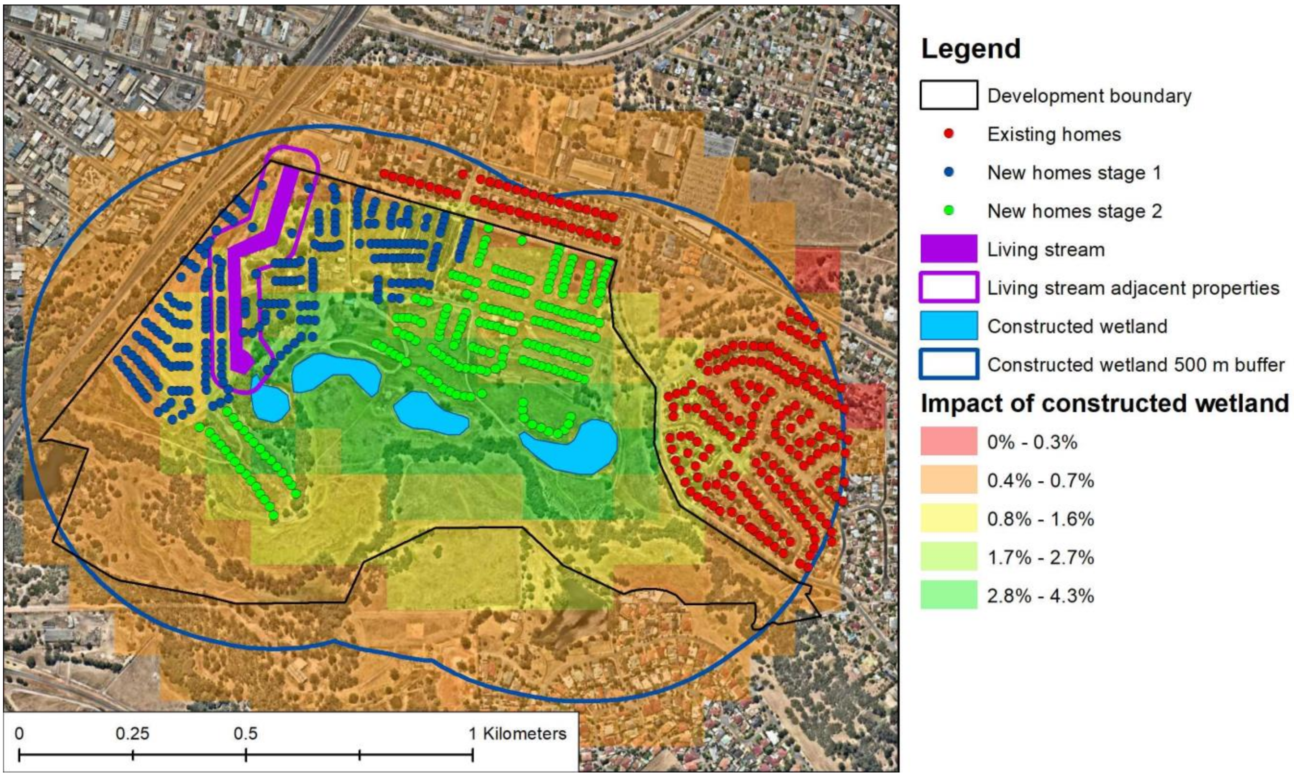
Where $log(p)$ is the sale price of a home, $\boldsymbol{X}$ is a vector of home attributes, and $\boldsymbol{\beta}$ is a vector of parameters to be estimated.

In our model, the underlying attributes include the number of bedrooms, number of bathrooms, lot area, number of parking places, age. In addition, we control for spatial heterogeneity among suburbs by including suburb-specific binary variables (spatial fixed effects), as well as for the temporal changes in the real estate market by including year-quarter specific binary variables (temporal fixed effects). Once coefficients are estimated, we can predict home prices in a new development using expected values of home attributes.

Using regression results, we predict the values of new homes in the development in 2018 for a range of lot sizes and median values of key parameters such as the number of bedrooms, bathrooms, and car parking places in Bellevue suburb in the third quarter of 2018.

Locations and lot sizes for new homes were obtained from the developer (Strategic Planning Institute P/L). We assume that constructed wetlands will affect existing homes within 500 m of the site as beyond this distance, the expected impact of constructed wetland become negligible (less than 0.4%). Figure 2 shows the outline of the development, locations of the living stream and constructed wetlands, the location of existing homes affected by the constructed wetland, and locations of homes being constructed. The construction of homes within the development is planned in two stages (Figure 2). The first stage is expected to be completed within the next 2-3 years and the second stage will start after that.

Figure 2 Location of new homes, existing homes affected by constructed wetland, as well as buffers of impact of living stream and constructed wetland.



Source: Own calculation

In order to estimate the potential impact of wetlands on house price, we use the parameterised function from the original study (Pandit, Polyakov et al. 2014). To estimate the value of the environmental amenities such as wetlands, Pandit, Polyakov et al. (2014) used gravity index constructed for each house following Powe *et al.* (1997). The gravity index captures the combined influence of the size and proximity of wetlands on property value and can be calculated as:

$$GI_i = \sum_{j=1}^{J} \frac{A_j}{(D_{ij})^2} \qquad (1)$$

where GI_i is the gravity index of wetlands for i-th home in the sample, J is the number of 100 m x 100 m grid cells within 3,000 m radius of the i-th home, A_j is the area of wetland site within j-th cell, and D_{ij} is the distance to the centre of the j-th cell from the i-th home.

The impact of constructed wetland on the property value is then calculated as:

$$\Delta p_i = exp(ln(GI_i + 1) \times \beta) - 1 \qquad (2)$$

Where Δp_i is the change of *i*-th house price due to constructed wetlands, GI_i is the gravity index for the house *i*, and β is regression coefficient obtained from Pandit et al. (2104). In addition to the point estimate (0.0438), we calculate upper and lower bounds by adding or subtracting the standard error of the regression coefficient (0.0221)[2].

Polyakov, Fogarty et al. (2017) measured the impact of retrofitting a conventional drain into a living stream in an established suburb as the percentage change of property price within 200 m of the site. They also observed that there is not much amenity benefit of living stream projects on houses located

[2] With a normal distribution assumption it is expected that there is 68% chance that the true value is within one standard error range.

more than 200 meters of the site[3]. It was estimated that within 200 meters, the increase in house price due to living stream could be between 2.9% to 6.5%[4]. The amenity value of living stream is calculated by multiplying values of homes within 200 m of living stream (Figure 2) by the percentage increase.

For both studies, we did not have to adjust estimates to income differences as house prices captured the income differences. Since the benefits were estimated as a percentage of house price, we did not adjust the values for inflation/time differences.

However, the living stream proposed in the application site is smaller in size (30 m wide, 1.7 ha) than the living stream in the Polyakov, Fogarty et al. (2017) study (50 m wide and 2.4 ha). The experts in the CRCWSC Regional Advisory Panel suggested that in a new development, the living stream will only impact the immediately adjacent properties. Therefore we made the appropriate adjustment for the benefit transfer by applying the benefit of living stream only to adjacent properties (i.e., within 50 metres).[5]

Because both features (wetlands and living stream) are located in the same area, one feature can act as a substitute for the other. Therefore we cannot add up both values. For homes that are affected by both constructed wetland and living stream, we selected the greater of the two values.

2.4 Estimation of pollution removal benefit

Estimation of pollution benefit relies on information about the hydrological conditions, expected removal of pollutants by the living stream and estimation of monetary benefits.

We use the standard hydrological model (UNDO) used by the Department of Water (Department of Water 2016) to generate the pollution scenarios. The model requires information on land use compositions and soil condition of the catchment. Based on the existing land use pattern, a catchment area for the living stream was considered (Figure 3). The total area of the catchment is 20 hectare. The main land-use is residential (52%) followed by transportation (33%) and public open space (15%)[6]. Drainage type was assumed as piped drainage as the control and soil type ‘Pinjarra’.

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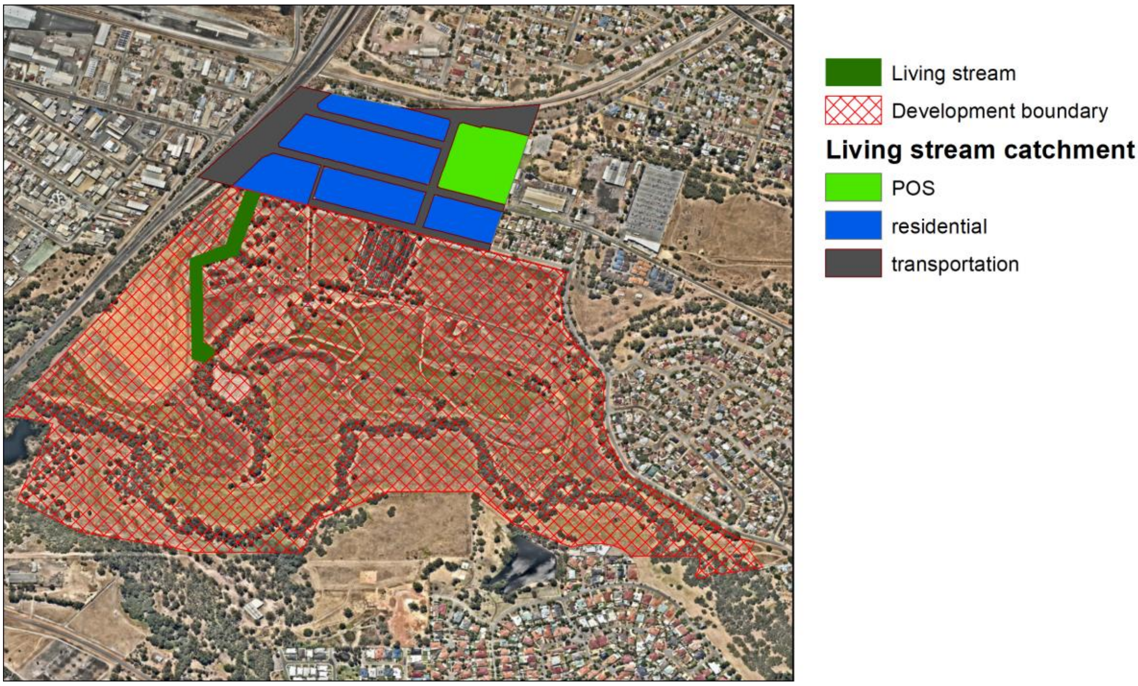
[3] They compared specification with uniform 200 impact with two other specifications with diminishing impact, and the former had the best statistical fit.

[4] It should be noted that in the original study the positive impact of living stream on house prices was observed during the period 7-13 years from the start of the living stream construction. Whereas, living stream in Bellevue will be completed before or at the same time the houses are built. Therefore, it is reasonable to assume that the value increase will be observed immediately.

[5] We are currently conducting a separate study of the value of living streams in greenfield developments in Perth metropolitan area. The initial results are consistent with the assumptions made in this report.

[6] Land use mix could change in the future. However, in the current analysis we do not consider this.

Figure 3 Living stream catchment and land use compositions



Source: Own calculation

Based on these land use configuration, the model generates loads of major pollutants (Total Nitrogen (TN) and Total Phosphorous (TP)) in the runoff. The relevant estimates are 51.30 kg per year for TN and 11.68 kg per year for TP. It has been further suggested in the model that if the living stream is fully functioning it has the capacity to remove approximately 50% of TN and 20% of TP. This estimate is somewhat similar to the empirical observations made by Torre *et al.* (2006). Therefore, we use these values as the pollutant removal capacity.

Finally, we need to identify relevant monetary values of pollution removal. For this purpose, we use the estimates provided by Polyakov, White et al. (2017). They estimated the cost of removing pollutants in Canning catchment for three scenarios under emission targets ranging from 20% to 100%: base case scenario where amenity value of the wetland is included, a scenario where banning regular fertiliser is a policy option and a scenario where amenity value of the wetland is not included. In this paper, we use relevant estimates from the base case scenario as it is the most relevant scenario for the Belle View Estate context.

To match with the base pollution removal capacity assumptions, we use the average estimates ($/kg) of 40% and 60% targets for TN. For TP, we use relevant estimate for the 20% target. Using these values, it is possible to calculate the annual pollution benefit of a living stream. However, we do not aggregate the values of removing nitrogen and phosphorous to avoid double counting.

Table 3 Calculation of annual value of pollutant removal by a living stream

Parameters	**TN**	**TP**
Load (kg/year)	51.30	11.68
Removal capacity (%)	50.00	20.00
Removed Pollutant (kg/year)	25.65	2.34
Unit value of pollutants ($/kg)	1,223	2,058
Monetary value of removing pollutants ($/Year)	31,370	4,816

Source: Own calculation

To calculate the total value, we use the following formula:

$$PV = \sum_{t=1}^{T} \frac{1}{(1+r)^t} AV \qquad (3)$$

Here, PV = Present Value of a pollutant benefit, t = effective life year of the living stream, r = discount rate and AV = Annual Value.

For this exercise, we assume an effective life of 25 years of the living stream. As part of sensitivity analysis, we consider three discount rate: 3%, 5% and 7% following standard practice. We also consider three levels of pollution removal capacity: Low (20% lower), Medium (Base value) and High (20% higher) to reflect the situation when the actual pollution load could be different from the base values used in the study.

3. Results

We present the results for amenity and pollution removal benefits separately, then follow with the total value estimates.

3.1 Amenity benefit

To predict house prices in the development, we used 826 sales of single-family homes in Bellevue and five nearest suburbs (Greenmount, Helena Valley, Koongamia, Midland, and Midvale) from 2013 to 2018. We assumed that the sale value of a home is determined by its attributes, including the number of bedrooms, number of bathrooms, lot area, number of parking places, age. We estimated a linear regression model with the natural log of the sale price as the dependent variable. We also control for time and location using suburb and year-quarter fixed effects. The results of the estimation are presented in Table 4. The model explains 38% of the variation in home price. While hedonic models usually have higher R^2 values, the values around 40% are not uncommon, for example, see Ma and Swinton (2011) and Tapsuwan *et al.* (2015). The relatively low R^2 of the current model is due to the small and relatively uniform sample and inclusion of only a few explanatory variables. The sample area is several neighbouring suburbs where prices of house were relatively homogenous. Since the purpose of the regression model is to make predictions only those variables were included in the model for which we have relevant data / information. The regression analysis shows that the most important predictors are lot area and the number of bathrooms. The number of bedrooms is not statistically significant because it is highly correlated with the number of bathrooms. The age of the home is not statistically significant because of the limited range of ages in the sample.

Table 4 Results of estimating a hedonic model of single-family home prices

Regression parameters	**Estimates of the regression coefficients**	**Standard Errors of the coefficients estimates**	**T Value**	**Pr > |t| (Probability that the coefficient equal to zero)**
Intercept	10.831	0.287	37.79	<.0001
Log(area)	0.174	0.029	6.05	<.0001
Bedrooms	0.023	0.021	1.12	0.263
Bathrooms	0.192	0.036	5.31	<.0001
Car Parks	0.042	0.019	2.19	0.0289
Age	0.000	0.001	0.23	0.8213
Suburb fixed effects	yes			
Year-quarter fixed effects	yes			
Number of observations	826			
R^2	0.38			

Source: Own calculation

Using the results of the regression, we predicted the value of homes in the development as well as within 500 m of the constructed wetlands outside of the development using actual lot sizes and house characteristics in the study area. We assumed that homes will have 3 bedrooms, 2 bathrooms, and 2 parking spaces for lot sizes between 200 to 400 m^2. Lots greater than 400 m^2 will have an additional bedroom, and lots less than 200 m^2 will have 1 less parking space.

These assumptions are based on the median values of numbers of bedrooms, bathrooms and parking spaces for homes built in the study area in the last 5 years. Predicted values of homes are presented in Table 5. It shows home values for homes of the 1st and 2nd stage of development separately, and for the existing homes that will be affected by the constructed wetland. The predicted base values do not take into account the amenity value of living stream and constructed wetland.

Table 5 Predicted house values

Stage of development	Number of houses	Mean	Std Dev	Minimum	Maximum
Development stage 1	334	$249,630	$15,688	$212,598	$290,022
Development stage 2	233	$255,396	$14,987	$230,899	$286,042
Existing homes	223	$286,630	$8,001	$225,100	$326,741

Source: Own calculation

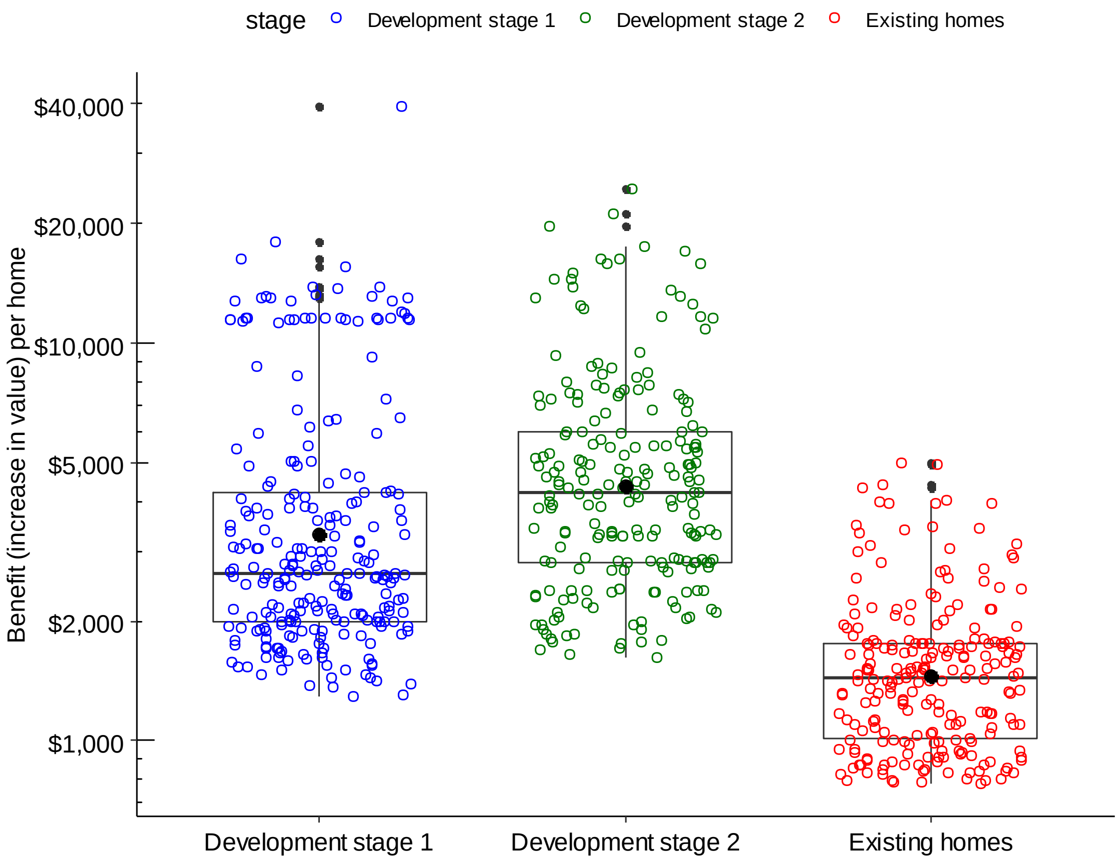
Amenity values of constructed wetlands and living stream (point estimates, as well as lower and upper bounds) were calculated for each house using methods described in Section 2.3. We used predicted base values for each home separately. The amenity value of the living stream was calculated for each home adjacent to the living stream by multiplying the base value by percentage increase due to the living stream[7]. The percentage value increase due to constructed wetland was calculated for each home separately by using equations (1) and (2).

There are some houses which could be potentially impacted by both wetlands and living stream (approximately 5% of the houses). Because the amenity value of living stream and amenity value of constructed wetland are strong substitutes, we selected the higher of two values for those houses.

Distribution of point estimates of amenity values for houses in the first and second stages of the development as well as for the existing houses outside of the development are presented in Figure 4. We use a logarithmic scale for benefits (y-axis) because of the skewness towards large values of the benefits: there are relatively few homes with much larger values of the benefits than the rest. The points of different colours show amenity values generated by water sensitive urban infrastructure for individual homes in stage 1 and stage 2 of the development, as well as for the existing homes. The boxplots (black rectangles and dots) show the means (black dots), the medians (the horizontal lines in the middle of the rectangles), and the distributions of the values. The rectangles indicate interquartile ranges (where 50% of values are located). The whiskers (vertical lines) indicate the ranges where 95% of values are located. The smaller black dots above the whiskers are outliers. The predicted amenity values are slightly higher for homes in the second stage of development than for homes in the first stage of development because homes in the second stage are on average closer to the constructed wetland. The lowest amenity values are for the homes outside of the development because they are not affected by the living stream and are located relatively far from the constructed wetlands.

[7] Here we assume that the residents will start to enjoy amenity benefits earlier than what has been observed in Polyakov et al. (2017). There are two reasons behind this assumption: (i) we assume that the living stream will be established before completion of the project; and (ii) it will take shorter period of time for it to start generating amenity benefits as it would not have extensive vegetation that might require long time to grow. Further, preliminary results from a separate study of ours on a new development suburb suggest that even planned living stream or POS could uplift value of adjacent properties.

Figure 4 Distribution of the benefits of WSUD measured as a calculated increase of home values (on y-axis) due to the implementation of the living stream and constructed wetland.



Source: Own calculation

Aggregate median estimates, as well as lower and upper bounds of amenity values of WSUD in Belle View Estate development, are presented in Table 6. Lower and upper bounds are calculated by subtracting or adding one standard error to/from the regression coefficient of the impact of the living stream or constructed wetland, respectively.

According to our estimate, the amenity value of the proposed WSUD in the first stage of the development is valued between $1M and $2.7M, the amenity value of WSUD for the second stage of the development is between $0.6M and $1.8M, and the amenity value of WSUD for the houses outside of the development is between $0.2M and $0.5M. The total amenity value generated by WSUD is estimated between $1.8M and $5.0M (Table 6).

Table 6 Total amenity value (in AU$ millions) from wetlands and living stream

Stage of development	Number of homes	Home values	The amenity value of WSUD		
			Lower bound	Median	Upper bound
Development stage 1	334	83.38	1.04	1.88	2.74
Development stage 2	233	59.51	0.58	1.18	1.79
Existing homes	223	63.92	0.18	0.36	0.54
Total	790	206.81	1.80	3.42	5.07

Source: Own calculation

It can be seen from the median estimates in Table 6 that a substantial portion of the amenity benefits (11%) will be captured by the local residents (existing houses). This could be considered as the public benefit generated by the project, in addition to the pollution removal benefits, which we describe below.

3.2 Pollution removal benefit

The present value of pollution removal over an estimated life of a living stream, under three levels of removal capacity and three discount rates, have been presented in Table 7. It can be seen that for Total Nitrogen (TN) the estimated benefit ranged from $0.16 million to $0.36 million. On the other hand, for Total Phosphorous (TP) the total benefit ranged from $0.06 million to $0.13 million. By comparing the values for TN and TP it could be observed that the pollution benefit is likely to be mostly generated from the removal of total nitrogen.

Table 7 Pollution removal benefit (in AU$ millions)

Discount rate	Removal capacity		
	Low	Medium	High
Total Nitrogen			
3%	0.24	0.30	0.36
5%	0.19	0.24	0.29
7%	0.16	0.20	0.24
Total Phosphorous			
3%	0.09	0.11	0.13
5%	0.07	0.09	0.11
7%	0.06	0.07	0.09

Source: Own calculation

3.3 Aggregate benefits

Finally, we combine the amenity and pollution removal benefits of constructed wetlands and living stream. It is possible to aggregate the amenity and pollution removal benefits as they are different types of benefits with limited risk of overlaps. The aggregate value ranges from $2.0M to $5.4M. It could be noted that at medium level around 93% benefit is accrued due to amenity benefits and 7% due to pollution removal benefit. Further, almost 16% of benefits are accrued to the local residents (existing houses) and community.

Table 8 Aggregate amenity and pollution benefits (in AU$ millions) of constructed wetlands and living stream

Benefit types	Benefit levels		
	Low	Medium	High
Private amenity benefit	1.62	3.06	4.53
Community amenity benefit (local residents)	0.18	0.36	0.54
Pollution removal benefit*	0.19	0.24	0.29
Total benefit	1.99	3.66	5.36

* Pollution removal benefit is based on TN removal benefit at 5% discount rate at the base (medium) capacity

Source: Own calculation

4. Concluding remarks

Our study shows the applicability of benefit transfer methods in estimating nonmarket benefits of WSUD. We have observed that aggregate amenity and pollution benefit is substantial. As expected, private residents/owners are going to enjoy most of the benefits (84%) from the implementation of the project. However, it is interesting to note that the residents and a wider community are also going reap amenity and pollution removal benefits from the implementation of the project. Therefore, even though the private developer is bearing the cost of the project, it would be beneficial to think about some sustainable long-term governance arrangement for the continuous management of the systems.

Given that the case study has relied on benefit transfer method, the analysis was limited by the availability of data. In spite of the extensive search of the literature, it was not possible to find relevant nonmarket values for all types of benefits. The pollution removal benefits are based on removal cost and do not include additional “savings” of money that may need to be spent in the management of nutrients if they were not removed (for example, if nutrients were not removed the downstream management actions such as operating of oxygenation plants etc.) would be higher. In addition, an effective on-site nutrient reduction has the potential to improve the amenity benefit of water bodies (e.g., through reduction of algal bloom) in the downstream. Therefore, in some sense, these estimations could be considered conservative. Future potential work would involve the collection of new information and updating the existing information when they become available.

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