Valuing Environmental Services Provided by Local Stormwater Management

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May 2017

Abstract

The management of stormwater runoff via distributed green infrastructures delivers a number of environmental services that go beyond the reduction of flood risk, which has been the focus of conventional stormwater systems. Not all of these services may be equally valued by the public, however. This paper estimates households' willingness to pay (WTP) for improvements in water security, stream health, recreational and amenity values, as well as reduction in flood risk and urban heat island effect. We use data from nearly 1,000 personal interviews with residential homeowners in Melbourne and Sydney, Australia. Our results suggest that the WTP for the highest levels of all environmental services is A$799 per household per year. WTP is mainly driven by residents valuing improvements in local stream health, exemptions in water restrictions, the prevention of flash flooding, and decreased peak urban temperatures respectively at A$297, A$244, A$104 and A$65 per year. We further conduct a benefit transfer analysis and find that the WTP and compensating surplus are not significantly different between the study areas. Our findings provide additional support that stormwater management via green infrastructures have large non-market benefits and that, under certain conditions, benefit values can be transferred to different locations.

Keywords: quasi-public goods, non-market goods, stated preference

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Funding from the Cooperative Research Centre for Water Sensitive Cities (CRC grant number 20110044) is acknowledged. This project has been approved by the Monash University Human Research Ethics Committee; MUHREC#: CF12/2511 - 2912001358. The data used in this paper are available at the following repository: https://www.dropbox.com/sh/qm3be3eqdi9jpia/AACTP-1X6BKLPKFQ6Yv1UvY6a?dl=0.

1 Introduction

Increasing urban population growth and limited public funds necessitate the efficient allocation of resources to public investments, including the management of stormwater runoff from the urban environment. Conventional stormwater systems focus on optimizing rapid drainage to receiving waters, causing significant hydrological and ecological degradation. Alternatively, stormwater management based on water sensitive urban design principles aims to capture stormwater in a system of distributed green infrastructues to slow surface runoff and infiltrate water locally. Examples of such infrastructures include rain gardens that are designed to retain and filter stormwater from impermeable surfaces, vegetated swales to convey stormwater in lieu of pipes, green roofs and walls, as well as constructed urban wetlands, ponds and sediment basins. Greener cities are associated with improvements to hydrological and ecological function, landscape amenity, and human thermal comfort. As a result of these ancillary environmental benefits, water sensitive stormwater management has the potential to yield higher economic net benefits compared to conventional systems, even when there are greater implementation and operating costs. Many policymakers and practitioners advocate for investments in green infrastructures to manage urban stormwater as a preferable way to cope with the host of problems associated with conventional stormwater drainage (*Wong et al.*, 2013).

Such a normative judgment requires an analysis that tests whether society assigns a sufficiently high value to all the ancillary environmental benefits associated with water sensitive urban design. In practice, these values are estimated by identifying willingness to pay (WTP) for the environmental services associated with local stormwater management. Some studies estimate the WTP for improvements in the quality of surface water (*Carson and Mitchell*, 1993; *Kukielka et al.*, 2008; *Van Houtven et al.*, 2007) and the prevention of flooding (*Bin and Polasky*, 2004; *Zhai et al.*, 2006, 2007) in the context of local stormwater management projects. *Londoño Cadavid and Ando* (2013) are the first to combine flood prevention and stream health benefits in a non-market valuation study and show for their sample of 131 households in Champaign-Urbana, Illinois, that individuals have a positive WTP for reductions in basement flooding, as well as improved water quality and stream health. Other benefits, including increased water security, have received comparatively little attention in the literature (*Cooper et al.*, 2011). Still other potential non-market benefits, such as combating the urban heat island effect with increased vegetation, have not yet been quantified in the stormwater context, making a comprehensive benefit-cost analysis of water sensitive urban design projects difficult.

Furthermore, it remains an open question whether the WTP values estimated for a stormwater project in one location can be transferred to a stormwater project in another location. The transferability of WTP values is particularly important in the context of spatially distributed stormwater management and the limited resources available to conduct new valuation studies. Many large cities need to decide whether to pursue green infrastructures for stormwater management and, thus far, the primary study of non-market benefits of water sensitive stormwater management was conducted in a town of less than 100,000 people (*Londoño Cadavid and Ando*, 2013).

The purpose of this paper is to address these two challenges. We design a discrete choice experiment that allows us to estimate the marginal willingness to pay (MWTP) for five key environmental services associated with water sensitive urban design practices. The data collection takes place in the two largest metropolitan areas in Australia, to test if the valuations are consistent across different geographic locations.

The environmental services, or attributes, analyzed in this study are identified by an interdisciplinary group of experts and stakeholders affiliated with Australia's Cooperative Research Centre for Water Sensitive Cities (CRCWSC). In a multi-step process, the group determines five key attributes representing the main environmental benefits from stormwater harvesting: (1) reduction in water restrictions, (2) reduction in flash flooding, (3) improvements in stream health, (4) improvements in recreational and amenity benefits, and (5) cooler summer temperatures. The team also identifies feasible levels of improvement for each attribute and the range of costs associated with these improvements.

We survey a randomized sample of almost 1,000 households in Melbourne and Sydney. Residents are personally interviewed to elicit their MWTP for each of the five attributes in the discrete choice experiment. The respondents' choices are analyzed using a mixed logit model, which makes it possible to identify the average respondent's preferences for individual attributes as well as the diversity of preferences across the sample population.

We find that respondents, on average, place a significant and positive value on the environmental benefits of local stormwater management. Across both Melbourne and Sydney, the mean WTP for a project delivering the maximum levels of environmental services across all attributes, which we call a "gold standard" project, is A$799 per household per year. However, the range of potential WTP values is substantial with the 95% confidence interval for this mean value spanning from -A$13 to A$1,611. The positive total WTP is mainly driven by the high and significant MWTP values for the improvements in stream health (A$297), reduction in water restrictions (A$244), prevention of flash flooding (A$104) and cooler summer temperatures (A$65). These findings provide further support for previous results that identify a positive WTP for stream health (*Londoño Cadavid and Ando*, 2013) and water security (*Cooper et al.*, 2011).

Since it is costly to develop original non-market valuation studies in every location considering water sensitive stormwater projects, determining the validity of benefit transfer is desirable. Previous studies identify differences in attitudes between Sydneysiders and Melbournians (*Forrest and Dunn*, 2010), perhaps owing to the somewhat different immigration and assimilation patterns in these two cities (*Edgar*, 2014). Moreover, there are distinct climatic differences between the two cities. Therefore, one cannot *a priori* dismiss the possibility that the benefits of stormwater management are valued differently in Melbourne and Sydney. We test this hypothesis using a benefit transfer framework. Benefit transfer is applied widely in the water literature and is the subject of a special *Water Resources Research* issue in 1992. We use contemporary benefit transfer tests (*Poe et al.*, 2005) to compare the MWTP for each attribute in Melbourne and Sydney. We then test for differences in compensating surplus, defined as the improvements gained by some positive combination of the attributes relative to the status quo, using the method developed by *Morrison et al.* (2002). We find that benefit transfer tests confirm transferability; the MWTP and compensating surplus are not significantly different across the study sites.

This analysis makes three primary contributions to the literature. Firstly, we estimate the MWTP for additional key benefits associated with stormwater management. Secondly, we estimate the value of non-market benefits in two cities, which may have different values than existing studies conducted in areas with lower populations. Lastly, we implement benefit transfer techniques to evaluate the differences in WTP between distinct metropolitan areas. We test for the equality of MWTP for changes in ecosystem services and the equality of compensating surplus measures to determine whether the benefits of stormwater management can be transferred between two regions.

The paper is organized as follows: section 2 describes the survey design and the study area; section 3 introduces the data; section 4 describes the empirical framework; section 5 presents the results; section 6 concludes.

2 Survey and Study Area

2.1 Survey

The data for this study come from surveys conducted in four local government areas in Australia. Warringah and Fairfield are located in the greater Sydney metropolitan region. Moonee Valley and Manningham are located in the greater Melbourne metropolitan region. The data were collected in two waves. In the first wave, from February 2, 2013 to October 7, 2013, a randomized sample of 981 householders were interviewed about their willingness to pay for the benefits from local stormwater management. The second wave occurred approximately one year after the conclusion of the first wave, between November 26, 2014 to December 21, 2014, resampling 318 of the wave 1 households using an identical survey instrument. Households were asked about their preferences for increased water security, reduction in flash flooding, improvements to stream health, improvements to the recreational and amenity benefits of local green spaces and waterways, and reductions in the heat island effect. The values were elicited using a choice experiment, which is described in detail in *Brent et al.* (2014).

Both survey waves were carried out by a professional survey company. Personal interviews, instead of phone, mail, or internet surveys, were used to ensure that the necessary support could be provided if respondents found the information difficult to understand. The choice sets were presented using clear visual images and were programmed into iPads to provide the respondents with a user-friendly interface. Supplementary visual aids were also made available throughout the choice experiment so respondents could easily remind themselves of how attributes and their levels are defined.

The survey comprises three sections: (1) A brief explanatory statement outlines the purpose of the survey (see Figure 1). (2) A discrete choice experiment elicits householders' WTP for the benefits associated with local water management. The experiment consists of two choice tasks. The first choice task is described below and evaluates the benefits associated with stormwater management. This is immediately followed by the second choice task, designed to elicit attitudes toward alternative sources of water. For this study, only the first choice task is relevant. (3) A demographic questionnaire collects data on socioeconomic characteristics and attitudes towards environmental goods and services.

The main objective of the survey is to provide input into the planning, scoping and development of a range of water management projects by ascertaining the monetary value of key benefits of local stormwater management. We do not specify a project (e.g. a rain garden) since the elicited values for attributes were aimed to help policymakers maximize the ancillary non-market benefits from different forms of green infrastructure. Not commonly priced in markets, these benefits are difficult to value using revealed preference methods and hence a discrete choice experiment is used to elicit householders' willingness to pay. We use an unlabeled choice experimental design, where householders are asked to choose amongst three water management options. One option describes the status quo, while the remaining two describe water management projects that yield benefits to varying degrees and come at a cost to the household. This design encourages respondents to pay attention to the variation in benefit levels between the non-status quo alternatives instead of making a pro-project versus anti-project decision and is a common design choice in comparable settings (*Rolfe* *and Bennett*, 2009). Each respondent selects the preferred option in 10 different choice sets, where the water management alternatives presented vary across five attributes describing the key benefits from stormwater management as well as costs. Figure 2 provides an example of such a choice set.

The selection and development of attributes and attribute levels in the discrete choice experiment occurred over a rigorous 18-month process of expert and stakeholder consultation through the Cooperative Research Centre for Water Sensitive Cities (CRCWSC). The CRCWSC holds regular meetings to facilitate the exchange and interaction between researchers, industry and government partners. During one of these meetings the participants were divided into small groups, each containing at least one representative of the local government, water authorities and providers, and researchers from various disciplines (engineering, hydrology, climate science, urban studies, economics, law, sociology, and political science). The groups were asked to compile a list of the 10 most important benefits of stormwater harvesting. These were subsequently discussed in a plenary forum and distilled into five choice attributes and a cost attribute, namely: reduction in water restrictions, reduction in flash flooding, improvements in stream health, recreational and amenity benefits, and cooler summer temperatures. We collaborated with CRCWSC researchers from the relevant disciplines in order to define appropriate attribute levels. For example, researchers in hydrology, engineering and climate science formed a task group to determine realistic levels of reduction in flash flooding, while the improvement levels to stream health were defined by a group of hydrologists, biologists and ecologists.

The attribute *reductions in water restrictions* is designed to elicit preferences for greater water security and has three levels. The lowest level represents the status quo with the full range of restrictions to outdoor water use being applicable to the local area. Level 2 (restrictions 3,4) provides exemptions from the more benign restrictions such as lawn watering only being permitted on specified days of the week, while level 3 (no restrictions) means that households in the local area are exempt from all water restrictions.

The second attribute, *reduction in flash flooding*, describes the frequency of local street level pluvial floods as these are a direct consequence of local water management. There is no change in the frequency of flash flooding under the status quo level, while level 2 (flood half) is characterized by the number of flash floods over a five year period being halved and level 3 (flood never) means that flash floods will be almost non-existent in the neighborhood.

Improvements in stream health relate to the ecological health of the local waterway. Local water management can lead to improvements in relation to bank erosion, presence of litter, biodiversity, and populations of nuisance insects. An intermediate level (stream medium) corresponds with reductions in bank erosion, banks being free of litter, greater biodiversity and the return of some iconic species. Level 3 (stream high) represents a healthy local stream characterized by a natural channel form and function, high species diversity and low populations of nuisance insects.

Local water management can result in greater *recreational and amenity benefits* by improving the water quality in local waterways as well as irrigating public green areas. Under the status quo, local sports grounds, parks and street line vegetation are not watered and will appear brown or may die during dry summers. Also, the local waterway is fit for paddling but not swimming. Level 2 involves irrigation to ensure that local parks and sports grounds are green all year round and that mature trees on residential streets are not lost during periods of drought. Under level 3, irrigation is complemented with greener streetscapes via the planting of additional trees as well as improvements to the water quality that result in local waterways being fit for paddling as well as swimming.

The fifth attribute, *cooler summer temperatures*, recognizes the shading and evaporative cooling effects from artificial water bodies and green, inner-city vegetation that are supported via local water management projects. This attribute has two levels. No change in local summer temperatures describes the status quo (level 1), while level 2 (temp -2) is characterized by hot summer days being 2 degrees C cooler.

As the benefits from stormwater harvesting are also weather-dependent and therefore subject to variation, we allow for outcome risk affecting two of the five benefits - water restrictions and stream health. Outcome risk is described as the probability that the specified improvement relative to the status quo will occur. The probability of achievement ranges from 40% to 100%.

The *cost* attribute is described as an annual increase to the water bill owing to the cost of the selected water management option. Specifically, the cost attribute is explained as follows: "These are the costs per household per year of providing the water management option. These costs would be added to your annual water bill." The levels of increases to the water bill were discussed with legal and policy experts and represent realistic upper bounds for an increase in the annual fixed water charge. They range from A$0 to A$30 and are also sufficiently high to cover the per household cost of the proposed water management projects. From a legal perspective, water charge increases are the most plausible payment mechanism that would be used to fund stormwater management projects at the community level.

The survey concludes with a questionnaire about the participant's experience with the different attributes of the choice experiment, their exposure to natural hazards and attitudes towards water management. Demographic information in the form of the respondent's age, gender, education and income is also collected.

The survey was piloted with a group of 10 employees of the Manningham and Mooney

Valley City Councils (VIC), who were working in areas other than local water management and volunteered for the study. The pilot was attended by a trained social psychologist, who evaluated the information content, wording, length and cognitive demands of the survey instrument and provided recommendations. The revised survey was tested on 10 randomly selected homeowner residents in Warringah (NSW) before the final version was rolled out. The survey was fielded by professional enumerators who received in depth training about the objectives of the survey as well as the survey instrument prior to commencing field work.

2.2 Study Area

Both Melbourne and Sydney are large metropolitan areas with 4.6 and 5.0 million residents, respectively (*ABS*, 2016). Each region has distinctive characteristics. Climatically, the two cities are measurably different. During the study period, Melbourne was subject to a wider range of temperatures, higher average rains, and lower peak rains than Sydney. Melbourne experienced a monthly mean temperature ranging from 14.5 to 31.3 degrees C and totaled 19 to 150 mm of rainfall per month. Sydney's monthly mean temperature ranged from 17.5 to 29.3 degrees C and monthly precipitation totaled 6.4 to 206 mm. Demographically, the cities may be different, too. Sydney and Melbourne are the two main immigrant receiving cities in Australia. The slight differences in assimilation patterns have led to some immigrant groups being more or less concentrated in Sydney than in Melbourne (*Edgar*, 2014). This factor may explain the different attitudes that have been observed between Sydneysiders and Melbournians, for example towards multi-culturalism (*Forrest and Dunn*, 2010).

In addition to standard demographic data, survey respondents are asked questions about environmental preferences and activities that are likely to affect the willingness to contribute to a water management project. These questions include whether individuals engage in outdoor recreation activities (*Recreation*); consider watering restrictions a burden (*Restrictions*); are concerned about water quality and/or biodiversity in local water bodies (*Water Quality*); think a flash flood is likely, have recently experienced a flood, or own flood insurance (*Floods*); and are concerned about increasing extreme summer temperatures (*Summer Heat*).

Table 1 displays the sample average of demographic and attitudinal variables, as well as the averages and sample sizes for the Melbourne and Sydney samples separately. We show the difference in means and the p-values for t-tests where the null hypothesis is that the sample means are equal in Melbourne and Sydney. The first set of variables are demographics, which are quite similar across Melbourne and Sydney; the populations are not significantly different across income, gender, number of children or age. The Melbourne sample has a higher proportion of respondents with a post-secondary degree. The attitudinal variables, which reflect environmental preferences, are all dummy variables created from one or more questions that are related to attributes in the choice experiment, as described above. The attitudinal variables show larger differences across the two locations; four out of the five variables have statistically different means. As a result, an F-test rejects joint equality of means across the two study locations. The differences in attributes between Melbourne and Sydney motivates our benefit transfer analysis that we present below.

3 Methods

The analysis takes place in four steps. First we estimate an econometric model of preferences based on the respondents' selections in the choice experiment. In this step we examine the impact of attribute uncertainty that we introduced in our design. Using the estimated parameters we then proceed in two subsequent steps: first we quantify the benefits at each study site in dollar terms. We then test whether the benefits transfer across the two sites. We quantify the benefits and conduct benefit transfer tests using two different methods: the marginal willingness to pay (MWTP) distributions for each of the attributes and the compensating surplus for a suite of attributes. Lastly, we examine sources of heterogeneity in the preferences for stormwater management. We provide details for calculating the monetary values and conducting the benefit transfer tests below.

3.1 Econometric Model

In order to quantify the preferences for stormwater management we fit an econometric model to the respondents' choice data. We assume that the respondents select their preferred alternative in each choice set based on a random utility model (RUM), as seen in equation 1.

$$U_{ijt} = V_{ijt} + \epsilon_{ijt} \tag{1}$$

The respondent's utility, U_{ijt}, is decomposed into a deterministic component, V_{ijt}, and an unobserved, or random component ϵ_{ijt}. In our setting V_{ijt} is comprised of the attributes present in each alternative stormwater management project. In this framework, respondent i chooses alternative j in choice t if that is the option that yields the highest level of utility. The probability of this choice occurring is displayed in equation 2.

$$\begin{aligned} \pi_{ijt} &= Pr(Y_{it} = j) = Pr(U_{ijt} > U_{iht}) : \forall : h \neq j \\ &= Pr(V_{ijt} + \epsilon_{ijt} > V_{iht} + \epsilon_{iht}) : \forall : h \neq j \end{aligned} \tag{2}$$

We model ϵ_{ijt} as a type I extreme value distribution leading to the logit specification shown in equation 3.

$$Pr(Y_{it} = j) = \frac{\exp(V_{ijt})}{\sum_{h \in J} \exp(V_{iht})} \tag{3}$$

In our setting, the respondents select one of three options from each choice set, requiring a model that accommodates multiple categories. Based on the results of a Hausman test (*Hausman and McFadden*, 1984) we reject the independence-of-irrelevant-alternatives assumption that restricts substitution patterns among options in the choice set.[1] Therefore, we eliminate the standard multinomial logit as a valid econometric model, and use the mixed logit (MXL), which *McFadden and Train* (2000) show can accommodate any set of substitution patterns, as our preferred specification.[2] Additionally, the MXL model is popular in the applied literature estimating WTP from discrete choice experiments; see among others *Revelt and Train* (1998); *Greene and Hensher* (2003); *Greene et al.* (2006); *Balcombe et al.* (2011); *Londoño Cadavid and Ando* (2013). The MXL allows for individual level heterogeneity by estimating a distribution of parameters as opposed to a fixed coefficient, and the probability that respondent i selects alternative j for choice t is

$$P_{ijt} = \int \frac{\exp(X'_{ijt}\beta)}{\sum_{h \in J} \exp(X'_{ijt}\beta)} f(\beta|\theta) d\beta. \tag{4}$$

The choice probabilities of the MXL model therefore are weighted averages of the observable component of utility. The weights are determined by the density $f(\beta|\theta)$, where θ are the distributional statistics such as the mean and variance that are estimated from the data. There is no closed form for the parameters in the model and therefore the estimates are approximated through numerical simulation (*Train*, 2009). We model all attributes as normally distributed random parameters with the exception of cost, which is distributed lognormally and multiplied by -1 in order to restrict the cost to the negative domain. Restricting the cost parameter ensures well-behaved moments for the distribution of the MWTP, which is the ratio of the attribute to the cost parameter.

3.2 Benefit Transfer Tests

Given the climatic and, in some cases, attitudinal differences between Sydney and Melbourne, we conduct two benefit transfer tests to assess whether the values elicited in the two cities

[1] The independence-of-irrelevant-alternatives assumption states that the preferences between two choices should not depend on a third choice. In our setting the probability of choosing hypothetical project A over the status quo should not depend on whether a second hypothetical project is available.

[2] We do estimate the conditional logit model. The results are both quantitatively and qualitatively similar to the MXL results, and are available from the authors upon request.

are comparable. The first benefit transfer method tests for the equality of the MWTP for specific attributes of stormwater management using the complete combinatorial approach of *Poe et al.* (2005). The MWTP is calculated by dividing each of the attributes by the exponentiated cost coefficient, since cost is distributed lognormal.[3]

$$MWTP_i = \frac{\beta_{attribute_i}}{exp(\beta_{cost})} \tag{5}$$

Since MWTP is a nonlinear combination of coefficient estimates we estimate the distribution of MWTP for each of the attributes through Krinsky-Robb (KR) parametric bootstrapping (*Krinsky and Robb*, 1986) with 1,000 draws. We present results of the median of the MWTP distribution, similar to *Londoño Cadavid and Ando* (2013).[4] We also use the KR bootstrapping method to estimate 95% confidence intervals which are the 2.5th and 97.5th percentiles of the distribution of KR draws.

Poe et al. (2005) developed a statistical test to assess if MWTP for attributes varies systematically across sites by utilizing the individual draws from the KR bootstrapping method. The complete combinatorial test replicates the first draw for Melbourne 1,000 times and subtracts each of the 1,000 draws from Sydney. We then repeat this procedure for each of the 1,000 draws for Melbourne, resulting in $1,000 \times 1,000$ calculated differences. The proportion of the differences less than zero has the interpretation of the p-value for a one-sided test. Formally the test for each attribute is conducted by,

$$Dif_{i,j} = MWTP_{M,i} - MWTP_{S,j} \ \ \forall i = 1, ..., m \ \ j = 1, ..., s \tag{6}$$

where $MWTP_{M,i}$ is the i^{th} KR draw for the MWTP for the attribute estimated using the Melbourne sample. $MWTP_{S,j}$ is the j^{th} KR draw for the MWTP for the attribute estimated using the Sydney sample. $Dif_{i,j}$ is the difference in MWTP between the i^{th} draw from Melbourne and the j^{th} draw from Sydney, and m and s are the number of draws for Melbourne and Sydney respectively. Thus, for each attribute, $Dif_{i,j}$ is an $m \times s$ empirical distribution of differences, which is used to generate the p-values of the hypothesis test.

The next benefit transfer test determines whether the compensating surplus is equal across the two study sites. Compensating surplus is the dollar value of the benefits from a hypothetical project, defined as some combination of the attributes, relative to the status

[3]The traditional MWTP is $-\frac{\beta_{attribute_i}}{\beta_{cost}}$, however, since we first multiplied the cost coefficient by -1 we do not need to multiply the ratio of the coefficients by -1.

[4]We prefer using the median MWTP as our parameter of interest because the median provides more conservative estimates of the central tendency of the MWTP distribution than the mean, which is sensitive to very low values of the cost parameter that appears in the denominator of MWTP.

quo. For example, a hypothetical project could improve stream health to a medium level, provide recreation amenities, and lower summer temperature, but not reduce the risk of flooding or remove any water restrictions.

We use a benefit transfer method developed by *Morrison et al.* (2002) that tests whether differences in compensating surplus between Melbourne and Sydney are statistically significant. Our choice set has five attributes; three of the attributes have three levels and two have two levels, resulting in $3^3 \times 2^2$ (108) possible combinations of attribute levels. We select a one-ninth subset (12) of the full set of possible combinations to conduct benefit transfer tests following *Morrison et al.* (2002) and *Interis and Petrolia* (2016). Selecting a random subset of combinations reduces the chance that the hypothesis tests depend on the selected combination of attributes. Contrary to *Morrison et al.* (2002), we do not include alternative specific constants (ASCs), and their interaction with demographic variables in our calculation of compensating surplus. We believe omitting ASCs is appropriate for two reasons. Firstly, including ASCs assumes that unobserved preferences for projects are equal in the two locations. Stormwater management is conducted at the local level and the objectives can be achieved with a wide variety of projects (green roofs, rain gardens, cisterns, permeable pavement, etc). These different types of projects can vary in their unobserved benefits (i.e. those not captured within our attributes), and thus the assumption of equality of unobserved features is not likely to hold in our setting. In fact, *Morrison et al.* (2002) state, "In contexts where wetlands are likely to differ substantially in the unobserved aspects, it may be prudent to rely solely on implicit prices when using benefit transfer."[5] Secondly, as shown in Table 1 the samples in Melbourne and Sydney are relatively balanced on observable demographic characteristics.

4 Results

Our first set of results describe attribute-specific preferences, while taking into account the effect of attribute uncertainty. As described in Section 2, we introduce uncertainty into two attributes, water restrictions and stream health, by designating the different probabilities of success. This is to account for the fact that even the best designed project cannot necessarily deliver the intended level of services at all times. For example, when there is an extreme drought, water restrictions may need to be imposed even in the presence of a stormwater harvesting project.

Table 2 presents the MXL models for the pooled population with different treatments of

[5]Wetlands was the project they examined, which can be replaced with the appropriate project or policy being valued. In our setting, for example, "wetlands" should read "stormwater management".

attribute uncertainty. The level of each certain attribute (all attributes except stream health and restrictions) is modeled as a dummy variable equal to one if that attribute-level is present for a given alternative within a choice set. The coefficients presented are the means of the randomly distributed parameters. The standard deviations are suppressed to save space and are available upon request. Standard errors clustered at the respondent level are presented below the coefficients in parentheses. The coefficients represent the impact of that variable on the respondent's utility; respondents prefer attributes with positive coefficients. We pool recreation medium and recreation high into one attribute in the econometric model. All models also include council-specific alternative specific constants (ASCs) for the status quo that capture local preferences for conducting any project relative to the status quo. The ASCs are suppressed to save space.

Column (1) in Table 2 presents the MXL model assuming that all attributes are achieved with 100% probability. Column (2) replaces uncertain attributes with their expected probability of success. The specification in column (2) assumes that respondents are risk-neutral: an attribute that is achieved 40% of the time generates 40% of the utility attributes achieved with certainty. Examining the differences between columns (1) and (2) shows that not accounting for probabilistic attributes biases the coefficients towards zero. All of the attributes are larger in column (2) compared to column (1), with the exception of Restrictions 3,4, which is almost unchanged compared to column (1). The results indicate that the respondents are accounting for the attribute risk in their decisions.

Columns (3) and (4) of Table 2 investigate whether respondents exhibit nonlinear risk attitudes. In the case of risk aversion, individuals gain less utility from a risky attribute than from the expected value of the attribute achieved with certainty, such that an attribute that is achieved 40% of the time will generate less than 40% of the utility of the same attribute being achieved with certainty. Our first approach of modeling risk aversion is to interact the attributes with a dummy variable if the probability is less than one. This assumes that respondents apply a common discount to all attributes achieved with probability less than one. Column (3) presents the results of the dummy variable for risk without accounting for the lower probabilities in the base level of the attributes; we simply augment the model presented in column (1) with the risk dummies. Both of the risk variables are negative and statistically significant, indicating that respondents prefer attributes achieved with certainty. Column (4) adds the risk dummy variables to the model presented in column (2) that accounts for attribute uncertainty, but assumes risk neutrality. In column (4) the stream risk dummy is essentially zero, and the restrictions risk dummy is significant at the 10% level. These results show that, conditional on the attribute probabilities, the respondents are risk averse with respect to lifting water restrictions but not for improving stream health.

While the results in Table 2 show a small degree of risk aversion, we will use the model presented in column (2) as our preferred specification. The coefficients measure the preferences for attributes when achieved with certainty, which is useful when generating welfare measures. Additionally, the model in column (2) has the best fit as indicated by the Akaike and Bayesian Information Criteria (AIC & BIC). The respondents do not value all the attributes of stormwater management equally. Respondents have statistically significant positive preferences for flood protection, the removal of water restrictions, improved stream health, and cooler temperatures. The preference for improved recreation is not statistically significant. With the exception of stream health, none of medium levels of the other attributes are statistically significant. All the council-specific ASCs, which are not shown in the table, are negative and statistically significant, indicating that respondents prefer a water management project to the status quo, all else being equal.

Next, we estimate the model separately for both Melbourne and Sydney using our preferred specification of the linear model for uncertain attributes (Table 2 column (2)). The results are presented in Table 3, with the preferred specification using the pooled sample for reference. Based on the parameters in the choice model, the preferences appear stable across Melbourne and Sydney. Although the coefficients between the two models are not directly comparable, most of the coefficients that are statistically significant in Melbourne are also significant in Sydney.[6] The relative ranking of the attributes is similar for Melbourne and Sydney.

In order to contextualize the parameters from the choice model, we quantify the benefits of stormwater management via green infrastructures in dollar terms. We generate two relevant values: the MWTP for the individual attributes, and the compensating surplus from implementing a hypothetical project defined by a combination of attributes. In order to gauge the stability of preferences for stormwater management across urban areas in a way that is robust to issues of scale, we conduct two formal benefit transfer tests based on each of these metrics as described above.

4.1 Marginal Willingness to Pay

Table 4 shows the estimates of the MWTP, as shown by equation 5. The MWTP represents the annual value per household per year of the specific benefits from stormwater management. The first and second columns show the median MWTP for Melbourne and Sydney respectively with the 95% confidence intervals using the KR method shown in parenthe-

[6]The mixed logit models are identified through a normalization of the scale term, which is specific to each unique model and dataset. Since the coefficients are normalized by a different scale term in each model they are not directly comparable.

ses. For the Melbourne sample, the MWTP for maximally improved stream health (A$234) and eliminating exposure to water restrictions (A$155) are statistically significant at the 95% level. In Sydney, the MWTP is statistically significant for all the attributes except recreation and halving the probability of flash floods.

Examining the difference in medians of the MWTP distributions, presented in column (3), shows that MWTP for the attributes is similar across Melbourne and Sydney. Five of the eight attribute-levels are within A$15 of each other. The major difference is that respondents in Sydney place higher value on removing water restrictions than respondents in Melbourne. Respondents in Sydney also have a relatively higher value for increasing stream health to a moderate level. None of the differences between Melbourne and Sydney are statistically significant based on the complete combinatorial benefit transfer test. The p-values for the test are in the fourth column of Table 4. We conclude that the MWTP for benefits of stormwater management is consistent across Melbourne and Sydney. Since the benefits transfer between the two sites, we also calculate the MWTP based on the pooled sample. With the pooled sample, we are able to use all the data, thus improving the precision of the estimates. The pooled MWTP, shown in the last column of Table 4, represents our preferred estimate of the value of the specific benefits associated with local stormwater management.

There is a large degree of uncertainty in many of the MWTP estimates for both Melbourne and Sydney. In some cases, the lower bound of the confidence interval includes zero. It is likely the benefits transfer, in part, because of the wide confidence intervals associated with each attribute. Yet, the attributes with the largest monetary values are consistently valued positively and are consistent across cities. For both Melbourne and Sydney the lower bound of the 95% confidence interval for the two highest valued attributes, maximum stream health and no restrictions, are well above zero. Additionally, the median MWTP for attributes with confidence intervals that do include zero are also quite similar. In the case of reducing exposure to flood risk (flood half), for example, the median MTWP value is identical. The complete combinatorial benefit transfer test confirms that there is no statistical difference in the estimates. Despite the similarity of the median MWTP and the results of the benefit transfer tests, the wide confidence intervals for many of the attributes do have policy implications as discussed in the conclusion.

4.2 Compensating Surplus

Next we present the compensating surplus, which quantifies the benefits from a combination of the attributes relative to the status quo. Table 5 displays the mean compensating surplus for Melbourne and Sydney, as well as the difference and p-value for the hypothesis test that the difference is equal to zero. The compensating surplus for the average project is approximately 18% higher in Sydney compared to Melbourne. However, this difference is not statistically significant in any of the hypothetical projects or averaged across all selected projects. The last column in Table 5 shows the compensating surplus for the pooled model, with an average value of approximately A$486 per household per year. The consistency of both the implicit prices and the aggregate consumer welfare indicate that the benefits of stormwater management via green infrastructures transfer across Melbourne and Sydney.

4.3 Preference Heterogeneity

As seen in Table 4 the confidence intervals for the MWTP for the attributes are often quite large and several include zero. We examine preference heterogeneity by interacting the attributes with three sets of variables: income, education, and intrinsic preferences. Income and education are relatively straightforward; we simply interact the attributes with a dummy variables indicating high income or high education. The income dummy is equal to one if the respondent self-reported high income and the eduction dummy is equal to one if the respondent completed a post-secondary degree. The intrinsic attributes are dummies indicating an existing predilection to the given attribute. We use the variables presented in Table 1 to generate these interactions. For example, flood protection attributes are interacted with the *Floods* variable that indicates the respondents think a flash flood is likely, have recently experienced a flood, or own flood insurance. The stream health attributes are interacted with *Stream Health*, water restrictions attributes are interacted with *Restrictions*, recreation is interacted with *Recreation*, and Temp -2 attribute is interacted with the *Summer Heat*. It is important to note there is likely correlation between how respondents answer the choice experiment and the various questions related to the attributes. Therefore, we caution interpreting the intrinsic interactions as causal effects and rather wish to highlight the difference in values for a sub-sample that has expressed interest in these attributes.

The heterogeneity regression are reported in Table 6. The columns represent the base regression, as well as the interactions with each of the three variables: income, education, and intrinsic preferences. The interaction terms are captured below the main attributes, where "Variable" is either a dummy for income, education, and intrinsic preferences. Since all the interaction terms are dummy variables, the base coefficients can be interpreted as preferences for the subpopulation where the interaction variable is zero. For example, the base effect for column (3) are the preferences for those without a college degree, and the joint effect of the base coefficient plus the relevant interaction term is the preferences for respondents with a college degree.

For income and education most of the interaction terms are not statistically significant, indicating similar preferences for respondents with different income and education levels. The only term that is significant at the 10% level is recreation for education, indicating that respondents with a post-secondary degree place more value on improved recreation. The results are somewhat stronger for the intrinsic preferences. The self-interested population exhibits stronger preferences for both flood protection and stream health. Interestingly, the interaction between restrictions and intrinsic preferences is negative and reasonably large, although it is not statistically significant. This suggests that respondents who find water restrictions burdensome are not willing to pay to lift them. While the heterogeneity results indicate some degree of preference heterogeneity, the preferences for stormwater management are not statistically different across the subgroups we examine.

5 Conclusion

Using a discrete choice experiment this study estimates the monetary values for non-market benefits associated with stormwater management. We conducted nearly 1,000 personal interviews with homeowners in Melbourne and Sydney, Australia to elicit MWTP for reductions in water restrictions, reductions in flash flooding, improvements in stream health, improvements in recreational and amenity benefits, and cooler summer temperatures. Respondents significantly value four of these attributes: reductions in flash flooding, reductions in water restrictions, improvements in stream health, and cooler summer temperatures. All of the findings relate to the value of *additional* environmental services, given the services already provided.

We compare WTP estimates between the Melbourne and Sydney to evaluate the potential for benefit transfer. Benefit transfer tests indicate that findings are not significantly different between the study areas. This suggests that non-market benefits of stormwater management via green infrastructures are potentially transferable across cities that exhibit differences of a similar range to Melbourne and Sydney. We also quantify the overall value for a project that provides a set of environmental services. The "gold standard" is a project that implements the highest level of environmental services across all attributes. We find that households are willing to pay A$799 per household per year for a "gold standard" project, with the 95% confidence interval ranging from -A$13 to A$1,611 per household per year. For a project that delivers the highest level of environmental services for only attributes that were significantly valued, we find that households are willing to pay A$737 per household per year, with the 95% confidence interval ranging from A$5 to A$1,470. Though this interval is large, the results reveal that people value the environmental services associated with local stormwater management.

Despite those monetary benefits and increasing advocacy for water sensitive urban design by researchers and environmental regulators (*Ando and Freitas*, 2011), there is still plenty of opposition to broader adaptation of local stormwater infrastructures (*Braden*, 2011). Our results can help inform decision-makers at different levels of governance and provide quantitative arguments concerning the societal benefits of stormwater infrastructure investments. It should be noted that many of the confidence intervals are quite large, indicating the uncertainty in the estimates. Policy makers who utilize these values in benefit-cost analysis should conduct sensitivity analysis for MWTP values other than the median. For example, would green infrastructure projects still pass a benefit cost test using non-market values one-half of the median MWTP or at the lower bound of the 95% confidence interval of MWTP? Moreover, non-market valuation should be one of the multiple inputs to benefit-cost analysis and decisions ought to be considered based on the suite of evidence available including but not limited to engineering estimates of changes in environmental outcomes at a given site.

At the more aggregate level (federal, state, or city), decisions on long-term urban water management policies often involve some form of societal benefit-cost analysis that compares the net benefits of different types of urban water infrastructure investment. Monetary benefits, such as those estimated in this study, can help identify the infrastructure projects that yield the highest societal net benefits for the population in a certain area. For example, if all of the approximately 1.5 million households in Melbourne and Sydney were delivered "gold standard" level local stormwater management projects, there is potential to generate A$1.2 billion per city per year in benefits. This dollar value is conditional on current levels of service. Over time, implementing more stormwater projects would improve the baseline for future improvements and would subsequently reduce the benefit from additional projects, resulting in lower WTP estimates.

Though these benefits may initially seem high, they are roughly consistent with other expressed values for water-related benefits. For example, the public-private partnership in a desalination facility costs Melbourne A$610 million per year (Melbourne Water, 2013). While currently not in use, the plant provides the benefit of water security.

At the community level (for example, a new residential development project), implementing stormwater management via green infrastructures often shifts the responsibility for stormwater management from the local government to developers and homeowners (*Braden*, 2011). Developers and private homeowners unsure about benefits of those new technologies might be reluctant to invest in green infrastructures to manage stormwater, instead preferring to stick to the status quo.

At any level of governance, non-market benefits are an important component to a benefit-cost analysis, but are not the only component. Because of the wide degree of uncertainty in the estimates, non-market values should be a component of valuation, but should not likely be used as an exclusive driver of project choice.

Our results show that residents in established neighborhoods value increases in the ancillary environmental services of water sensitive urban design practices, beyond the service of flood protection. This reveals that investment in local stormwater management infrastructure can yield large benefits in the form of private and local public goods. Our results provide monetary values for these non-market environmental benefits that can be used by planners and developers in establishing a business case for the implementation of water sensitive urban design practices.

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Figure 1: Introduction Letter

MONASH University

CRC for Water Sensitive Cities

Your household has been randomly selected to take part in an **important study about water.**

The interviewer will assist you with completing the study. It will take approximately **25 minutes** to complete.

Participation is **voluntary and confidential**. Your details will not be stored with your responses and will not be passed on to any third party. You will not receive any phone calls or junk mail as a result of participating.

Details of study

Title of study

Analysis of how individuals make decisions with respect to water management in Australia.

Benefits of the study

The findings from this study will be used to help design **water management policies** in your community and Australia in general. You will also receive a monetary amount to thank you for participating, in addition to a certain amount being contributed to a water project in your local community.

What you will need to do

There are three short components to this study:

One and two: Activities to examine how important the various benefits associated with different ways of managing water are to you and your community.

Three: A short questionnaire.

Researchers:

This study is being conducted by I-view on behalf of Monash University researchers Prof. Lata Gangadharan, Dr. Anke Leroux and Dr. Paul Raschky and the CRC for Water Sensitive Cities, Prof. Tony Wong.

To find out more:

For more **information** on the study or to be informed of the findings after the project is complete, please contact **Professor Lata Gangadharan**, Department of Economics, Monash University

☎03 9905 2345
✉ lata.gangadharan@monash.edu

If you have any **concerns** about how this study is conducted, please contact the **Executive Officer** at the Monash University Human Research Ethics Committee, quoting reference number: CF12/2511 – 2912001358:

☎03 9905 2025
✉ muhrec@monash.edu

An Australian Government Initiative

CRC AUSTRALIA

Figure 2: Explanation Document - part 1

Explanation for Salient (without Risk) Group

ACTIVITY 1

Local water management initiatives can carry a number of benefits for residents. These benefits are improvements in five key attributes, which will be explained now. Note that the improvement in two attributes, water restrictions and stream health, can be subject to uncertainty due to climatic conditions. We have therefore included pie-charts (circles) that illustrate the likelihood of a successful improvement in these attributes. The implementation success of the remaining three attributes can be considered as certain.

[USE INSTRUCTIONS CHOICE SET 1 HERE AND EXPLAIN DIFFERENT ATTRIBUTE LEVELS]

We want to understand how important these different benefits are to you. You will now be asked to make a series of 10 choices between the current situation (Status Quo) and alternative options, which involve improvements in some or all of the attributes explained above.

Example: Here is an example of one choice set that you may see on the screen.

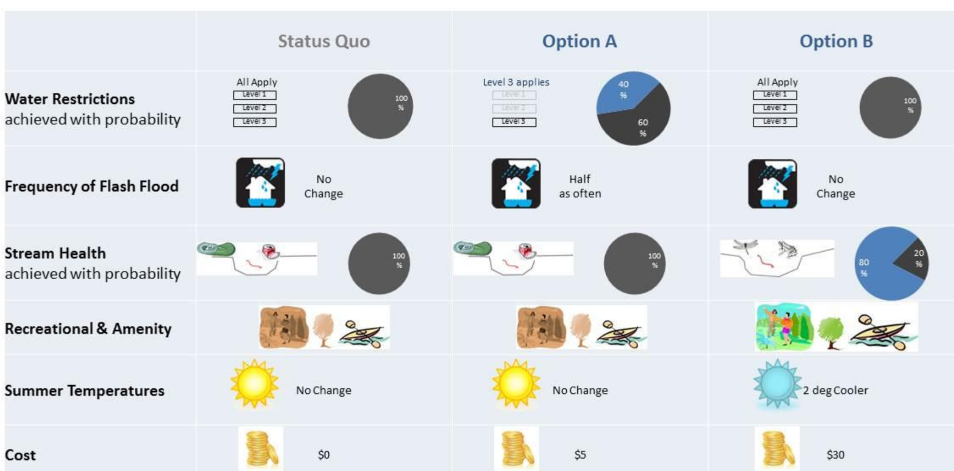

Figure 3: Explanation Document - part 2

- You can choose between the **Status Quo** option, **Option A** and **Option B** and you can only choose 1 option per choice set.
- The **Status Quo** option will mean:
  - No change in the current situation of water management in your council area.
  - The costs to you are zero.
- **Option A** offers **two** benefits compared with the **Status Quo**:
  - One: there is a 40% chance (as indicated by the blue area in the circle) your neighbourhood will be exempt from all future [Stage 1 and 2 [IF VIC], Level 1 and 2 [IF NSW]] water restrictions that are imposed. But, a 60% chance (as indicated by the grey area in the circle) remains that all water restrictions will apply as they do currently.
  - Two: the number of flash floods occurring in your neighbourhood will be reduced by half.
  - Choosing **Option A** would increase your annual water bill by $5. So, if this choice set were selected for payment today, $5 would be taken off your total interview earnings.
- **Option B** compared with the **Status Quo** this option
  - Carries no benefits in terms of improved water security or reduction in the frequency with which flash floods occur.
  - But, there is an 80% chance (as indicated by the blue area in the circle) that the condition of your local stream improves to medium health. A 20% chance (as indicated by the grey area in the circle) remains that there will be no improvement to local stream health compared with its current condition.
  - There are recreational and amenity benefits from keeping all local sportsgrounds and parks green and all local street trees watered during dry months.
  - Under **Option B** your local area would also be about 2 degrees Celsius cooler during the hot summer months.

Figure 4: Explanation Document - part 3

  - **Option B** would add $30 to your annual water bill. If this choice set was randomly selected for payment today and you had chosen **Option B**, $30 would be deducted from your interview earnings.
- Which Option would you choose? The **Status Quo**, **Option A** or **Option B?**

Your choices in this activity will help decision making on how water is managed within the community and Australia in general.

PLEASE TAKE IN TO CONSIDERATION THAT THERE ARE NO CORRECT OR WRONG DECISIONS. THESE DECISION PROBLEMS ARE NOT DESIGNED TO TEST YOU.

However, we are interested in your truthful answer about your value for these different benefits. Therefore, you should make your decisions knowing that one of the 10 choice sets will be randomly drawn by you and your final payment from this survey will be your earnings so far minus the cost of the option you have selected. Your final pay-out will always be positive but can range between $0.60 and $53.10. The full amount of money subtracted from your earnings will be donated by CRC and Monash University towards [INSERT COUNCIL WATER PROJECT], which is a project in your local area. The total amount collected from all participants will be published in [INSERT LOCAL PUBLICATION AND ISSUE DATE].

After you have completed all activities in this survey, the interviewer will ask you to randomly draw a number between **1 and 10**. This number will indicate which choice set is selected for payment and the cost of your chosen option will be deducted from your interview earnings and be put towards [INSERT COUNCIL WATER PROJECT].

In this example, **your final earnings** would have been equal to the following:

If you had chosen the Status Quo:

Your final earnings: = initial payment– $0.

If you had chosen Option A:

Your final earnings: = initial payment– $5.

If you had chosen Option B:

Your final earnings: = initial payment– $30.

Do you have any questions?

Table 1: Balance on Observables

	Pooled	Melbourne		Sydney		Melbourne-Sydney	
	Mean	Mean	N	Mean	N	Difference	p-value
Demographics							
Low Income	0.25	0.25	455	0.25	462	0.00	0.954
Medium Income	0.64	0.64	455	0.65	462	-0.01	0.757
High Income	0.11	0.11	455	0.10	462	0.01	0.688
Education	0.40	0.46	485	0.35	488	0.11	0.001
Female	0.46	0.46	486	0.47	495	-0.02	0.617
Children	0.60	0.56	480	0.65	494	-0.09	0.162
Age	54.48	54.23	485	54.73	494	-0.51	0.626
Environmental Preferences							
Floods	0.57	0.71	486	0.44	495	0.27	0.000
Restrictions	0.11	0.09	486	0.14	495	-0.05	0.020
Stream Health	0.35	0.43	486	0.27	495	0.15	0.000
Recreation	0.37	0.36	486	0.38	495	-0.02	0.523
Summer Heat	0.53	0.70	483	0.36	490	0.34	0.000
Joint Significance							23.12

Notes: All variables except Children and Age are indicator variables and the means are sample proportions. Children is the number of children and Age is measured in years.

Table 2: Base Regressions Incorporating Uncertainty

	(1) Base	(2) Risk Neutrality	(3) Base+Risk Dummy	(4) Risk Aversion
Flood Half	0.034	0.042	0.042	0.042
	(0.041)	(0.042)	(0.042)	(0.043)
Flood Never	0.059	0.132**	0.102*	0.126**
	(0.044)	(0.045)	(0.045)	(0.045)
Restrictions 3,4	0.086	0.073	0.196***	0.084
	(0.045)	(0.049)	(0.055)	(0.050)
No Restrictions	0.201***	0.296***	0.342***	0.321***
	(0.042)	(0.048)	(0.053)	(0.049)
Stream Medium	0.107*	0.160**	0.192**	0.172**
	(0.052)	(0.055)	(0.059)	(0.056)
Stream High	0.218***	0.363***	0.311***	0.370***
	(0.046)	(0.047)	(0.053)	(0.049)
Recreation	0.016	0.072	0.059	0.078
	(0.041)	(0.042)	(0.043)	(0.043)
Temp -2	0.071*	0.080**	0.075**	0.089**
	(0.028)	(0.028)	(0.028)	(0.029)
Log Cost	-6.782***	-6.742***	-6.993***	-7.301***
	(0.711)	(0.486)	(0.338)	(0.524)
Stream Risk			-0.087**	0.026
			(0.032)	(0.030)
Restrictions Risk			-0.164***	-0.069*
			(0.037)	(0.028)
BIC	22704	22618	22687	22667
AIC	22539	22454	22507	22488
Observations	12,954	12,954	12,954	12,954
Individuals	981	981	981	981

Notes: The coefficients presented are the mean of the random distributions, except for Status Quo which is modeled as a fixed coefficient. All attributes are normally distributed except Cost, which is lognormally distributed. Standard errors clustered at the respondent level are presented in parentheses. The columns designate different samples. *** p<0.01, ** p<0.05, * p<0.1

Table 3: Mixed Logit Regression Results by City

	(1) Both	(2) Melbourne	(3) Sydney
Flood Half	0.042	0.034	0.034
	(0.042)	(0.057)	(0.064)
Flood Never	0.132**	0.132*	0.132*
	(0.045)	(0.066)	(0.063)
Restrictions 3,4	0.073	0.007	0.139*
	(0.049)	(0.068)	(0.070)
No Restrictions	0.296***	0.234***	0.365***
	(0.048)	(0.067)	(0.069)
Stream Medium	0.160**	0.130	0.178*
	(0.055)	(0.075)	(0.078)
Stream High	0.363***	0.362***	0.350***
	(0.047)	(0.065)	(0.069)
Recreation	0.072	0.085	0.065
	(0.042)	(0.062)	(0.060)
Temp -2	0.080**	0.068	0.082*
	(0.028)	(0.039)	(0.041)
Log Cost	-6.742***	-6.519***	-6.496***
	(0.486)	(0.498)	(0.371)
BIC	22618	11403	11327
AIC	22454	11267	11191
Observations	12,954	6,480	6,474
Individuals	981	486	495

Notes: The coefficients presented are the mean of the random distributions, except for Status Quo which is modeled as a fixed coefficient. All attributes are normally distributed except Cost, which is lognormally distributed. Standard errors clustered at the respondent level are presented in parentheses. The columns designate different samples. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 4: Marginal Willingness-to-Pay Values for Attributes

Attribute	Median_M (95% CI)	Median_S (95% CI)	Difference	p-value	Median_P (95% CI)
Flood Half	22 (-81, 274)	22 (-57, 201)	0	.5	34 (-49, 291)
Flood Never	83 (-40, 573)	85 (1, 370)	-2	.505	104 (9, 746)
Stream Medium	84 (-61, 479)	117 (13, 433)	-33	.619	131 (12, 814)
Stream High	234 (86, 1283)	229 (111, 746)	5	.475	297 (121, 1599)
Restrictions 3 & 4	5 (-183, 224)	90 (0, 383)	-85	.863	58 (-49, 464)
No Restrictions	155 (29, 987)	242 (113, 815)	-87	.727	244 (94, 1450)
Recreation	54 (-84, 394)	41 (-35, 244)	13	.43	58 (-27, 421)
Temp -2	45 (-25, 314)	54 (2, 211)	-9	.573	65 (11, 379)

Notes: The first two columns presents the median MWTP for Melbourne and Sydney respectively, with the 95% confidence created using the Krinsky-Robb method in parentheses. The third column shows the difference in the median MWTP between Melbourne and Sydney, and the fourth shows the p-value from the full combinatorial benefit transfer test of Poe et al. (2005). The final column shows the MWTP for the pooled model, combining the data from Melbourne and Sydney.

Table 5: Compensating Surplus Values and Transfer Error

Project Valuation

	Melbourne	Sydney	Difference	(p-value)	Pooled
Hypothetical Project 1	383	501	-119	0.69	566
Hypothetical Project 2	598	658	-61	0.88	799
Hypothetical Project 3	215	238	-23	0.91	300
Hypothetical Project 4	531	594	-62	0.87	723
Hypothetical Project 5	286	395	-109	0.70	438
Hypothetical Project 6	132	212	-81	0.64	226
Hypothetical Project 7	377	444	-67	0.83	534
Hypothetical Project 8	444	509	-65	0.85	610
Hypothetical Project 9	220	330	-110	0.65	362
Hypothetical Project 10	174	276	-102	0.64	295
Hypothetical Project 11	354	421	-67	0.81	498
Hypothetical Project 12	393	362	31	0.91	480
Average Project	342	412	-69	0.80	486

Project Attributes

	Restrictions	Flooding	Stream Health	Recreational	Cooler Temps
Hypothetical Project 1	None	Never	Medium	Status quo	Yes
Hypothetical Project 2	None	Never	High	Improved	Yes
Hypothetical Project 3	Status quo	Half	Medium	Improved	Yes
Hypothetical Project 4	None	Half	High	Improved	Yes
Hypothetical Project 5	Stage 3,4	Never	Medium	Improved	Yes
Hypothetical Project 6	Stage 3,4	Half	Status quo	Improved	Yes
Hypothetical Project 7	Stage 3,4	Half	High	Improved	Yes
Hypothetical Project 8	Stage 3,4	Never	High	Improved	Yes
Hypothetical Project 9	Stage 3,4	Half	Medium	Improved	Yes
Hypothetical Project 10	Stage 3,4	Half	Medium	Improved	Status quo
Hypothetical Project 11	Stage 3,4	Status quo	High	Improved	Yes
Hypothetical Project 12	Status quo	Never	Status quo	Improved	Status quo

Notes: The compensating surplus is calculated based on the linear combination of attributes normalized by the median cost coefficient. The standard errors are calculated via the delta method. The p-value is for the hypothesis test that the mean compensating surplus for Melbourne minus the mean compensating surplus for Sydney is equal to zero. Hypothetical projects are determined by a one-ninth subset of all possible combinations of attributes. The pooled compensating surplus is calculated using the estimates for the full sample.

Table 6: Preference Heterogeneity

	(1) Base	(2) Income	(3) Education	(4) Intrinsic
Flood Half	0.042	0.042	0.009	-0.045
	(0.042)	(0.045)	(0.050)	(0.053)
Flood Never	0.132**	0.117*	0.104*	0.045
	(0.045)	(0.048)	(0.052)	(0.055)
Restrictions 3,4	0.073	0.065	0.042	0.104
	(0.049)	(0.053)	(0.060)	(0.054)
No Restrictions	0.296***	0.305***	0.262***	0.320***
	(0.048)	(0.051)	(0.057)	(0.050)
Stream Medium	0.160**	0.124*	0.121	0.052
	(0.055)	(0.058)	(0.067)	(0.067)
Stream High	0.363***	0.333***	0.313***	0.241***
	(0.047)	(0.051)	(0.059)	(0.058)
Recreation	0.072	0.056	-0.000	0.051
	(0.042)	(0.058)	(0.053)	(0.050)
Temp -2	0.080**	0.082**	0.113**	0.031
	(0.028)	(0.030)	(0.036)	(0.043)
Log Cost	-6.742***	-6.481***	-6.742***	-7.265***
	(0.486)	(0.421)	(0.596)	(0.421)
Flood*Variable		0.113	0.059	0.147**
		(0.108)	(0.064)	(0.055)
Restrictions*Variable		-0.109	0.058	-0.216
		(0.128)	(0.079)	(0.117)
Stream*Variable		-0.025	0.067	0.278**
		(0.145)	(0.086)	(0.093)
Recreation*Variable		0.079	0.185*	0.088
		(0.131)	(0.076)	(0.067)
Temp -2*Variable		-0.043	-0.065	0.055
		(0.083)	(0.052)	(0.057)
BIC	22618	21588	22728	22492
AIC	22454	21387	22527	22290
Observations	12,954	12,269	12,954	12,854
Individuals	981	917	981	973

Notes: The coefficients presented are the mean of the random distributions, except for Status Quo which is modeled as a fixed coefficient. All attributes are normally distributed except Cost, which is lognormally distributed. Standard errors clustered at the respondent level are presented in parentheses. The columns designate different samples. *** p<0.01, ** p<0.05, * p<0.1