Evaluating residents' preferences for remediation technologies: A choice experiment approach

Elisabeth Huynh[1,*], Jorge E. Araña[2], Jason Prior[3,**]

[1]Institute for Choice, University of South Australia, Australia
[2]Institute of Tourism and Sustainable Economic Development (TiDES), University of Las Palmas de Gran Canaria, Spain
[3]Institute for Sustainable Futures (ISF), University of Technology Sydney, Australia
*** Correspondence to:** E. Huynh, Institute for Choice, University of South Australia, Level 13, 140 Arthur Street, North Sydney, NSW 2060, Australia. Tel +61 8 8302 1648
E-mail: Elisabeth.huynh@unisa.edu.au
**Correspondence to: J. Prior, Institute for Sustainable Futures, University of Technology Sydney, PO Box 123, Broadway, New South Wales 2007, Australia.

Highlights

- Framework for evaluating remedial technologies using residents' preferences
- Choice experiment identifies residents' preferences for technology types
- Identifies that preferences for technologies are affected by their intrinsic values

Abstracts

The choice of technologies used to remediate contaminated environments are increasingly made through engagement with a multitude of stakeholders including affected residents. Despite this, little is known about how residents perceive remediation technology applications. In this study a choice experiment is designed to explore ways of understanding and measuring residents' preferences for different remediation technologies approaches using a sample of 944 residents in New South Wales, Australia. Analysis reveals that the residents' acceptability of remediation technologies can be explained by both the efficacy of the technology in improving the environmental quality of the community, and the reputational value of the technology. In particular it is found that residents prefer Monitor Natural Attenuation and Bioremediation to other remediation technologies. In particular they are willing to pay an increase in yearly taxes of $44.60 and $41.15 respectively for implementing such technologies instead of alternative remediation technologies like Chemical remediation.

Graphical Abstract

- Figure 1 around here-

Keywords: Discrete Choice, Environmental valuation, Choice modelling, Environmental remediation, Contamination, Decision making.

1. Introduction

Over the past few decades, programs and policies have begun to encourage more inclusive and participatory approaches to evaluate technologies that can be used to remediate contaminated environments. These participatory approaches involve a multitude of stakeholders including residents, and in particular those residents affected by environmental contamination (Bardos et al., 2011b; Benn et al., 2009; Brown and Benn, 2009; Cole, 2011; Hillier et al., 2009; National Environment Protection Council, 1999; Pollard et al., 2004; Surf-UK, 2009; U.S. Sustainable Remediation Forum, 2009; Cooperative Research Centre for Contamination Assessment and Remediation of the Environment, 2014b; EnHealth, 2012).

When combined with other stakeholders like remediation experts, residents' views provide an alternative knowledge that may be useful to the evaluation of remedial technologies (Huntington, 2000; Raymond et al., 2010; Ribeiro and Lima, 2016; Prior & Rai, 2017). This is based on growing recognition that it is impossible for any single perspective, discipline, or knowledge to monopolise the answers and solutions to complex environmental challenges, like contamination, and that the identification of solutions to those environmental challenges, like the selection of remedial technologies, requires plural knowledges (Reid et al., 2013; Evans and Plows, 2007). Acknowledgment of these alternative knowledges within the remediation context has been motivated by remediation policies that acknowledge the value of residents' perceptions of risk (Cooperative Research Centre for Contamination Assessment and Remediation of the Environment, 2014b; EnHealth, 2012; National Environmental Protection Council, 2011) and more recently their perceptions of benefits (Cooperative Research Centre for Contamination

Assessment and Remediation of the Environment, 2014a; International Organisation of Standardisation, 2015; National Environmental Protection Council, 2011; SuRF Australia et al., 2011) associated with the management and remediation of contaminated environments.

Whilst a growing diversity of decision support tools - cost-benefit analysis, multi-criteria decision analysis, technology selection criteria analysis – are being developed to assist with the transparent processing of the diverse knowledges brought to the evaluation and selection of remediation technologies by multiple stakeholders (Bardos et al., 2011a; Carlon et al., 2007; Critto et al., 2006; Efroymson et al., 2004; Greenberg et al., 2012; Onwubuya et al., 2009; Söderqvist et al., 2015; Steele et al., 2009; Van Wezel et al., 2008), significant challenges still remain. One of these challenges is the identification of tools that can, firstly, be utilised to facilitate the evaluation of remediation technologies by residents who generally have little or no expert knowledge of remediation, and secondly, provide insight into perceptions and preferences that residents utilise when they evaluate remediation technologies. Answering this challenge will help pave the way for residents' perceptions and preferences to be translated to government and companies to help inform the evaluation and selection of remediation technologies for contaminated environments.

This paper presents a choice experiment (CE) that was designed to address this challenge. Whilst CEs have been utilised for various types of environmental valuation, including water usage and marine protection (see e.g., Hoyos, Mariel and Hess, 2015; Justes, Barberan and Farizo, 2014; Can and Alp, 2012), CEs have yet to be investigated as a means for understanding and measuring residents' preferences for different technologies that might be utilised to remediate contaminated environments.

The CE is part of a broader research project, which explored residents' perceptions and acceptance of the application of different types of remediation technologies (For further findings see Prior, 2016; Prior et al., 2017; Prior et al., 2014: Prior & Rai, 2017). In particular, the CE involved, firstly, a series of focus groups with remediation experts, and residents living near contaminated sites, in New South Wales (NSW), Australia, to develop the CE tool, and secondly, a sample of residents living across NSW, who were the respondents to the pilot and final CE survey, a proportion of these respondents were aware of contamination in their local environment. Within the context of the CE remediation technology applications were made up of attributes that were intelligible to residents. These attributes included aspects of the remediation technologies, including type and location of waste, and their different effects on the quality of life of residents, including impacts on human health, access to safe water supply, clean air, gardening, and recreational opportunities. Furthermore, the researchers utilise an attribute for cost of the application of remediation technologies (a willingness to pay measure) to help elicit the value that residents place on the other attributes. The CE involves asking residents to make trade-offs among the application of different remediation technology applications made up of varying combinations of the attributes outlined above, to provide an elicitation of preferences for environmental improvements from the application of remediation technologies that may affect their quality of life, and an elicitation of their acceptance of technology types. Residents' acceptability of technology types in the context of the CE is defined as their willingness to consider the technology type in question as a viable option to remediate a contaminated environment. We distinguish the concept of residents' acceptability from technical feasibility assessments of remediation technologies by experts (e.g. feasibility of a technology due to contaminant, site characteristics, or regulatory requirements). A technology type can be technically feasible yet fail the test of residents' acceptability (Prior, 2016).

The paper is organized as follows: Section 2 describes the CE approach and the proposed valuation framework and analysis for understanding residents' preferences for remediation technology applications. Section 3 presents the design and application of CE surveys. Section 4 presents the results of the CE and Section 5 draws conclusions.

2. CE approach and valuation framework

2.1 Approach

The CE approach here is proposed as an alternative to more conventional revealed preference (RP) models. RP models utilise market data from goods or activities somehow related with the level of environmental quality in the area. Some notable examples come from the analysis of variability of housing prices among high and low contaminated residential areas (Jackson, 2001; Morancho and Bengoechea, 2003), or exploring residents' expenditure levels on mitigation or adaptation measures like water-filter devices or water tanks (De López et al., 2011). The CE model in this study is directly based in designing an active social participation frame in which residents can choose among alternative combinations of remediation technologies involving different costs and levels of effect on residents' quality of life (see Louviere et al., 2000; Hensher et al., 2005).

CE have advantages over market data because they explore scenarios not yet available in the market particularly in the evaluation of non-market goods like environmental quality, enabling us to investigate levels of attributes that do not exist in markets and achieve estimation efficiencies by controlled statistical design of the CE (even when they are perceived levels which are the key drivers of choice). As demonstrated in the example in Figure 1, through the experimental design paradigm, we observe a sample of residents making choices between different remediation policies formed by environmental attribute level bundles (or a package of air quality, water quality, waste management, implementation cost and type of technology). The CE approach can provide disaggregated estimates of direct and cross-attribute elasticities of interest.

- Figure 1 around here-

For the current study, the CE involves a respondent comparing the levels of agreed attributes of various competing alternative remediation technology applications (see for example Figure 2). The respondent is then asked to choose one of these alternatives. The process of choosing among the alternatives is repeated an agreed number of times, each repetition is known as a choice scenario in which each choice situation involves varying the levels of each attribute associated with the different alternatives (as informed by the experimental design). This approach will enable the evaluation of the influence of the set of attributes that represent the items of interest in a CE, which provides the empirical inputs for a discrete choice model, so that parameter estimates can be obtained to indicate the role specific attributes play in determining the choices. Once identified, specific and meaningful levels are attached to each attribute, which are then systematically varied in the CE by the researcher.

2.2 Valuation model framework

The CE in this study is designed to explore ways of understanding and measuring residents' preferences for different remediation technology applications. There are two main difficulties in measuring and understanding residents' preferences for remediation technology applications in a way that can be employed to guide decision makers.

The first challenge when investigating residents' views about remediation technologies is the low level of their environmental understanding (Bauer et al., 2004). For instance, several authors have found that aquatic systems are often poorly understood by non-experts (Fisher and Young, 2007). Yet, despite an awareness of the challenges involved in communicating environmental concepts in resident surveys in general and in CEs in particular, the scrutiny given to indicator use and interpretation within the environmental literature has not been matched in the economics literature. This has frequently led to a disparity between indicators considered valid in environmental science and those applied in stated preference (SP) valuation methods.

To address these ongoing complex challenges, we propose to overcome these issues by decomposing residents' preferences for remediation technologies into two components. The first component measures the impact of increases in the technical efficiency of each remediation technology (e.g., its ability in improving environmental quality) on its acceptability by residents. The second component accounts for the stigma/reputation attached to each remediation technology by residents, and cannot be explained.

The process can be formally modelled in the following way. Let´s assume that a community needs to choose among K remediation technologies to be applied to a specific contaminated site. Let's define *Cj* as the monetary cost of implementing each remediation technology *j* of the *K* available technologies. The index *j* encompasses remediation technologies like bioremediation, thermal remediation, physical remediation, among others. The conventional rationale is to let the experts decide which technology or combination of technologies should be employed and how much money should be spent on such technologies. Under this approach, the problem turns into a mere technical decision based on choosing the best cost-effective combination of remediation technologies.

If one aims at considering perceived social benefits of technologies, an extended model needs to be specified and estimated. Extending ideas of valuation by characteristics originally developed by Lancaster (1966), the residents' acceptability level for a specific remediation technology *j* can be seen as a function of the impacts of the applications on different environmental aspects of the community $Q_j = (Q_{j1}, Q_{j2},\ldots,Q_{jL})$. Where *L* represents the number of factors represented by *Q* such as air quality, water quality, and waste management. Based on the issues defined previously (e.g. poor understanding of environmental concepts among residents and difficulty of communicating environmental changes to them), we propose an extended definition of the utility function in which residents can also associate an intrinsic valuation (attachment) to specific technologies that are not explained by the effectiveness of its application. This effect can be called "stigma/reputation effect" of the technology and it can be measured by including a constant specific parameter for each technology in the utility function, that is,

$$U_j = \alpha_j + \theta * Q_j + \epsilon_j = \beta_j X_j + \epsilon_j \quad (1)$$

Where $\theta * Q_j$ collects the impact of any improvement on the technical features of the remediation technologies to improve the different environmental dimensions on residents' valuation; and α_j is the constant specific parameter for each technology and collects the stigma/reputation value of each technology. In other words, α_j accounts for the portion of the residents' valuation of a technology j that cannot be explained by its ability to recover initial levels of environmental quality. The random error term, ϵ_j, represents the unobserved portion of the utility function. For the sake of simplification in presenting the model, we can define $\beta_j = (\alpha_j + \theta)$ and X_j collecting all perceived social benefits of remediation technology including stigma/reputation effects.

2.3 Analysis

Recent statistical model developments in CEs (e.g. Keane and Wasi, 2013; Hess and Train, 2017) show that there are different models that can be employed to represent the data, and that some models are more appropriate than others for capturing heterogeneity across the sample. Among these alternatives, the most popular option for analyzing choice data comes from the use of the Mixed logit model (MIXL) (McFadden and Train, 2000). Formally MIXL models can be represented as:

$$U_{ij} = (\beta + \eta_i)X_{ij} + \epsilon_{ij} \qquad (2)$$

This specification implicitly accounts for unobserved individual preference heterogeneity in the sampled resident population by assuming that the error term, ϵ_{ij}, represents the standard multinomial logit specification (i.e. extreme value) and β_i is the mixed distribution which is a collection of variables that are independent and drawn from a specific statistical distribution, that is, $\beta_i = (\beta + \eta_i)$, where β represents the mean value of individuals' preferences across the resident population, and η_i is the deviation from the mean of the preferences of an individual i. McFadden and Train (2000) prove that, by modifying the specification of the mixed function, the MIXL is consistent with any utility maximization problem employed by the decision maker when making a choice among remediation technology applications. The randomness of the parameters can be tested by the Lagrange Multiplier test, as proposed by McFadden and Train (2000), and the t-statistic of the deviation of the random parameter. Whereas, the distribution of the parameter can be tested following Fosgerau and Bierlaire's (2007) and Hensher and Greene (2003) for example.

.

3. Design and application of survey

The CE approach and valuation model framework discussed in section 2 guided the design and application of the survey. The CE survey focuses on preferences for different remediation technologies from residents across the state of New South Wales (NSW), Australia. NSW population is 7.52 million (June 2014). In 2015, 332 contaminated sites were being regulated by the NSW Environmental Protection Agency and 130 sites had been remediated in NSW with 860 sites still awaiting assessment (NSW EPA, 2015).

3.1 Design of survey

The CE survey was designed through: in-depth review of academic literature on remediation technologies and case studies; a workshop with a group of 15 remediation technologies experts from NSW in September 2013 (see Prior et al., 2017 for details); and two focus groups, with residents who lived near contaminated sites across NSW, each group involving 10-12 residents, in October 2014. The aim of these activities was to identify, refine and develop the scenarios, attributes, levels, wording and design of the survey instrument, so that they were intelligible to residents and ensured scientific validity (see Sections 3.2 and 3.3). Accumulated knowledge from these activities suggested that the impact of remediation technologies on the level of water quality, the way that waste is managed and the level of air quality seems to significantly affect residents' preferences for technologies, and therefore the overall level of social acceptability of specific technologies. Finally, an online pilot survey of 150 residents across NSW was carried out to trial the survey analysis (see section 4) in November 2014 and detect potential anomalies that were corrected for the final survey of 944 residents across NSW in January 2015.

3.2 Attributes and levels

3.2.1 Remediation technology types

For the purposes of this CE resident survey, remediation technologies have been separated into four key types, the CE resident survey also included monitored natural attenuation (see Prior et al., 2017 for a more extensive breakdown):

- Bioremediation: generally refers to any process that uses biological processes (microbes, fungi, plants or their enzymes) for the clean-up of contaminated land and water. Bioremediation is most usually referred to in the context of treating soils (e.g. for hydrocarbon contamination), and should not be assumed to refer only to groundwater remediation.
- Thermal remediation: generally refers to the use of heat, on the basis of introducing heat into the treatment zone and carrying out treatment in situ (e.g. steam injection, resistive heating and conductive heating); or carrying out treatment of excavated soil ex situ (e.g. thermal desorption in a rotary kiln). In particular thermal treatment used to treat recalcitrant compounds such as persistent organic pollutants.

- Chemical remediation: generally involves the use of chemical reagents to oxidise or reduce contaminants, particularly in groundwater, although the method can extend to soils. For example, there are a number of chemical oxidants that can be used to treat chlorinated solvents, and certain mobile heavy metals. A new development is the use of chemical reagents that comprise nanoparticles, such as zero valent iron in nanoparticle form.
- Physical remediation: generally involves a range of physical techniques such as vacuum extraction (to remove contaminants in vapour form), soil washing, and separation. Excavation and removal of contaminated soil and disposal in a landfill is a very common method of remediation, although increasing costs of landfill disposal are making this less widely used.
- Monitored natural attenuation (MNA): may be used after remediation has been carried out to the extent practicable through other technology types. It may be acceptable to allow the residual contamination to degrade naturally (e.g. monitored natural attenuation). This particularly applies in the case of residual groundwater contamination, where the residual matter poses a low risk.

3.2.2 Environmental quality attributes and levels

Each hypothetical technology application was described by the specific technology type and also a list of attributes and the associated levels describing the most important environmental dimensions affected by the implementation of this remediation technology type. Some researchers argue that public perceptions of environmental quality changes in recreational resources -like coastal waters- can be better explained using cultural theory (Langford et al., 2000). This raises the possibility that without adequate information on environmental quality, personal, social or cultural misperceptions of environmental health risks might bias respondents' preferences and willingness to pay estimates. For this reason, and following contemporary guidance for stated preference studies (Johnston et al., 2017), environmental quality ladders have be designed for the CE that are both accepted by experts as scientifically robust and understood by residents. Building on the work of previous researchers, who have used derivatives of the environmental quality ladder devised by Vaughan (1984), and feedback on possible ladders from residents and remediation experts during the survey design stage (see section 3.1) we identified the final list of attributes and levels presented in Table 1.

In environmental valuation, trade-offs are often measured by payments, such as one-time payments and local taxation. These payments are not intended as a true payment for implementation, the payment is used in the valuation to gather information in terms of willingness-to-pay in order to describe perceived benefits to residents in terms of monetary gains (from preferences). During the survey design several payment methods were trialed, a one-off payment to a fund managed by scientists to ensure remediation technologies are implemented according to scientific requirements was adopted, given that it was most meaningful to residents.

-Table 1 around here-

3.3 Survey instrument

The main survey instrument has six parts: Part 1 introduces the survey and Part 2 asks respondents questions on their perceptions and views on remediation generally to warm them up to the task. The third part introduces and defines each of the features (e.g., technologies and payment vehicle) in the experiment and includes questions on the respondent's status quo. Part 4 presents the stated choice screens (twelve per respondent), followed by attitudinal questions in Part 5 and ends with general socio-demographic questions.

A key aspect in CE is the design of the set of choice alternatives (i.e., competing remediation applications in the case of the CE) that are presented to the respondent. Since there are two design attributes involving five levels (technology and contribution), one involving 6 levels (air quality); and three involving two levels (gardening, outdoor and waste), the number of potential alternatives of remediation policies design is 5^2 x 6^1 x 2^3=1200. Since this number is too large to be evaluated by the respondent, it was reduced by utilizing an optimal design. We employed a Bayesian D-efficient design based on the software NGENE. D-efficient designs are constructed by selecting the set of scenarios that minimise the elements of the asymptotic variance-covariance matrix around the set of prior parameters for discrete choice models (see Rose and Bliemer, 2009 for a review of such designs). The experimental design method was chosen because it produces lower standard errors and therefore more reliable parameter estimates for a relatively small sample size. Another advantage of using a Bayesian-efficient design is that it allows for a reduced number of the choice occasions to be specified that were tested in the qualitative stage to ensure any respondent would be able to respond without suffering from fatigue or tiring effects. Therefore, it allows researchers to maximize statistical efficiency and, at the same time, does not compromise respondent efficiency (Severin, 2001).

Fixed priors from the mean values of the pilot study were used and the prior distributions of the parameters of interest were uniform. Also, the parameter distributions were bounded according to the expected signs (positive or negative) based on previous recommendations (Scarpa and Rose, 2008). This led to a final design of 12 choice sets that were randomly grouped in 6 cards with two blocks. The final choice scenario situation included in the experiment is presented in Figure 2.

-Figure 2 around here-

The survey was conducted from 28th January to 16th February 2015. Each survey took 20 min to complete on average.

3.4 Survey sample

A sample of 944 valid respondents randomly selected NSW-wide from the online panel provider (GMI lightspeed) completed the survey out of a total of 1258 people that started the survey (75% completion rate) but did not complete or were screened out (301). Fixed quotas of age and gender (based on ABS, 2006 Census data) were employed to ensure sample representativeness. The descriptive analysis of the main demographic variables in Table 2 shows that modal age in the survey is around 35-44 years old. Males were slightly under represented 48% male compared to 49.4% (ABS, 2006 Census data for NSW). Having a school certificate or diploma was the highest qualification held by 27% of the sample, followed closely by 25% with a university bachelor's degree. More than 37% of the sample have household gross income (before tax) greater than $72,800 ($1400 per week). Of the households that were surveyed, 61% indicated there were no contamination problems in their community right now, while the rest indicated they experienced some form of land contamination.

-Table 2 about here -

4. Results

The results section firstly presents the findings on the performance of the MIXL model from the CE data. The results section then presents the findings from the analysis of the CE survey revealing residents' acceptance of different technology types as viable options to remediate contaminated environments and their preferences for environmental outcomes from the application of these technology types.

Following Daly, Hess and Train (2012) a lognormal distribution for the monetary coefficient in the random coefficients model is used to ensure the theoretically correct signs for the monetary coefficient and to avoid issues of infinite moments for the distribution of WTP. For non-monetary coefficients, such as waste management, the distributions were tested using the Lagrange Multiplier test proposed by McFadden and Train (2000). The t-statistics of the estimated deviations were estimated and observed, but not employed in deciding which parameters were random or not, since Mariel et al. (2013) showed how misleading they can be if employed as a unique test. Thus, the final model was a MIXL with a normal distribution for each attribute but cost, which follows a lognormal distribution. The estimation was performed in R studio using 2000 shuffled Halton draws (Sándor and Train 2004). The standard errors were simulated using 10^6 draws (Krinsky and Robb 1986). The results are presented separately in different tables and figures to better suit the discussion of the findings.

4.1 Residents' acceptability of Remediation Technology types

Table 3 presents the main parameters of Equation (1) explaining the transformation of residents' perceptions of remediation technology types and their social acceptability level (see section 2). All variables considered in the analysis are statistically significant. The interpretation is that residents' acceptability of remediation technology types can be explained by both i) the efficacy of the technology type in improving the environmental quality in the community and; ii) the ‘reputation effect’ associated with each technology type. The only attribute with a really small estimated mean coefficient was “outdoor water”, which did not significantly affect average resident acceptability levels. It is likely that the reason for this result is that a large portion of the sampled resident population may not have access to outdoor (bore) water and therefore they do not attach a significant positive value to technology types that improve water for such purposes.

Another interesting result obtained from Table 3 is that all remediation technology types considered have a quite significant ‘reputation value’ attached. In other words, the level of residents’ acceptability of alternative remediation technology types seems to be affected by an intrinsic value associated to it. For instance, the probability that an average resident favours MNA over a chemical technology with the same impact on objective environmental quality levels (e.g. air and water quality) is much larger. In fact, since the parameter associated is the higher in the analysis, residents prefer MNA over any other types of remediation technologies when the level of environmental quality improvement is similar.

-Table 3 about here -

The second preferred technology is biotechnology. Physical and thermal technology have a similar effect on resident acceptability and chemical technology has the lowest level of acceptability. It can be interpreted as having the highest stigma effect and needs better levels of environmental quality improvement in order to be accepted by the residents over other technology types.

An easier interpretation of the parameters can be obtained if they are associated with the one-off payment (for a hypothetical fund managed by scientists to ensure remediation technologies are implemented according to scientific requirements). As predicted by economic theory, Table 3 shows that if the implementation of remediation technologies would involve a one-off payment, the probability that residents accept such technology types is reduced. Moreover, the larger the one-off payment the lower the resident's acceptability of implementing any remediation technology type. By comparing the impact of increases in the amount of the one-off payments and the impact of adopting different types of remediation technology on resident's acceptability, the equivalent amount of a one-off payment that can be charged to residents and leave them with the same level of environmental quality can be calculated. This statistic is often called marginal willingness to pay (WTP).

-Figure 3 about here -

For the sake of interpretation Figure 3 summarizes these WTP estimates for each technology. Thus, it can be seen that an average citizen is WTP $41.15 a year for a remediation technology application that involves biotechnology rather than chemical technologies. The same average values for a strategy of MNA over chemical technology is $44.60 per citizen a year. Values for physical and thermal technologies over chemical are $34.35 and $25.30, respectively. This information is useful since resident preferences, and therefore residents' acceptability, can be useful to inform remediation policy makers and remediation experts in designing and implementing remediation technologies.

It is important to bear in mind that, since these values are averaged for the resident sample in NSW, to obtain absolute values of remediation technology types they should be estimated by the overall population of the state. This means that some residents not residing in (or close to) a contaminated environment may also be willing to accept a payment increase if the money is employed in implementing remediation technologies aimed at improving the environmental quality of such areas.

4.2 Resident preferences for environmental attributes and levels

Table 3 also reports the parameters associated with the preferences of an average resident for improvements in the different environmental attributes affected by the implementation of remediation technologies. For instance, from Table 3 it can be seen that if the improvement in water quality allows gardening practices by residents, the probability that they would accept the implementation of a specific technology would increase substantially. The same is true for remediation technology applications that involve off-site waste management rather than when the waste management is treated on-site.

On the other hand, since all the parameters associated with air quality levels are statistically significant in Table 3, the analysis supports the hypothesis that residents' acceptability of remediation technologies increases significantly when it involves an improvement in air quality levels. Moreover, we have included dummies to account for the non-linear relationship, that is, the impact of the same air quality improvement on remediation technology type acceptability would depend on whether the status quo level of air quality ranged from bad to good: very unhealthy, healthy, healthy for sensitive groups, moderate, good. The coefficients for air quality represent the differential effects between the given category (healthy, healthy for sensitive groups, moderate and good) and the reference category ('very unhealthy') on utility. For example, the estimated coefficient for the 'moderate' dummy category represents the effect of 'moderate' air quality compared to 'very unhealthy' on utility. It can be seen that the highest marginal value is obtained when a small improvement is provided and the status quo is perceived as 'very unhealthy' (e.g. technology changes the perceived quality from very unhealthy to unhealthy). Such a change provides a high impact on residents' acceptability.

Nevertheless, as with the reputation effects, a more intuitive explanation of the results can be obtained by calculating the associated marginal WTP for any environmental quality improvement. These results are presented in Figure 4 and 5. Figure 4 presents the WTP for improvements in air quality. It shows that an average resident is WTP up to $246.10 for increasing the level of air quality from very unhealthy to just unhealthy. Improvements from very unhealthy to higher levels of air quality -unhealthy for sensitive groups, moderate and good - are valued on average in a range from $111.30 to $123.90 per person a year..

-Figure 4 about here-

-Figure 5 about here-

Estimations of residents' WTP for improvements in water quality are included in Figure 5. Figure 5 reveals that the maximum amount of extra money residents are willing to pay in a one-off payment for being able to have gardening quality water is $117.75 per person. On the other hand, the average WTP for outdoor water activity is significantly much lower ($4.40), which is probably not very representative of the distribution of preferences in the resident population since this value comes from a large proportion of the resident population paying nothing because they have no access to outdoor water activities at home. Finally, the average WTP for adopting off-site waste management is $26.90 per person in a once off payment, which provides a clear sign that although residents favour off-site waste management and are willing to pay a significant amount for such a policy, the strength of their preferences for such policies is 10 (and 7) times lower than for policies aimed at improving more dimensions more directly of their daily quality of life like air (and water) quality.

5. Concluding discussion

At the outset of this paper we highlighted the growing importance that is being placed on addressing environmental challenges, like the remediation of contaminated environments, through access to knowledges beyond those of just experts. The argument here being that all forms of knowledge, whether it be that of a remediation professional or that of a resident living near a contaminated site has the potential to contribute to better decision making in the face of an environmental challenge. An argument that has been increasingly recognised through the inclusion of multiple stakeholders, including residents, in the evaluation and selection of possible remediation technology applications. The CE presented within this paper has addressed a challenge that remained unanswered within this context: to identify tools that can, firstly, be utilised to facilitate the evaluation of remediation technologies by residents who generally have little or no expert knowledge of remediation, and secondly, provide insight into the preferences that residents use when they evaluate remediation technologies. Each of these achievements, as well as their limitations and implications, are discussed in this conclusion.

5.1 Tools and models for uncovering residents' preferences for remediation technologies

Firstly, the CE has provided insight into tools and methods that can be utilised as a means of evaluating residents' preferences for remediation technology applications. The development of these tools and methods required close engagement with residents and experts, which required considerable time and effort. Time was needed to address many logistical and procedural issues, such as harmonizing the knowledge of experts and residents within the tools application scenarios. To determine and quantify the key drivers of residents' preferences with respect to remediation technology, a CE survey was designed to be administered to community members. Through engagement with residents and experts a valuation framework was developed in which social preferences for remediation policies is decomposed into two components: perceived social benefits of environmental quality and reputation of technologies. Quantitative analysis of the choice survey under this framework provided quantifiable relative importance and trade-offs the community is willing to make with regard to features that impact their welfare (quality of living) and with regard to different remediation technologies to correct specific contaminations.

The developed CE survey tool was designed to elicit and communicate residents' preferences in a way that was intelligible to a broader audience, with the intent of exploring how it may be possible to translate residents' preferences, value and benefit for remediation technology applications. For example, WTP was adopted within the tool design to enable translation and comparison of residents' values for different attributes of the remediation technology applications. WTP provided a means of measuring value and benefit, value and benefit that residents perceived for different technology types and the quality of life impacts from those applications. Whilst many of the benefits accounted for by remediation experts from implementation of remediation technologies might be measured on the market and commonly accounted for in environmental management plans (Boardman et al., 2011), the developed CE survey provides access to an understanding of values and benefits that are often referred to as 'non-market' value, not necessarily accessible through other means, an understanding of residents' preferences.

5.2 Residents' preferences for remediation technologies

In addition to developing tools that can be used to evaluate residents' preferences, this study has also utilised that tool to provide a valuation of residents' preferences for remediation technologies. The CE provided rare access to knowledge on how residents evaluate remediation technology applications, in particular the CE drew attention to the high value that residents place on a technologies reputational value when assessing a remediation technology's acceptability for application. The empirical analysis of stated choices within the study showed that reputation effects are statistically significant with MNA and Biotechnology favoured over other technologies. In particular, it was found that residents are willing to accept an increase in taxes of $44.60 and $41.15 respectively for implementing MNA and Biotechnology instead of alternative remediation technologies like Chemical, Thermal or Physical technologies.

The analysis also supports the hypothesis that residents' acceptability of remediation technologies increases significantly when it involves an improvement in environmental quality levels. For instance, results indicate that an average resident is WTP up to $246.10 (one off payment) for an improvement in air quality from very unhealthy to just unhealthy. Additional improvements to higher levels of air quality – unhealthy for sensitive groups, moderate and good - are valued on average in a range from $111.30 to $123.90 per person a year. It is also found that on average residents are willing to pay $117.75 per person when remediation technologies allow them to enjoy gardening water quality, and an average of $26.90 per person for adopting off-site waste management.

5.3 Limitations and further research

Whilst this study has contributed significantly to an understanding of how residents' preferences for remediation technologies can be evaluated, and provided unique insights into those preferences, the study is not without limitations, and there are also evident lines of enquiry for future research.

Firstly, some of the evident limitations of the tools and methods that have been created through the CE study is their costs in both time and expenses, and their need for further development. Furthermore, consideration needs to be given to how these choice tools might be more fully integrated into the growing decision support tools that are being developed to support multi-stakeholder evaluation of remediation technologies options. Alternatives like Benefit Transfers which allow the combination of results from previous studies on residents' valuation of remediation technologies would significantly and increasingly ameliorate these costs (Johnston et al., 2015).

Secondly, since environmental quality attributes considered are intrinsically public goods, the social welfare associated with the implementation of remediation technologies include a significant portion of non-use values. That is, residents who do not live in the surroundings of the contaminated sites can have some preferences for the improvement of the environmental quality in those areas, therefore be willing to sacrifice part of their income in order to ensure that remediation technologies are implemented. As a consequence, economic value of remediation technologies is larger than the residents' valuation considered here, which leads to an undervaluation of remediation technologies in the present study. Further research should explore elicitation measures of non-use values to approximate the social valuation of remediation technologies (Arrow et al. 1993). Finally, whilst the objective of this CE was to provide a valuation of residents preferences for remediation technologies, within this CE it was assumed that, because all members of society potentially bear the opportunity cost or externalities of remediation applications, it is appropriate to use the values of this group in decision making. There are, however, also arguments that the values used in decision making should be from those within the population who are experiencing land contamination particularly if values change considerably at this point. Further research is needed to determine values for specific populations at the unique contaminated sites and determine whether they are comparable.

Acknowledgements

The authors acknowledge the support of the Cooperative Research Centre for Contamination Assessment and Remediation of the Environment (CRC CARE) (1.2.1.11-12) for project funding.

References

Arrow, K., Solow, R., Portney, P. R., Leamer, E. E., Radner, R., & Schuman, H., Report of the NOAA panel on contingent valuation. *Federal register* **58**(10), 1993, 4601-4614.

Bardos P., Bone B., Boyle R., Ellis D., Evans F., Harries N., et al. Applying sustianable development principles to contaminated land management using the SuRF-UK Framework. *Remediation Journal*, **21**, 2011a, 77-100. http://dx.doi.org/10.1002/rem.20283

Bardos P., Harries N.D. and Smith J.W.N., Applying sustainable development principles to contaminated land management using the SuRF-UK framework, Spring 2011b, 77-100.

Bauer D., Cyr N.E. and Swallow S.K., Public preferences for compensatory mitigation of salt marsh losses: a contingent choice of alternatives. *Conservation biology*, **18,** 2004, 401-411. http://dx.doi.org/10.1111/j.1523-1739.2004.00367.x

Benn S., Brown P. and North-Samardzic A., A commentary on decision-making and organisational legitimacy in the Risk Society. *Journal of Environmental Management* **90,** 2009, 1655-1662. https://doi.org/10.1016/j.jenvman.2008.05.021

Boardman A.E., Greenberg D.H., Vining A.R. and Weimer D.L. (2011). Cost-Benefit Analysis. Concepts and Practice, 4tn edn. Pearson Education, Inc., Upper Saddle River, NJ.

Brown P. and Benn S., Special issue: toxic risk and governance: the case of hexachlorobenzene. *Journal of Environmental Management*, **90**, 2009, 1557-1558. http://dx.doi.org/10.1016/j.jenvman.2008.05.010

Can O. and Alp E., Valuing of environmental improvements in a specially protected marine area: a choice experiment approach in Göcek Bay, Turkey. *Science of the Total Environment*, **8**, 2012, 291–298. http://dx.doi.org/10.1016/j.scitotenv.2012.09.002

Carlon C., Critto A., Ramieri E. and Marcomini A., DESYRE: decision support system for the rehabilitation of contaminated megasites. *Integrated Environmental Assessment and Management*, **3**, 2007, 211-222. http://dx.doi.org/10.1897/IEAM_2006-007.1

Cole D., Contaminated Sites Law & Policy Directory: Australia. CRC Contamination Assessment and Remediation of the Environment, Adelaide, Australia, 2011.

Cooperative Research Centre for Contamination Assessment and Remediation of the Environment. Application Guide for Identifying and Selecting Remediation Options, National Remediation Framework. Cooperative Research Centre for Contamination Assessment and Remediation of the Environment, South Australia, 2014a.

Cooperative Research Centre for Contamination Assessment and Remediation of the Environment. Remediation and management of contaminated sites Guideline for stakeholder engagement. Cooperative Research Centre for Contamination Assessment and Remediation of the Environment, South Australia, 2014b.

Critto A., Cantarella L., Carlon C., Giove S., Petruzzelli G. and Marcomini A., Decision support-oriented selection of remediation technologies to rehabilitate contaminated sites. *Integrated environmental assessment and management*, **2**, 2006, 273-85. https://doi.org/10.1002/ieam.5630020307

Daly A., Hess S. and Train K. (2012). Assuring finite moments for willingness to pay estimates from random coefficients models. Transportation 39 (1), 19-31.

De Lopez T.T., Elliott M., Armstrong A., Lobuglio J. and Bartram, J., Technologies for climate change adaptation-the water sector, 2011.

NSW EPA, 2015. New South Wales State of the Environment 2015 EPA 2016/0187 http://www.epa.nsw.gov.au/resources/soe/20150817soe-2015.pdf (accessed 18th April 2017)

Efroymson R.A., Nicolette J.P. and Suter G.W., A framework for net environmental benefit analysis for remediation or restoration of contaminated sites. *Environmental Management*, **34**, 2004, 315-331. https://doi.org/10.1007/s00267-004-0089-7

EnHealth. Environmental Health Risk Assessment: Guidelines for assessing human health risks from environmental hazards. Commonwealth of Australia, Canberra, ACT, 2012

Evans R. and Plows A., Listening Without Prejudice?: Re-discovering the Value of the Disinterested Citizen. *Social Studies of Science*, **37**, 2007, 827-853. https://doi.org/10.1177/0306312707076602

Fischer A. and Young J.C., Understanding mental constructs of biodiversity: implications for biodiversity management and conservation. *Biological Conservation*, **136**, 2007, 271-282. https://doi.org/10.1016/j.biocon.2006.11.024

Fosgerau M. and Bierlaire M., A practical test for the choice of mixing distribution in discrete choice models, *Transportation Research Part B: Methodological*, **41** (7), 2007, 784-794.

Greenberg M., Haas C., Cox A., Lowrie K., McComas K. and North W. Ten Most Important Accomplishments in Risk Analysis, 1980-2010. *Risk Analysis*, 32, 2012, 771-781. http://dx.doi.org/10.1111/j.1539-6924.2012.01817.x

Hensher D.A., Rose J.M. and Greene W., Applied choice analysis: a primer. Cambridge: Cambridge University Press, 2005.

Hensher D.A. and Greene W., The mixed logit model: the state of practice, *Transportation*, **30** (2), 2003, 133-176.

Hess S. and Train K., Correlation and scale in mixed logit models. *Journal of Choice Modelling*, **23**, 2017, 1-8. https://doi.org/10.1016/j.jocm.2017.03.001

Hillier N., Gennissen J., Pickering B., Smolenski R., with an introduction by Brown P., Our battle with hexachlorobenzene: Citizen perspectives on toxic waste in Botany. *Journal of Environmental Management*, **90,** 2009, 1605-1612. https://doi.org/10.1016/j.jenvman.2008.05.015

Hoyos D., Mariel P. and Hess S., Incorporating environmental attitudes in discrete choice models: an exploration of the utility of the awareness of consequences scale. *Science of the Total Environment,* **505**, 2015, 1100–1111. https://doi.org/10.1016/j.scitotenv.2014.10.066

Huntington H.p., Using traditional ecological knowledge in science: methods and applications. *Ecological applications*, **10**, 2000, 1270-1274. https://doi.org/10.1890/1051-0761(2000)010[1270:UTEKIS]2.0.CO;2

International Organisation of Standardisation. Soil Quality: Guidelines on sustianable remediation (Committee Draft ISO/CD 18504), 2015.

Jackson T., The effects of environmental contamination on real estate: A literature review. *Journal of Real Estate Literature,* **9**, 2001, 91-116.

Johnston R.J., Rolfe J., Rosenberger R.S. and Brouwer, R., *Benefit Transfer of Environmental and Resource Values*. Dordrecht: Springer, 2015. http://link.springer.com/content/pdf/10.1007/978-94-017-9930-0.pdf

Johnston R.J., Boyle Kevin J., Adamowicz Wiktor (Vic), Bennett Jeff, Brouwer Roy, Cameron Trudy Ann, Michael Hanemann W., Hanley Nick, Ryan Mandy, Scarpa Riccardo, Tourangeau Roger and Vossler Christian A., Contemporary guidance for stated preference studies, *Journal of the Association of Environmental and Resource Economists* 2017 4:2, 319-405.

Justes A., Barberán R. and Farizo B., Economic valuation of domestic water uses. *Science of the Total Environment*, **8**, 2014, 472–712. http://dx.doi.org/10.1016/j.scitotenv.2013.11.113

Reid W., Berkes F., Wilbanks T. and Capistrano D., Conclusions: bridging scales and knowledge systems, In: World Resources Institute W, Millennium Ecosystem Assessment, Reid W., Berkes F., Wilbanks T. and Capistrano D. (Eds.), Bridging Scales and Knowledge Systems, 2013, Island Press; Washington, United States, 315-331.

Keane M. and Wasi N., Comparing alternative models of heterogeneity in consumer choice behavior. *Journal of Applied Econometrics*, **28**, 2013, 1018-1045. http://dx.doi.org/10.1002/jae.2304

Krinsky I. and Robb A.L., On Approximating the Statistical Properties of Elasticities. *The Review of Economics and Statistics*, **68**(4), 1986, pp. 715-719

Lancaster K.J., A new approach to consumer theory, *Journal of political economy*, **74**, 1966, 132–157, https://doi.org/10.1086/259131

Langford I.H., Georgiou S., Bateman I.J., Day R.J. and Turner R.K., Public perceptions of health risks from polluted coastal bathing waters: a mixed methodological analysis using cultural theory, *Risk Analysis*, **20**, 2000, 691–704, https://doi.org/10.1111/0272-4332.205062

Layton D.F. and Lee S.T., Embracing model uncertainty: strategies for response Pooling and model averaging. *Environmental and Resource Economics*, **34**, 2006, 51-85. http://dx.doi.org/10.1007/s10640-005-3784-9

Leamer E.E., Specification searches: *Ad hoc inference with nonexperimental data* (Vol. 53). John Wiley & Sons Incorporated, 1978.

Louviere J.J., Hensher D.A. and Swait J.D., Stated choice methods: analysis and applications. Cambridge University Press, 2000. http://dx.doi.org/10.1017/CBO9780511753831

Mariel, Ayala, A., Hoyos, D. and Abdullah S., Selecting random parameters in discrete choice experiment for environmental valuation: A simulation experiment. *Journal of Choice Modelling*, **7**, 2013, Pages 44-57.

McFadden D. and Train K., Mixed MNL models for discrete response. *Journal of applied Econometrics*, **15**, 2000, 447-470.

Morancho A.B., A hedonic valuation of urban green areas. *Landscape and urban planning*, **66**, 2003, 35-41. http://dx.doi.org/10.1016/S0169-2046(03)00093-8

National Environment Protection Council, In: Council NEP, (Ed), *Schedule B (8) - Guideline on Community Consultation and Risk Communication*, 1999, National Environmental Protection Council Service Corporation; Canberra.

National Environmental Protection Council and Council NEP, (Eds.), *Schedule B (8) - Guideline on Community Engagement and Risk Communication: Draft for Public Consultation*, 2011, National Environmental Protection Council Service Corporation; Canberra.

NSW EPA, 2015. New South Wales State of the Environment 2015 EPA 2016/0187 http://www.epa.nsw.gov.au/resources/soe/20150817soe-2015.pdf (accessed 18th April 2017)

Onwubuya K., Cundy A., Puschenreiter M., Kumpiene J., Bone B., Greaves J., et al. Developing decision support tools for the selection of "gentle" remediation approaches. *Science of the Total Environment*, **407**, 2009, 6132-6142. https://doi.org/10.1016/j.scitotenv.2009.08.017

Pollard S.J.T., Brookes A., Earl N., Lowe J., Kearney T. and Nathanail C.P., Integrating decision tools for the sustainable management of land contamination. *Science of The Total Environment*, **325**, 2004, 15-28. https://doi.org/10.1016/j.scitotenv.2003.11.017

Pretty J.N., Morison J.I. and Hine R.E., Reducing food poverty by increasing agricultural sustainability in developing countries. *Agriculture, ecosystems & environment*, **95**, 2003, 217-234. http://dx.doi.org/10.1109/TSMCA.2003.817387

Prior J., The norms, rules and motivational values driving sustainable remediation of contaminated environments: A study of implementation. *Science of The Total Environment*, **544**, 2016, 824-836. https://doi.org/10.1016/j.scitotenv.2015.11.045

Prior J. and Rai T., Using residents' perceived risks and benefits about technology as a way of resolving remediation dilemmas. *Science of The Total Environment*, 2017; **601-602,** 1649-1669 . http://doi.org/10.1016/j.scitotenv.2017.05.187

Prior J., Partridge E. and Plant R., 'We get the most information from the sources we trust least': residents' perceptions of risk communication on industrial contamination. *Australasian Journal of Environmental Management*, **21**, 2014, 346-358. http://dx.doi.org/10.1080/14486563.2014.954011

Prior J., Hubbard P. and Rai T., Using residents' worries about technology as a way of resolving environmental remediation dilemmas. *Science of the Total Environment*, **580,** 2017, 882-899. http://dx.doi.org/10.1016/j.scitotenv.2016.12.035

Raymond C.M., Fazey I., Reed M.S., Stringer L.C., Robinson G.M. and Evely A.C., Integrating local and scientific knowledge for environmental management. *Journal of Environmental Management*, **91**, 2010, 1766-1777. https://doi.org/10.1016/j.jenvman.2010.03.023

Ribeiro R. and Lima F.P., The value of practice: a critique of interactional expertise. *Social Studies of Science*, **46**, 2016, 282-311. https://doi.org/10.1177/0306312715615970

Rose J.M. and Bliemer M.C., Constructing efficient stated choice experimental designs. *Transport Reviews*, **29**, 2009, 587-617. http://dx.doi.org/ 10.1080/01441640902827623

Sandor Z. and Train K., Quasi-random simulation of discrete choice models. *Transportation Research Part B: Methodological*, **38** (4), 2004, p. 313-327.

Satterfield T., Kandlikar M., Beaudrie C.E., Conti J. and Harthorn B.H., Anticipating the perceived risk of nanotechnologies. *Nature nanotechnology*, **4**, 2009, 752-758. http://dx.doi.org/10.1038/nnano.2009.265

Scarpa R. and Rose J.M., Design efficiency for non-market valuation with choice modelling: how to measure it, what to report and why. *Australian journal of agricultural and resource economics*, **52**, 2008, 253-282. http://dx.doi.org/10.1111/j.1467-8489.2007.00436.x

Schaafsma A., Limay-Rios V., Baute T., Smith J. and Xue Y., Neonicotinoid insecticide residues in surface water and soil associated with commercial maize (corn) fields in southwestern Ontario. *PLoS One*, **10**, 2015, p.e0118139. http://dx.doi.org/ 10.1111/j.1467-8489.2007.00436.x

Severin V., Comparing statistical and respondent efficiency in choice experiments. (Unpublished Ph. D. Dissertation) In: *Discipline of Marketing, Faculty of Economics and Business*, 2001, The University of Sydney.

Söderqvist T., Brinkhoff P., Norberg T., Rosén L., Back P.E. and Norrman J., Cost-benefit analysis as a part of sustainability assessment of remediation alternatives for contaminated land. *Journal of Environmental Management*, **157**, 2015, 267-278. https://doi.org/10.1016/j.jenvman.2015.04.024

Starr C., Social benefit versus technological risk. *Readings in Risk*, **165**, 1969, 183-194. http://dx.doi.org/10.1126/science.165.3899.1232

Steele K., Carmel Y., Cross J. and Wilcox C., Uses and misuses of multicriteria decision Analysis (MCDA) in environmental decision making. *Risk Analysis*, **29**, 2009, 26-33. http://dx.doi.org/10.1111/j.1539-6924.2008.01130.x

SuRF Australia, Cooperative Research Centre for Contamination Assessment and Remediation of the Environment, Australisian Land and Groundwater Association. Draft: A Framework for Assessing the Sustainability of Soil and Groundwater Remediation. Sustainable Remediation Forum Australia, 2011.

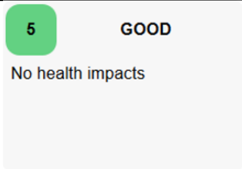
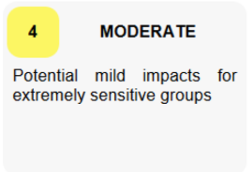
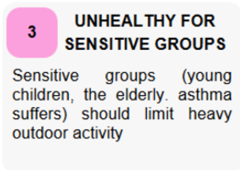
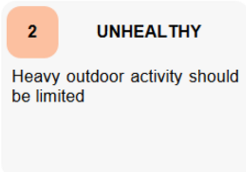
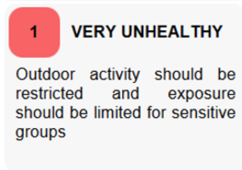
SuRF-UK. A Framework for Assesing the Sustainability of Soil and Groundwater Remediation. Draft Copy Subject to Public Consultation May 2009. Sustainable Remediation Forum UK, 2009.

U.S. Sustainable Remediation Forum., Sustainable remediation white paper—Integrating sustainable principles, practices, and metrics into remediation projects. *Remediation Journal*, **19**, 2009, 5-114. https://doi.org/10.1002/rem.20210

Van Wezel A., Franken R., Drissen E., Versluijs K. and van den Berg R., Societal cost-Benefit analysis for soil remediation in The Netherlands. *Integrated Environmental Assessment and Management*, **4,** 2008, 61-74. https://doi.org/10.1897/IEAM_2007-034.1

Vaughan W.J., The water quality ladder. Appendix to RC Mitchell and RT Carson, A Contingent Valuation Estimate of National Freshwater Benefits. Prepared for the US Environmental Protection Agency, Resources for the Future, 1984.

Table 1. Final List and Definition of Attributes and levels

	Attribute	Level (Text)	Image
1	Technology	1. Biotechnology 2. Thermal technology 3. Chemical technology 4. Physical technology 5. Monitoring natural attenuation	N/A
2	Air Quality (Picture only)	Good	
		Moderate	
		Unhealthy for Sensitive groups	
		UnHealthy	
		Very Unhealthy	
3	Gardening (picture + text)	1. Groundwater <u>CAN</u> be used for gardening	
		2. Groundwater <u>CANNOT</u> be used for gardening	
4	Outdoor water activities (picture + text)	1. Safe for outdoor water activities in the backyard	

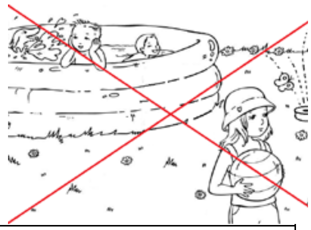
		2. NOT safe for outdoor water activities in the backyard	
5	Waste management	1. On-site 2. Off-site	N/A
6	Contribution ($)	AUS$ 12, AUS$ 20, AUS$ 24, AUS$ 48, AUS$ 65	N/A

Table 2. Sample descriptive statistics

	Percentage
Male	48.0
Age (years)	
18-24	10.3
25-34	18.4
35-44	19.3
45-54	19.1
55-64	15.4
65-74	10.1
75+	7.5
Household type	
Family household	18.3
Couple family with no children	29.1
Couple family with children	21.9
One parent family	7.3
Other family	1.5
Single person household	18.1
Group household (i.e., shared)	3.7
Highest qualification	
Postgraduate degree	12.2
Graduate diploma & graduate certificate	9.5
Bachelor degree	25.1
Advanced diploma & diploma	10.5
Certificate III & IV	15.5
School certificate or diploma (Year 12/Year 10)	27.2
Annual household income in AUD per annum	
<$12,999 (i.e. <$249 a week)	4.2
$13,000-$25,999 (i.e. $250-$499 a week)	10.1
$26,000-$51,999 (i.e. $500-$999 a week)	20.1
$52,400-$72,799 (i.e. $1,00-$1,399 a week)	15.5
$72,800-$103,999 (i.e. $1,400-$1,999 a week)	19.0
$104,000-$155,999 (i.e. $2,000-$2,999 a week)	11.1
$156,000-$207,999 (i.e. $3,000-$3,999 a week)	4.2
$208,000 or more (i.e. $4,000 +)	2.8
Prefer not to answer	13.0
Contamination ("My community…")	
Has no contamination problems right now	61.0
Currently has contamination issues but has not started treatment/remediation yet.	20.1
Has contamination issues and is undergoing treatment/remediation	14.8
Had a contamination issue but after the remediation policies were implemented the environmental quality levels went back to average.	4.0

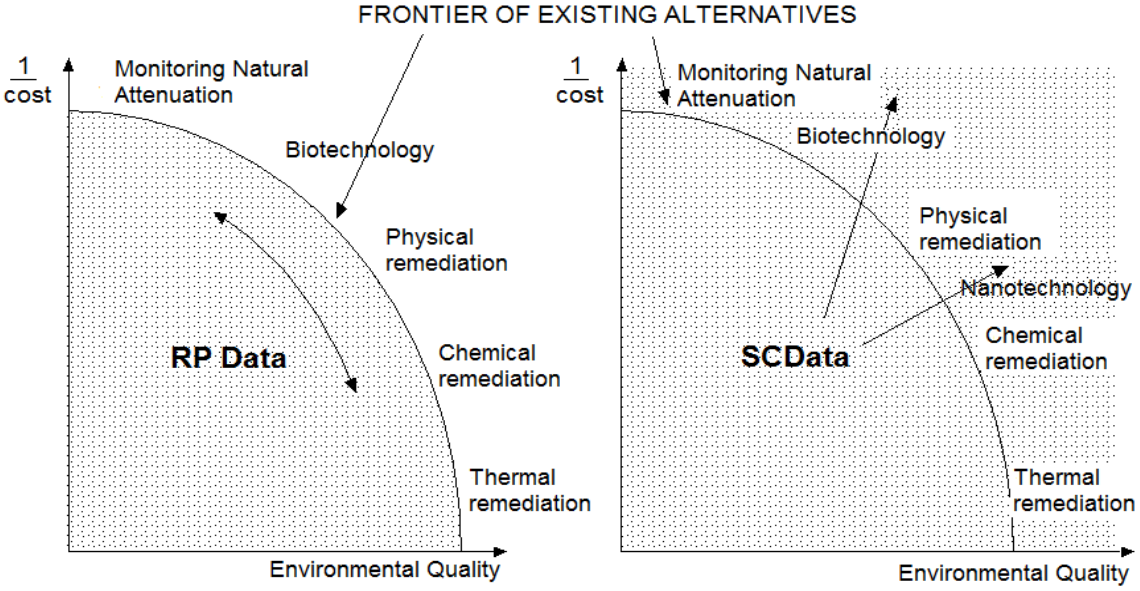
Table 3. Residents' Acceptability of Remediation Technology types. Econometric models estimates.

	MNL	MIXL	
	Mean (SE)	Mean (SE)	SD (SE)
Technology types reputation effect			
Monitoring natural attenuation	0.214***	0.223***	0.187***
	(0.097)	(0.087)	(0.073)
Physical technology	0.167***	0.172***	0.096***
	(0.048)	(0.030)	(0.041)
Biotechnology	0.195***	0.206***	0.148***
	(0.045)	(0.036)	(0.027)
Thermal technology	0.136***	0.125***	0.051***
	(0.052)	(0.031)	(0.024)
Chemical technology	-	-	-
Environmental quality			
Gardening	0.559***	0.586***	0.396***
	(0.071)	(0.059)	(0.039)
Outdoor water	0.000***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)
Waste management	0.108***	0.132***	0.089***
	(0.062)	(0.054)	(0.028)
Air quality good	0.504***	0.617***	0.542***
	(0.061)	(0.045)	(0.031)
Air quality moderate	0.513***	0.564***	0.519***
	(0.058)	(0.049)	(0.037)
Air quality unhealthy for sensitive groups	0.521***	0.557***	0.503***
	(0.072)	(0.051)	(0.043)
Air quality unhealthy	1.194***	1.225***	1.136***
	(0.085)	(0.079)	(0.057)
Air quality very unhealthy	-	-	-
One-off payment	-0.004***	-0.005***	-0.014***
	(0.002)	(0.001)	(0.006)
Model Characteristics			
Log Likelihood	−4,376.63	−3,875.04	
McFadden pseudo R^2	0.11	0.23	
AIC/n	2.612	2.158	
BIC/n	2.641	2.015	
n	5664	5664	

***, **, * Statistical significance at 1, 5, 10% level, respectively. Chemical Technology and Very Unhealthy Air quality were the reference categories for their respective dimensions.

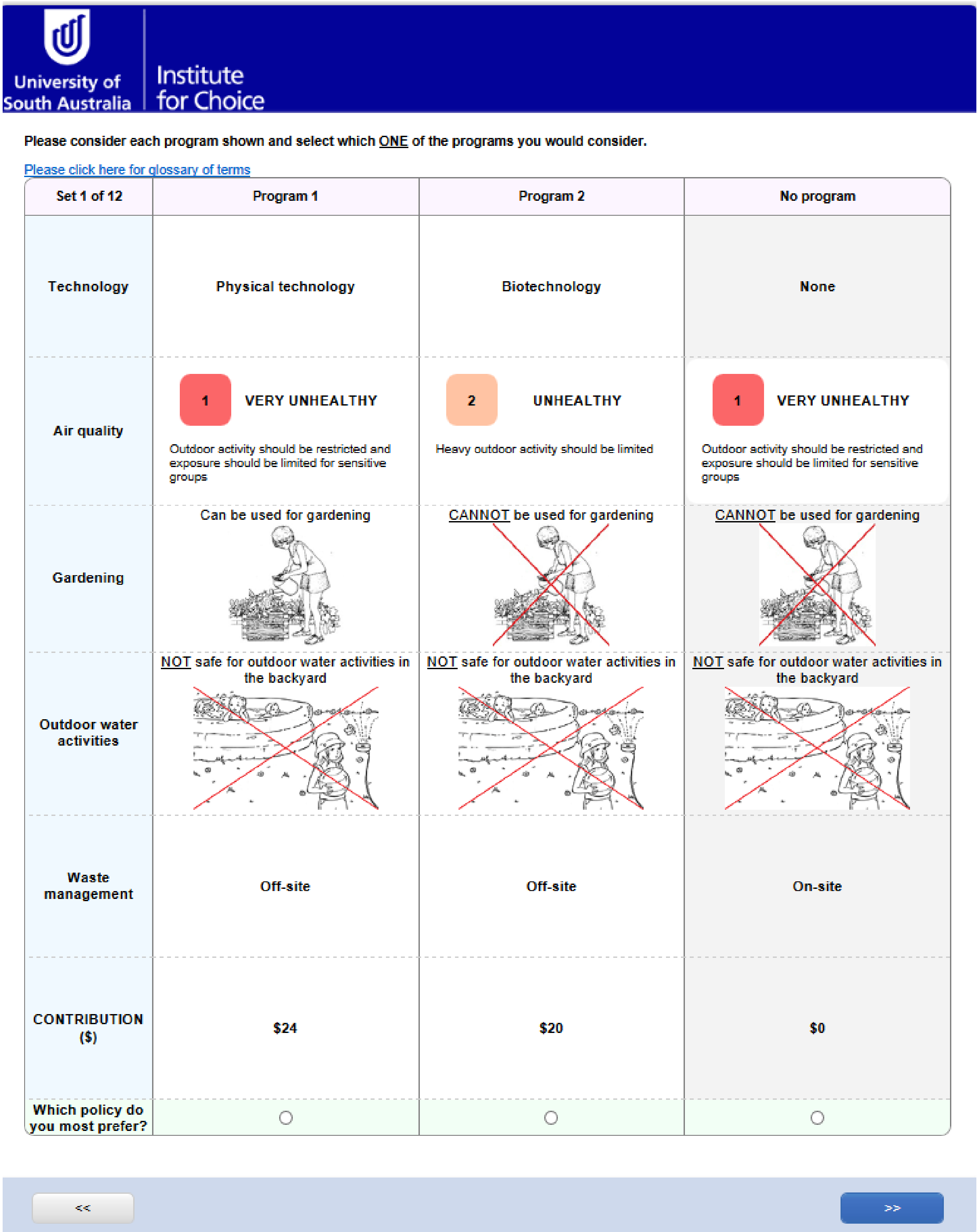
The final MIXL model assumes a normal distribution for each attribute but cost, which follows a lognormal distribution. The estimation was performed using 2,000 shuffled Halton draws. Standard errors were simulated using 10^6 draws (Krinsky and Robb 1986).

Figure 1: Attribute space of Revealed Preference and Stated Choice data



Source: Adapted from Hensher, Rose and Green (2005)

Figure 2 Example of Choice Scenario



University of South Australia | Institute for Choice

Please consider each program shown and select which ONE of the programs you would consider.

Please click here for glossary of terms

Set 1 of 12	Program 1	Program 2	No program
Technology	Physical technology	Biotechnology	None
Air quality	1 VERY UNHEALTHY Outdoor activity should be restricted and exposure should be limited for sensitive groups	2 UNHEALTHY Heavy outdoor activity should be limited	1 VERY UNHEALTHY Outdoor activity should be restricted and exposure should be limited for sensitive groups
Gardening	Can be used for gardening	CANNOT be used for gardening	CANNOT be used for gardening
Outdoor water activities	NOT safe for outdoor water activities in the backyard	NOT safe for outdoor water activities in the backyard	NOT safe for outdoor water activities in the backyard
Waste management	Off-site	Off-site	On-site
CONTRIBUTION ($)	$24	$20	$0
Which policy do you most prefer?			

<< >>

Figure 3. Mean WTP for implementing different types of remediation technology type. ("Remediation technology type reputation effect")

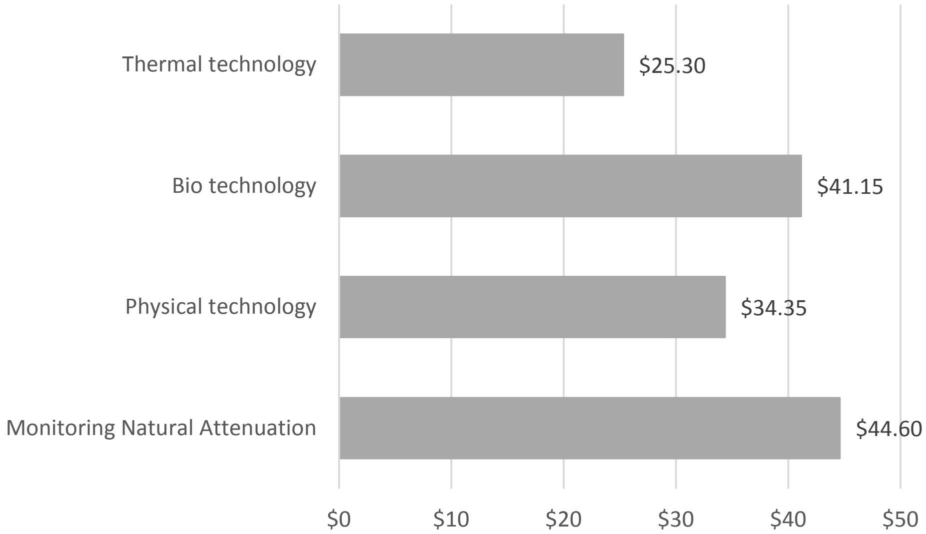


Figure 4. Marginal WTP for improving air Quality index (reference point very unhealthy)

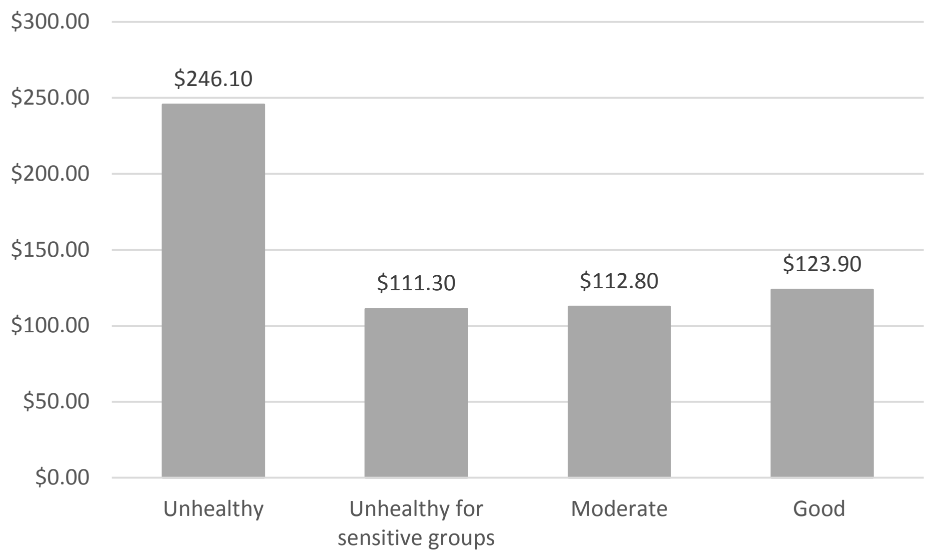


Figure 5. Mean WTP for different levels of water quality