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Using choice modelling to reveal waste water preferences in regional Victoria

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Abstract

Water reuse and recycling is the subject of intense scrutiny in Australia as demand for the resource approaches sustainable supply limits. In many cases this has resulted in substantive work being undertaken to understand the engineering or technical solutions to recycling problems. In addition, much of the focus on wastewater recycling is centred on larger urban communities where the scale of engineering works is most likely to prove financially defensible. However, focusing attention solely on recycling from this relatively narrow perspective overlooks the broader catchment-wide benefits of improved wastewater treatment, particularly in smaller communities. This paper contends that improving wastewater treatment in such communities provides significant recycling opportunities that extend beyond the immediate locale. On this premise, the growing interest in improved wastewater treatment in rural Victoria is explored before offering a methodology for quantifying individual preferences in small towns.

Keywords: Wastewater preferences; Choice modelling; Small towns

1. Introduction

Water is both an integral component of the ecosystem and a fundamental social and economic good [1]. In addition, management of the resource is receiving unprecedented attention as demand continues to rise and approaches the limits of sustainable supply, particularly in parts of Australia. On the demand side, three broad factors have been responsible for increasing the demand for water resources: (1) expanded use of water in agricultural and industrial contexts; (2) enhanced water distribution strategies for large urban populations, and (3) recognition of

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water as a potentially effective human and industrial waste transport and treatment mechanism [2].

The significant relationships between these elements of demand make it difficult to consider each in isolation. Only when the resource is abundant relative to total demand is it possible to consider using water as a vehicle for treating and transporting waste separately from its usefulness in servicing the water consumption needs of urban populations. Even then there will be critical thresholds to the capacity of the resource to adequately fulfill both tasks, since diffuse wastes still bring potential harm to human health. It is this interrelationship among the various demands for water that has prompted calls for holistic approaches such as integrated catchment management (ICM) or total catchment management (TCM) [3], which allow for consideration of decisions across all users and uses.

Attention to ICM and the acknowledgement that water resources have become critically scarce in Australia have collectively served to sharpen resource managers' focus on what was once euphemistically referred to as "waste" water. Symptomatic of the current attention to this component of the water cycle is the widespread designation of "reclaimed" water, "reuse" water, "nutrient-rich" water, and the like [4]. Clearly, what was once regarded as a costly side-effect of human and industrial consumption has now assumed the status of an alternative resource.

The current trend towards examining wastewater as an alternative water resource has, to date, been dominated by two approaches. Firstly, an expansive literature has developed dealing with the technological/engineering facets of the reuse debate with numerous authors reporting on the relative merits of alternative treatment technologies [5–8]. Secondly, there is a growing literature focusing on the economic dimensions of reuse [4,9–11]. This latter genre of work has tended to employ techniques like benefit cost analysis to adjudge the welfare implications of particular reuse projects, often studying the ramifications on larger communities where economies of scale favour adoption. By way of contrast, relatively little is known of the economics of amending wastewater technologies in small rural towns, primarily because recycling and reuse are usually viewed as financially unviable in these contexts.

One of the problems of adopting this outlook is that it neglects the downstream recycling benefits that can accrue to the total catchment as a result of wastewater treatment in small towns. Thus, according to a TCM philosophy, a geographically broadened scope of interest is indicated. In economic parlance, this implies that the property rights pertaining to the externality benefits from improving wastewater in small towns are ill-defined, thereby leading to an inefficient outcome.

The *Macquarie Dictionary* defines the term "recycled" as "appearing again in an altered guise or role" [12]. Similarly, "recyclable" is described as "of or relating to products or materials which can be broken down after use to serve as the raw materials for new manufactured products" [12]. Importantly, neither definition places a spatial constraint on the concept, and yet we often conceptualise recycling as occurring within a single home, town or city. Our contention in the present context is that enhancing the wastewater stream emanating from a given town (albeit a small town) exemplifies a form of catchment-wide recycling that should not be disregarded. Put simply, whilst the localised economics of wastewater reuse within small urban communities may not stack up, when considered in the context of the wider catchment, it deserves closer scrutiny.

In line with this philosophy, the Victorian government is presently examining wastewater technologies in smaller urban communities with a view to identifying appropriate technical improvements. Ultimately, improving the wastewater treatment in small country towns could produce two distinct benefits. Firstly, it would demonstrably address local environmental and human health concerns in these centres. Secondly, it stands significantly to enhance water quality for downstream users and thereby offer a form of catchment-wide reuse. However, whilst such benefits are assumed desirable, their relative importance in the minds of consumers has not been assessed.

It is the purpose of this paper to detail research aimed at empirically eliciting the preferences for enhanced wastewater services of residents in small rural towns. This paper utilises an empirical approach to examine consumers' decisions to improve their current wastewater system. In particular, it examines a conjoint technique known as choice modelling and discusses how the initial stages of this technique have been utilised in the current context.

The paper itself comprises five main parts. Section 2 identifies various issues apparent in the water and wastewater sector, specifically focusing on the current status of wastewater services in small rural towns across Victoria. In Section 3 some theoretical considerations are explored in the experimental design process necessary to underpin any analysis of consumer preferences in this context. The initial findings from interviews and focus group phases of the experiment are presented in Section 4.

2. Water and wastewater in Victoria

2.1. National water dimension

Perhaps the most notable national influence on urban water reform was the CoAG Agreement on Water Resource Policy (or Water Reform Framework) signed in February 1994, and later the Competition Principles Agreement in April 1995. These reforms included establishing prices to fully recover costs, recognising that the environment has a legitimate demand on the resource, separation of delivery and resource management functions and breaking the nexus between land and water rights to foster water trade. Notably, urban water authorities were expected to introduce tariff regimes that reflected usage, place greater emphasis on service delivery and broadly adopt the principle of "user pays".

Subsequently, water quality, water availability, environmental health and sustainability have developed into significant political issues [13]. However, at the national level, wastewater management has received relatively limited attention. It was not until August 2003 that the National Water Reform Framework began to incorporate recycled water into its considerations [14]. This was followed in 2004 with CoAG agreeing to establish national guidelines for water sensitive urban design, presumably incorporating a closer examination of urban reuse. In sum, there is an increasing consensus that wastewater effluent, rainwater, and stormwater are not merely problems to be solved. In the current milieu they are potentially resources of value.

2.2. Victorian water reform

The legislation governing water resource usage in Victoria is predominantly encapsulated in the Water Act of 1989. However, in 2003 the government released a Green Paper followed in 2004 by a White Paper titled "Securing our Water Future" [15]. This embodied a range of reforms aimed at irrigators, environmental interests, industrial and urban users. In the context of urban wastewater services and reuse, the document also proffered several pertinent policy statements including the following:

"Urban water supplies comprise all available water resources including recycled water, stormwater, rainwater and greywater" (15, p.106)

- "The Government will require all urban water authorities to assess opportunities for the use of recycled water and other alternative supplies in the development of Water Supply–Demand Strategies [which] ... will establish water recycling targets" [15, p. 106].

- "The Government will support strategic recycling and water recovery projects that provide significant benefits at a State and regional scale" [15, p. 110].
- "All Victorians will be provided with safe and reliable drinking water and sewerage services that protect public health and the environment" [15, p. 121].

The latter two of these policy stances represent a significant challenge with approximately 42,000 properties in outer Melbourne requiring sewerage infrastructure and another 22,000 properties in towns of more than 100 properties lacking reticulated sewerage [15].

2.3. Wastewater services in Victoria

In the early 1970s the Victorian non-metropolitan water industry comprised 370 water trusts, sewerage authorities and local councils, each operating independent water and sewage services. The election of the Kennett government in October 1992 ushered in a range of controversial reforms to local government and the administration of water and wastewater services. The 1993 amalgamations reduced the number of water authorities from 83 to 17 [16]. Currently, non-metropolitan water and wastewater services are ostensibly provided by only 14 regional water authorities.

Whilst the provision of water and wastewater services in non-metropolitan Victoria now resides with rural urban water authorities (RUWAs), smaller towns are often excluded from the declared areas for which RUWAs are responsible. Moreover, the amalgamation process has left most RUWAs with a complex mix of water and wastewater distribution systems. Some areas have little potential for economies of scale and yet pressure remains to achieve financial sustainability and to deliver the levels of service expected by communities. These challenges were increased in 1997 when the state government made a commitment to sewer all Victorian towns with a population in excess of 500 by 2001. Since 2001, the state has relied primarily on the use of water service agreements to encourage RUWAs to extend wastewater services to small towns under the New Town Sewerage Initiative. This initiative provided $22.5 million of funding and resulted in sewering more than 50 rural and regional towns [15].

However, two main challenges remain. Firstly, the provision of wastewater services to small rural towns is constrained by the need for water authorities to remain financially viable. Most authorities also realise that there are economic limits that prevent most small communities from funding such works in their entirety (i.e., it is not feasible to invoke the user pay principle). Moreover, it is common for the community in a small town to react negatively to a proposed extension of wastewater services because of the financial implications for households and the perception that such services amount to "gold-plating". In light of this constraint, the state has announced its intention to explore innovative approaches more suited to small-scale applications [15].

Secondly, in those communities not sewered, responsibility for enforcing appropriate management of wastewater rests predominantly with local government, often resulting in significant enforcement costs. Moreover, local government faces a conundrum insofar as the requirement to maintain larger lot sizes to suit on-site disposal is often at odds with their desire to increase development in order to yield higher rate revenues.

Both of these problems are exacerbated by the relative dearth of public information about the preferences of such communities for different types and levels of service. Similarly, there has been insufficient attention paid to the alternative technologies for meeting health and environmental concerns and the ways in which the attitudes of small communities vary between these alternatives. A way forward would appear to reside in treating wastewater systems and services as "products" with the potential to contribute value to consumers. Moreover, being able to unbundle the attributes of these products and establish their contribution to overall utility would provide valuable insight for decision makers, particularly those with a view to enhancing the downstream reuse prospects of the resource.

3. Conjoint analysis and choice modelling

According to consumer decision theory, consumers make decisions based upon a product's attributes [17]. The aim of conjoint analysis is to statistically unbundle these attributes and assign the part-worth utilities to them. However, this relies upon consumers being able to allocate utility to the various levels of an attribute and subsequently develop a total utility for a specified product or service, which can be real or hypothetical [18]. Operationalising this technique requires that the product/service/idea be appropriately described in terms of its relevant attributes and levels, and that respondents are subsequently provided with suitable stimuli [19]. Thus, if we consider wastewater systems to be a product, then a conjoint study will enable us to identify its attributes and determine their relative importance for consumers.

Choice modelling (CM) is a type of conjoint technique. CM provides for the identification of the trade-offs that each consumer makes between attributes. For instance, if one of the attributes is the price that an individual would pay to secure the change, estimates of the marginal value of changes in each attribute can be generated. In addition, CM can develop estimates of compensating surpluses for product changes relative to the business-as-usual situation [21].

The research problem requires a methodology capable of providing empirical estimates of consumers' willingness to pay for the specific attributes of a wastewater system. Information about towns' preferences and capacity to pay for water services will thereby assist RUWAs in prioritising welfare maximising investments.

In a CM experiment, participants were given a series of choice sets, each containing alternative products. An alternative is comprised of a number of attributes, with each attribute assigned a value, generally referred to as a level. For instance, an alternative for a wastewater system may be described in terms of the price of the system and the environmental benefits that it offers. Each choice set contains a no change option, which enables estimation of the absolute value of alternatives. Participants are required to select their preferred option from each choice set. The specified attributes are common across all options; however, according to an experimental design, their levels differ from one option to another [21]. An example of a choice set that might be used in such an experiment is provided in Table 1.

3.1. Experimental design implications

"Designing the project is a critical step to success" [19, p. 399]. CM typically uses an experimental design process to develop the choice sets for respondents. Essentially, this process has two main functions. Firstly, to identify those

Table 1
Example of a choice set

Which wastewater system would you choose?		Price per year ($)	Type of wastewater system
Option 1	X	50	Reticulated
Option 2		75	Independent with aeration
Option 3		No change	No change

attributes that are likely to influence consumer references and assign relevant levels for the conduct of the research. Secondly, the process aims to develop an appropriate model for consumer preferences. Moreover, the experimental design is characterised by an iterative process. In some cases, the attributes of one alternative may impinge upon the utility of another; however, effective survey design can minimise this and enhance the precision with which parameters are estimated [22].

3.2. Discovering relevant attributes and levels

Several aspects are important to consider when specifying attributes and their levels. Firstly, inclusion of all attributes within a choice experiment is not feasible, as a larger number of attributes results in an increased number of parameters that must be statistically estimated. Therefore, the researcher must identify those attributes that are simultaneously significant to the research question, important in the choice decision of most respondents, and controllable within the context of the experiment. Ultimately, this can be achieved by employing an iterative process involving interviews, focus sessions, and survey pre-testing [23].

Secondly, it is important to include levels of attributes that are "actionable". More specifically, attribute levels such as small, medium, and large restrict the respondent's ability to develop precise judgements about the impact of a level on the choice decision [19], thus, limiting certainty about the part-worth estimates derived from the experiment.

Finally, when designing the choice experiment, the researcher must consider the potential for multi-collinearity. Essentially, this effects the estimation of parameters within the model and may cause unrealistic choice options. However, multi-collinearity can be overcome by the utilisation of super-attributes, comprising a number of attributes, although this increases the complexity of the choice experiment [24].

3.3. Limitations of choice modelling

Essentially, a number of limitations surround the CM technique. Specifically, the design of the experiments, the presence of strategic behaviour, fatigue, learning and the complexity of the experiment itself require consideration [25]. Additionally, whilst choice models allow for the unbundling of the part-worth utilities of the various product attributes, they do not, however, explain why individuals make particular choices [26]. In order to improve our understanding of the decision process, the researcher can supplement the choice experiment with additional psychographic and demographic information, although it needs to be acknowledged that this adds greater burdens to participants.

In this paper we specifically designate wastewater technologies as a product that consists of various attributes of interest to potential consumers. Thus, our aim is to use CM to identify those attributes that are most valuable to small rural communities and thereby explore mechanisms for expanding water recycling options.

4. Initial findings of this CM: determination of attributes and levels

Any CM experiment should (1) include attributes in the experiment that are meaningful to participants and (2) have a range of levels that prompts choice variation to allow empirical estimation of part-worth utility. To ensure that salient attributes are identified and appropriate levels selected for the choice experiment, several iterative phases are commonly undertaken. Firstly, in-depth focus interviews with informed individuals are conducted to gain an appreciation of the decision context likely to confront participants. The second phase involves using focus groups to test the understanding proffered by "experts" and ensure that the experiment is real from the participants' perspective.

4.1. Interview phase: technical perspective

Initially, in-depth focus interviews were conducted with several technicians from RUWAs in the northeast of the state. These sessions had three primary objectives. Firstly, they provided an overview of the extant wastewater management for smaller rural towns across northeast Victoria. Secondly, the interviews were likely to enhance the researcher's knowledge of the available wastewater systems and the technological characteristics of these systems. Finally, it was presumed that technical expertise would assist in identifying the relative level of environmental and human harm that accompanies each wastewater system and the likely levels of other attributes. Ultimately, it was assumed that these interviews would at least reveal those product attributes that are valuable from a technical or supplier perspective.

Most of those interviewed indicated that the amount paid by the household for the wastewater service was likely to be the most salient product attribute. Perhaps not surprisingly, technicians tended to approach the levels of this attribute from a cost perspective. Put differently, most technicians were more inclined to consider construction, maintenance and operating costs as the foundation for establishing prices rather than what consumers were willing to pay to acquire the benefits of the service. In most cases technicians tended to draw on previous experiences with the New Town Sewerage initiative which comprised a mostly conventional sewerage infrastructure.

The second attribute to be developed from in-depth technical interviews was the impact of alternative wastewater systems on the environment and human health. Attempts to refine this attribute usually resulted in extensive debate about specific systems and a location-specific impact. The problem with this approach was that it would severely limit the extent to which a wider CM could be applied in a range of settings. To progress the development of this attribute, technicians were asked to consider, in general terms, the impact of three broad wastewater management systems. More specifically, technical experts were asked to suggest an approximate likely impact on environmental and human health which might be attributable to each system. Fig. 1 illustrates the initial levels for this attribute which might later be presented to participants as "type of wastewater system".

One of the advantages of this approach was that it avoided the potential collinearity problem resulting from separating human and environmental health. Put simply, these variables track together, and statistical modelling where these were treated as separate explanatory variables proved problematic. In essence, developing a wastewater systems attribute amounts to a "super-attribute" in the Hair et al. [19] nomenclature.

At the conclusion of this phase it appeared feasible to conduct a choice experiment that comprised only two variables, namely, price and wastewater system type, which encapsulated the effects on human and environmental health.

4.2. Focus group phase: consumer perspective

Extensive focus group sessions were conducted within small towns across rural northeast Victoria in an attempt to gain an understanding of the consumers' perspective on wastewater. Focus group participants varied across a number of demographic and positional factors, although most groups were dominated by active community members. Essentially, these focus sessions aimed at identifing the salient attributes and levels relative to wastewater systems from a user (as opposed to a supplier) perspective.

Independent system with aeration component
This is a septic tank system with an installed aeration filter that is able to improve the effluent quality being discharged on-site. With this system there is a:
50% chance that individuals will not get sick, and
the system is able to have a positive effect on the environment **60%** of the time.

Semi-independent system (septic-pumped)
This system provides limited treatment onsite, where wastewater is stored until a contractor or authority collects it. The wastewater is transported to a remote location for treatment. With this system there is:
70% chance that individuals will not get sick, and
the system is able to have a positive effect on the environment **80%** of the time.

Reticulated system
This is a communal system where all installations directly discharge to a reticulated wastewater treatment system. With this system there is a:
98% chance that individuals will not get sick, and
the system is able to have a positive effect on the environment **95%** of the time.

Fig. 1. Description of the three potential wastewater systems developed from a technical perspective.

Each session began with an introduction addressing the current issues surrounding wastewater systems in small rural towns, followed by an example of a CM exercise. Participants were then asked to freely discuss the issues that they felt important when deciding whether and how to improve their current wastewater system. Where an attribute was raised, participants were then pressed to discuss the likely range of that attribute. For example, after the price of an improved wastewater system was mentioned as being a significant factor, participants were asked to suggest what price they would be prepared to pay to remedy the current wastewater situation. Like the technical experts employed for this project, many residents endeavoured to approach the task of assigning a price level from a cost perspective. Only by resisting pleas for information to extract a cost were participants ultimately forced into revealing the likely range of what they regarded as a fair price.

The focus sessions also revealed the difficulty of describing the price attribute consistently. It is common practice for new water and wastewater infrastructure to attract an up-front payment and on-going annual contributions from residents. Varying the ratio between these would make it difficult to gain a consistent estimate of the willingness to pay. The two main issues of concern were varying discount rates between consumers and the knowledge, by some in the focus sessions, that the government had previously capped the up-front contribution that could be applied by RUWAs to $800. In light of these difficulties, it was decided that a simple annual payment for the service would provide the most reliable empirical estimate of willingness to pay. The most common lower and upper limits for this attribute suggested by participants in the focus sessions was $100–$700.

It also became apparent during the focus sessions that the wastewater system attribute suggested by the technical group would not be effective in capturing the pertinent part-worth utilities from a consumer's perspective. The problems with this attribute were threefold. Firstly, whilst the technical group had emphasised the environmental and human health impacts of each system, focus group participants universally considered the problem to be related solely to environmental health. That is, human health was not considered to be affected by the *status quo*, and suggesting so in the choice sets may undermine the realism of the experiment from the consumers' perspective. (This should not be taken to imply that there is no impact on human health pertaining to the present methods of dealing with wastewater systems.) The second problem with this attribute was that it invariably caused respondents to consider the technical intricacies of application in each household rather than the bundle of benefits that might be realised from adoption. Thirdly, participants in the focus sessions were clearly inclined to consider higher order attributes that went beyond the descriptions developed by the technical group. Each of these attributes is briefly discussed below.

4.3. Specifying attributes and levels

Four attributes for inclusion in the choice experiment were ultimately identified from the consumer focus sessions. These include price (described above), environmental improvement, subdivision potential, and on-going personal responsibilities to maintain the optimality of the system.

4.3.1. Environmental improvement

It became apparent that the impact of wastewater services on human health was not an area of great concern for residents. This can be attributed to the fact that, to their knowledge, there were no cases of individuals becoming ill from the current wastewater discharges. However, environmental concern was evident. As one participant summarised it: *"That's rubbish — nobody around here has ever been sick from wastewater. Yes, I can see that it's spoiling our environment but it hasn't harmed any of us."*

4.3.2. Subdivision

Without sewerage infrastructure the potential for residential subdivision is reduced in several rural towns. This was identified by some participants as an important consideration in their decision to purchase wastewater systems. Whilst not unanimous across all focus sessions, there was sufficient commentary in most to indicate a *prima facie* case for including this variable in the choice sets. As some respondents put it: *"This place would really take off if we had sewerage because we are so close to town". "There are plenty of people just waiting for sewerage to come so they can subdivide".*

4.3.3. On-going responsibilities and required maintenance

All focus sessions indicated that one of the primary motivations for purchasing a wastewater service was that residents could shift responsibility, along with maintenance expenditures, to others. Participants accepted that in order to function at an optimal level, alternative systems required varying degrees of time, cost, and effort after installation on the part of the householder. As two respondents noted: *"What I want to know is can I push the button and forget about it?" "Will I have to worry that others are not doing*

Table 2
List of attributes and levels to be used in CM of wastewater services in rural Victoria

Attribute	Levels and coding
Price (annual payment)	\$100; \$300; \$500; \$700
Environmental improvement (% positive change from status quo)	50%; 65%; 80%; 98%
Subdivision potential: (approval possible)	Yes = 1; No = 0
On-going householder responsibility: (% of responsibility retained by householders to ensure optimal performance)	10%; 30%; 50%; 70%

their bit on their property to make the thing work?"

Whilst there are clearly two dimensions to this issue, it was the opinion of most in the focus groups that they were not sufficiently independent to warrant separation. Again, participants suggested that a percentage metric would adequately describe the extent to which they would be responsible for maintaining the adequate functioning of the wastewater system.

The list of attributes and levels derived from this phase of the study are presented in Table 2.

5. Conclusions

What has euphemistically been referred to as "wastewater" has unequivocally assumed new status as water scarcity becomes increasingly critical in Australia. Increasing demand and limited water supply are arguably driving a wider acceptance of the need to adopt a holistic approach to the management of the resource. Moreover, this is evident in legislative and administrative arrangements that are giving greater credence to efforts to deploy urban wastewater to alternative uses.

To date, much of the analysis of water reuse has focussed on the technical dimensions of the problem supported by some limited economic analyses. This second genre of research has centred mostly on larger urban reuse schemes and tended to employ a relatively narrow or localised definition of reuse. Smaller urban communities have been largely overlooked in this debate although a truly integrated view would acknowledge that wastewater from such communities can be reused by others only if the quality of wastewater is addressed.

In Victoria, urban wastewater for small towns is under scrutiny, partly as a consequence of the latest reform measures articulated in the White Paper. However, improving wastewater treatment from small rural towns is likely to prove problematic, and this is exacerbated by the lack of data pertaining to the preferences of residents in these towns.

An opportunity exists to improve our understanding in this area by using a conjoint technique known as CM to discover the trade-offs individuals are willing to make to achieve a welfare improvement. To date, this study has revealed non-trivial differences in the attributes deemed to be important from a technical perspective to those that are relevant from a consumer perspective. Applying this information to a choice experiment will ultimately provide an empirical estimate of the relative value of each of these attributes to consumers, and potentially lead to improved policy decisions in this context. This phase was proposed for late 2004, providing timely advice to policymakers.

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