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SETTING AND EVALUATING CUSTOMER SERVICE STANDARDS

Overarching Report

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EXECUTIVE SUMMARY

Reform of the Australian water industry over the past 20 years has been extensive. These reforms have changed the industry's structures, its regulatory oversight and pricing arrangements. The reforms have delivered substantial efficiency gains in the form of lower real prices, higher dividends, higher real rates of return, higher standards and greater capital investment. While further efficiency may be available in the water industry, it is fair to say that future gains will be lower and that higher standards may result in increased prices for services.

The need for regulation in the industry is self-evident, but it is imperative that it be as effective and efficient as possible and deliver real community benefits. One regulatory area of importance to the water industry is standard setting. In particular, the industry suggests that the upward trend in standards in the areas of customer service, public health and the environment is resulting in sharp increases in capital expenditure for the urban water industry. With capital costs accounting for sixty percent of the industry's total costs and with underground pipes amounting to around seventy percent of all capital costs, setting standards for areas such as water continuity is particularly important.

It is therefore valuable to make decisions on the level at which future standards will be set within a framework that evaluates both the benefits (from the customers' perspective) and costs of the proposed higher standards; higher standards can then be adopted when it is clear that the benefits outweigh the costs.

Accordingly, CSIRO Urban Water entered into a partnership with the Water Services Association of Australia (WSAA) to develop an appropriate methodology for such a framework. The project has three separate modules:

- The identification of customer preferences and a methodology for measuring these preferences;

- The economic component which values customers' preferences, measures social costs associated with water interruptions and develops the overall cost benefit framework; and

- The identification and evaluation of lifecycle costs of meeting standards for water continuity.

The above framework will assist water utilities and regulators to understand better what is important to customers and will include total community costs (and not merely the costs to the water utility). The framework incorporates long-term assessments and not merely short-term impacts of such decisions.

This Overarching Report shows how the component parts of the framework operate in concert to enable cost and benefits to be compared. This 'integrated' methodology has been developed using water system continuity as a test case.

It is not the intent of this Overarching Report to provide to provide a detailed summary of the component methodologies: readers are directed to the associated technical reports in this regard. Rather, sufficient information is given to provide an insight into each component and then the application of the component methodology is demonstrated. The approach shows the interrelationships between the components and the approach a water company or regulator could take in developing standards within a cost-benefit framework.

Through this work, three subordinate methodologies have been developed. These include:

- A methodology for determination of customer preferences

- A methodology for determining customer willingness to pay to achieve their stated preferences or willingness to accept compensation if a reduction in a standard is proposed

- A methodology and associated model for determining the cost of achieving these preferences, which can be manipulated to show the cost of difference standards under a range of policy settings

Utilising the above methodologies in an integrated fashion will allow cost benefit analysis of proposals to alter standards to be carried out, or quantify the cost and benefit of achieving company-determined performance goals. Included in the cost analysis are social costs, which stem from traffic disruptions and business loss due to water service interruptions. As this project was directed to developing a methodological framework and associated tools for cost benefit analysis it utilised as its 'test case' water service discontinuities. The approach would, however, potentially also be applicable to other water company services.

It is important that it be understood that while this project delivered integrated methodologies through which cost benefit analysis could be carried out all aspect of the integrated methodology do not need to be implemented whenever a change in a standard is contemplated. Partially for this reason, the development of the methodology dealing with customer preferences included the development of a Subjective Social Indicator (SSI) which is a readily implemented approach that acts as a litmus test to determine whether customers perceive a discontinuity between the level of service provided and the investment made by Government (in this case through the water utility) in provision of that service (which would include under and over-servicing). If the SSI, which has been extensively tested for its reliability and validity, does not reveal such a discontinuity, no further action would rationally be taken.

The customer preference methodology also includes a latitude of acceptance scale that allows customers to nominate service discontinuities they 'could cope with'. This is important in that attitudes to water service interruptions are non-crystallised (i.e. firm opinions are not held). The latitude of acceptance approach can be used to determine the points at which standards *might* be set, assuming the cost-benefit analysis is positive.

Equally fundamentally, the methodology allows identification of those aspects of services customers value (or do not wish to see as part of the service). Critical findings included:

- Respondents generally could cope with short interruptions, and the components of interruptions that were deemed to be important were:

  o Duration of the interruption;

  o If they are notified of the interruptions;

  o Time of day the interruptions happened; and

  o The number of interruptions per year (both planned and unplanned, although there was a greater tolerance for planned interruptions than unplanned.)

- Compensation was generally not expected for planned or unplanned interruptions, with customers more interested in having the problem fixed, than any form of rebate (which they felt they would pay for anyway through increased water bills)

The willingness to pay methodology was based upon the technique of Choice Modelling. While still a non-market approach, this technique is considered the state of the art in this area, and is a significant improvement on approaches such as contingent valuation that are subject to 'context' effects (i.e. distortion due to the way in which the questions are asked). One example of a Choice Modelling questionnaire is shown in Figure 4. By questioning a statistically valid number of customers and confronting different subsets of this number with subtly varied choices, it is possible to quantify customers willingness to pay for various attributes. The attributes selected for inclusion in the choice modelling exercise were based on the findings of the customer preference activity.

By identifying attributes valued by customers and their willingness to pay for them, the benefits side of the equation is complete

On the other side, of course, are costs. In this project, a model was developed to allow prediction of the costs to the utility of meeting various customer service standards. A state of the art model was developed which moves beyond the approach of existing planning models, which predict failures for cohorts of assets, to prediction of the performance of individual assets. While the model itself remains the proprietary product of CSIRO, failure curves for individual assets are available to the industry that

can be calibrated for its particular circumstances and the experience of developing the model points the way for standardised data collection across the industry.

Also developed was an understanding of the social costs associated with water service provision. These included the cost of traffic disruption due to pipe failures, repairs or replacement, and the loss to business of water service interruptions. These costs can be significant depending on the circumstances and should not be ignored. Interestingly, social costs are high at both very tight standards and very liberal ones, as social costs are incurred when pipes are frequently replaced to achieve the higher standard and frequently fail under looser regimes. (See Figure 8 for further information).

The integrated methodology developed in this project represents a significant body of work, which is world leading. There is the potential to apply it throughout the Australian water industry and to promote it to the industry and its regulators overseas.

TABLE OF CONTENTS

TABLE OF FIGURES

1.0 OVERVIEW OF THE ISSUES

The following sections set out in detail the forces that are driving water companies to seek ways to manage their expenditure on pipeline assets. Put as simply as possible the following statements define the problem:

- Asset management costs tend to rise in response to more stringent regulation and as assets age

- Risk based asset management strategies have been adopted to mitigate rising costs, but further development of these techniques is warranted

- Standards need to reflect customer demands

- The benefits customers gain from changes in standards should be greater than the costs of achieving them

Social costs of interruptions need to be considered within the equation

The potential impact of changed standards on costs is self-evident. Where efficiency gains have already been driven from an industry – as the water industry claims – total outlays must increase if improved performance is required. A system operating 24 hours a day will occasionally suffer interruptions. Generally speaking, the likelihood of unexpected interruptions can be reduced if pipelines and related assets are replaced more frequently. Our modelling, however, shows that replacement of these component parts is often more expensive than repair. As replacement strategies begin to dominate over repair, costs increase along an exponential curve. Depending where one is on the curve, the impact of moving to a more stringent standard can be significant.

1.1 The Problem of Aging Assets and the Development of Risk-based Approaches

Water pipeline assets age at different rates, due to the different materials used, the conditions in which they are laid, the pressures they operate under and other factors. Nevertheless, there is a large cohort of assets now reaching 'middle age'. This is due to the rapid expansion of water and sewerage services after World War II to the mid-1970s. Assets created in that period are now between 27 and 57 years old. Consequently, water authorities around the world have predicted a bulge in expenditure in coming years, as illustrated in Figure 1, below.

Figure 1 - Expenditure over time: Set Age Replacement vs. Strategically Managed
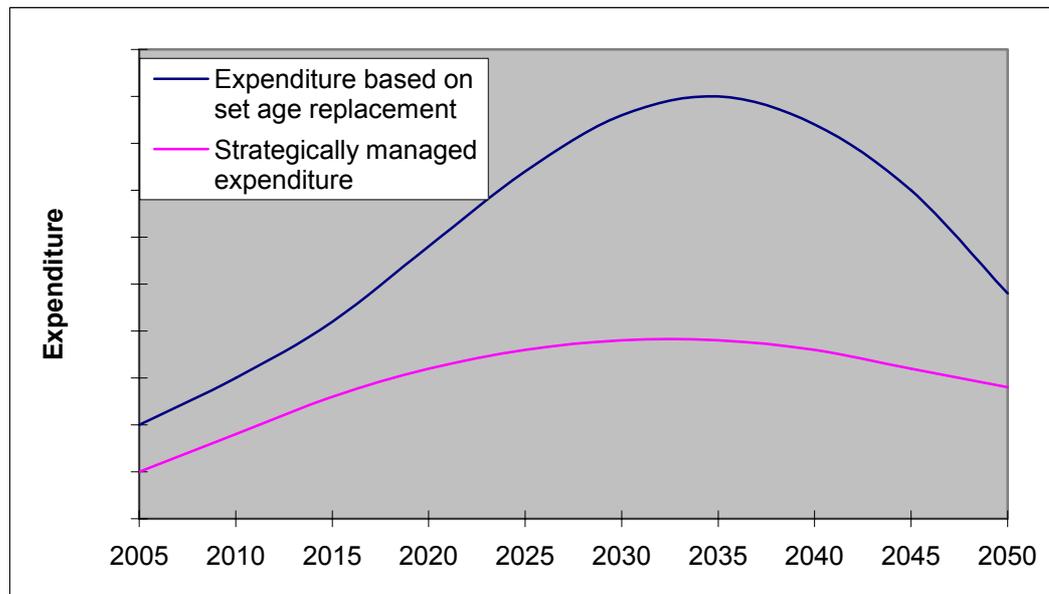
As indicated, pipes age at different rates and the consequence of their failure is not equally significant in all locations. Thus, the industry has adopted risk management strategies reflecting the likelihood and consequence of failure, and incorporating new techniques of condition monitoring. These techniques allow some prioritisation of asset renewal and replacement, which flattens the predicted expenditure curve, as shown in the pink line in Figure 1.

Understanding of the performance of pipes is, however, largely based on historical evidence. For some materials, such as PVC, there is a paucity of such evidence, and the capacity for operators to predict performance is limited. Further, the effects on individual assets of operating conditions (pressure, aggressiveness of soils etc) are not well developed, increasing the uncertainty and the likelihood of failure of critical assets. Reduction of this uncertainty would improve predictive ability of operators such that risk strategies become more robust. There is consequently a need for further development of risk-based models and techniques. These techniques should seek to provide estimates of costs based on the optimal mix of asset management strategies such as replacement, maintenance and policy options.

1.2   Role of Standards and Need to Determine Customer Preferences

Any asset management strategy must be directed to some type of goal. Higher standards will accelerate replacement of assets, and lower standards will defer them. In Australia regulators set goals for performance of assets as an aspect of preventing the abuse of monopoly power. Often mandatory standards are included in Operating Licences or similar instruments specifying performance. Thus, for example, Melbourne retail water companies are regulated on the number of interruptions. Other jurisdictions may regulate duration of interruptions or cumulative duration of interruptions. Asset management strategies are directed toward achieving these goals at the lowest possible cost through use of techniques such as clamping, replacement, pressure management and reduction in 'shut-off block size' (i.e. reduction in the number of properties between valves).

The derivation of these standards is, however, often historically based. That is, upon the introduction of regulation the standards adopted were those particular water companies were attempting to achieve to meet their perception of what constituted quality service. These were based on the water authorities' knowledge of the level and type of complaints it received from customers at the time. In

any case, standards are inconsistent even within the same jurisdiction and may not accurately reflect current customer requirements.

Thus, a robust methodology for determining customer preferences is important if the industry is to meet the expectations of those to whom it provides a service. That such a methodology has not been fully developed reflects the fact that analysis of customer preferences is difficult and appropriate tools have not, to date, been available.

1.3 Link to Willingness to Pay or Be Compensated

Identification of customer preferences does not quantify the value received from those preferences were they to be met. Consequently, it is important that they be quantified though identification of a customer's willingness to pay for their achievement. That is, a choice of one or more options might be easily made if the context of the cost consequences of these choices is not also provided. A customer may readily nominate a high standard without understanding cost impacts.

As a result, various techniques have been developed which attempt to elicit customers' willingness to pay for higher standards or willingness to accept compensation if standards are lowered. To date, however, these techniques have been subject to significant and valid criticism. The challenge within this project was to overcome – to as great an extent as possible – the short-comings of these techniques to develop a robust method of determining customer's willingness to pay for current or improved standards, or willingness to accept compensation for lower standards. The state of the art mechanism for assessing willingness to pay or accept is a technique known as choice modelling.

1.4 Incorporation of Social Costs

When an interruption to service occurs, and repairs need to be effected, a range of costs is incurred by third parties that are not usually included in calculations of the cost of the repair. That is, repair costs are usually taken to include only the cost of materials and labour. However the financial impact of the interruption on certain groups may be significant; loss of a restaurant's business or traffic delays caused by excavation are examples. As long as these costs are not included, the cost of an interruption is understated and cost-benefit analyses carried out on a changed standard will be flawed. This project sought to identify and quantify these unaccounted for costs.

2   METHODOLOGICAL FRAMEWORK

The intent of this project is simple: to develop a methodology to identify customer preferences; their willingness to pay to achieve these preferences (or willingness to accept compensation where a reduced standard is contemplated) and the cost of achieving their preferences (on a whole of life cost basis, taking into account social costs). This methodology allows robust cost benefit analysis to be carried out, as illustrated in Figure 2.

Figure 2 - The Methodological Framework
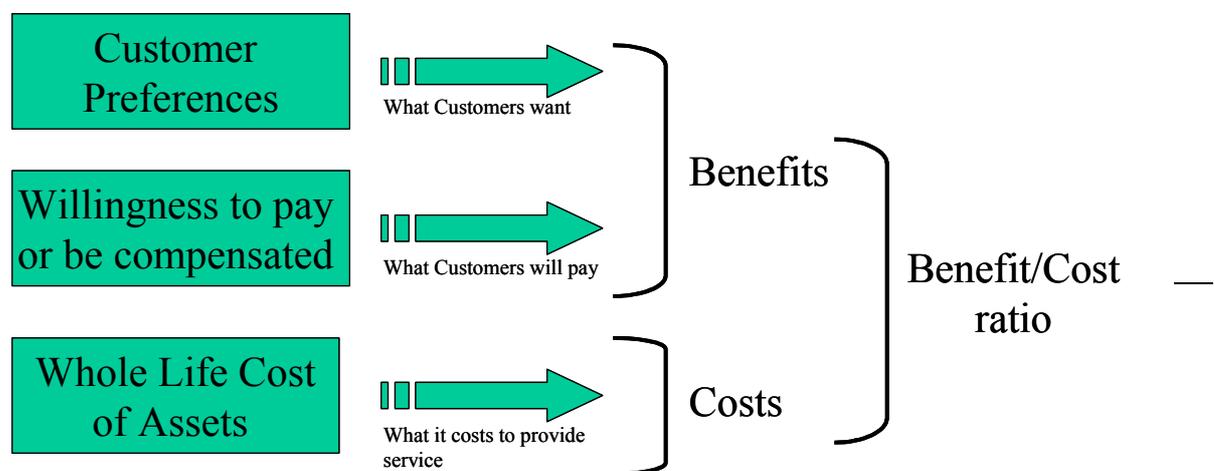
2.1   Position of the Overarching Report

The Project's methodology can be broken down into three separate components: Identification of Preferences; Valuation of Preferences and Costing of service provision and third party impacts. This Overarching Report demonstrates the way these components are linked and can be used by water companies and regulators to set standards within a cost benefit framework. The detail of each component is contained in separate technical reports, as follows:

- The Development of a Methodology for Assessing Customer Preferences for Levels of Service – Continuity of Supply (ARCWIS, 2001)

- Valuing Water Supply Interruption Preferences: The Development of a Methodology (Hatton MacDonald, D. and Young, M., et al. 2002)

- The Cost of Customer Preference: The Development of a Pipeline Asset Risk Management System – PARMS (Burn, L.S. et al. 2002)

The Overarching Report is not an attempt to summarise the underlying technical reports. Rather, its purpose is to outline the basic methodological steps included in our approach and the application of those steps such that efficacy of the methodology is demonstrated. In providing such a description, it is important to keep in mind that the project was undertaken using sample sets of consumers in two major metro areas (Adelaide and Melbourne) with some additional work on the preferences of neighbourhood shop owners in Perth. Therefore, while this report shows the way in which the

methodology would be used, using actual results, the data sources are geographically disparate and the results not necessarily applicable to any one site. Tremendous care is necessary when transferring anything other than the methodology to any location, including cities where part of the work was undertaken. All integrated analysis is for a hypothetical location.

2.2   Service Selection and Justification

The methodological framework developed through this project is applicable to all services provided by the water industry. In developing our methodology, however, we selected water service continuity as our 'test case' on the recommendation of the Water Services Association of Australia. Water service continuity is often regulated by various agencies through Operating Licences and achievement of increased standards represents a 'big ticket item' for the industry. *(Note: In early focus groups convened during this project customers expressed a preference for the term 'interruptions' to describe breaks in continuity of water service. This term is used in the rest of this report).*

2.3   Composite Analysis

This report contains examples of cost-benefit analyses that might be carried out using the methodology described here. We stress, however, that while the cost benefit analyses use actual data derived from our analysis, not all data was gathered from the same location. Consequently, the results of the analysis cannot be said to represent conditions or standards that should be set at any particular site. For example, we assume a customer base of 500,000 connections, which is broadly analogous to Adelaide. However, the cost side of the analysis was based on analyses of data on asset costs supplied by another water utility. This 'composite' situation is, therefore, not fictitious, as all data is real, but the cost-benefit analysis is a composite of data from different locations, compiled for the purpose of demonstrating the efficacy of the methodology.

2.4   Protecting Customers in Problematic Areas

Readers should be cognisant of the difference between average system performance (the level of service most customers would receive) and regulatory standards (generally referred to as 'safety net standards'). Safety net standards are designed to protect a small percentage of consumers who experience service significantly poorer than the bulk of the population. Examples include a maximum number of interruptions that can affect an individual property each year, or the cumulative duration of interruptions allowed in this period.)

In determining a methodology for the setting of a system performance standard, the same principles apply whether consideration is being given to varying average performance or to the safety net standards. Both cases involve a clear and robust consideration of customer preferences and the benefits and costs of any change.

3   DETERMINATION OF PREFERENCES

We have strongly emphasised the importance of working out what the customer wants from a water service as the basis for carrying out cost benefit analysis. Water companies, regulators and customers all have views as to what constitutes a quality service, but it is customers' opinions that must carry the most weight. A methodology is required, therefore, that enables the industry and regulators to have confidence in the views expressed by customers and that enables customers to express their preferences across the full range of attributes (that is, not just, say, frequency or duration of interruptions, or but the need for rebates or notification of interruptions and so on).

Most important in determining preferences is to work out what issues 'are on the customers' radar'. That is, what issues are of concern to them? Standards should only be changed when it is evident that there is customer dissatisfaction with the existing circumstances.

In order to determine satisfaction with a service attribute simply, but in a robust manner, a Subjective Social Indicator (SSI) was developed, based on the work of Shinn and Gregg (1984) in the United States. Unlike other methods, the work of Shinn and Gregg focused on perceptions of the current service level and government responsibility to provide the service, in order to estimate the needs of government to provide more or less of that service. In this way, the focus is shifted from the traditional approach on consumption needs of the public to the production needs of government (or in this case water utility). Our focus group work associated with the determination of customer preferences showed that the provision of water services is seen as a public good. Note, at this level of analysis the customer is expressing the need for additional investment, without making the connection that this investment may lead to higher prices.

The intent of the Subjective Social Indicator (SSI) is to determine whether there is a gap between Achieved levels of Service Provision (ASP) and the Goal of Service Provision (GSP). The ASP dimension was measured by asking the respondents to rate from 1 to 10 how satisfied they are with the ways the water utility handles water pressure, quality, restrictions and interruption issues as well as their preference for greater spending on those issues. The scores from both questions above were summed and then standardised by multiplying the total scores by five so that their scores could vary from 0 to 100. These scores become an index for the ASP dimension.

Two separate questions were asked to measure the GSP. Again using a 10 point scale the respondents were required to rate the importance of the ways the four water service issues are handled in regard to their present lifestyle, and the responsibility of the water utility to provide a good level of service for handling those four water service issues. The scores were again summed and standardised as above, and the standardised scores were used to represent the GSP dimensional index.

The final Need for Service Provision score (which represents the gap between the GSP and ASP) would thus vary from a low of –100 to a high of +100. A negative score indicates an over-provision of service, while a positive indicates a need for improvement in the service. The quality of the service for water interruptions was found to be 'about right' using this scale.

The sample set analysed to develop and test the methodology was drawn equally from groups who had, and had not experienced water service interruptions, to ensure that people were not just responding to their personal experience, or not responding because such conditions were beyond their experience. In the end, there was no statistically significant difference in the responses from the two groups.

Some comment is required here as to why customers were asked about interruptions alongside three other unrelated water service attributes. The answer lies in our need to test for a context or 'embedding' effect. An embedding effect can be said to exist when customers over-state their preferences due to the context in which the questions are asked. We were aware of the risk of such

effects existing, because they were evident in the results of questions related to valuation of the four water service attributes. These questions were included in the questionnaires specifically to see if embedding effects were evident. The SSI – which provides evidence of concern about an attribute relative to other attributes – needed to be free of such effects if the methodology was to be considered reliable and indeed, the methodology proved to be free of embedding effects indicating that the same result would be obtained whether interruptions were considered alongside other attributes or on their own. (A full description of the tests conducted for reliability and validity are included in Section 12 of ARCWIS, 2002. The four SSI questions are reproduced in isolation in Appendix 1 to this report).

We therefore propose the SSI as a key methodological advance that will enable customer preferences to be identified. However, we would not recommend that it be used completely in isolation. In our surveys, the four SSI questions were included in a range of questions relevant to the particular attribute we were investigating (interruptions). This allowed us to identify preferences related to attributes of interruptions (duration, frequency, etc), but equally importantly, it encouraged customers to come to an understanding of issues relevant to water service provision prior to them encountering the SSI questions. This is important, particularly if there is not a high awareness of issues under consideration (as was the case in our surveys).

Our results showed that customers considered standards for water service interruptions were about right. Were the integrated methodology actually being implemented, investigations would stop at this point and no subsequent attempt would be made to quantify willingness to pay for or cost alternative standards[1]. However, for the purposes of this exercise we assumed that customers are, in fact, dissatisfied with current service levels.

We consequently examined through various survey questions and focus groups the attributes of interruptions customers were most concerned about. The questionnaire included both the SSI questions contained in Appendix 1, and various other questions concerned with the attributes of water service. (The entire questionnaire appears in Appendix 6 of ARCWIS 2001). The detail of the results is reported in the technical report. For the purposes of this report, however, the following can be stated:

- Attitudes were generally non-crystallised, meaning that strong attitudes were not held

- Respondents generally could cope with short interruptions, and the components of interruptions that were deemed to be important were:

    o   Duration of the interruption;

    o   If they are notified of the interruptions;

    o   Time of day the interruptions happened; and

    o   The number of interruptions per year (both planned and unplanned, although there was a greater tolerance for planned interruptions than unplanned.)

- Compensation was generally not expected for planned or unplanned interruptions, with customers more interested in having the problem fixed, than any form of rebate (which they felt they would pay for anyway through increased water bills)

For the purposes of explanation in this report, we will provide an example of the quantified benefits and costs of a change in service standard to reduce the duration of interruptions from 6 hours to 4 hours and the allowable frequency of unplanned interruptions from 2 p.a. to 1 p.a..

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[1] Note that this finding does not negate the importance of researching willingness to pay for changed standards or a changed mix of attributes. There were sufficiently strongly held views about aspects of service provision that warranted further investigation in order to develop and test the effectiveness of the method. The suggestion that investigations might have stopped at this point applies only to water companies who would clearly make the decision not to proceed on the basis that further investment into willingness to pay or accept compensation is not warranted given the relatively low level of concern by customers.

While our choice of demonstration standards is essentially arbitrary it is worthwhile commenting on the means through which actual standard changes might be determined. Given the non-crystallised nature of the attitudes a process that measured the *latitude of acceptance* scale of the various components of the services was used. This also ensured that valid attitudes and not non-attitudes were measured. The latitude of acceptance approach allowed people to have a 'grey area' when indicating preferences. For example, when deciding their preferences for the number of unplanned interruptions in a year, people could state their absolute choices of acceptability and unacceptability. However, the method also provided for uncertainty in that people could offer numbers that they 'could cope with'.

Figure 3, below, illustrates the latitude of acceptance for duration of interruptions

Figure 3 - Example of Latitude of Acceptance: Duration of Interruptions
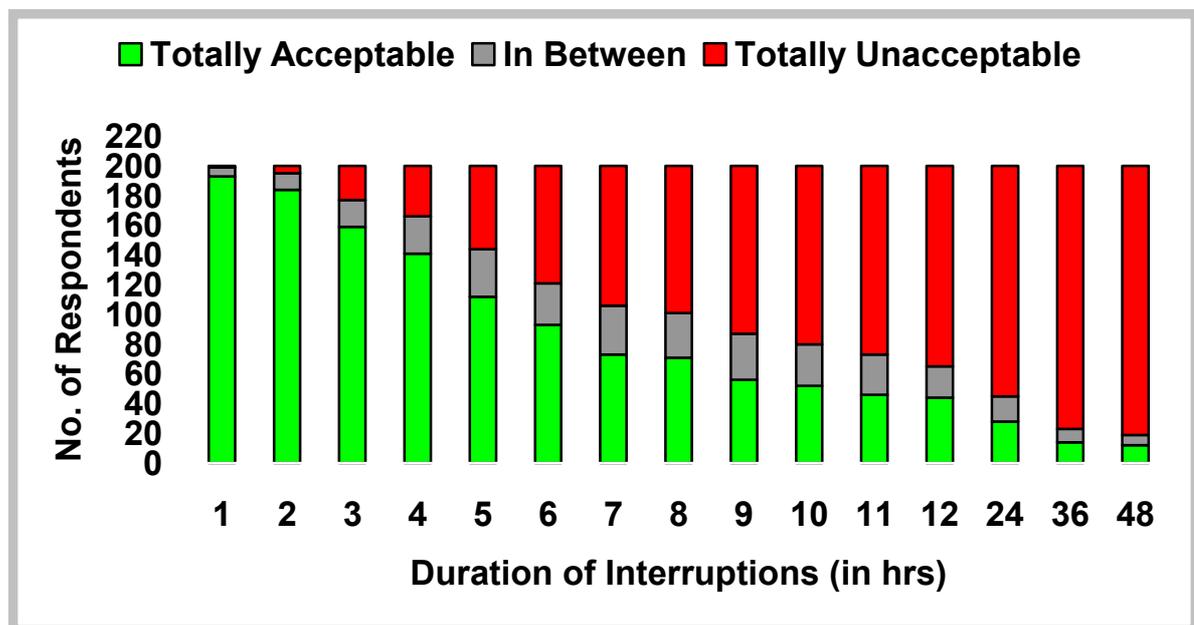
From this result we can see, for example, that as the duration of interruptions increases, the level of dissatisfaction increases. At a duration of 7 hours or greater, the majority of customers are dissatisfied.[2]. One can also see, however, that at a duration of 5 hours   the majority of respondents (56%) would not be dissatisfied. A decision to adopt such a standard might be sensible, assuming the perceived benefits of such a tightening outweighed the costs of achieving it.

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[2] Note that this example makes no distinction between duration of planned and unplanned interruptions. Survey 2, however, asked respondents to differentiate between duration of planned and unplanned interruptions if it made a difference.

4 EVALUATING BENEFITS – WILLINGNESS TO PAY OR WILLINGNESS TO ACCEPT COMPENSATION

Key attributes that matter to the customers are the duration and frequency of unplanned interruptions. If the SSI had revealed that the issue of interruptions had warranted further investment, one of the things we would need to investigate would be customers' willingness to pay. This is the benefits side of the cost/benefit framework. There is a number of methodologies for determining consumers' - for instance, contingent valuation – for determining willingness to pay for a level of service. Many of these have evident flaws and, in the absence of a market, these flaws cannot be fully overcome. However, the technique of Choice Modelling has been chosen as the preferred methodology for this study as it significantly reduces these deficiencies[3].

Essentially, this Component sought a methodology to provide information enabling regulators and WSAA members to explore the question of whether or not a different configuration of attributes would improve customer satisfaction.

Choice modelling uses a survey approach where the respondent is asked to choose A, B or C where each option is a package of good attributes and/or customer service attributes. In choosing among A, B or C, the respondent is being asked to trade-off these attributes. A choice modelling questionnaire was subsequently developed through an iterative process of consultation with industry representatives, a focus group and extensive pre-testing of the instrument and was put to groups of customers in late 2001

The initial design suggested that over 614 usable responses would be required for validity. This meant that we should aim for 768 questionnaires with choice modelling questions stratified as follows:

- Half the respondents should be asked about standards they would expect if in the last 12 months they had experienced a water supply interruption "once before" and half what they would expect if a disruption had "never" happened;

- Half the questionnaires offered a willingness to pay choice set and half a willingness to accept compensation choice set

- A sub-sample of the willingness to pay choice set was given a payment scale that was half the scale developed with focus groups to test for the possibility of embedding[4].

The approach taken in the choice modelling survey has been to use a Willingness to Pay (WTP) measure to estimate customer valuations of increased standards and a Willingness to Accept Compensation (WTAC) to derive customer valuations of decreases in standards. Effectively, this approach allows for the possibility of what economists refer to as a 'kinked demand curve'. That is, if customers perceive that the status quo is a quasi-property right, they may seek greater compensation for reductions in standards than they will be willing to pay for a corresponding increase in standards.

Figure 4, below, provides a sample of one of the choice modelling questionnaires. As can be seen, respondents are confronted with A, B and C choice sets, which differ in quite subtle ways. By asking customers to select one of these combinations customers are being asked to choose a range of attributes, not just make a single selection. If a sufficiently large number of respondents is questioned

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[3] A useful description of the choice modelling technique is provided in Bennett, J. and Blamey, R. (2001) *The Choice Modelling Approach to Environmental Factors* Edward Elgar

[4] If a statistical difference is found to exist then embedding may be present.

using a range of differing choice sets it is later possible to identify which of the attributes is of most value to customers and relate this to their willingness to pay (or accept compensation)

The methodology developed to elicit information on customer willingness to pay/accept compensation is sophisticated and robust. As indicated above, one would only investigate WTP in the event that customers had revealed a desire for further investment in this area following application of the SSI

For this report, we are determining willingness to pay for a reduction in duration of an interruption of 6 hours to 4 hours and for a reduction in frequency of interruptions from 2 p.a. to 1 p.a. The results of this analysis show the following:

- Those in the Adelaide sub-set (the only group included in the Choice Modelling questionnaires) were willing to pay $2.35 per annum to achieve the desired improvement in the standard for duration from 6 to 4 hours. Assuming a site of 500,000 properties translates this into a total annual WTP of $1,175,000 p.a.   The Net Present Value of such a permanent increase in a water bill is $19,583,333.

- Customers were willing to pay $2.20 p.a. for an improvement in the frequency standard from 2 p.a. to 1 p.a. This is a total WTP of $1,190,000 p.a. and a Net Present Value of $18,333,333.

In order to test the methodology we needed to choose numbers that people believed or was meaningful to them.   There are only a limited number of jurisdictions that specifies allowable numbers of interruptions. One of these is Victoria. It sets the limit for allowable interruptions at 5 p.a. However, only a minute proportion of customers (1.5%) experienced even 4 interruptions (WSAA*Facts* 2001). In a system operating around the standard of no more than 5 interruptions, some 35% of customers potentially experience one or two interruptions. Thus, the Choice modelling questionnaire asked about respondents' willingness to pay for a reduction from a standard of 2 interruptions p.a. to 1 p.a.

To test for the existence of an embedding (context) effect, 64 respondents who were given willingness to pay questionnaires, had the payment scale associated with their choice sets adjusted down to $0, $30 and $60, as opposed to $0, $40 and $80[5] for the larger group in this subset (128 respondents)[6].   If the characteristics (income levels, age, etc) of the sample sets are similar it could be expected that different choices would be made as the payment scale changes. If the same choices are made, an embedding effect is present, as price is not influencing choices. While some oddities arose with the characteristics of the sample set who received the sub-survey, and the sample subset size was small, no embedding effect was observed.

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[5] It was found in Component 1 that any amount less than $30 was seen only as a 'donation' not a meaningful number

[6] The total number of WTP Choice Sets distributed was 337 (including the 'Experienced' and Inexperienced" subsets). Each respondent faced 6 choice experiments allowing 2022 choices to be observed.

Figure 4 - Example of Choice Modelling Set

Imagine that the water pipes in your area have been breaking unexpectedly – possibly due to expansion of the clay soils after heavy rain. The water supply company is trying to fix the problem and tells you your water supply may be interrupted, without warning, over the next twelve months.

Now, imagine it is a weekday, a water pipe breaks and your water has to be shut off immediately. The interruption occurs at 5:30am on a weekday. In the last 12 months, this has happened once before…

In this scenario you can only choose one column of options.

Please tick one box at the bottom of the table.

	Column A Current Practice)	Column B	Column C
Without warning your house might be without water from…	5:30 am to 8:30 am (i.e. **3 hours**)	5:30 am to 11:30 am (i.e. **6 hours**)	5:30 am to 2:30 pm (i.e. **9 hours**)
In the last year your water supply has been **interrupted one.** The water supply company tells you that your water supply might fail…	**No more times** in the next 12 months	**No more times** in the next 12 months	**One more times** in the next 12 months
You were advised about the interruption by…	A **card** put in your letterbox **after** the interruption	A **card** put in your letterbox **after** the interruption	If you listened to a **radio station** that was notified
The **alternative water supply arrangements** offered were…	A **two litre bottle of water** to every household where someone is home	A **two litre bottle of water** to every household where someone is home	Water provided at **a central location** (water tanker in street)
As part of the package your water supply bill…	**No change** to your next water bill	**A $50 once-off** rebate on your next water bill	**A $25 once-off** rebate on your next water bill
	□ Column A	□ Column B	□ Column C
	□ Don't know		

5 CALCULATING SOCIAL COSTS

The customer preferences survey identified the attributes of water services customers felt were important. The Choice Modelling surveys enabled determination of willingness to pay or willingness to accept compensation. However, quantification of the value of attributes only completes the determination of the **benefits** of a certain strategy. The third element of the methodology was, therefore, to identify community **costs** and to do this so that:

- Social costs can be identified and incorporated in cost calculations.

- A good mix of renewal and replacement strategies can be identified in response to desired standards so that a low cost approach to meeting them can be determined

Detailed analysis was carried out of the social costs that might exist. Suffice to say here, however, that those likely to lead to significant cost impacts are loss of business (say, where strip shops are without water) and traffic disruptions, arising from the need to close lanes or entire roads to effect pipeline repairs or replacements. The methods used to value these social costs are set out below. Before proceeding, however, it should be noted that the term 'social costs' has been chosen as a catchall to include externalities and customer impacts, and is used in this way from this point forward.

5.1 Business Loss

The impacts on strip shopping businesses arising from water supply interruption vary according to the business. The severity of these effects was determined by a survey of differing business type proprietors in Perth and the results are incorporated in Figure 5. Operations such as newsagents, real estate agents and the like may suffer little or no loss of business, as they are not reliant on water supply for other than toilets or hand-basins. Other businesses, such as childcare centres and restaurants, are dependent upon a water supply and would be forced to close if water supply were interrupted for more than a very short period.

To calculate business loss a simple rule based approach was adopted. In this approach categories of impact were identified and standard valuation procedures applied. Figure 5 provides a sample of the categories of impact adopted based on analysis of actual suburban retail shopping areas, excluding major shopping malls.

Figure 5 - Categories of Impact on Business Customers

Impact	Effect on net business income in first 2 hours	Effect on net business income for next 2 hours	Examples
Negligible Impact	<1%	<1%	Newsagent, hardware, bike shop, Pharmacy, Liquor store, Boutique, Craft Shop, Pool shop, cemetery, Real estate, Telecommunications, Solicitors

Minor Impact	1-20%	1-20%	Physiotherapy, plant nursery, Milk bar, Grocery* Tattoo shop, Service Station
Significant Impact	20-40%	20-60%	Medical surgery, Café, Bakery
Major Impact	40-60%	60-80%	Veterinary surgery, Sea Food Store, Butcher, Hair salon, Hotel
Extreme Impact	60-80%	80 –100%	Dentist, Radiologist, Restaurant, Fast food, beauty salon, Laundry, Photo developer

It is assumed in this analysis that a decline in net income due to an interruption represents a reduction in the value added by that business. The rule (process) based approach assumes a certain value added per employee. Thus, the methodology takes the number of employees * an average hourly rate for wages * a value representing the value added by each employee (eg, 2.5 * average hourly rate). Figure 6 below gives one worked example for a large strip shopping area examined in the project.

Figure 6 - Worked Example: Business Loss due to Water Supply Interruptions

	No. Connections	Estimated no. employees at peak times	Assumed effect on value added (Proportion of value added)		Effect per hour on value added for a 4 hour disruption	
			1st 2-hour period	2nd 2-hour period	Total	$ connection per hour
Negligible impact	135	512	0.01	0.01	461	3.41
Minor impact	6	27	0.10	0.10	189	31.50
Significant impact	8	44	0.30	0.40	1134	141.75
Major impact also outside business hours	3	12	0.50	0.70	648	216.00
Major impact in business hours	15	75	0.50	0.70	3240	216.00
Extreme impact in business hours only	7	25	0.70	0.90	2016	288.00
Extreme impact restaurant	17	89	0.70	0.90	7344	432.00
Not applicable – Private Residence	5	0	0.00	0.00		
Not applicable – Vacant	19	0	0.00	0.00		
Total	**215**	**784**			**15031.80**	**69.62**

As can be seen, a significant cost accrues to a shopping area such as the one used in the example for an interruption of moderate duration. Thus, if the interruption can be avoided a benefit of $15,000 is gained. Alternatively, it could be said that the cost of an interruption is $15,000 greater than the mere cost of materials and labour to effect a repair. These costs can be incorporated in the model. However, as it is costly and difficult to track the types of shops existing in a particular shopping strip it is probably impractical to carry out such detailed analysis. It is recommended, instead, that water companies ensure their asset database is linked to their GIS system to the extent necessary to identify assets serving commercial zonings and that an average value of business disruption of value be determined so that average business disruption costs can be quantified. Where a particular shopping area's potential losses are likely to be significant (say, for example, where there is a preponderance of restaurants) costs associated with interruption could be calculated manually. The social cost functions of PARMS could be used to assist in these circumstances   Whether the PARMS model is used to identify strategic asset management options or another model substituted for it, better linkages between asset management systems and asset models should be established

It should also be mentioned at this point that domestic social costs were not ignored in this study. However, they were identified as not significant and were not further dealt with.

Finally, note that in the worked example, the cost of business interruption was high ($15,000) compared to an average reported cost of repair of $1,500 to $2,000. However, neighbourhood businesses comprise only 2% of water companies' customers (Melbourne example) and clearly most interruptions will not incur such costs. Further, as discussed below, planned interruptions can be scheduled for periods were business cost can be minimised, and not all unplanned interruptions occur in critical periods (the costs above assume critical times and are therefore maximum).

5.2   Traffic Disruption

Effecting repairs following a break may also produce social costs due to traffic disruption where a main is under or adjacent to a roadway. The cost of traffic disruption is well researched as it is used, inter alia, to calculate saving generated when roads are redesigned to alleviate bottlenecks. There was no need in this project to reproduce the methodologies used and thus well-established means were employed to calculate the cost of interruptions as expressed in traffic congestion.   These generally rely on calculating the value of time * the time cost of interruptions.

Figure 7, below, gives one worked example for a road with a normal traffic flow of 1200 cars/hour (a moderately busy two-lane road), reduced by 1/3 for one hour, with traffic taking 15 minutes to clear once repairs are completed. 30% of vehicles area chose to take an alternative route around the congestion. If, however, only 15% divert, the cost increases exponentially. In this example, the time value was taken from the RTA Economic Analysis Manual (1999).

Figure 7 - Worked Example: Cost of Traffic Interruptions

	Hours	People per vehicle	Time value per person ($/hr)	Flow-on value to commercial business $ per vehicle	Total Cost of traffic interruption
Private vehicles	84	1.12	8.38		788
Business vehicles	5.25	1.2	16.98		107
Light commercial	11.55	1.3	16.98	0.91	265
Heavy commercial	4.2	1	18.23	17.15	149
Total	105				1200

6   THE PARMS MODEL

One of the critical factors that define the end of a pipeline's useful life is the customer service standards that are in place. If customers are unwilling to accept any interruptions to water supply then the useful life of the pipeline is much shorter than that for a pipeline whose customers are willing to accept interruptions associated with failures and the subsequent repair of these failures. However, the additional cost of providing the higher level of continuous service needs to be compared to a customer's willingness to pay. At the moment customer service levels are set by regulation based on historic performance, rather than on an assessment of both costs and benefits.

Statisticians model the probability of bursts using regression techniques on attributes of the pipe, its environment and handling to establish relationships, which can be used for prediction of failures[7]. Many independent records on actual bursts are required for a successful estimation via regression. It also means that the more explaining variables are used, the more observations are needed. In most databases the number of burst records for individual pipes is too small for good individual estimates, so pipes are bundled into age cohorts with similar environment. The cohorts of large pipes, however, are still left with large estimation uncertainties because of either few observations or large variation within cohorts.

Engineers can describe the physical processes in an individual pipe to explain the breaks and perforations for the material under study. This is the only method available for estimating the remaining lifetime of large pipes for which there is almost no observation of bursts. To estimate the remaining lifetime of a pipe, it has to be measured at regular time intervals for stress, pit depth, etc. The deterioration process can be estimated via regression and the time to critical burst conditions extrapolated.

The methodology developed by CSIRO for application in the PARMS model starts with a model for the expected number of failures for each asset in each year. Key aspects in the development of the failure model were:

- 13 combinations of material and time laid were identified in the data. These included the 6 main material types, but particular groups of years were then identified which, based on the data, appeared to behave quite differently from other years.

- Failure rates were assumed to grow with age according to an existing model.

- "Standard curves" for failure rate against age were produced for each of these 13 combinations, for the specific case of an 80mm diameter pipe, with 60m pressure, a particular soil type (here alluvial sands), and a particular traffic intensity (here, High).

- The failure rate curve against age for any other asset was then determined by adjustment of the standard curve by multiplying the standard curve by an appropriate factor. These multiplying factors allow the generic failure rate curves to be increased or decreased for other assets in the same material class, according to the diameter, soil type, pressure or traffic conditions.[8]

- A further adjustment to the expected failure rate was made, based on the failure history of individual assets using a technique known as "*BLUP*s" (best linear unbiased predictors).

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[7] We speak here of interruptions due to pipe failure, not interruptions caused by misadventure, such as a car knocking over a hydrant or workers breaking a main.

[8] Note that the generic failure curves developed are applicable to other Australian water authorities with adjustment for local factors. Approximately 5 years data on pipe performance is needed for this local tailoring

By this means, the expected failure rate over time can be described for every individual asset in the network. While this might seem an ambitious aim, it avoids the problem of most of the current systems (e.g. KANEW, NESSE), which require that the assets be grouped into cohorts large enough to have "good" statistical properties. The PARMS model is then able to identify individual assets for replacement in contrast to these earlier models, which can only identify replacement strategies for a cohort of similar pipes. Additionally PARMS is able to assess replacement based upon the predicted number of failures in any one year, and thus is able to include customer preferences, whilst other models do not use the predicted number of failures in determining the end of a pipeline's useful life.

The model calculates potential future costs for the collection of assets over a defined forecast period (currently 30 years). The model predicts failures and interruptions for one year, applies a selected replacement strategy to the pipe assets, and then moves on to the next year in the forecast period and repeats the process on the updated asset set. The calculation process for each year involves:

- Estimating the expected number of failures of each pipe for each of the years in the forecast period using the relevant statistical or physical failure prediction model. This expected number is then converted into an integer number of failures using a negative binomial probability distribution.

- Estimating the cost of each failure. This involves modelling whether the failure was repaired by clamping; how long the interruption was and when it started; and consequentially what rebates and penalties applied (where local regulators require such payment); and whether neighbouring pipes in the same shutoff block also experienced an interruption.

- Stochastically allocating events such as main-to-meter leaks, hydrant leaks and third party damage events to pipes. These events also generate costs for repair, and may also cause customer interruptions and have an associated cost.

- Evaluating (in conjunction with a set of policy options) which pipes should be considered for replacement. Pipes that are identified as replacement candidates are then either replaced or considered for shut-off valve insertion. Pipe replacement may be by trenching or trenchless methods. Replaced pipes are selected to be made of a specified replacement material, and of age 0. Shut-off valve insertion does not change the age or material of the pipe, but reduces the length (or number) of the pipe(s) in the shut-off block. The cost of the selected option is accumulated.

- The chosen policy options determine when a pipe is a candidate for replacement. This can be on the basis of the number of failures experienced by the pipe or the number of unplanned interruptions or the net present value of the future costs of the alternatives of maintenance or replacement.

Many of the policy options relate to which pipes are selected for replacement and the associated costs and consequences. One policy option (pressure reduction) affects the failure rate directly rather the consequences of failure. The policy options available are:

- *Pressure reduction* – if a maximum pressure is specified, pressure reduction valves are inserted as necessary to ensure that no pipe in the network exceeds that pressure with the effect of reducing the probability of pipe failure.

- *Failure/interruption trigger for replacement* – determines the maximum annual number of failures or unplanned interruptions to be allowed in a pipe segment before action is taken to either replace the pipe (or to introduce an additional shut-off valve).

- *Net present value trigger for replacement* – provides an option to replace a pipe when the Net Present Value of the discounted predicted maintenance and associated costs over a specific period exceed the discounted cost to replace the pipe and any (usually minor) maintenance costs of a new pipe.

- *Shut-off block reduction* – identifies whether shut-off valve insertion should be preferred instead of pipe replacement. The minimum length of pipe resulting from the valve insertion is

also specified. If the length of the pipe is too short for a shutoff valve, replacement is considered instead.

- *Maximum budget available* – limits the total available annual funds to be expended in any one year. This amount (less the cost of repairs, rebates, social costs and penalties) is then used to control which pipes are considered for replacement.

- *Discount rate* – specifies the discount rate to be applied to all future cash flows in determining the Net Present Values of the costs of repair, replacement, rebates, social costs and penalties of the pipe network over the assessment period.

Another objective of the model development was to provide the industry with a tool for determining the mix of replacement and renewal strategies (including shut-off block reduction), which represented least cost to the water company, regardless of customer preferences. This capability is now close to completion.

Using the capabilities described above, we can calculate the cost of changed standards. Figure 8, below, provides a stylised view of the typical cost curve for frequency of interruptions showing a 'U' shaped curve where a the cost of achieving a standard mandating a very limited number of interruptions is driven by replacement costs, and a liberal standard is driven by social costs.

Figure 8 - Example of Predicted Costs of Standards
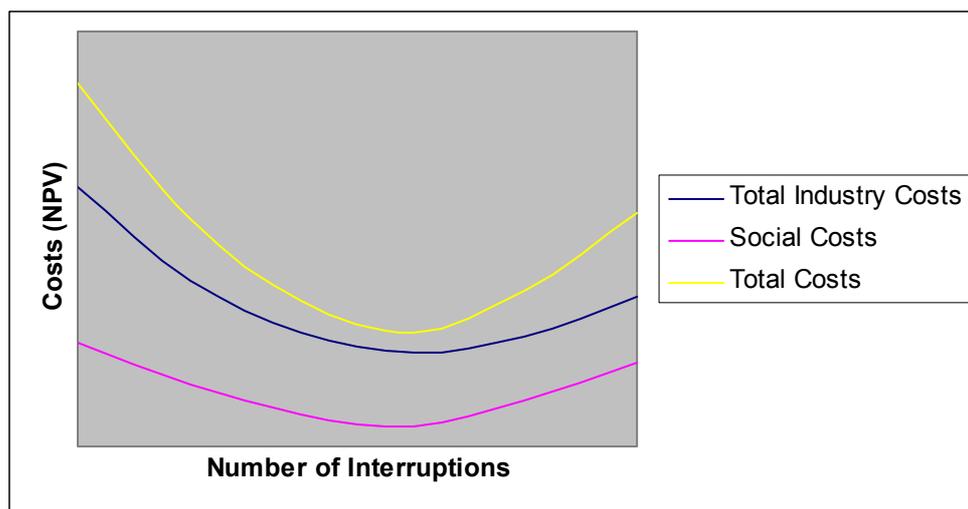
While the above provides an insight into what might occur as a standards increases in stringency. We have also, however, calculated the cost of changed standards relating to reduced duration and frequency of unplanned interruptions[9], continuing the example given in the discussion of customer preferences and willingness to pay. As with other calculations reported in the Benefits section, above, there are a number of caveats surrounding this calculation. Foremost among these is that we have utilised data from only one water utility (the one in which provided the most robust data). This utility reports an average cost of repair of $1703. Other authorities provide suggest and average cost between $1500 and $2000. These figures should not be taken to suggest varying levels of efficiency on behalf other any water company, but rather different operational conditions and different contractual arrangements that exist between the water companies and their maintenance providers.

Secondly, it must be noted that to reduce duration of interruptions, more crews would need to be added. The PARMS model is capable of calculating these costs, but has not requested data on such increased costs from water companies. Consequently, in the following analysis only the base figure of the average cost of repair has been included. However, to overcome this deficiency in data, we have

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[9] Note that the term 'Interruptions' refers here to interruptions caused by pipe failure, not misadventure. Were misadventure included the frequency of interruptions would increase by 0.25 to 2 p.a.

carried out a sensitivity analysis in which average repair costs were increased by 10% and 20% in two runs, to determine the effect this would have in the cost-benefit analysis subsequently conducted.

As mentioned earlier, it should also be noted that data on costs and benefits my have been gathered from different cities. We are providing analysis based on this data to demonstrate the efficacy of the methodology we have developed. However, the results of the cost-benefit analysis should not be taken as being applicable to any one jurisdiction in Australia.

A further caveat is that NPV costs have been calculated for one water company that has a different number of assets than the water company whose customers were surveyed to obtain an estimation of benefits. Thus, the costs and benefits are not necessarily comparable. However, we have ignored this discrepancy as we are merely trying to demonstrate the efficacy of the methodology, not prove or disprove the need to adjust an actual standard.

Finally, note that the water company from which data on costs of achieving various frequency and duration standards, is working to a standard of 5 interruptions p. a. Thus the costs of going from 5 pa to 1 pa would be greater than if the utility had been working to a standard of 2 pa already because a greater percentage of the system would be new pipes. One would be unlikely to require such a standards 'leap' in the real world.

6.1 Explanation of the process

The case studies presented below show the costs of moving from, respectively, a reduction in the duration of interruptions from 6 to 4 hours and a reduction in the frequency of unplanned interruptions from a standard of 2 p.a. to 1 p.a. These calculations examine the cost of repair and social costs (traffic disruption and business loss). As unplanned interruptions can occur at any time, we have taken into account the lower social costs that would be incurred if, say, the interruption happened at midnight, as opposed to 6 am. Our examination of data provided by one water company (the same company from which was taken the average cost of repair) reveals that unplanned interruptions occur as follows:

Figure 9 - Time of day of interruptions

Time of Day	Percentage of Events
6am – 9am	5.9%
9am – 4pm	43.6%
4pm – 7pm	18.9%
7pm – 6am	31.5%

Accordingly, business costs and traffic disruption costs have been calculated taking these frequencies into account. That is, these costs have been calculated separately for each of these timeframes and discounted accordingly

6.2 Costs of Change to Duration Standard

Figure 10, below, shows the spread of repair times reported by one water utility. While some of these are in excess of 6 hours, we are assuming that these repairs are all effected within 6 hours in line with our modelled standards. To move to a 4 hour standard we assume that those repairs previously taking more than 4 hours to repair are, in fact, now completed within 4 hours (Figure 11).

Figure 10 - Case 1: Currently Reported Duration of Interruptions

Interruption Duration	*Percentage*
0-1	14.34
1-2	15.34
2-3	27.13
3-4	24.75
4-6	17.22
6-8	0.93
8-10	0.12
10-15	0.12
15-20	0.05

Figure 11 - Case 2: Reduction in Allowable Duration to 4 hours

Interruption Duration	Percentage
0-1	14.34
1-2	15.34
2-3	27.13
3-4	43.19

Costs associated with this duration, based upon replacing the pipe using NPV assessment over 25 years are as shown in Figure 12. The 10% and 20% cases are essentially sensitivity analyses in the absence of actual data about the increased costs that would be associated with hiring of additional crews so that faster repairs could be effected. All dollars are in $millions.

Figure 12 - Cost of Adopting 4-hour Standard

	Maintenance	Replacement	Social costs	Total
Case 1	56.25	1.68	26.87	84.97
Case 2	56.25	1.68	23.14	81.07
10% rise	61.57	2.00	22.93	86.5
20% rise	66.84	2.26	22.68	91.77

By forcing the earlier repair of the interruptions, social costs have fallen by 13.8% over a 30-year period, with all other costs remaining static. This is because the repairs are now required to be carried out within 4 hours of the failure being reported; consequently costs associated with traffic disruptions will fall, as the interruptions are shorter. If the costs of repair associated with the faster repair time rise by 10% then the costs associated with repairing in a shorter time frame rise. Because the replacement

analysis is done on a NPV basis some extra pipes will be replaced because replacement becomes more favourable over the 30-year analysis period.

6.3   Costs of Change to Frequency Standard

Figure 13, below shows the cost difference between the shifting to 3, 2 and 1 allowable interruptions per annum and the cost of a standard of 5 allowable interruptions. As is evident, the tighter standards require more frequent replacement of pipes, leading to higher NPV costs, whereas maintenance steadily falls, as fewer interruptions occur. Social costs escalate at the tighter standards as more frequent replacement of pipes is required, meaning that more works must be carried out. It could be expected that social costs would also escalate should standards be relaxed from 5 allowable interruptions as there will be more interruptions and more maintenance costs. Maintenance costs would should also be expected to rise, and replacement costs would fall. As suggested in Figure 8 there is a minimum cost that can be determined, although in the absence of willingness to pay analysis it cannot be said that selection of this minimum cost point as a standard would produce the highest customer satisfaction. All costs in Figure 8 are in $ millions.

Figure 13 - Costs of Changed Frequency Standard[10]

	Maintenance	Replacement	Social costs	Total
1 interruptions	19.10	941.00	40.45	1000.54
2 interruptions	46.67	197.86	28.43	272.96
3 interruptions	56.27	34.51	27.40	118.18
5 interruptions	58.54	0.71	27.68	86.94

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[10] Current standard for the water company from whom costs were obtained is 5 interruptions p.a.   Willingness to pay analysis was based on 2 and 1 interruptions p.a.

7   THE BENEFIT/COST RESULT

We now have available to us, modelled values (from the willingness to pay analysis) and modelled costs (from PARMS). We stress again that there are a number of caveats around this data, as expressed earlier. However, none of these caveats undermine our ability to perform the calculations described. Rather, they are related to the use of data from different geographical locations, and from different sub-set sizes.

With this data, we can now perform the cost-benefit analysis. Figure 14 and Figure 15 show the costs and benefits of the change to the duration on interruptions, and of changes to the frequency standard. Note that Figure 14 includes the sensitivity analyses undertaken to account for lack of data on the costs of additional crews to carry out more efficacious repairs (Note that the PARMS model could calculated these costs if the data were available.) All values in the second columns of Figure 14 and Figure 15 are in $ million.

Figure 14 - Cost/Benefit Analysis - Duration Of Interruptions (6 hours to 4 hours)

	Benefits/Costs (NPV)[11]	/Benefit/Cost Ratio
Benefits Derived	$19.6	
Costs of Achievement	$90.2	0.22
Costs of Achievement (10%)	$95.6	0.20
Costs of Achievement (20%)	$101.0	0.19

Figure 15 - Cost/Benefit Analysis - Interruption Standard (1 p.a.)

	Benefits/Costs (NPV)	Benefit/Cost Ratio
Benefits Derived	$18.3	
Costs of Achievement	$1,003	0.018

None of the increased standards can be justified in these examples, taking into account willingness to pay. This should not be surprising. Recall that the preference analysis suggested that customers felt that additional public investment was not warranted. We cannot expect that customers will demonstrate a significant willingness to pay for something they don't consider needs further public investment.

The particularly low ratio in Figure 15 occurs largely because we only analysed a change in standard from 2 allowable interruptions per annum to 1 p.a. No water company is anywhere near this standard and the costs of such a step increase would be massive. Had the methodology been used to determine customers' willingness to pay for moving to 4 interruptions p.a. from 5 p.a. a more realistic ratio may have been derived, although it is impossible to say what this ratio may have been.

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[11] All figures in this column are rounded to the nearest million.

7.1   Applicability of the Methodology

We found in testing the Choice Modelling methodology that there was evidence that the results could be applicable extrapolated taking into account socio-economic differences across other Australian urban centres. Similarly we found commonality in the outcomes from the Preference work between Adelaide and Melbourne. Additional research would be required to verify our initial results with respect to willingness to pay.

8   CONCLUSION

This project – initiated and supported by CSIRO and the Water Services Association of Australia has produced robust results that will enable standards to be set within an effective cost benefit framework. The methodology produced is applicable to the range of services offered by water authorities. It has potential for widespread application by water authorities and will provide sound information that can be drawn on by regulators in determining the issues of concern to customers, their wiliness to pay for increased standards and the cost of efficiently meeting those standards.

Foremost among the outcomes of the project is the development of a robust cost-benefit framework including:

- A means of identifying, firstly, the extent to which customers feel further investment in a service by government (the water service provider) is warranted (the Subjective Social Indicator) *and,* secondly, the attributes of a service that customers feel are important. The SSI provides an early warning of issues worthy of attention and the related questionnaire approach enables refocussing of historically based standards on to standards the customer really cares about.

- Effective and valid estimates of customers' willingness to pay (WTP) for changed standards, which allow determination of WTP for the *individual* attributes considered important to customers, as opposed to the coarser standards that may have been derived in the past

- A means of determining the optimal long-term costs of achieving standards the customer considers important, such that costs to the water utility can be compared with willingness to pay to achieve a benefit.

These methodologies are now developed, and are capable of being applied of the full range of services offered by water companies.

Additionally, the scope of the research included in the project has given us confidence that the methodologies could be used in other Australian urban areas. Confirmation of this view would be achieved through additional research on other services and service attributes, but results to date suggest that this view can be put with some certainty.

The project has included the development of a very sophisticated asset planning model – PARMS – which allows long term costs to be calculated, taking into account customer preferences. More targeted asset management strategies can be developed as a result of its approach. It is not necessary, of course, for water utilities to utilise this particular model. However, it is essential that an approach that considers long terms costs and optimal mixes of replacement, repair and policy to achieve a specified goal be employed within the water industry.

We have presented, within this report, a description of an integrated methodology. It should be understood that not all aspects of the methodology need to be used each time a standard is to be reviewed. Rather, it is the purpose of the SSI that a periodic review can be carried out of the extent to which customers feel further investment is needed, or where over-servicing is occurring. Where no such investment need is indicated, use of the remaining components of the methodology is not required.

Finally, in addition to developing a robust methodology for setting customer service standards, the project has provided the following deliverables:

- An insight into the attributes of service delivery that are important to customers but which appear to be different from those which are frequently the subject of regulation

- Subjective Social Indicator questions used to test whether interruptions are becoming a matter of concern for customers (see Appendix 1). These are fully developed and suitable for adoption by water businesses to determine whether additional investigation is warranted

- Generalised pipe failure curves for the water industry that are available to the water industry for calibration to their specific circumstances; and

- A required data format for pipe history information. It is recommended that the industry adopt this data format to ensure collation of information across the industry in a consistent manner.

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APPENDIX 1 - SSI QUESTIONS[12]

1. Could you tell me how *satisfied* you are with the ways your water utility handles the following water service issues?[13]

Water pressure ----

Water quality ----

Water Restrictions ----

Water interruptions ----

Scale

1	2	3	4	5	6	7	8	9	10

Extremely
Satisfied   **Extremely**
                                                                              Dissatisfied

2. How *important* to your present lifestyle is the way the following water service issues are handled by your water utility?

Water Restrictions ----

Water quality ----

Water interruptions ----

Water pressure ----

Scale

1	2	3	4	5	6	7	8	9	10

Extremely   **Not at all**
Important   **important**

---

[12] The full questionnaire in which the SSI questions were included appears in Appendix 6 of the Technical Report (ARCWIS 2001)

[13] Note that the order in which these service attributes are read to the respondent is varied each time

3. The way each service issue is handled could be improved by investing more money to the water system. For the water utility to do this, it could involve some increase in water costs.

FORM 1[14]

With this in mind…. how *wasteful* do you think it would be if the water utility increased spending to specifically improve the way these service issues are handled?

OR FORM 2

With this in mind…. how *wasteful* do you think it would be if the water utility increased spending by 10% to specifically improve the way these service issues are handled?

OR FORM 3

With this in mind…. how *wasteful* do you think it would be if the water utility increased spending by 30% to specifically improve the way these service issues are handled?

Water quality	----
Water Restrictions	----
Water pressure	----
Water interruptions	----

Scale

1	2	3	4	5	6	7	8	9	10

Extremely good investment   **Extremely wasteful**

---

[14] Note that three differing questionnaires were distributed in order that validity and reliability could be tested. See Technical Report for details (ARCWIS 2001)

4. Could you tell me how much you think it is the water utility's responsibility to provide a good level of service for handling the following water service issues?

Water quality	----
Water pressure	----
Water Restrictions	----
Water interruptions	----

Scale

1	2	3	4	5	6	7	8	9	10

Complete responsibility   **No responsibility**