Appendix 1.1.N - Avertive behaviour

Wessex Water

September 2018

Wessex Water
YTL GROUP

Business plan section		Supporting document	
	Board vision and executive summary		
1	Engaging customers	**1.1**	**Summary of research findings**
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NERA
ECONOMIC CONSULTING

Revealed Preference Valuation of Short Term Interruptions

Prepared for Wessex Water

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1. Introduction

NERA Economic Consulting (NERA) has been commissioned by Wessex Water to conduct research to inform its assumptions on the value of avoiding supply interruptions, which may inform its cost-benefit analysis (CBA) as part of its PR19 Business Plan.

Specifically, Wessex Water has asked that we value the consequences of short-term interruptions for domestic customers using "avertive" behaviour models. This revealed preference technique seeks to understand customers' behaviour in the event of an interruption, in order to value the economic costs of mitigating the impacts of the incident.

Working with Wessex Water, we have developed a survey questionnaire for customers living in areas recently affected by supply interruptions, and analysed their responses along with market data to derive valuation estimates. We have designed our valuation model, which takes survey results and derives valuation estimates, using a flexible structure that enables Wessex Water to update the results on an ongoing basis as more survey data from affected customers becomes available. In essence, this will enhance Wessex Water's ability to draw valuation information from its ongoing interactions with customers.

We set out our detailed methodology, approach and findings from this revealed preference research in this report. However, in forming our recommendations about how this valuation information should be used in Wessex Water's CBA modelling for the business plan, it is important to consider that this research is one of several pieces of research that Wessex is undertaking to inform its Business Plan. As such, we understand that Wessex Water will produce other estimates of the value of avoided supply interruptions to inform "triangulated" valuation estimates for use in business planning.

In particular, the results from this study are likely to constitute a lower bound on the societal value of avoiding supply interruptions, since this method is unable to account for some elements such as the inconvenience for the customer, Wessex Water's private costs of managing the incident, or externalities.

2. Valuing Short Term Interruptions Using Avertive Behaviour Techniques

2.1. Overview of the Methodology

In economics, market evidence on actual consumption decisions represents the most reliable basis to value changes in service and/or prices. However, for most services provided by (or influenced by) water companies, such market evidence is not available. In these circumstances, Revealed Preference (RP) methods represent a potential alternative. In contrast to Stated Preference (SP), which uses specially constructed questionnaires to elicit estimates of respondents' willingness to pay for (or willingness to accept) particular outcomes, RP observes behaviour and outcomes in *related* markets and uses this evidence to derive implied valuations for other goods or services.

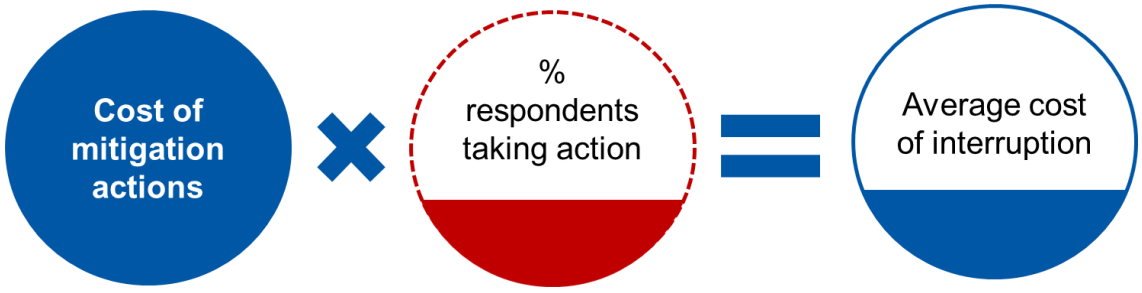
The RP approach of this study uses avertive behaviour techniques to value the avoidance of interruptions to water supply. It estimates this value by using the market value of goods that customers might consider a substitute to water supply during an interruption event. Examples of substitutes include buying/using bottled water, eating/drinking at restaurants or friends' houses, or visiting the gym to use shower facilities.

Wessex Water has surveyed to date a total sample of 1,061 households across 31 different areas recently affected by supply interruptions. Respondents answered questions about the actions they had to take as a result of losing water supply. These included detailed questions about the number of times they had to undertake each action, and/or the total distance travelled as a result of the incident.

We estimated the cost of each action based on a survey of market data taken from the Wessex Water supply area. With regards to travel costs, we used a range of available sources including the Department for Transport's estimates of the value of travelling time. We describe our assumptions in more detail in Section 2.3.

By combining our cost estimates for each action with the results from the survey, we estimated the total cost of the interruption for an average household living in the affected area, as illustrated by Figure 2.1. We also repeated this exercise using different sub-samples depending on the length of the interruption, and/or whether the interruption was planned or unplanned.

Figure 2.1
Estimating the Cost of the Interruption for an Average Household in the Affected Area



Source: NERA Illustration

The advantage of this approach relative to more traditional SP methods is that it is less subject to respondent bias. It draws on information about customers' actual behaviour in the event of an interruption, rather than relying on customer choices in a hypothetical context. It is also less subject to cognitive error, since questions are unidimensional and simply relate to actions customers have taken in the past.

However, we acknowledge a number of limitations and caveats with this approach, which need to be taken into account during the triangulation process when interpreting the results of this study:

- Firstly, it is important to note that the RP estimated value of avoiding interruptions to water supply is a lower bound estimate. This approach only accounts for internal costs incurred by households. It does not reflect the total inconvenience to the customer from the interruption, and hence it cannot capture customers' full willingness to pay to avoid the interruption. Therefore, the valuations from RP are likely to be lower than the results from comparable SP studies;
- Secondly, the RP valuation refers only to customer costs associated with supply interruptions. To obtain a full societal valuation, Wessex Water may wish to add its private costs incurred during the interruption, such as management costs and the costs of providing bowsers and bottled water;
- Finally, this RP approach does not measure the external costs (externalities) which arise due to the interruption of supply to non-domestic customers. For instance, the inconvenience of interrupted supply will have a negative effect on third parties such as customers of the affected businesses. This may include travel costs to another business, the inconvenience of having to re-arrange an appointment or, in the case of school closure, parents having to take a day off to take care of the children.

2.2. Approach to Quantitative Fieldwork

Wessex Water has interviewed a total of 1,061 domestic customers living in areas recently affected by short interruptions of different types and length. Table 2.1 summarises the key characteristics of each of the 27 interruptions covered by the surveys, along with the corresponding number of respondents in the sample. One of the interruptions covered by this research lasted for more than three hours, and all interruptions occurred on a weekday.

In this report, we focus on the differences in valuation results by type (planned or unplanned) and duration of the interruption. Table 2.2 provides a breakdown of the sample size across these two dimensions. The table shows that a greater number of respondents were affected by unplanned rather than planned interruptions, and by interruptions lasting less than three hours. Furthermore, most of the planned interruptions lasted less than two hours. Therefore any differences between results for planned and unplanned interruptions need to be interpreted with care, since part of the difference could be explained by the effects of duration.

Table 2.1
Recent Supply Interruptions Covered by the Survey

Interruption Type	Length of Interruption	Start Time (hh:mm)	End Time (hh:mm)	Interruption date	Weekend?	Location	Number of Respondents
Planned	0 h 10 min	12:15 PM	12:25 PM	10/01/2018	No	Taunton	5
Planned	0 h 25 min	8:10 PM	8:35 PM	30/11/2017	No	Watchet	50
Planned	0 h 40 min	8:10 PM	8:50 PM	04/12/2017	No	Chard	72
Planned	0 h 45 min	10:15 AM	11:00 AM	15/11/2017	No	Sampford Brett	8
Planned	1 h 00 min	1:15 PM	2:15 PM	19/1/2018	No	Sherborne	7
Planned	1 h 05 min	1:20 PM	2:25 PM	18/1/2018	No	Petherton	19
Planned	1 h 25 min	10:05 AM	11:30 AM	13/11/2017	No	Charmouth	5
Planned	1 h 30 min	10:00 AM	11:30 AM	11/12/2017	No	Dorchester	6
Planned	1 h 45 min	11:15 PM	1:00 AM	07/12/2017	No	Templecombe	34
Planned	1 h 45 min	9:00 AM	10:45 AM	12/01/2018	No	Yeovil	9
Planned	2 h 10 min	10:25 AM	12:35 PM	06/12/2017	No	Charmouth	21
Planned	2 h 35 min	9:30 AM	12:05 PM	27/11/2017	No	Wool	17
Planned	2 h 45 min	10:00 AM	12:45 PM	08/02/2018	No	Bishop Lydeard	4
Unplanned	0 h 10 min	11:50 AM	12:00 PM	30/11/2017	No	Bourton	5
Unplanned	0 h 15 min	11:00 AM	11:15 AM	14/11/2017	No	cedar grove	7
Unplanned	0 h 15 min	12:00 PM	12:15 PM	24/11/2017	No	Home Drive, Yeovil	9
Unplanned	0 h 15 min	11:20 AM	11:35 AM	16/11/2017	No	Beech Rd, Weymouth	2
Unplanned	0 h 22 min	4:08 PM	4:30 PM	04/12/2017	No	Marlborough	28
Unplanned	0 h 25 min	12:20 PM	12:45 PM	14/11/2017	No	Abbotsbury Rd, Weymouth	17
Unplanned	0 h 35 min	2:10 PM	2:45 PM	17/11/2017	No	Bridport	6
Unplanned	0 h 36 min	5:15 PM	5:51 PM	29/11/2017	No	Bridgwater	6
Unplanned	0 h 45 min	4:20 PM	5:05 PM	21/12/2017	No	Devizes	55
Unplanned	1 h 00 min	10:30 PM	11:30 PM	13/12/2017	No	Poole	16
Unplanned	1 h 00 min	8:00 PM	9:00 PM	23/1/2017	No	Monksilver	13
Unplanned	1 h 55 min	10:25 AM	12:20 PM	28/11/2017	No	Middle lane, Trowbridge	11
Unplanned	2 h 55 min	11:15 AM	2:10 PM	14/11/2017	No	Taunton	577
Unplanned	15 h 53 min	7:00 PM	10:53 AM	31/08/2017	No	Westbury	53

Table 2.2
Sample Distribution by Type of Interruption

Interruption Type	Interruption Length			
	All	0-2h	2-3h	>3h
All	1061	390	619	52
Planned	257	215	42	0
Unplanned	804	175	577	52

The survey method was initially based on recruiting customers living in the areas that had been affected by an interruption via SMS, and then sending them a link to an online questionnaire. Wessex Water then changed to telephone recruitment and interviews to increase response rates. The survey used is in Appendix A.

This approach to recruitment, and the fact that the surveys were only undertaken for customers in areas affected by interruptions, means that the sample obtained is not necessarily representative of the population in the Wessex Water area. We discuss how we have mitigated the potential bias caused by the lack of representativeness of the sample in Section 3.2.

2.3. Valuation Assumptions

As described above, RP valuation methods are based on valuing the cost of substitute market goods to the targeted non-market good, which in this case is water supply. Therefore, where possible we have surveyed market price data for each of the goods related to the "avertive" actions customers took during the interruption, such as bottled water, ready meals or showers at the gym.

We have used a conservative approach and based our survey on brands within the lower end of the price range for each product. In order to measure the effects of geographical variation (where applicable), we have surveyed market prices from the same brand across different locations within the Wessex supply area. Where respondents did not provide details on the number of units (eg. the number of ready meals purchased), we assumed a household size of 2.3 occupants, based on the average household size in the Wessex supply area.[1]

We have also estimated the unit cost of travel for each of the modes of transport included in the survey, based on the same market data approach where applicable (eg. for buses, taxis). With regards to travelling time, we have used data from the Department for Transport (DfT) on the value of "non-work" time lost travelling. We converted these unit values per hour into values per mile based on assumptions on average speed by mode of transport.

[1] Based on household size distribution provided to us in the file "Wessex_area_statistics.xlsx" on 15th January 2018.

The tables below summarises our assumptions and sources.

Table 2.3
Unit Cost Assumptions for each Potential "Avertive" Behaviour Action

Good	Unit Value	Source
Bottled Water	£0.20 per litre of bottled water	Based on minimum price per 100 ml of bottled water on Tesco's groceries website (November 2017)[2]
Ready Meal	£5.7 per household meal	Based on a sample of four ready meals on Tesco's groceries website (November 2017),[3] and our assumption of 2.3 occupants per household.
Restaurant Meal	£23.1 per household meal	Based on Nando's basic food menu,[4] which applies to all restaurant locations in the area, and our assumption of 2.3 occupants per household.
Night at a hotel	£63.8 per night	Based on the average price of a family room over a sample of seven Travelodge hotels and eight Premier Inn hotels at different distances from the town centres of Bath, Yeovil, Poole and Dorchester (November 2017).
Use of gym facilities	£10.3 per time	Based on third lowest price per visit among a sample of 33 gyms within 20 miles of Bath that offer "pay-as-you-go" rates,[5] and our assumption of 2.3 occupants per household.
Use of a launderette	£16.6 per time	Based on the price of a 12lb laundry at a sample launderette in Westbury.[6]
Use of a public toilet	£0.2 per time	Based on typical price of a public toilet in the UK, adjusted to account for the fact that many public toilets have free access.
Return bus journey	£4 per time	Based on the price of two adult single tickets for up to three miles in the Wessex supply area, as published in the First Group website (November 2017).[7]
Taxi journey	£3.1 per journey plus £1.3 per mile	Based on Uber estimates for a sample of ten journeys in different locations across the Wessex Water area.[8]

2 https://www.tesco.com/groceries/en-GB/shop/drinks/bottled-water/still-water/all, accessed November 2017.

3 https://www.tesco.com/groceries/en-GB/shop/fresh-food/ready-meals/all, accessed November 2017.

4 https://www.nandos.co.uk/food/menu, accessed November 2017. Our estimate is based on two adult meals (1/2 chicken plus two regular sides per person) plus 0.3 times the "Nandino" children meal (assuming households have 2.3-2=0.3 children, as a conservative estimate).

5 From a specialised search engine website: https://www.payasugym.com/gyms-in-bath

6 https://www.cleanmachinedrycleaners.co.uk/service/the-clean-machine-westbury-wiltshire/wash-and-fold-laundry, accessed November 2017.

7 https://www.firstgroup.com/bristol-bath-and-west/tickets/ticket-prices, accessed November 2017

8 https://www.uber.com/en-GB/fare-estimate/, accessed November 2017

Good	Unit Value	Source
Car fuel	£0.07 per mile	Based on HMRC minimum advisory fuel rates.[9]
Non-work travelling time	£5.4 per hour	Based on DfT's weighted average Value of Travel Time for non-work travel.[10]

Table 2.4
Assumptions on Average Speed by Mode of Transport

Good	Unit Value	Source
Average car speed	29 miles per hour	DfT travel time measures for the Strategic Road Network and local "A" roads, South West Region.[11]
Average cycling speed	15 miles per hour	Approximation based on available estimates of average cycling speed in Britain.[12]
Average bus speed	10 miles per hour	Upper range of average bus speed in London, based on TfL statistics.[13]
Average walking speed	3 miles per hour	Approximation based on available estimates of average walking pace.[14]

9 HMRC (August 2017), "Guidance, How Advisory Fuel Rates are calculated". https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/470229/vtts-phase-2-report-non-technical-summary-issue-august-2015.pdf

10 2014 values indexed to inflation. Department of Transport (August 2015), "Provision of market research for value of travel time savings and reliability". https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/470229/vtts-phase-2-report-non-technical-summary-issue-august-2015.pdf

11 https://www.gov.uk/government/statistics/travel-time-measures-for-the-strategic-road-network-and-local-a-roads-july-2016-to-june-2017

12 See for example: http://www.cyclingweekly.com/fitness/training/13-ways-increase-average-cycling-speed-144937

13 Transport for London estimates average bus speeds between nine and ten miles per hour for London See: https://tfl.gov.uk/corporate/publications-and-reports/buses-performance-data

14 See, for example, the British Heart Foundation's (BHF) website: https://www.bhf.org.uk/get-involved/events/training-zone/walking-training-zone/walking-faqs

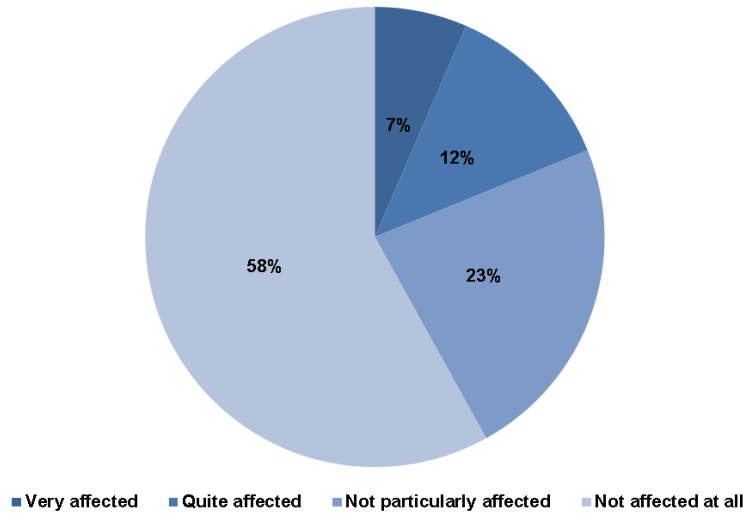
3. Valuation Analysis and Results

3.1. Overview of Respondents' Experience

Before using the results of the survey to estimate RP valuations, we have used the survey results to review the respondents' overall experience during the supply interruptions. In particular, we analyse the extent to which respondents were affected by interruptions, and how this varied by type of interruption (planned or unplanned) and by length of the interruption.

As shown in Figure 3.1, out of the 1,061 respondents, only 19 per cent considered themselves to have been "very" or "quite" affected by the interruption, while 23 per cent responded that they were "not particularly affected", and 58 per cent were "not affected at all".

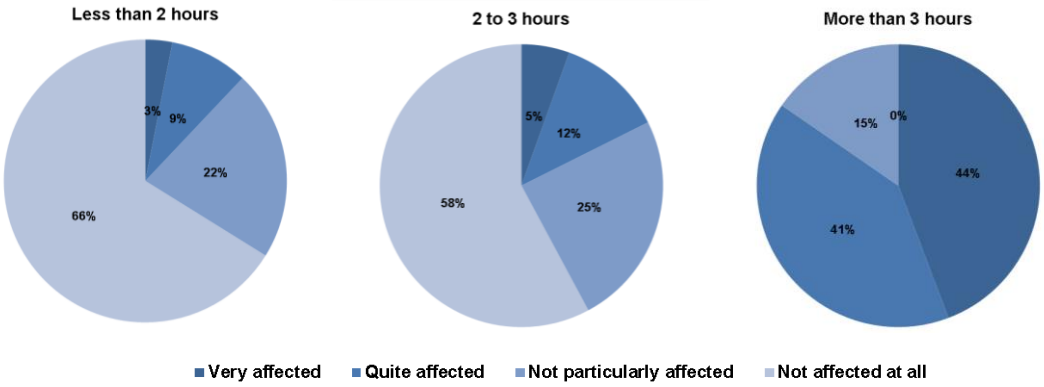
Figure 3.1
Only 19 per cent of Respondents Were either "Very" or "Quite" Affected by the Interruption



However, these results vary considerably depending on the duration of the interruption, as shown in Figure 3.2. Only three per cent of respondents who experienced interruptions of less than two hours considered themselves "very affected" by the interruption, which increases to 44 per cent for respondents who experienced an interruption of more than three hours.

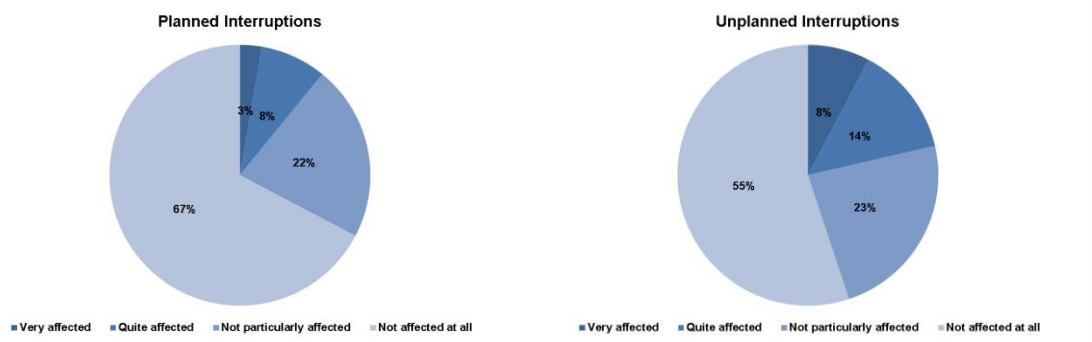
Similarly, 66 per cent of respondents who experienced interruptions of less than two hours were "not affected at all", and none of the respondents who experienced interruptions of more than three hours gave this response.

Figure 3.2
Respondents' Perception of the Impact of the Interruption, by Duration



As shown in Figure 3.3, the results also vary slightly depending on the type of interruption. The proportion of respondents who were "very" or "quite" affected is 11 per cent for planned interruptions, compared to 22 per cent for unplanned interruptions. Similarly, the proportion of respondents who were "not affected at all" is 67 per cent for planned interruptions, compared to 55 per cent for unplanned interruptions.

Figure 3.3
Respondents' Perception of the Impact of the Interruption, by Type of Interruption



As explained in Section 2.2, part of the differences in the results for planned and unplanned interruptions might be explained by the characteristics of the interruptions included in each sub-sample, such as duration. However, one of the advantages of planned interruptions is that respondents can fill up containers in advance. This reduces the need for them to take the "avertive" actions included in our valuation analysis, and avoids the associated cost.[15]

Figure 3.4 shows that 12 per cent of the respondents living in areas affected by planned interruptions filled up containers in advance. This is a considerable number, particularly

[15] One potential cost could be the purchase of containers if they did not have any at home, and the value of any time lost in the process. With regards to the value of the tap water used (in the case of metered customers), we can assume (conservatively) that customers would have consumed the same amount of water if the interruption had not taken place. Given the overall low materiality, for the purposes of this study we assume that no additional costs were incurred for this activity.

given that only 43 per cent of these respondents were affected by the interruptions at least to some extent (see Figure 3.3).

Figure 3.4
12 per cent of Respondents Living in Areas Affected by Planned Interruptions Filled up Containers in Advance

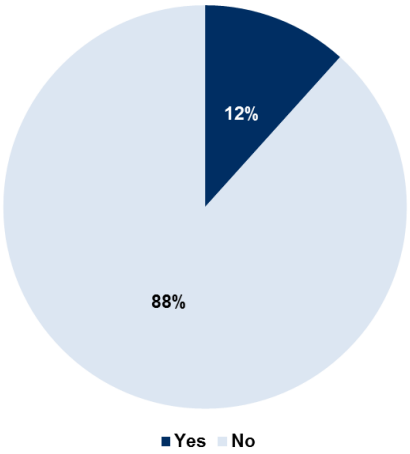


Figure 3.5 shows how these proportions vary depending on the duration of the planned interruption. The difference is relatively small, but it follows an intuitive relationship, with a higher proportion of respondents filling up containers in advance for longer planned interruptions.

Figure 3.5
Percentage of Respondents Living in Areas Affected by Planned Interruptions who Filled up Containers in Advance, by Duration

Note: There are no planned interruptions of more than three hours in the sample.

3.2. Our Approach to Estimating Customer Valuations

As described in Section 2.2, Wessex Water has surveyed a total sample of 1,061 domestic customers living in areas affected by a range of recent supply interruptions of varying durations and types. The survey included questions about the mitigating ("avertive") actions respondents had to take due to the interruption.

We have constructed a bottom-up estimate of customers' total expenditure, based on their "avertive" purchases and the associated cost of travel. Table 3.1 shows the categories of cost included in this analysis. By summing up the costs incurred by customers across all categories, we calculate an estimate of the economic consequences of a supply interruption for an average household living in the affected area.

Table 3.1
Categories of Cost Considered in the Domestic Survey

Bottled Water	Buy bottled water
Food	Eat out Get a takeaway or a ready meal
Other	Visit a launderette Travel to use a shower/bath Travel to use a toilet Take laundry to a family member or friend's home Stay a night at a hotel Stay a night at the home of a friend or family member

Using this methodology, we estimated a valuation across a pooled sample of all respondents affected by all the interruptions covered by the surveys. We also repeated our analysis based on different sub-samples, varying by the type of interruption (planned or unplanned) and its duration (less than 2 hours, 2 to 3 hours and more than 3 hours). These results are presented in Section 3.3.

However, as noted above, the respondents included in this sample are not necessarily representative of Wessex Water's population for several reasons. First of all, the demographic characteristics of the areas recently affected by interruptions may be different from those of the general population. Furthermore, the characteristics of the people who chose to respond to the survey may also differ from those of the overall population.

For these reasons, we also present a second set of results derived by weighting responses to achieve valuation results more reflective of the demographic characteristics of the population in the Wessex Water supply area. We have tested three different weighting options:

- *Weighting responses by the number of occupants in the household*. This characteristic may affect the amount of goods purchased, such as bottled water or the number of visits to the gym/public toilets.
- *Weighting responses by household income*. Households' decisions to purchase substitutes may have been affected by income, as wealthier households may have been relatively less willing to suffer inconvenience from the interruption and thus more likely to have undertaken avertive measures. The nature of the substitute goods purchased may also have differed with income. For instance, more affluent households may be more likely to have chosen to go to a restaurant rather than purchasing (potentially cheaper) ready meals due to the interruption.
- *Combined weighting for both number of occupants and household income*. Ideally, we would want to take both factors into account. However, as we describe below, an

excessive use of weights creates the risk that our results place high weight on a small number of observations, which reduces the precision of our valuation results.

Table 3.2 and Table 3.3 show the weights applied to responses under the first and second options. For each demographic characteristic, the weights are based on proportional differences between the characteristics of the respondents covered by the sample and the distribution of population characteristics in Wessex Water's supply area.[16] For example, Table 3.2 shows that, while there are 20 per cent of households in the Wessex Water area with a weekly household income between £520 and £660, only 6.6 per cent of the sample belonged to this income band. Therefore, these 6.6 per cent of responses are given a higher relative weight of 20÷6.6=3.03 with respect to a baseline weight of 1.

Therefore, in cases where a customer group was particularly underrepresented in the sample, under this approach a small number of responses is applied a significantly higher weight. Then, the risk of placing a very high weight on a small number of responses becomes increasingly high. This risk is particularly high in the weights by household income, where (for example) 3.4 per cent of responses receive a relatively high weight of 5.89 each.

Given this trade-off between sample representativeness and the risk of imprecise estimates from placing high weight on a small number of observations, our preferred approach is to weight only by the number of household occupants, where the weights are less "extreme" than the income weights. However, the model we have developed allows for the use of income weights in the future as the sample size grows.

Table 3.2
Weights Applied to Responses based on Household Income

Wessex Water's Weekly Income Bands (£)		Wessex Water Customer Base %	Sample %	Weight Applied to Responses
520	660	20.0%	6.6%	3.03
660	710	20.0%	7.8%	2.56
710	760	20.0%	34.7%	0.58
760	830	20.0%	3.4%	5.89
830	1070	20.0%	47.5%	0.42

Source: NERA analysis of ONS "Model-based estimates of income for MSOAs" dataset and Wessex Water's full list of postcodes in the supply area.

[16] We have estimated Wessex Water's income distribution by extracting post-code level income estimates from the ONS "Model-based estimates of income for MSOAs" dataset, based on a full list of postcodes in the company's supply area provided to us by Wessex Water.

Table 3.3
Weights Applied to Responses based on Number of Household Occupants

Number of Household Occupants	Wessex Water Customer Base %	Sample %	Weight Applied to Responses
1	27.9%	28.8%	0.97
2	36.0%	43.0%	0.84
3	13.8%	8.7%	1.59
4 or more	17.0%	14.1%	1.20
N/A	5.4%	5.4%	1.00

Source: NERA analysis of Wessex Water's own demographic statistics.

3.3. Unweighted Results by Type of Interruption

This section presents our results using the unweighted sample of survey responses. Figure 3.6 shows the proportion of all respondents who undertook each "avertive" action as a result of the interruption, while Table 3.4 describes the expected costs associated with each action.

For each action, we consider the direct costs associated to any purchases of goods or services, as well as the costs of travelling to the location where the good or service is provided. As described in Section 2.3, our estimated travelling costs include the value of personal time lost, as well as any fuel or other expenses incurred.

Our estimates of "expected" costs are expressed in terms of pounds per household living in the affected area, and based on multiplying the percentage of respondents who took each action by the corresponding costs of the action.

Figure 3.6
Actions Respondents Took as a Result of Supply Interruptions (% of All respondents)

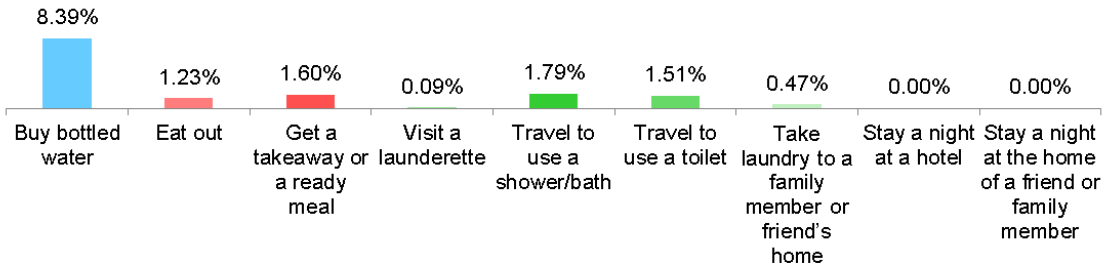


Table 3.4
Expected Costs by "Avertive" Action, in £ per Household in Affected Areas

Expenditure categories		% of all respondents	Expected direct expenditure	Expected Travel cost	Subtotals
Bottled Water	Buy bottled water	8.39%	0.09	0.06	0.15
Food	Eat out	1.23%	0.30	0.02	0.33
	Get a takeaway or a ready meal	1.60%	0.11	0.03	0.14
Other	Visit a launderette	0.09%	0.02	0.00	0.02
	Travel to use a shower/bath	1.79%	0.20	0.03	0.23
	Travel to use a toilet	1.51%	0.01	0.02	0.03
	Take laundry to a family member or friend's home	0.47%	0.00	0.01	0.01
	Stay a night at a hotel	0.00%	0.00	0.00	0.00
	Stay a night at the home of a friend or family member	0.00%	0.00	0.00	0.00
Total Expected Cost			0.72	0.17	**0.88**

As shown in Table 3.4, our estimated expected costs based on the unweighted sample are £0.88 per household living in the affected area. This relatively low valuation result is largely driven by a relatively small proportion of the respondents taking any mitigation actions as a result of the interruption. This is consistent with our statistics on the self-reported overall impact of the interruptions shown in Section 3.1.

However, these results vary significantly depending on the duration and type of the interruption. As shown in Table 3.5, our estimate for an interruption of less than two hours is £0.21 per household in the affected area, while for an interruption of more than three hours the estimate is £5.84 per household. Similarly, the results range from £0.31 per household for planned interruptions to £1.07 per household for unplanned interruptions.

The above results follow an intuitive pattern, given that a longer, unplanned duration is expected to have a higher negative impact on customers. However, the results for sub-samples based on a combination of type and duration are less intuitive. For interruptions of less than two hours, planned interruptions are associated with higher costs than unplanned interruptions, while for interruptions of two to three hours, we find the reverse result.

These counter-intuitive results are most likely caused by the effect of small sample sizes. Small sample bias can be caused by either unusual responses (ie. individual responses which are significantly far from the population average) or the specific timing of the interruptions included in the sub-samples. For instance, some of the unplanned interruptions could have taken place at times of day when they had less impact on residential customers (eg. at night or during the working day). In any case, we do not recommend relying on these joint relationships between duration and type of interruption for the purposes of CBA modelling, at

least until the analysis can be expanded with more data by surveying customers affected by future interruptions.

Table 3.5
Expected Costs by Type and Length of Interruption, in £ per Household in Affected Areas

Type	Interruption Length			
	All	0-2h	2-3h	3h<
All	**0.88** (1,061)	0.21 (390)	0.89 (619)	5.84 (52)
Planned	0.31 (257)	0.25 (215)	0.65 (42)	0.00 (0)
Unplanned	1.07 (804)	0.17 (175)	0.91 (577)	5.84 (52)

Note: Sample sizes in parenthesis.

Figure 3.7 to Figure 3.9 show the main drivers of the differences in results with respect to the length of the interruption. As duration increases, the number of households who buy bottled water or who travel to use a shower, a toilet or a launderette increases. The increase in respondents who eat out is smaller, but it also has a significant impact on the results since it is one of the most expensive "avertive" actions.

Figure 3.7
"Avertive" Actions Taken by Respondents – Interruptions of Less than Two Hours (percentage of sub-sample)

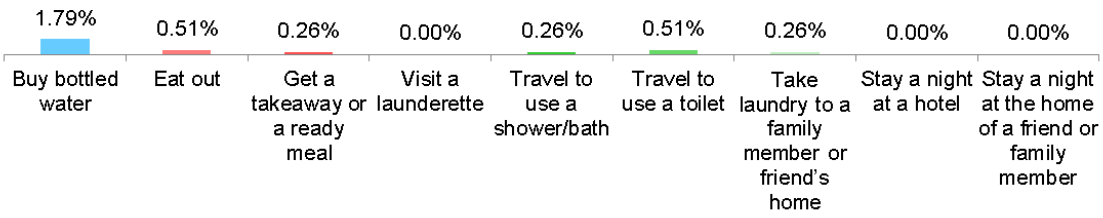


Figure 3.8
"Avertive" Actions Taken by Respondents – Interruptions of Two to Three Hours (percentage of sub-sample)

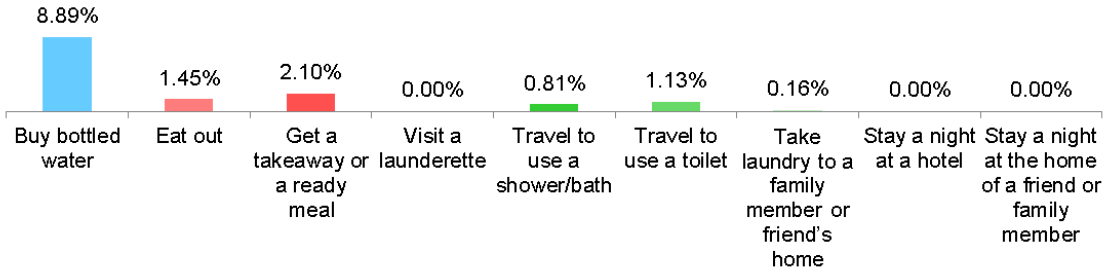


Figure 3.9
"Avertive" Actions Taken by Respondents – Interruptions of More than Three Hours (percentage of sub-sample)

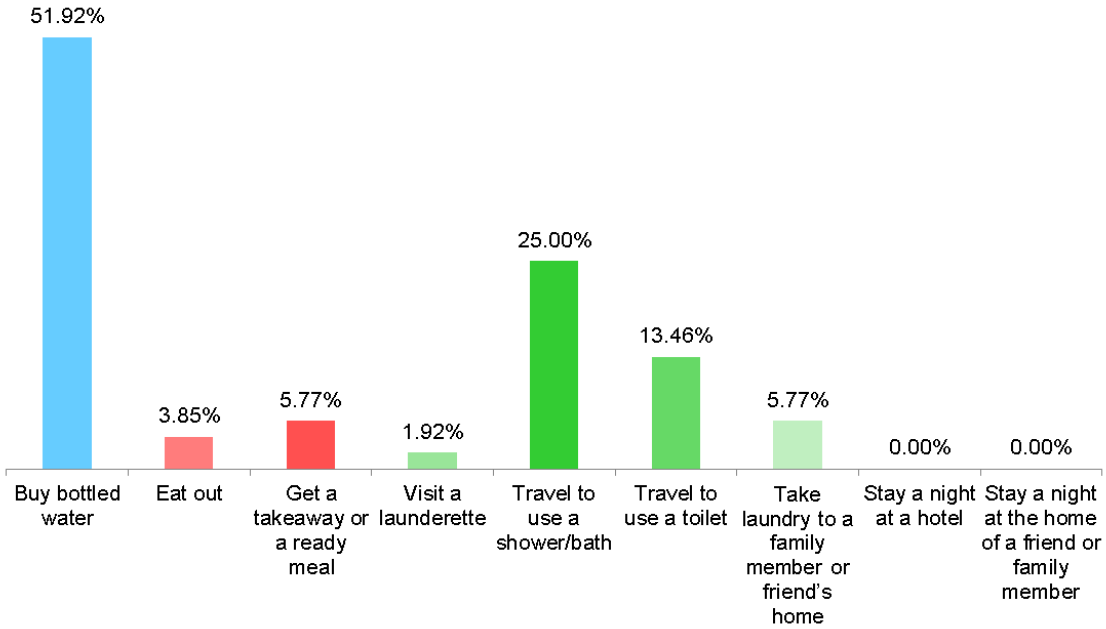


Figure 3.10 and Figure 3.11 show the main drivers of the differences in results with respect to whether the interruption was planned or unplanned. These drivers are broadly similar to the drivers of duration effects. However, as mentioned in Section 2.2, it may be difficult to infer a clear relationship between type of interruption (planned or unplanned) and "avertive" behaviour, given that part of the difference in results may be driven by differences in the duration of both types of events in the sample.

Figure 3.10
"Avertive" Actions Taken by Respondents – Planned Interruptons (percentage of sub-sample)

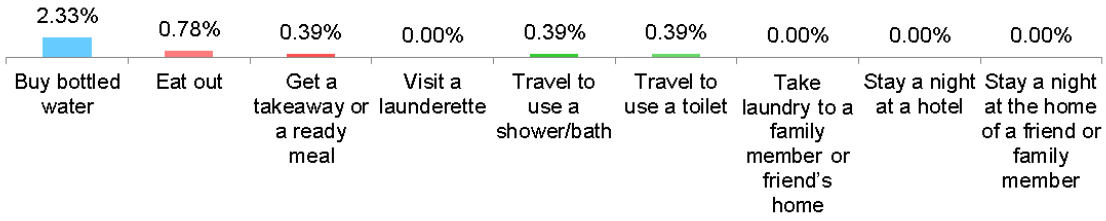
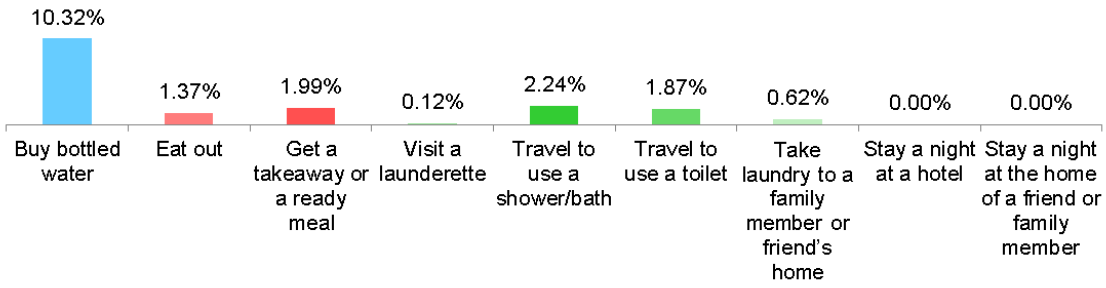


Figure 3.11
"Avertive" **Actions Taken by Respondents – Unp**lanned Interruptons (percentage of sub-sample)



3.4. Weighted Results by Type of Interruption

As described in Section 3.2, we have also estimated valuations using a weighted sample to improve representativeness, and given the trade-off between representativeness and the inaccuracies caused by small samples, our preferred weighting approach is by the number of household occupants.

3.4.1. Preferred approach: weighting by number of household occupants

This section presents the same results as above, but using weights to achieve representativeness in the number of household occupants. After applying weightings, Figure

3.12 shows the proportion of all respondents who undertook each "avertive" action as a result of the interruption, while Table 3.6 describes the expected costs associated with each action.

These proportions of people undertaking avertive actions are slightly higher than those estimated using the unweighted sample, as our sample has a higher proportion of households with one or two occupants than the population in Wessex Water's service area. As a result, valuation estimates are also slightly higher.

Figure 3.12
Actions Respondents Took as a Result of Supply Interruptions (% of All respondents)

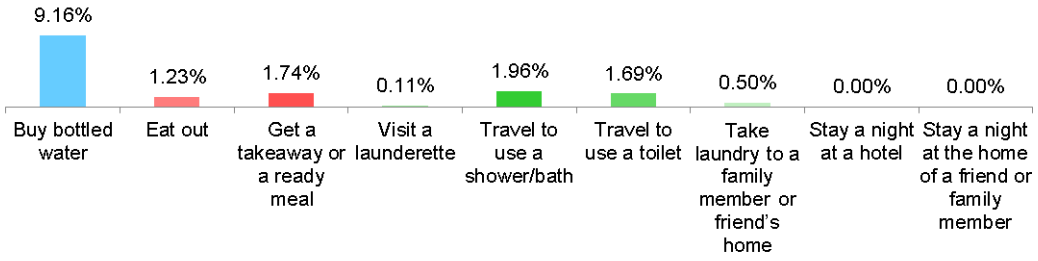


Table 3.6
Expected Costs by "Avertive" Action, in £ per Household in Affected Area

Expenditure categories		% of all respondents	Expected direct expenditure	Expected Travel cost	Subtotals
Bottled Water	Buy bottled water	9.16%	0.10	0.07	0.16
Food	Eat out	1.23%	0.32	0.02	0.34
	Get a takeaway or a ready meal	1.74%	0.11	0.03	0.14
Other	Visit a launderette	0.11%	0.02	0.00	0.02
	Travel to use a shower/bath	1.96%	0.22	0.03	0.24
	Travel to use a toilet	1.69%	0.01	0.02	0.03
	Take laundry to a family member or friend's home	0.50%	0.00	0.01	0.01
	Stay a night at a hotel	0.00%	0.00	0.00	0.00
	Stay a night at the home of a friend or family member	0.00%	0.00	0.00	0.00
Total Expected Cost			0.77	0.18	**0.94**

As for the unweighted results, our estimates vary significantly depending on the duration and the type of interruption. For planned interruptions of two to three hours, the value is higher in the weighted compared to the unweighted sample: £1.98 per household as compared to £0.65 in the unweighted sample.

Table 3.7
Expected Costs by Type and Length of Interruption, in £ per Household in Affected Area

Type	Interruption Length			
	All	0-2h	2-3h	3h<
All	**0.94** (1,061)	0.22 (390)	0.96 (619)	6.02 (52)
Planned	0.37 (257)	0.25 (215)	1.98 (42)	0.00 (0)
Unplanned	1.12 (804)	0.17 (175)	0.96 (577)	6.02 (52)

Note: Sample sizes in parenthesis.

Figure 3.13 to Figure 3.17 show the main drivers of these differences in results. The observed relationships between duration or type of interruption and "avertive" behaviour are similar to those observed in the unweighted results.

Figure 3.13
"Avertive" Actions Taken by Respondents – Interruptions of Less than Two Hours (percentage of sub-sample)

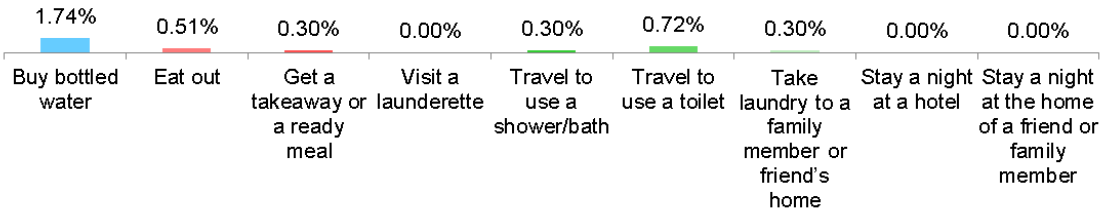


Figure 3.14
"Avertive" Actions Taken by Respondents – Interruptions of Two to Three Hours
(percentage of sub-sample)

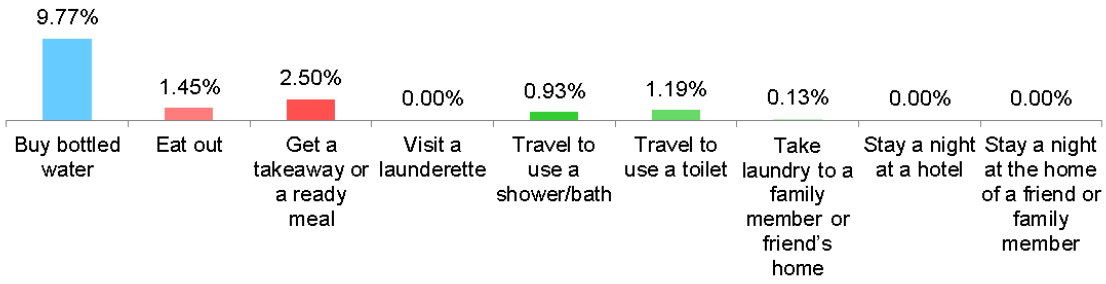


Figure 3.15
"Avertive" Actions Taken by Respondents – Interruptions of More than Three Hours
(percentage of sub-sample)

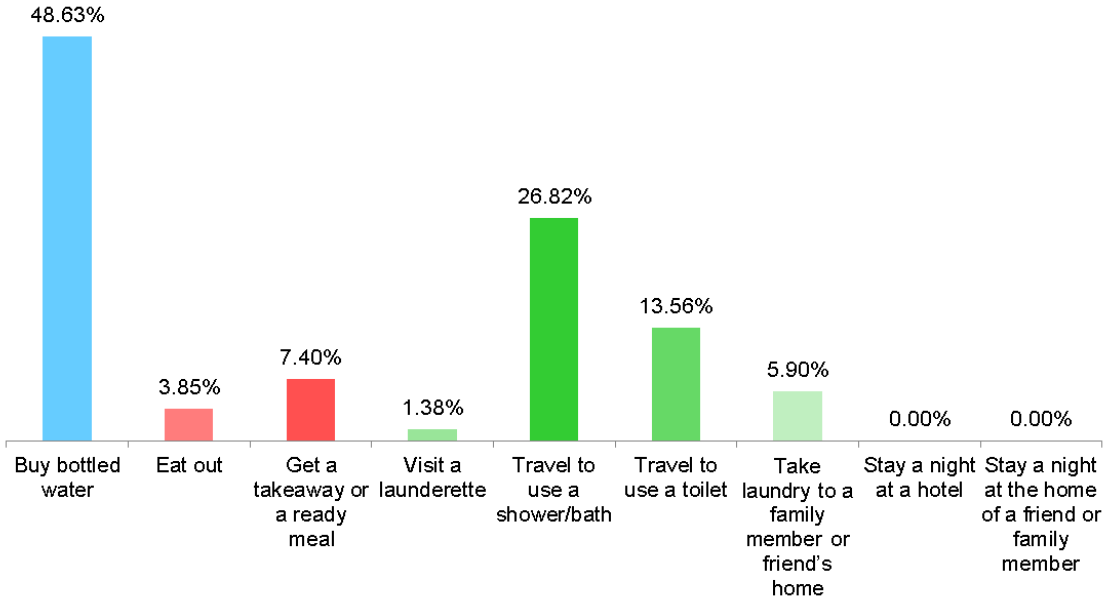


Figure 3.16
"Avertive" Actions Taken by Respondents – Planned Interruptons (percentage of sub-sample)

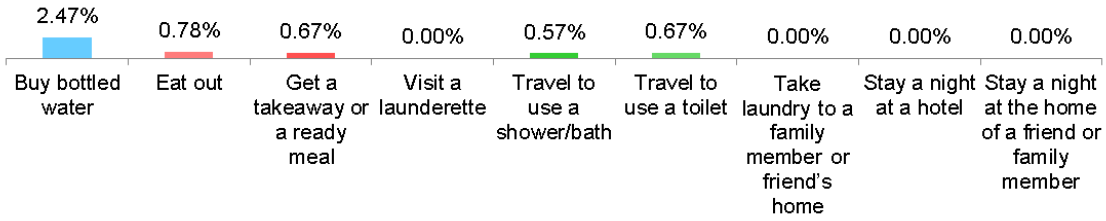
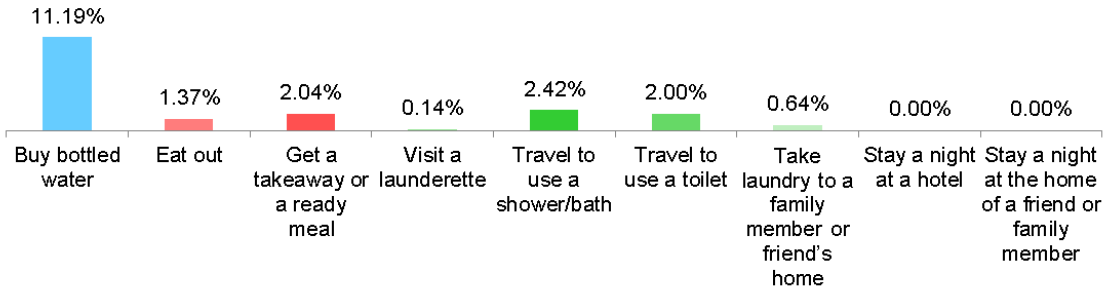


Figure 3.17
"Avertive" Actions Taken by Respondents – Unplanned Interruptions (percentage of sub-sample)



3.4.2. Weighting by income

Figure 3.18 shows the proportion of all respondents who undertook each "avertive" action as a result of the interruption after applying the income weights shown above, while Table 3.8 shows the valuation results.

These results are slightly lower than those estimated using the unweighted sample. This reflects the skew of the sample towards higher income bands. Therefore, the results decrease after giving higher weights to responses from households with lower income.

Figure 3.18
Actions Respondents Took as a Result of Supply Interruptions (% of All respondents)

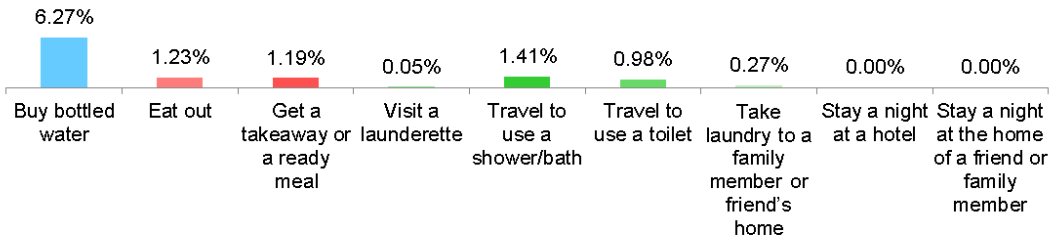


Table 3.8
Expected Costs by "Avertive" Action, in £ per Household in Affected Area

Expenditure categories		% of all respondents	Expected direct expenditure	Expected Travel cost	Subtotals
Bottled Water	Buy bottled water	6.27%	0.06	0.04	0.11
Food	Eat out	1.23%	0.30	0.01	0.31
	Get a takeaway or a ready meal	1.19%	0.08	0.01	0.09
Other	Visit a launderette	0.05%	0.01	0.00	0.01
	Travel to use a shower/bath	1.41%	0.19	0.02	0.21
	Travel to use a toilet	0.98%	0.00	0.01	0.01
	Take laundry to a family member or friend's home	0.27%	0.00	0.00	0.00
	Stay a night at a hotel	0.00%	0.00	0.00	0.00
	Stay a night at the home of a friend or family member	0.00%	0.00	0.00	0.00
Total Expected Cost			0.64	0.10	**0.74**

As for the unweighted results, our estimates vary significantly depending on the duration and the type of interruption. These weighted results follow a similar relationship with duration and type of interruption as the unweighted results.

Table 3.9
Expected Costs by Type and Length of Interruption, in £ per Household in Affected Area

Type	Interruption Length			
	All	0-2h	2-3h	3h<
All	**0.74** (1,061)	0.18 (390)	0.94 (619)	5.84 (52)
Planned	0.32 (257)	0.26 (215)	0.44 (42)	0.00 (0)
Unplanned	0.87 (804)	0.09 (175)	1.07 (577)	5.84 (52)

Note: Sample sizes in parenthesis.

Figure 3.19 to Figure 3.23 show the main drivers of these differences in results. The observed relationships between duration or type of interruption and "avertive" behaviour are similar to those observed in the unweighted results.

Figure 3.19
"Avertive" Actions Taken by Respondents – Interruptions of Less than Two Hours (percentage of sub-sample)

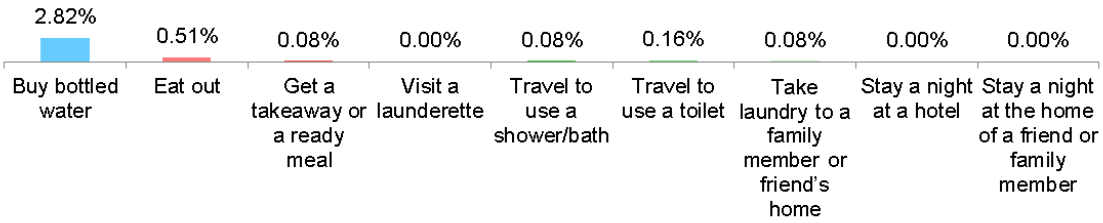


Figure 3.20
"Avertive" Actions Taken by Respondents – Interruptions of Two to Three Hours
(percentage of sub-sample)

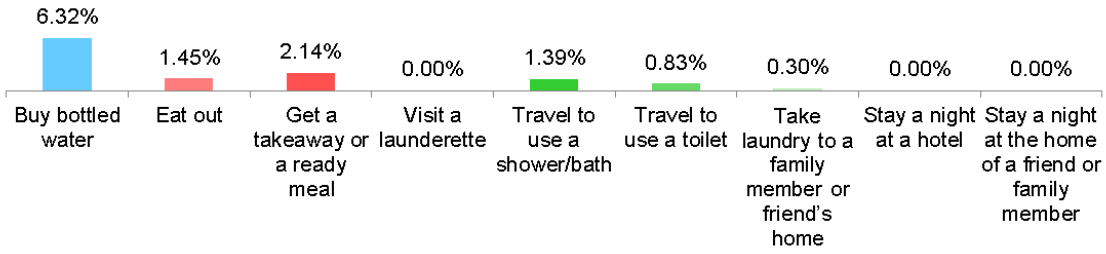


Figure 3.21
"Avertive" Actions Taken by Respondents – Interruptions of More than Three Hours
(percentage of sub-sample)

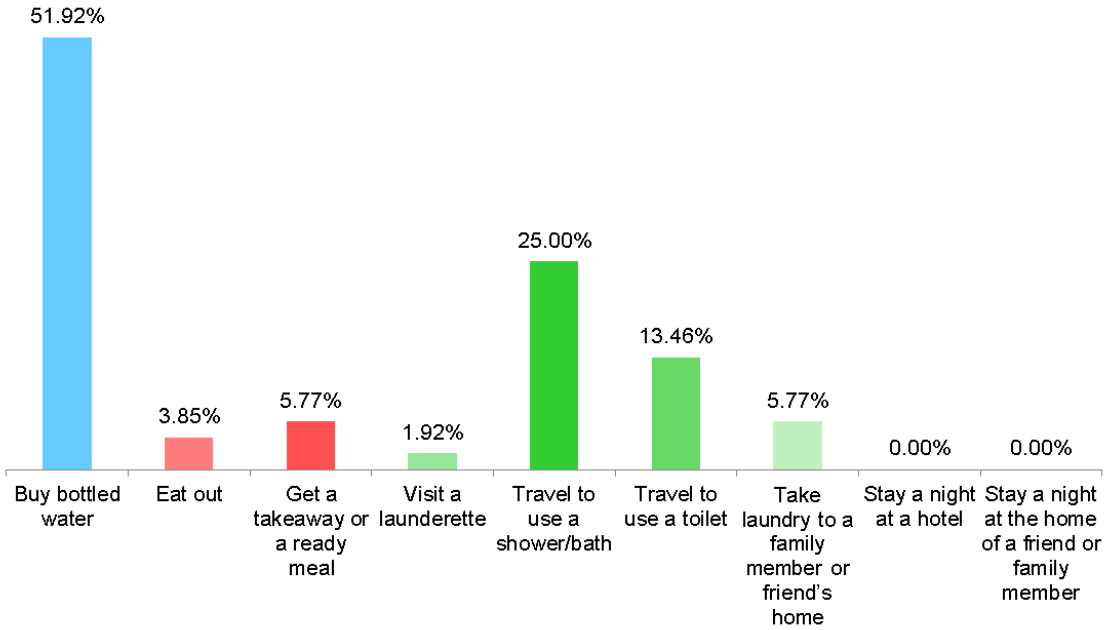


Figure 3.22
"Avertive" Actions Taken by Respondents – Planned Interruptons (percentage of sub-sample)

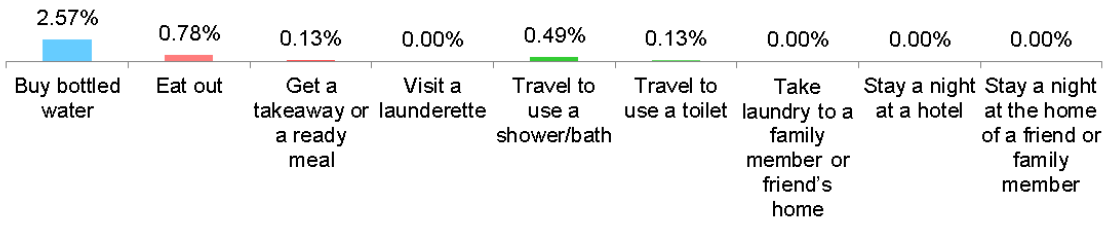
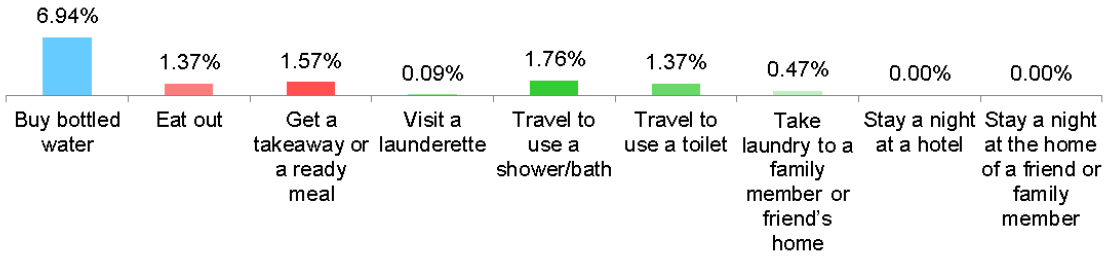


Figure 3.23
"Avertive" Actions Taken by Respondents – Unplanned Interruptons (percentage of sub-sample)



3.4.3. Combined weighting

As explained above, when compared to the unweighted results, applying income and household size weights has the opposite effect on results. Therefore, as Figure 3.24 and Table 3.10 show, are between the results of applying the two weighting approaches individually. The proportion of people taking avertive measures and the resulting valuations are also slightly lower than those we obtain from the unweighted sample. As Table 3.11 shows, the combined weighting approach also shows similar relativities across the interruption types.

As discussed in Section 3.2, we consider this approach of combining weights risks placing very significant emphasis on a small number of results, which may create inaccuracies. However, the similarity between the results below and the unweighted results suggests such effects may be limited in this particular sample.

Figure 3.24
Actions Respondents Took as a Result of Supply Interruptions (% of All respondents)

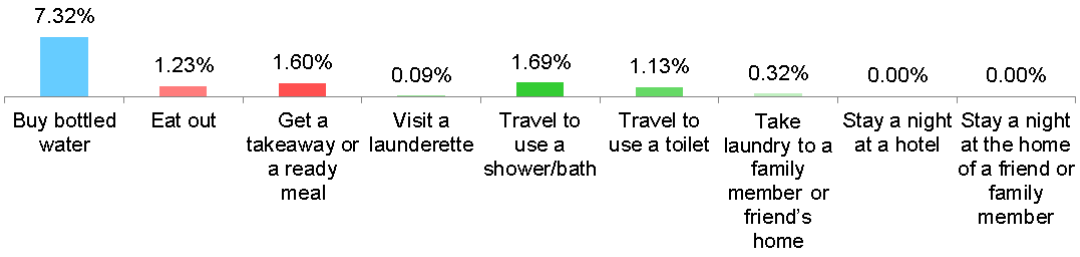


Table 3.10
Expected Costs by "Avertive" Action, in £ per Household in Affected Area

Expenditure categories		% of all respondents	Expected direct expenditure	Expected Travel cost	Subtotals
Bottled Water	Buy bottled water	7.32%	0.08	0.04	0.12
Food	Eat out	1.23%	0.31	0.01	0.32
	Get a takeaway or a ready meal	1.60%	0.10	0.02	0.12
Other	Visit a launderette	0.09%	0.01	0.00	0.01
	Travel to use a shower/bath	1.69%	0.23	0.02	0.25
	Travel to use a toilet	1.13%	0.00	0.01	0.01
	Take laundry to a family member or friend's home	0.32%	0.00	0.00	0.00
	Stay a night at a hotel	0.00%	0.00	0.00	0.00
	Stay a night at the home of a friend or family member	0.00%	0.00	0.00	0.00
Total Expected Cost			0.73	0.11	**0.84**

Table 3.11
Expected Costs by Type and Length of Interruption, in £ per Household in Affected Area

Type	Interruption Length			
	All	0-2h	2-3h	3h<
All	**0.84** (1,061)	0.19 (390)	1.34 (619)	6.02 (52)
Planned	0.36 (257)	0.27 (215)	1.03 (42)	0.00 (0)
Unplanned	0.98 (804)	0.12 (175)	1.16 (577)	6.02 (52)

Note: Sample sizes in parenthesis.

Figure 3.25 to Figure 3.29 show the main drivers of these differences in results. The observed relationships between duration or type of interruption and "avertive" behaviour are similar to those observed in the unweighted results.

Figure 3.25
"Avertive" Actions Taken by Respondents – Interruptions of Less than Two Hours (percentage of sub-sample)

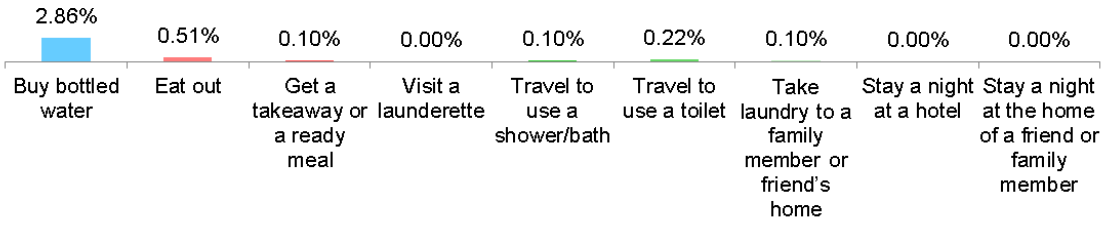


Figure 3.26
"Avertive" Actions Taken by Respondents – Interruptions of Two to Three Hours
(percentage of sub-sample)

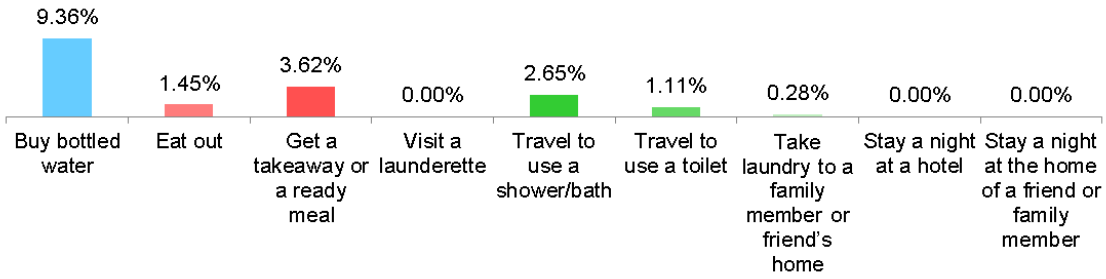


Figure 3.27
"Avertive" Actions Taken by Respondents – Interruptions of More than Three Hours
(percentage of sub-sample)

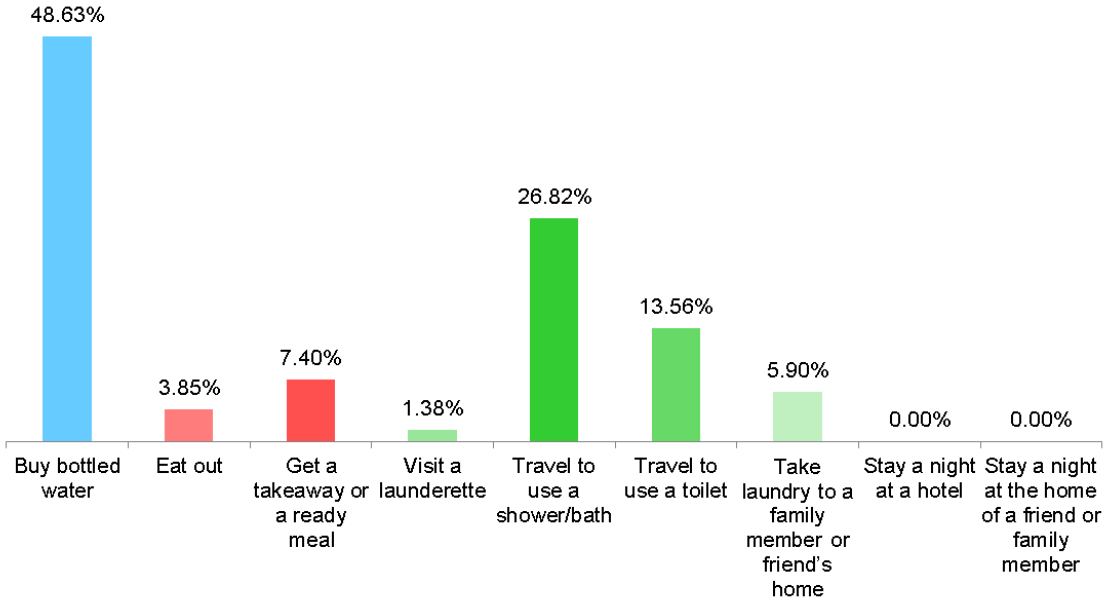


Figure 3.28
"Avertive" Actions Taken by Respondents – Planned Interruptions (percentage of sub-sample)

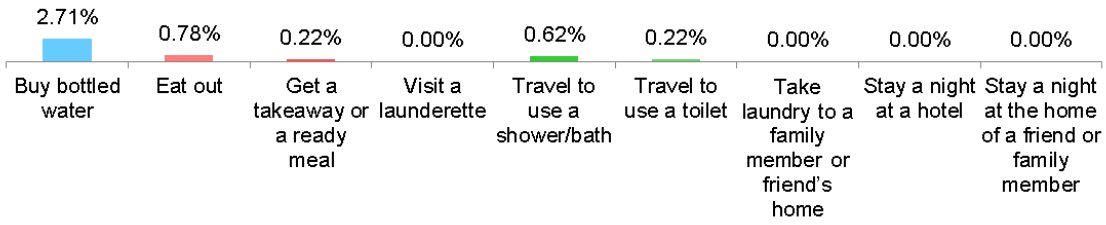
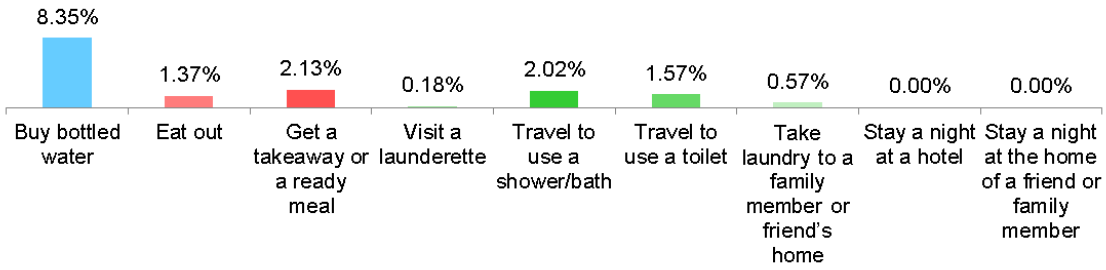


Figure 3.29
"Avertive" Actions Taken by Respondents – Unplanned Interruptions (percentage of sub-sample)



4. Summary of Valuation Results

Table 4.1 provides a summary of our results for each type of interruption and duration range, under each alternative weighting approach. We highlight in bold the results from our preferred approach, which we recommend using as the "base case" valuation emerging from this study during the triangulation process. However, Wessex Water may also wish to take into consideration the full range of results for sensitivity testing.

Table 4.1
Summary of Valuation Results by Sub-Sample and Weighting Approach, in £ per household living in the affected area

	Unweighted	Weights by Nr of Occupants	Weights by Income	Combined Weights
All Interruptions	0.88	**0.94**	0.74	0.84
Planned	0.31	**0.37**	0.32	0.36
Unplanned	1.07	**1.12**	0.87	0.98
Less than 2h	0.21	**0.22**	0.18	0.19
2h to 3h	0.89	**0.96**	0.94	1.34
More than 3h	5.84	**6.02**	5.84	6.02

As discussed in the previous sections, the lowest valuation results correspond to the sample weighted by household income, given that higher weights were placed to lower income respondents. Similarly, the highest valuation results correspond to the sample weighted by the number of household occupants, since higher weights were placed to households with a greater number of occupants. However, we consider that weighting by the number of household occupants provides an appropriate balance between sample representativeness and the potential inaccuracy introduced by relying on extremely small samples.

Appendix A. Survey Questionnaire

1. Out of 5, how much did the water being off affect you? (5 = extremely affected, 1 = not affected at all)
    a. Scale 5-1

2. What, if anything, did you do differently as a result of the water being off?
    a. Open text answer

3. Did you do any of the following as a result of the water being off? (select from list of options, if selected route to follow-up questions)
    a. Filled up containers in advance [for planned interruptions only]
    b. Buy bottled water
    c. Travel to use a shower/bath
    d. Travel to use a toilet
    e. Buy a water filter
    f. Run taps to clear any discolouration of water
    g. Eat out
    h. Get a takeaway or a ready meal
    i. Visit a launderette
    j. Take laundry to a family member or friend's home
    k. Stay a night at a hotel
    l. Stay a night at the home of a friend or family member
    m. Other – (please state)
    n. None of the above

4. Follow up questions if ticked at Q3
    a. (1) How many litres of bottled water did you buy? (2) How far did you travel to buy bottled water? (3) [If yes to (2)] What mode of transport did you use? [select from: walk, cycle, car, taxi, public transport], (4) How long did the return journey take (minutes)?
    b. (1) How far did you travel to use a shower/bath (miles)? (2) How many times did you do this? (3) What mode of transport did you use? [select from: walk, cycle, car, taxi, public transport]
    c. (1) How far did you travel to use a toilet? (miles)? (2) How many times did you do this? (3) What mode of transport did you use? [select from: walk, cycle, car, taxi, public transport]
    d. No extra question
    e. No extra question
    f. (1) How far did you travel to eat out (miles)? (2) What mode of transport did you use? [select from: walk, cycle, car, taxi, public transport]
    g. (1) How far did you travel to buy your takeaway or ready meal (miles)? (2) What mode of transport did you use? [select from: walk, cycle, car, taxi, public transport], (3) How many times did you get a takeaway or ready meal?

h. (1) How far did you travel to use the launderette (miles)? (2) What mode of transport did you use? [select from: walk, cycle, car, taxi, public transport]
i. (1) How far did you travel (miles)? (2) What mode of transport did you use? [select from: walk, cycle, car, taxi, public transport]
j. (1) How many nights did you stay? (2) How far did you travel (miles)? (3) What mode of transport did you use? [select from: walk, cycle, car, taxi, public transport]
k. (1) How far did you travel (miles)? (2) What mode of transport did you use? [select from: walk, cycle, car, taxi, public transport]

5. About you
    a. How many adults aged 16 and over live in your property?
        i. (select number)

    b. How many children under 16 live in the property?
        i. (select number)

    c. Which of the following describe any of the adults in your household? Tick all that apply
        i. Retired, working full/part time, housewife/husband, student, unemployed, long term sickness or disability, other (specify)

6. Is there anything else you'd like to tell us about your experience of the water being off? (open text answer)

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16 May 2017

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BA2 7WW

Subject: Proposal to Support Wessex Water in Conducting Valuation Analysis Using Post-Event Surveys

Dear Harriet

Thank you for our recent discussion on how NERA might support you in performing valuation analysis using "post-event surveys". This letter provides a short proposal setting out the approach we would follow and the resources it would require.

Our Approach

Wessex Water has asked NERA for support in conducting post-event surveys, as a means of conducting Revealed Preference (RP) valuation research. The objective of this research is to use the impact of incidents of service failure to derive valuation information to inform business planning, based on the "avertive" measures customers take to mitigate the effects of service failure. As we have discussed, Ofwat has suggested it expects companies to consider a range of customer valuation methods as they engage with their customers and develop PR19 business plans. As such, this form of RP research may provide a useful piece of evidence in informing your business planning work.

The "avertive behaviour" RP method will be particularly useful for valuing relatively common forms of service failure, such as short interruptions, low pressure events, and temporary aesthetic problems with water quality. For instance, customers who experience poor water taste/odour may mitigate this by purchasing bottled water, or purchasing water filters. The market price of these transactions would tend to provide a lower bound estimate of the value of service improvement. (It is a lower bound because it would not capture nuisance effects, but this could be useful as part of a triangulation process.)

Implementation

To implement this study, we would design a short survey that Wessex Water could send to customers affected by service failures. This survey will ask customers a series of questions

about the impact that service failures have had on them. We would also ask them a range of questions about what measures they took to avert the impact of the event, as well as information to gather demographic information (age, income, etc).

Following our recent discussions, we assume you would then implement these surveys following incidents of service failure using your existing surveying systems. To derive robust valuation estimates that form part of your "triangulated" valuations that inform your PR19 business plan, we would ideally require a sample of around 500 customers. Then, once we know what customers typically do in order to moderate the impacts of service failure (eg. buying mineral water) we will provide you with an estimate of the value of service improvement (eg. value = change in probability of problems x price of mineral water).

To derive valuation estimates that are applicable to the population of Wessex Water customers, not just those that happen to have been affected by service problems in a sample period, we will also apply weights when performing our analysis. These weights will seek to ensure that the valuations match the characteristics of the population within your region based on key demographics, like income.

Outputs

The main output from this study would be a thorough technical report, documenting our methods, assumptions and findings. We will also provide guidance in the report on the likely biases in our results that should be considered as part of the Wessex Water "triangulation" process and PR19 business planning modelling (such as explaining why this form of RP is likely to produce a lower bound valuation).

This report would be written with a view to convincing regulatory and other external audiences as to the validity of the findings. However, it will also include an executive summary aimed at less technical audiences. We would also be delighted to present our findings to Wessex Water management and/or external stakeholders (e.g. the Partnership Board).

Our Team

The NERA project team will be led by Richard Druce, an Associate Director in our London utilities practice. Richard works extensively on the regulation of network utilities, with a focus on the application of micro-econometrics, including willingness to pay and valuation assignments. Richard acted as project manager for the NERA inputs into the PR14 willingness to pay study provided to Wessex Water, and has been supporting a number of companies on structuring their PR19 valuation research.

Richard will be supported by Adriana Linares**,** a researcher in our London office. Adriana works in NERA's water practice, working on a range of regulatory projects for water companies in the UK and Ireland, including recent work for Water UK on national water resource planning, which involved compiling and analysing evidence on willingness-to-pay.

Resources

The resources required for this assignment would be relatively modest, on the basis that we assume Wessex would take main responsibility for implementing the survey, and providing the resulting data to NERA using your existing capacity to run surveys of customers who are affected by incidents of service failure.

We assume that, following commissioning, we could develop a survey instrument within around 2-3 weeks (allowing some time for project set-up and an inception meeting). We would then hand it over to you for programming into your surveying system and implementation.

Once you have gathered survey responses from affected customers, we would then perform the economic and statistical analysis required to derive valuations and report on our findings. In total, we envisage we can perform this analysis and prepare a report within around 3-4 weeks of receiving data from you.

For this level of input, we would charge a fixed fee of £VALUE REMOVED, excluding VAT, which we have calculated assuming Richard Druce and Adriana Linares will work on this assignment for 6 and 12 days respectively. We would charge for travel expenses to attend meetings at cost to NERA.

Please do not hesitate to get in touch if you would like to discuss any aspect of this proposal.

Yours sincerely

Richard Druce
Associate Director, NERA