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Non-market values for fresh water in the Waikato region: a combined revealed and stated preference approach

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Disclaimer

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Abstract

This report summarises the results of a non-market valuation study carried out to support decision-making by central government, regional government and the wider community on the potential impacts of setting freshwater objectives and limits in the Waikato River Catchment. The first part of the study uses data collected about recreational and cultural use of fresh water to create a “revealed preference” model of site choice and the relative importance of water quality. The second part uses a choice experiment to estimate willingness to pay for water quality improvement. The final section of the report illustrates how these models may be used to analyse the benefits of a range of water quality policy scenarios.

Executive Summary

Introduction and background

The Waikato Economic Impact Joint Venture Project studies were undertaken to support and inform decision-making by central government, regional government and the wider community on the potential impacts of setting freshwater objectives and limits in the Waikato River Catchment.

The purpose of the Non-Market Valuation study is to assess non-market values of fresh water quality in the Waikato/Waipa catchment in terms of willingness to pay by households. Non-market value refers to the value of goods which are not bought or sold directly so do not have a market "price". The scope of non-market values assessed in this study consists of recreation and cultural use, option values for future use, and non-use or existence value.

Willingness to pay is an appropriate measure of non-market benefits of improved water quality that can be considered alongside potential costs (e.g. agriculture or industry) in assessing the different choices or policy options in setting freshwater objectives and limits.

A complete assessment should also acknowledge issues such as intrinsic ecosystem value and equity (the distribution of costs and benefits) but they are outside the scope of this report.

This report presents three models that have been developed for assessing changes to water quality attributes clarity, human health risk and ecosystem health. The models are based on data collected from two surveys. The "revealed preference" model uses information about real-world behaviour and provides a detailed baseline estimate of recreational and cultural use of fresh water. The "stated preference" model allows us to expand the analysis by including non-use values and disentangling the effects of human health risk and ecosystem health from the more visible attribute of clarity. We also combine the two data sets in a joint model to compare and confirm consistency of results. Finally, we explain how the models can be used to help inform the policy using some hypothetical water quality scenarios. It is important to note that the results are not based on actual policy scenarios and the report does not contain any policy recommendations.

This report comprises five sections: a literature review of related studies, revealed preference analysis, stated preference analysis, joint analysis of revealed and stated preferences and a marginal benefit analysis of hypothetical scenarios for water quality in the catchment.

Data collected

Data collection consisted of two surveys delivered in August/September 2013 and February 2014. Existing data sources including GIS biophysical data, census data and data from the qualitative water values survey collected by WRC in 2012[1] were also used.

Revealed preference analysis

The purpose of the revealed preference study was to collect primary data to learn about where and when people use fresh water for recreational or cultural activities and what these activities are. We also use the information collected to determine what features influence site visits and calculate travel costs and infer a minimum value of a

[1] http://waikatoregion.govt.nz/TR201331

recreation trip. We designed an online survey named "Waikato fresh water recreation and cultural use survey". A "user" is defined as someone who has visited fresh water for the purpose of doing recreational or cultural activities in, on or near the water in the past year.

We collected spatially referenced information from 1370 users of Waikato fresh water and 616 non-users, The information included geographic coordinates for fresh water trip origins and destinations, trip details (duration, activities, companions etc.), perceptions of water quality, preferred features of sites and standard demographic questions. For people who had not used fresh water for recreation or cultural activities in the past year we asked why not (to determine if water quality was a factor).

Positive and negative features of sites

Participants were asked what they liked or disliked about each site they visited. Figure 1 shows the proportion of visitors to each management zone who selected each positive feature and figure 2 shows the negative features.

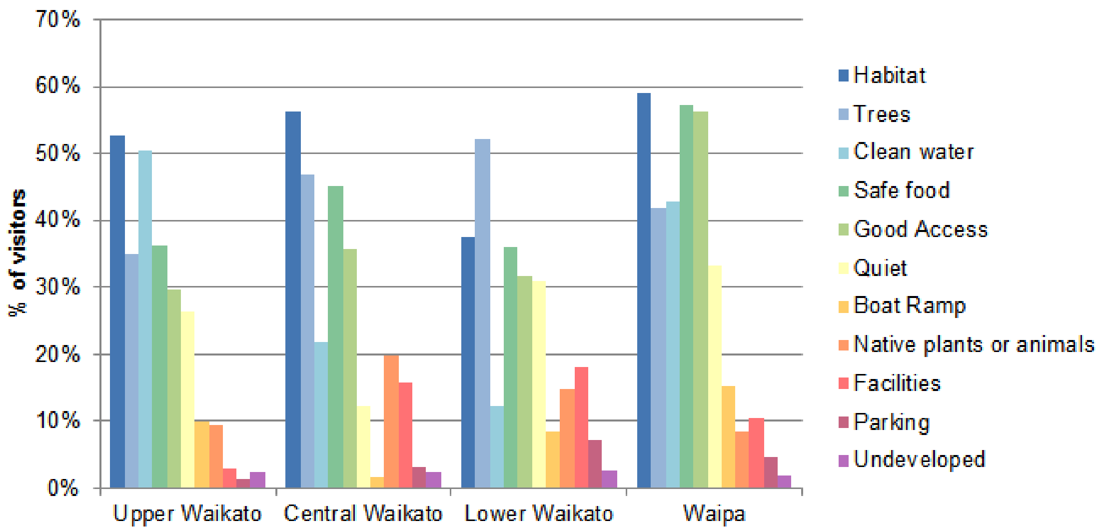


Figure 1 - Reasons for liking a site by management zone

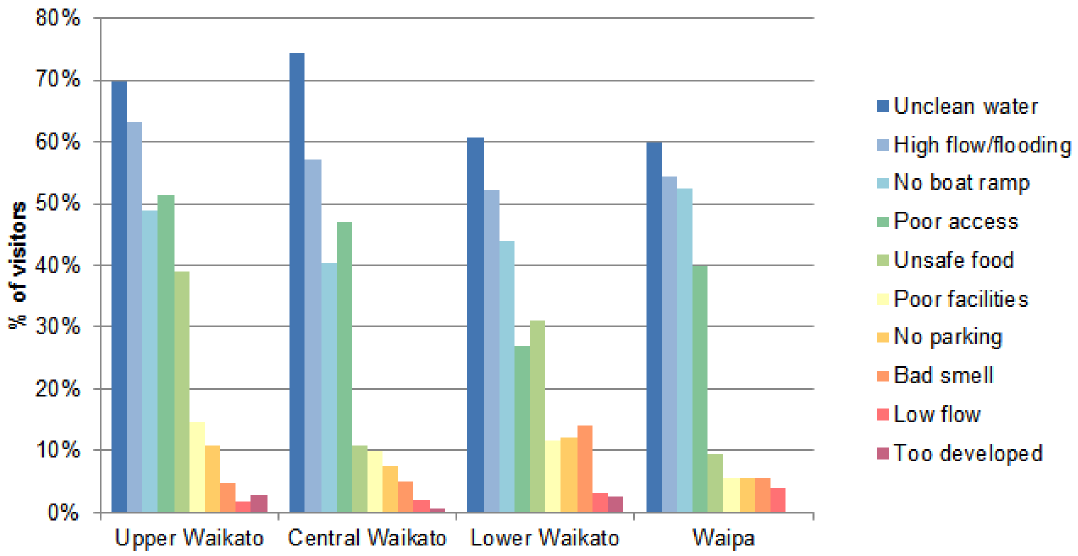


Figure 2 - Reasons for disliking a site by management zone

Total travel cost

We use travel cost and opportunity cost of time to estimate the minimum willingness to pay to access a fresh water site. We exclude trips further than 290km from the travel cost analysis because the literature suggests this is an appropriate cut-off point for single-purpose recreation trips. Travel cost is calculated using a per-kilometre cost of $0.20 for vehicle expenses and an opportunity cost of time equal to 25 per cent of the individual's hourly wage. We calculate low, medium and high estimates of the total number of users in the population to estimate the total value of recreation trips.

The data reveal that:

- the majority of trips reported are relatively short. The median is 49km and the average is 106km;
- the median travel cost **per trip** is $24 and the average is $44;
- the median cost **per year** is $101 per year and the average is $270 and
- the total value of fresh water recreation trips is in the range of **$28 to $91 million per year**.

Destination choice model

There are two parts to the revealed preference analysis, a destination choice "random utility" model to explain what influences recreation site choices and a trip cost model to explain the number of trips taken per individual.

In the destination choice model the value of water quality may be inferred indirectly by analysing how far people travel to visit sites of varying quality. The variables that best explain site choice (from all rivers, streams and lakes in the region) include travel cost, clarity, land cover (urban and forest), facilities, accessibility, development, perceived cleanliness, perceived safety of food gathered and flow adequacy. Human health risk and ecosystem health measures were not significant and are highly correlated with clarity so were not included in the final model.

The bar chart shows the average influence of each factor. Travel cost is a significant negative effect and means that sites further away are less likely to be visited, all else being equal. Clarity has just as large a positive effect. However, user-perceived cleanliness has the largest impact overall and is significant even after including clarity in the model.

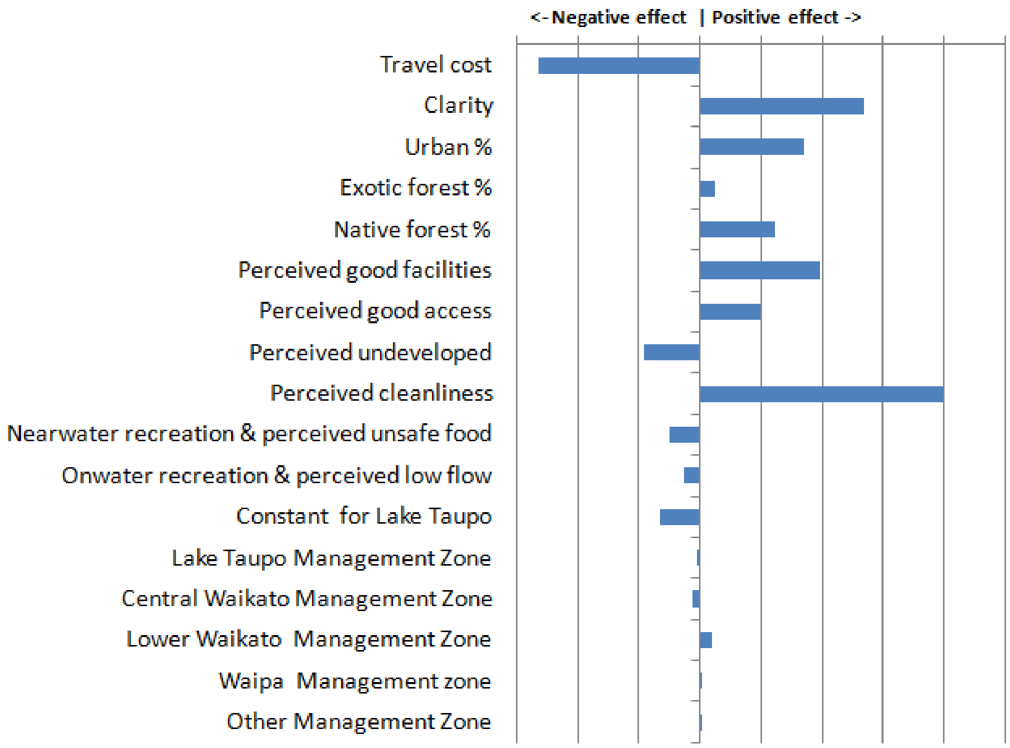


Figure 3 - Relative impact of coefficients at average levels of each variable

Trip count model

The other component of revealed preference analysis is a model to explain the number of trips that individuals make. The trip count model reveals that:

- older and more highly educated people make more trips for fresh water recreation and
- water quality may not have a significant effect on total number of trips, which means that improvements in quality are more likely to result in **substitutions between sites** than an increase in the total number of trips per person.

Application of revealed preference findings

The information obtained from the revealed preference analysis is useful to help understand the *total* non-market use value of fresh water visits to each site (or at least a lower bound on this value). The model also helps us to understand how visits may be redistributed amongst sites if water clarity improves.

Limitations of the revealed preference analysis

- Revealed preference analysis only covers use value.

- Behaviour depends on peoples' *perceptions* of site quality, which are not necessarily consistent with objective measures of quality. This is why we need additional information from the stated preference method to estimate values for human health risk and ecosystem health.

- The model assumes all fresh water sites are substitutes (after controlling for distance and quality). This assumption may not hold for some activities.

- The assumption that a quality change would result in substitutions rather than a change in the total number of trips is difficult to prove without a before-and-after survey of an actual change.

Stated preference analysis

The purpose of the stated preference analysis is to allow us to estimate the non-use portion of non-market values and quantify marginal values for human health risk and ecosystem health that could not be identified from the revealed preference analysis. We designed a second online survey to include a choice experiment, some attitudinal questions and standard demographic questions, and collected information from over 1,000 respondents.

Survey participants were provided information on the current state of water quality at five sites and in the Waikato river catchment overall, in terms of water clarity, ecosystem health and human health. Participants were then asked to make a series of choices from scenarios of improvements to water quality attributes at a cost in terms of rates or taxes.

Willingness-to-pay for individual sites

The following charts show marginal willingness-to-pay for the three different water quality attributes based on the stated preference model. The reference level is the *lowest* quality level for each attribute. To calculate the value of an improvement at a specific site we need to subtract the value of the current quality level.

There are several factors which are correlated with the amount people are willing to pay, including choice certainty, user versus non-user, Māori ethnicity, ratepayers versus non-ratepayers, attitude towards water quality and distance from the site.

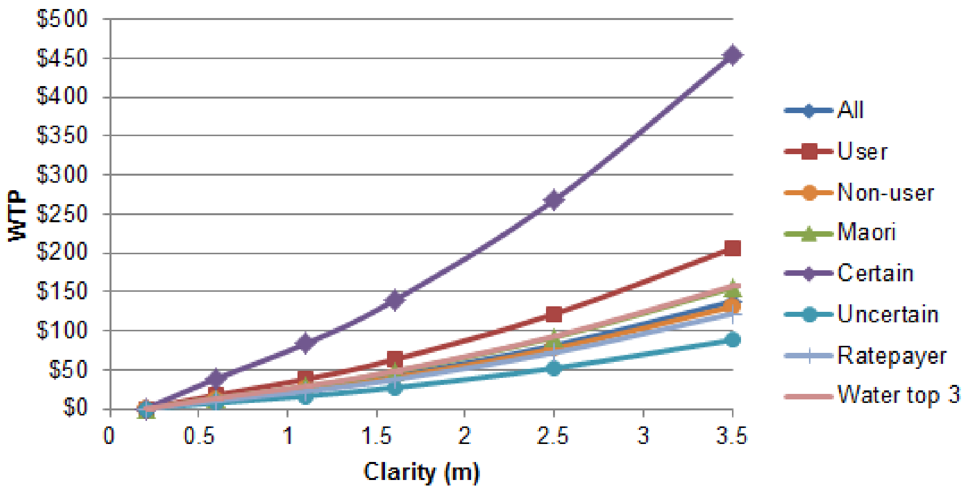


Figure 4 – WTP per household per year for clarity including interaction effects

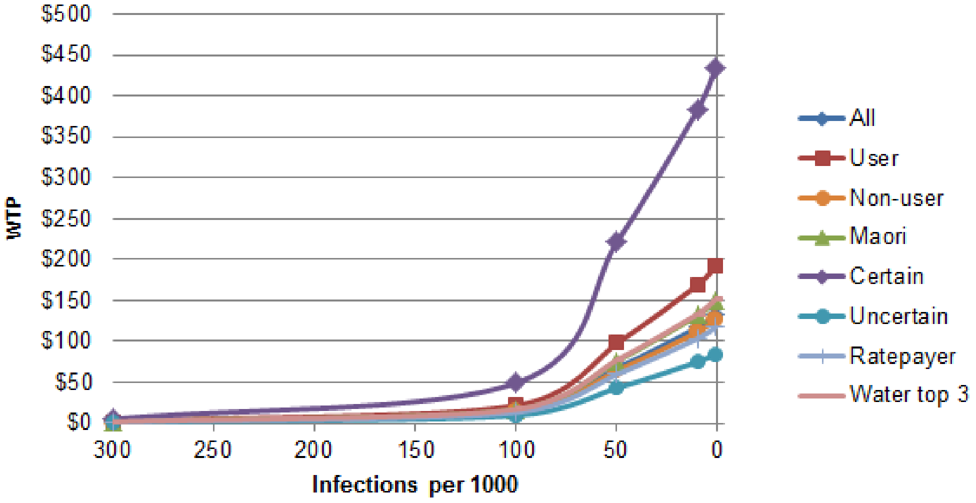


Figure 5 – WTP per household per for infection risk including interaction effects

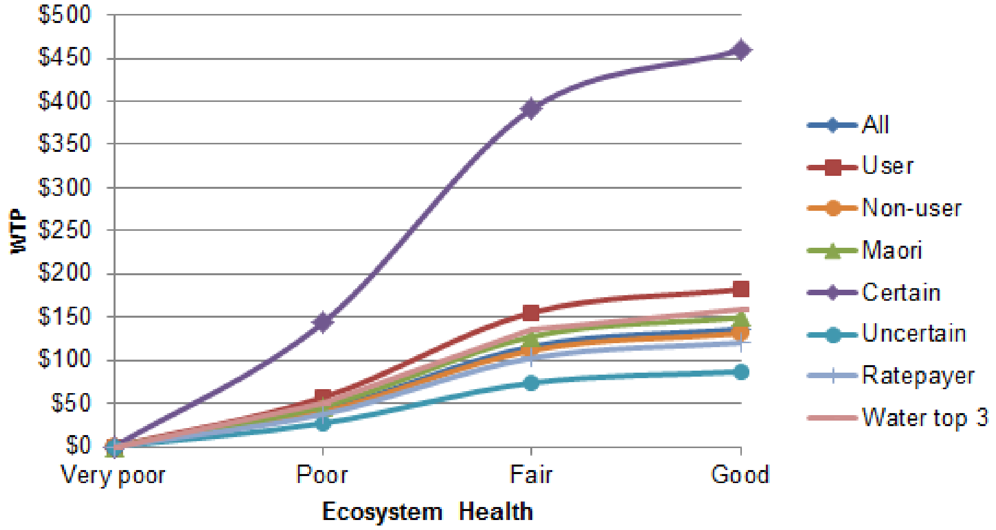


Figure 6 – WTP per household per year for ecosystem health including interaction effects

Willingness-to-pay for whole-catchment improvements

The following figure shows WTP derived from the whole-catchment choices. The same factors (users versus non-users, for example) also affect WTP for the whole catchment but the chart only shows the average for simplicity.

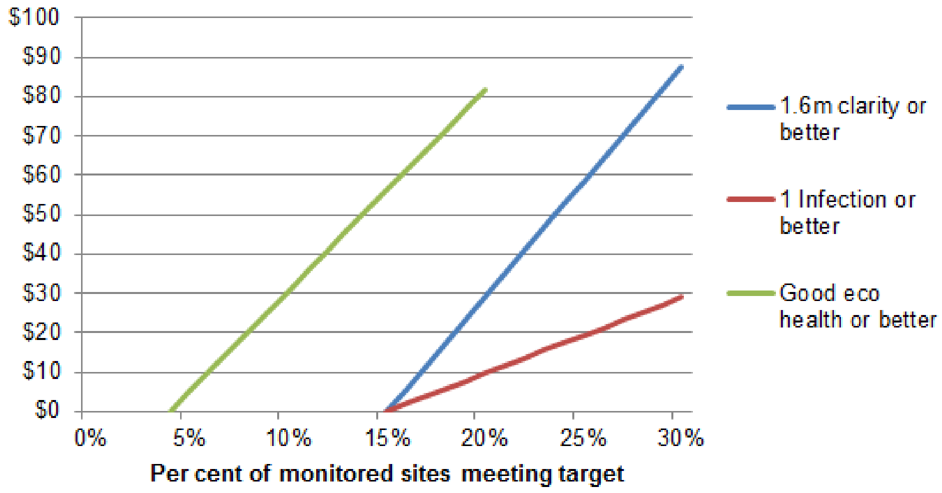


Figure 7 - WTP for whole catchment water quality

Application of stated preference WTP estimates

The stated preference model results can be used to analyse welfare effects of various scenarios that involve a change in quality for individual sites, multiple sites, or the whole catchment. The scenario must be framed in terms of changes to clarity, E.coli (human health) or nitrogen and phosphorus (ecosystem health).

Limitations of stated preference model

Stated preference studies are sensitive to framing of attributes, scenarios and geographic scope. We mitigate the geographic scope issue by including whole-catchment choices in the experiment.

Values can be affected by non-response bias and hypothetical bias so adjustments are factored into the marginal benefit analysis.

Joint model

The purpose of combining the two data sources in one model is to improve on the separate models by taking advantage of the different strengths of both methods.

The jointly estimated model results support the theory that the same underlying preferences for water quality affect both destination choice and stated willingness to pay. Marginal use values for SP and RP are broadly consistent.

Marginal benefit analysis

The purpose of a marginal benefit analysis is to use model results to estimate the impact on total welfare of changes to water quality attributes (the “scenario”). The two steps necessary to this process consist of 1) defining the population over which to aggregate values and 2) framing the scenario in terms of changes to model parameters.

Scenario 1: Improvement across the catchment

This hypothetical scenario is based on a 30 per cent reduction in median nitrogen and total phosphorus across the entire catchment. This analysis only considers the effect on ecosystem health because the effect of reduced nutrients on clarity is difficult to quantify and beyond the scope of this report.

The following table shows the estimated non-market benefit of this scenario under different assumptions about the total number of users in the population. The total ranges from $18.9 to $28.3 million.

These figures are conservative because the most pessimistic adjustments for hypothetical and non-response bias are used. Without these adjustments the total value is twice as large.

Table 1 - Total WTP per year for different estimates of the total number of users

Region		**Low use**	**Medium use**	**High use**
Waikato	User	$4,100,000	$5,300,000	$5,800,000
Waikato	Non-user	$1,200,000	$900,000	$800,000
Waikato	Total	$5,300,000	$6,200,000	$6,600,000
Auckland	User	$2,600,000	$5,200,000	$11,000,000
Auckland	Non-user	$8,300,000	$7,600,000	$6,200,000
Auckland	Total	$10,900,000	$12,800,000	$17,200,000
Bay of plenty	User	$800,000	$1,500,000	$2,900,000
Bay of plenty	Non-user	$2,000,000	$1,900,000	$1,500,000
Bay of plenty	Total	$2,800,000	$3,400,000	$4,500,000
All 3 regions	**User**	**$7,400,000**	**$12,000,000**	**$19,700,000**
All 3 regions	**Non-user**	**$11,500,000**	**$10,400,000**	**$8,600,000**
All 3 regions	**Total**	**$18,900,000**	**$22,400,000**	**$28,300,000**

Scenario 2: prevent the decline in quality in the Waikato river from the upper to central zone

The central zone of the Waikato river (from Karapiro dam to Ngaruawahia) is the most commonly visited fresh water site in the Waikato-Waipa catchment. For this scenario we assume that Waikato river water quality will no longer decline throughout the upper Waikato catchment. This means median water clarity at Hamilton will improve from 1.6 to 2.5 metres and ecosystem health will improve from “poor” to “fair”

The revealed preference model predicts the number of visits to central Waikato river would increase by 12 per cent, with a welfare increase of $5.16 per trip and **$16 million per year** based on the medium use estimate.

The following table shows the results from the stated preference model. Total stated WTP ranges from **$32.1 to $42 million** per year.

Table 2 - Total WTP for different estimates of the total number of users

Region		**Low use**	**Medium use**	**High use**
Waikato	User	$4,900,000	$7,100,000	$9,300,000
Waikato	Non-user	$2,500,000	$2,000,000	$1,600,000
Waikato	Total	$7,400,000	$9,100,000	$10,800,000
Auckland	User	$2,900,000	$5,000,000	$10,100,000

Auckland	Non-user	$16,500,000	$15,900,000	$14,300,000
Auckland	Total	$19,400,000	$20,900,000	$24,400,000
Bay of plenty	User	$900,000	$1,600,000	$3,100,000
Bay of plenty	Non-user	$4,400,000	$4,200,000	$3,700,000
Bay of plenty	Total	$5,300,000	$5,700,000	$6,800,000
All 3 regions	**User**	**$8,700,000**	**$13,700,000**	**$22,400,000**
All 3 regions	**Non-user**	**$23,400,000**	**$22,100,000**	**$19,600,000**
All 3 regions	**Total**	**$32,100,000**	**$35,700,000**	**$42,000,000**

Limitations of the marginal benefit analyses

In addition to the limitations inherent to the models (discussed in the relevant sections), the marginal benefit analysis is also limited by the need to frame a policy scenario in terms of changes to attributes used in the model (clarity, human health and ecosystem health). There are various uncertainties that mean the “true” value could either be higher or lower. The pessimistic bias adjustments mean that WTP is probably understated if anything.

1 Introduction

The Waikato Economic Impact Joint Venture Project studies were undertaken to support and inform decision-making by central government, regional government and the wider community on the potential impacts of setting freshwater objectives and limits in the Waikato River Catchment.

The studies will help ensure that the Healthy Rivers: Plan for Change/ Wai Ora: He Rautaki Whakapaipai project for the Waikato and Waipa river catchments is supported by analysis on the potential economic and environmental impacts of different policy scenarios. The overall Waikato work can be used with other data sources for the Healthy Rivers/Wai Ora Technical Alliance experts to consider when making decisions about the way ahead for management of the Waikato and Waipa rivers catchment.

Many of the values (benefits) of good water quality cannot be directly assessed in dollar terms 'in the market'; so they are called 'non-market values'. This is in contrast to the cost of restoring and protecting rivers and other water bodies where a dollar value (or market value) can be put on many of the costs (e.g. improved sewage treatment systems, effluent disposal systems, changes in farm management). Non-market valuation methods have been developed and have proved to be a very useful tool for assessing the value of environmental resources for which there is no price tag. These methods enable policy makers to take account of the costs and benefits of alternative policies, while taking account of both market and non-market values.

The purpose of the Non-Market Valuation study is to assess non-market values of fresh water quality in the Waikato/Waipa catchment in terms of willingness to pay by households. The scope of non-market values assessed in this study consists of recreational and cultural use, option values for future use, and non-use or existence value.

This report explains the methodology and how the models can be used to help inform policy using some hypothetical water quality scenarios. This research consists of five components: a literature review of related studies, revealed preference analysis, stated preference analysis, joint analysis of revealed and stated preferences and a marginal benefit analysis of scenarios for water quality in the catchment.

2 Valuation framework

In the total economic value (TEV) framework the value of fresh water consists of use and non-use values, which are further disaggregated in direct use, indirect use, options for future use, bequest and existence values (see Figure 8). For this non-market valuation study we are concerned with the "unpriced benefits" of recreational and cultural use, future option values for those benefits, bequest and existence values.

The purpose of this study is to quantify the change in these values that might result from policies to improve fresh water in the catchment. In other words the *marginal* values rather than *total* economic value.

Non-market indirect benefits such as flood control, carbon storage and waste assimilation are outside the scope of this study because we do not yet know whether or how these functions would be affected by improvements to water quality.

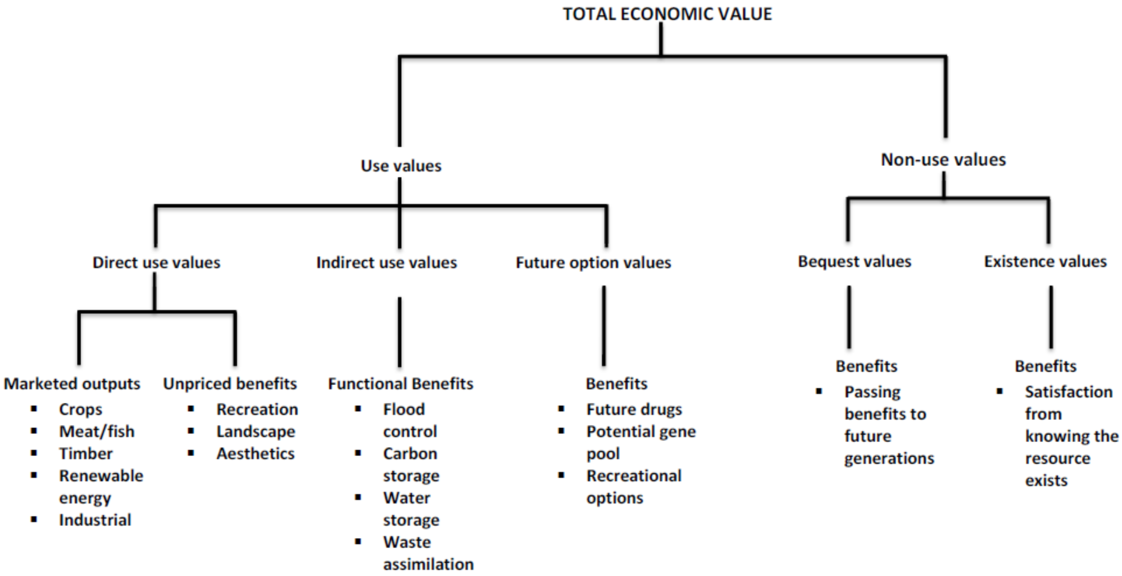


Figure 8 - Total Economic Value framework

2.1 Non-market valuation methods

Valuation methods can be classified into two groups, *revealed preference* (RP) and *stated preference* (SP). In revealed preference methods we analyse real-world behaviour such as recreation site visits and indirectly infer value based on travel and other access costs.

The advantage of revealed preference methods is that it uses real-world choices made by individuals. Issues or problems with revealed preference analysis include:

- the inability to capture non-use values;
- site attributes may be highly correlated in the real world and difficult to separately estimate;
- only existing quality levels may be analysed;
- choices depend on perceived attributes which may be different to objective measures of quality;
- trips may include multiple sites or purposes;
- values may be higher than the cost of site access

Stated preference techniques involve eliciting people's preferences or willingness to pay for a hypothetical scenario. Using the *contingent behaviour* method people may be asked how their use of a site would change under a given scenario. With the *contingent valuation* method people are asked whether or how much they would be willing to pay for a scenario. A *choice experiment* is a type of contingent valuation study in which people are presented with alternatives that comprise a bundle of features, one of which is usually cost. The participant has to trade-off the different features when ranking or choosing a preferred alternative. The choice experiment is well suited to situations where a policy may have multiple impacts on different aspects of environmental quality, as it does in this case.

The advantage of stated preference is that it allows us to construct scenarios that circumvent all the issues with RP methods above. However, SP methods have a different set of issues including:

- sensitivity to framing of attributes and scenarios;
- sensitivity to geographic scope (part-whole bias);
- incentive compatibility (is there an incentive to answer untruthfully);
- hypothetical bias (inadvertent over-estimation of willingness or ability to pay).

For this study we use both revealed and stated preference methods in two distinct surveys. The RP survey grounds the non-market values by using information about real-world behaviour and provides a detailed baseline estimate of use. The SP survey allows us to expand the analysis by including non-use values and disentangling the effects of human health risk and ecosystem health from the more visible attribute of clarity.

Other issues that can arise with any survey include response bias and measurement error. These issues are discussed in more detail in the results.

2.2 Limitations of the valuation framework

One of the criticisms of non-market valuation is that it presumes to assign a dollar value to something that may be essentially irreplaceable and priceless. The concept of "intrinsic" value means that the environment has value in its own right, whether or not people are willing to pay for it. A homocentric view of non-market value may also ignore the fact that some areas or species are more important to the functioning of the overall ecosystem than others.

The purpose of this study is not to attempt to quantify the intrinsic or overall ecosystem value of fresh water. The purpose of the Non-Market Valuation study is to assess non-market values of fresh water quality in the Waikato/Waipa catchment in terms of willingness to pay by households. Willingness to pay is an appropriate measure of non-market benefits of improved water quality that can be considered alongside potential costs (e.g. agriculture or industry) in assessing the different choices or policy options in setting freshwater objectives and limits.

The other limitation of non-market valuation is that estimated value is constrained by *ability* to pay as well as *willingness* to pay. People on low incomes may enjoy clean rivers just as much, if not more than people with higher incomes who have a higher WTP. Equity issues such as who should pay versus who receives the benefits of environmental protection are beyond the scope of this report.

In summary, willingness to pay is a useful measure of non-market value. But it is not the only measure and a policy that affects environmental quality needs to consider intrinsic value and equity issues as well.

3 Literature review

3.1 Purpose

A literature review was prepared by Marsh and Mkwara (2013) at Waikato University. The purpose of the review was to identify non-market values associated with fresh water in the Waikato region and to prioritise values for further analysis. The authors also investigate whether non-market values from the literature may be applied directly to the Waikato catchment using a "benefit transfer" approach.

3.2 Method

The review included studies with a similar social, economic and environmental context from the Waikato region, New Zealand and international literature from 1990 onwards. The report also summarised information from some existing sources on cultural values associated with water bodies in the Waikato Region.

Information collected included reported values, context, and the methodology used for the study. All dollar values were converted to New Zealand dollars and adjusted for inflation to the year 2012.

3.3 Summary of findings

The following tables summarise the values found in New Zealand and international studies. The values are dependent on context, valuation method, and the definition of attributes but may be used to help understand the order of magnitude of non-market values.

In the Waikato region there have been non-market value studies of Lakes Karapiro and Arapuni, streams in the Karapiro catchment, Hamilton urban streams, Lake Rotoroa (in Hamilton) and Tongariro river. The Tongariro study only assessed value for anglers.

Table 3 - Summary of Waikato studies (Marsh & Mkwara p. 41)

Non-market value	**Low**	**Median**	**High**	**Number of studies**
Swimming/household/year	$70	$131	$239	3
Rowing/person/year	$173	$205	$236	1
Fishing/person/year	$67	$67	$67	1
Access/Facility/household/ year	$0.1	$8	$25	2
Landscape/Aesthetic/household /year	$12	$38	$54	2
Ecosystem Health/household/year	$25	$120	$255	5
Biodiversity/household/year	$23	$58	$172	4
Water Quality/household/year	$18	$58	$143	7
Economic/household/year	$85	$138	$185	3

Comparison between different studies in New Zealand is made difficult by variation in how attributes are described and whether they were valued separately or jointly with other attributes. There is a lack of data for Māori-specific values and for several types of recreation common in the Waikato region. Non-use values are not separated from use values.

Table 4 - Summary of New Zealand studies (Marsh & Mkwara p. 36)

Non-market value	Low	Median	High	Number of studies
Swimming/household/year	$72	$101	$129	1
Fishing/angler/trip	$5	$31	$125	5
Fishing/household/year	$2	$25	$603	4
General recreation /household/year	$6	$93	$236	6
Landscape/Aesthetic/ household/year	$1.2	$55	$160	11
Biodiversity/ household/year	$5	$12	$31	3
Ecosystem health/ household/year	$0.5	$43	$269	9
Water quality/ household/year	$1.4	$73	$222	13
Food gathering/ household/year	$17	$39	$61	1

The table of international studies shows that a wide range of values is possible for different water bodies and different contexts. General recreation, for example, varies from $2 to $612 per household per year.

Table 5 - Summary of international studies (Marsh & Mkwara, p. 32)

Non-market value	**Low**	**Median**	**High**	**No. of studies**
Primary contact/household/year	$7	$88	$407	12
Fishing/person/trip	$0.17	$26	$567	5
Fishing/person/year	$0.03	$31	$191	11
Boating & Kayaking/person/day	$45	$77	$339	1
Boating & Kayaking/person/year	$136	$204	$272	2
Wildlife viewing/household/year	$23	$130	$324	3
General recreation/person/trip	$57	$178	$298	5
General recreation/household/year	$2	$34	$612	7
Access & facility/person/year	$0.6	$113	$191	3

Landscape & aesthetic/person/year	$4	$31	$283	3
Landscape & aesthetic/household/year	$0.5	$49	$174	8
Landscape & aesthetic/household1	$33,656	$46,946	$60,236	2
Water quality/person/year2	$0.2	$53	$260	4
Water quality/household/year2	$0.8	$69	$362	12
Ecosystem health/household/year	$0.1	$46	$474	28
Biodiversity/household/year	$0.4	$34	$474	11
Gas regulation/hectare/year	$287	$324	$1822	1
Flood & erosion control/household/year	$ 0.4	$0.4	$0.4	1
General ecosystem services/household/year3	$ 0.1	$59	$600	9
Cultural & social/household/year	$0.4	$186	$489	8
Research & education/household/year	$0.01	$0.01	$0.01	1
Economic/person/year 4	$258	$484	$720	1
Economic/household/year5	$0.1	$90	$435	8
Option/household/year	$7	$8.6	$30	3
Existence/household/year	$7	$20	$30	1

The authors conclude that none of the existing studies meet the criteria for reasonably accurate benefit transfer. These criteria are that the resources to be valued must be essentially equivalent; the baseline and extent of change should be similar and the affected populations should be similar.

The authors suggest some areas of priority for primary data collection: spatially explicit values (so that value may be estimated as a function of distance), values of visitors from outside the region, values of water body types for which there is little or no data and aggregate rather than disaggregated values (e.g. for different recreational uses).

3.4 Limitations

With a literature review we are limited by the scope and quality of the literature. There are large gaps in terms of water bodies and values assessed, and the attributes are not necessarily defined in ways that are useful in the context of scenarios we wish to analyse. As more New Zealand studies are undertaken in the future it may be possible to undertake a meta-analysis. A meta-analysis would enable us to better understand the drivers of non-market value so that benefit transfer techniques might reasonably be used.

Another limitation of a literature review is that we only have access to the information that is published and not the raw data. There may be useful information (about context, or methodology) that was not included in the report because it was not a primary focus of the publication.

3.5 Application of findings

The main implication of the literature review findings is that primary data collection is necessary in the absence of any values suitable for benefit transfer. We noted that non-market values for Karapiro and Arapuni lakes have already been assessed so these were not an area of focus for the choice experiment. Finally, we took on board the recommendation to identify aggregate values rather than try to obtain values for each type of use and then aggregate them.

4 Revealed Preference Analysis

4.1 Purpose

The purpose of the revealed preference study was to collect primary data to learn about where and when people use fresh water for recreation or cultural activities and what these activities are. We also use the information collected to determine what features influence site visits and calculate travel costs and infer a minimum value of a recreation trip.

To achieve these objectives we designed a survey named “Waikato fresh water recreation and cultural use survey”. For the purposes of this study a “user” is someone who has visited fresh water for the purpose of doing recreational or cultural activities in, on or near the water in the past year.

We collected spatially referenced information from 1370 users of Waikato fresh water and 616 non-users. The information included geographic coordinates for fresh water trip origins and destinations, trip details (duration, activities, companions etc.), perceptions of water quality, preferred features of sites and standard demographic questions. For people who had not used fresh water for recreation or cultural activities in the past year we asked why not (to determine if water quality was a factor).

4.2 Methodology

4.2.1 Design

The survey was designed with input from technical leads of the Waikato Economic Impact Joint Venture studies and advice from Waikato University to ensure it would collect information necessary to fulfil the purpose above.

Information from the earlier Water Values survey (Versus Research, 2012) was used to classify recreation and cultural activities. The trip mapping functionality was inspired by the Public Participation GIS (PPGIS) approach developed by Dr Greg Brown and used in a Department of Conservation study in Southland (Oyston and Brown, 2011)[2].

4.2.2 Development

An independent contractor (Alex Kravchenko) programmed the survey website. The free Google Maps API for Javascript[3] was used to implement the necessary trip mapping functionality. This allowed participants to search for locations and place or move map markers. Marker locations were stored as latitude/longitude coordinates.

4.2.3 Delivery and recruitment

The survey was delivered as a publicly accessible website. Participants for the online survey were recruited in a variety of ways. There was an initial phone recruitment pilot in which external contractor Versus Research called 500 people asking for an email address to send the survey to. Only 33 of those people eventually completed the survey so phone recruitment was discontinued.

Many participants were recruited from Facebook using sponsored posts on the Waikato Regional Council Facebook page and advertisements targeting people in the North Island of New Zealand.

The majority of the sample was obtained using advertisements placed on the Google Display Network. This network consists of thousands of websites sites affiliated with Google. We targeted anyone in New Zealand and used keywords relating to outdoor recreation and Waikato freshwater features.

[2] http://www.doc.govt.nz/Documents/about-doc/role/policies-and-plans/cms/southland-values-survey-results.pdf
[3] https://developers.google.com/maps/documentation/javascript/tutorial

Figure 9 - Google Display Network advertisement

The advantage of recruiting via advertisements was that it allowed us to specifically target a large number of Waikato fresh water users from all over the country. The disadvantage is that the sample were self-selected and therefore not necessarily representative of all fresh water users. However, a truly representative sample is difficult to obtain by any method when participation is voluntary.

Purchasing an existing web panel (as we did for the second survey) is a good alternative approach when the goal is to obtain a sample broadly representative of the general population. The disadvantage of purchasing a panel is that it is not very cost effective when only a small proportion of the population qualifies for the survey. The proportion of Waikato fresh water users in the population declines with distance so we would have had to purchase very large samples from more distant regions to find enough users.

4.3 Descriptive statistics

The final sample after removing rest data consists of 1987 completed surveys. The majority (74 per cent) came from the Google Display Network advertisements. A further 21 per cent came from Facebook advertisements and sponsored posts. The remainder found the survey some other way (3 per cent) or were part of the phone recruitment pilot (2 per cent).

Of the people who started the survey, 59 per cent completed it. The Facebook sample had the highest completion rate at 63 per cent (perhaps Facebook users had more spare time). The phone sample had the lowest completion rate (42 per cent).

Table 6 - Survey completion by recruitment type

Sub-sample	Complete	Completion rate
Facebook	408	63%
Google	1464	58%
Other	58	45%
Phone	24	42%
Grand Total	1987	59%

4.3.1 Age and gender

It is often the case that surveys have more female than male participants but in this case only 47 per cent of the sample was female. The Facebook and phone sub-samples had higher proportions of women, 56 per cent and 58 per cent respectively.

The following Figure 10 shows the age distribution of the sub-samples and the whole of New Zealand. The Facebook sub-sample had a higher proportion of participants aged 20-29 while the phone sub-sample had a large proportion of people aged 60 and over. The telephone survey in 2012 about fresh water values (Versus Research, 2012) exhibited a similar age profile. The overall sample has more people age 40 to 60 than the population.

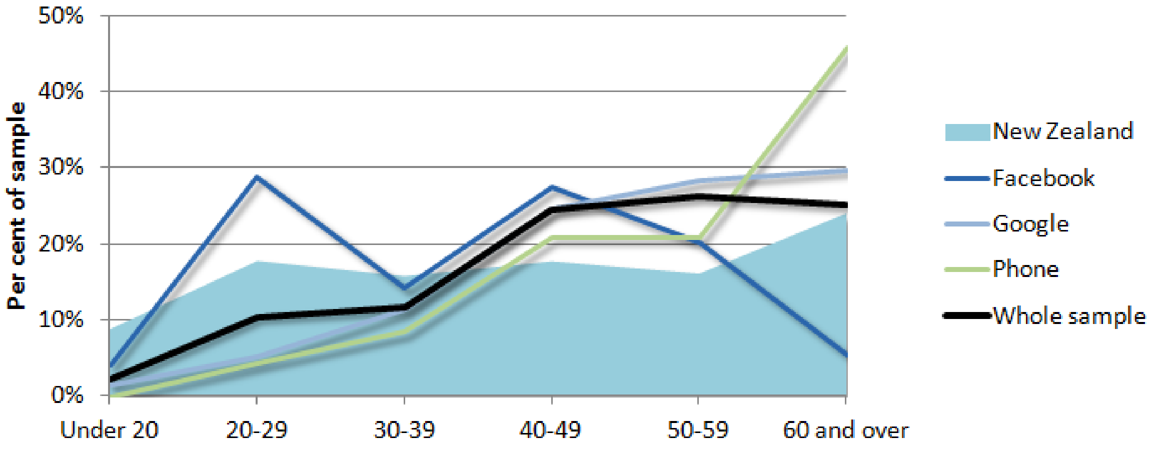


Figure 10 - Age structure of sample

4.3.2 Ethnicity

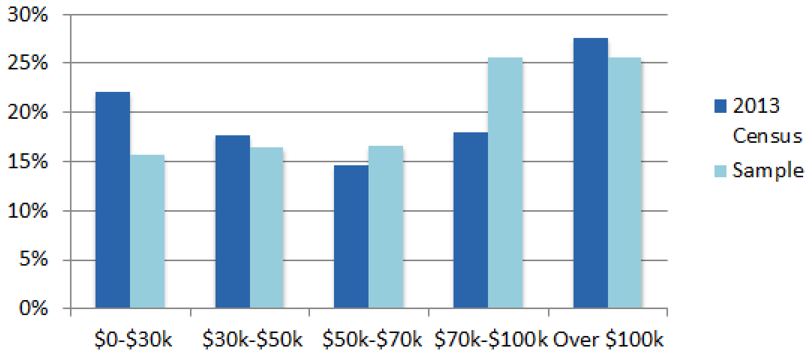
Minority ethnic groups are typically under-represented in phone or web surveys and this survey is no exception. Eleven per cent of the sample identified as New Zealand Māori, compared with 14 per cent in the 2006 Census. However, there were still over 200 Māori participants in total.

Table 7 - Ethnicity for survey samples and census

Ethnicity	This survey	Values survey	Census
NZ European	78%	88%	65%
Māori	11%	10%	14%
Pacific Islander	3%	1%	7%
Asian	3%	0%	9%
Other	9%	6%	
Refused	5%	1%	

4.3.3 Income and education

People with high incomes and higher education qualifications tend to be over-represented in web surveys. The following chart shows that households in the $70,000 to $100,000 income group are over-represented and the zero to $30,000 group is under-represented compared with the 2013 New Zealand Census.



The proportion of the sample with a post-school education qualification is 59 per cent, significantly higher than in the 2013 census (39 per cent). There is likely to be some sample bias towards high income and highly educated people, but it is possible that fresh water users also have higher incomes and education than non-users.

Figure 11 - 2013 Census household income versus sample

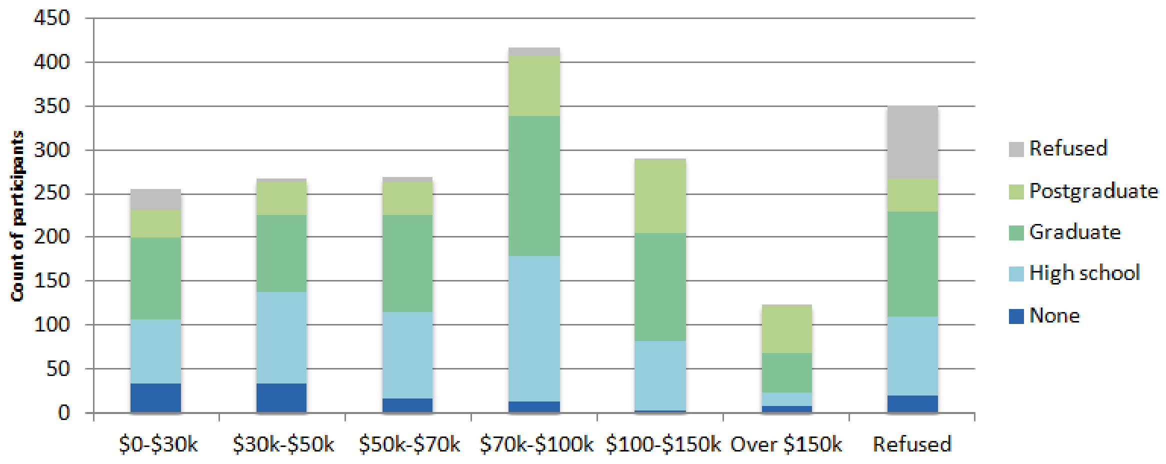


Figure 12 - Household income and individual highest education qualification

4.3.4 Users versus non-users

Participants were asked whether they had visited a river, stream, lake or wetland, and whether they had visited one in the Waikato region. The majority of people (85 per cent) said they had visited at least one of these freshwater bodies anywhere in New Zealand. A slightly lesser proportion of participants (69 per cent) had visited a freshwater body in the Waikato region. The proportion of non-users of Waikato fresh water was therefore 31 per cent but this is not necessarily representative of the population since we were specifically targeting users.

Rivers were the most common type of freshwater visited in the Waikato region (57 per cent of participants). The next most common type was lakes (51 per cent). However, this question was ambiguous about whether hydro lakes count as a lake or a river. A third of participants said they had visited a stream, and 17 per cent a freshwater wetland.

The 2012 water values survey (Versus Research, 2012) also asked participants whether they use rivers or streams in the Waikato region. Two-thirds of the Versus sample were users. The similar result is noteworthy because the Values survey was a randomly selected sample of Waikato residents who did not know the topic in advance, while participants in this survey self-selected and did know the topic in advance. This implies that the true rate of freshwater usage in the population is indeed very high.

The following Figure 13 shows usage rates by age group. Usage rates appear to peak in the 25-34 years age group and decline with age.

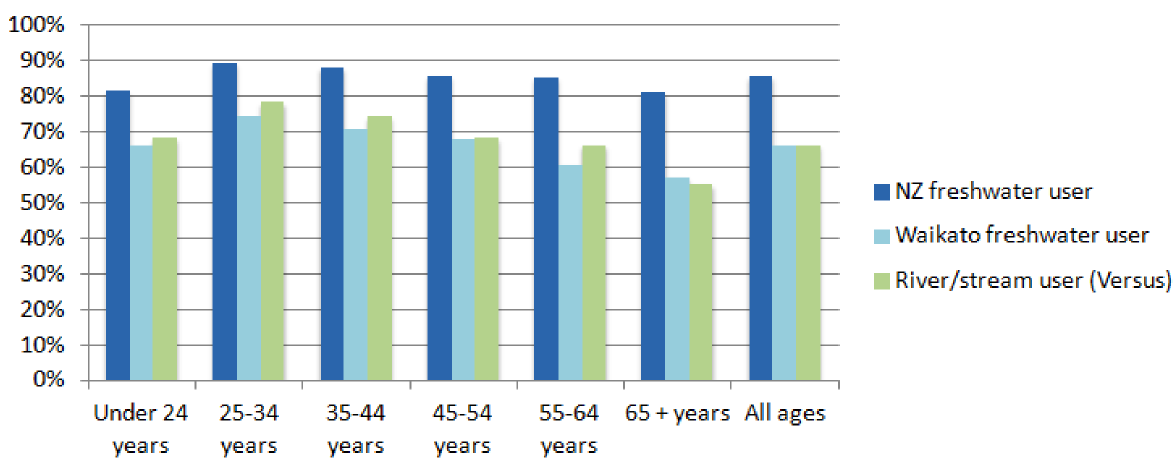


Figure 13 - Proportion of users by age group

Figure 14 shows the same breakdown for the different ethnic groups. People who identify as New Zealand Māori are more likely to be Waikato fresh water users (75 per cent versus 66 per cent for the whole sample). There were few Pacific Island or Asian participants in either sample so it is difficult to draw any conclusions about these groups.

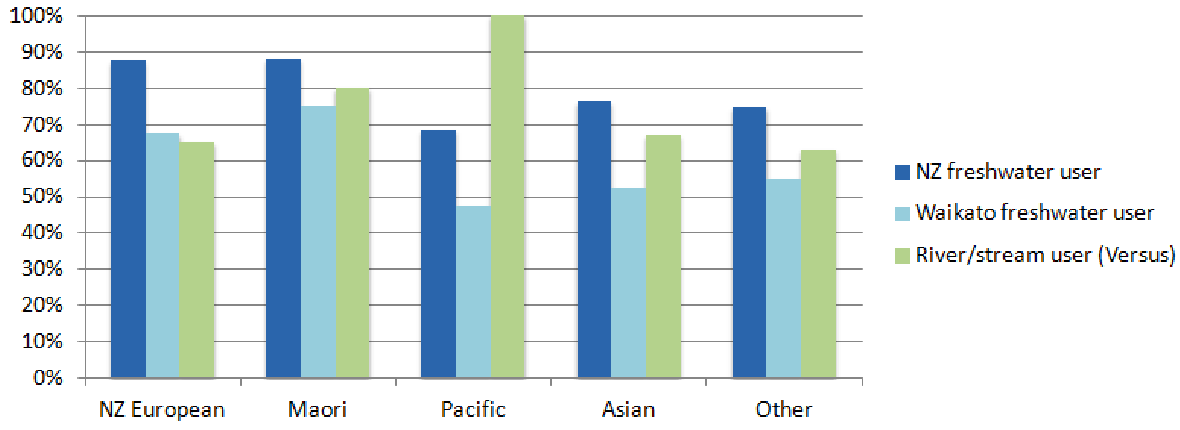


Figure 14 - Proportion of users by ethnic group

The freshwater average user is more highly educated than non-users. Seventy per cent of participants with a post-school education qualification were Waikato fresh water users compared with 60 per cent of people with no formal qualification.

The income group with the highest Waikato freshwater usage rate is the $50,000 to $70,000 category (79 per cent). The lowest usage rate is in the $30,000 to $50,000 group (57 per cent).

4.3.5 Where participants live

There were participants located in every region of New Zealand. The largest group were from the Waikato region, as expected. The following Figure 15 shows the proportion of freshwater users in each group. There were high rates of fresh water use in every region but people from more distant areas such as the South Island were less likely to have visited a freshwater site in the Waikato region. People in the Auckland region were less likely to be regular fresh water users, probably because they are surrounded by beaches instead of rivers and lakes.

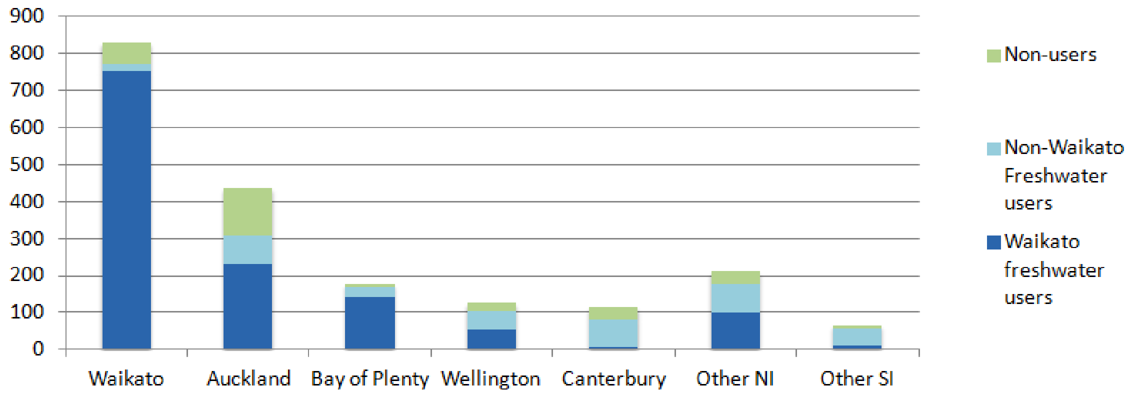


Figure 15 - Fresh water users and non-users by region

The following Figure 16 is a heat map showing where Waikato freshwater users live. A quarter of users live in Hamilton urban area, followed by 18 per cent from Auckland. There are clusters of users in every urban area around the upper North Island.

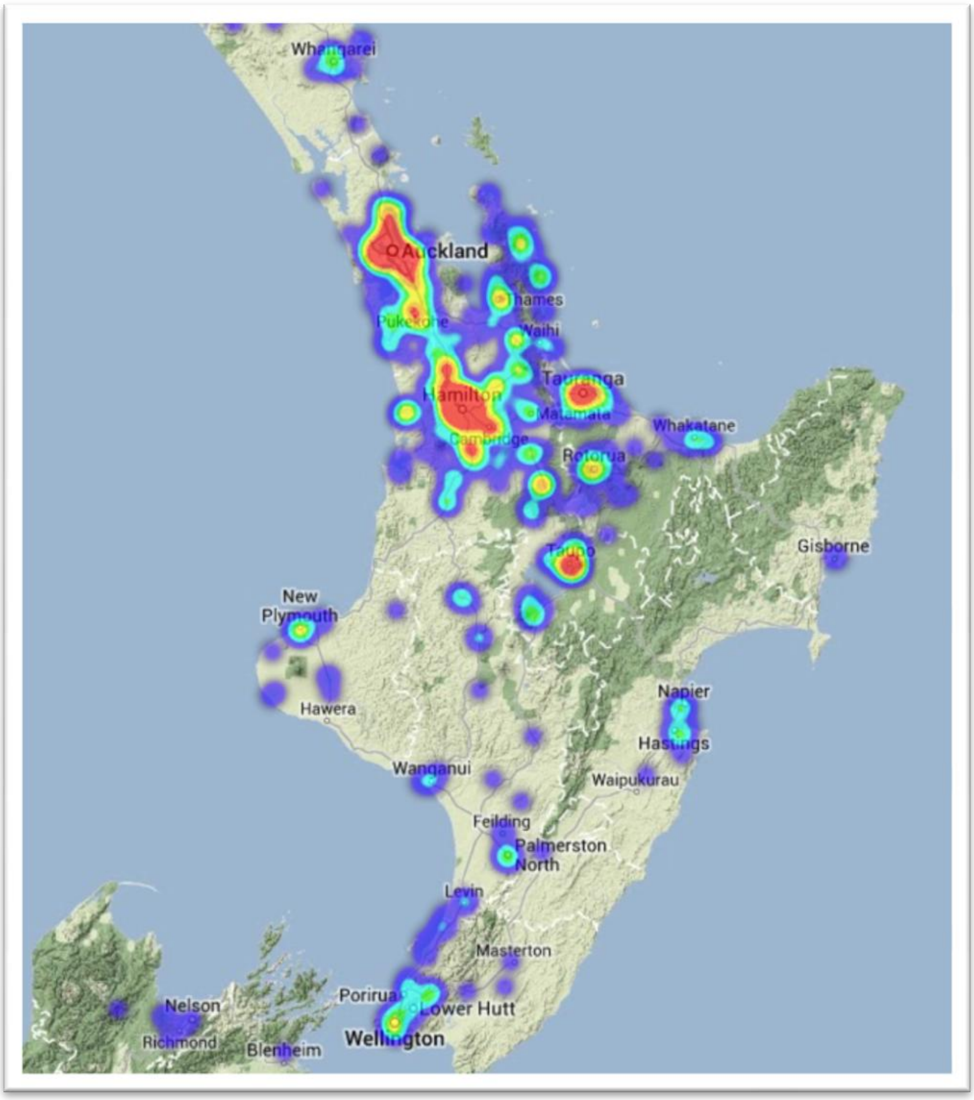


Figure 16 - Heat map showing where Waikato freshwater users are from

4.3.6 Activities of Waikato fresh water users

The activities were loosely grouped into “on the water” (e.g. boating), “in the water” (e.g. swimming or fishing) and “near the water” (e.g. picnicking). The most common activities people did at Waikato freshwater sites were walking or jogging or relaxing near the water. The majority of users (94 per cent) reported engaging in one or more activities near the water.

Swimming or paddling was the most popular activity in the water (48 per cent of users), followed by fishing (37 per cent). Boating was the most popular on-the-water activity (33 per cent). A smaller proportion of people reported doing traditional cultural activities such as collecting mahinga kai (8 per cent), ceremonial use (3 per cent) and customary activities (8 per cent).

People from outside the region use Waikato freshwater in slightly different ways to Waikato residents, as illustrated in Figure 17. Waikato residents are more likely to use sites for boating, swimming, relaxing, sightseeing, picnicking and cycling than people from outside the region. Users from Auckland did more dragon boating, rowing, eeling, white-baiting and collecting mahinga kai. Users from Bay of Plenty residents did more Waka ama and jet skiing. Part of this difference may come down to the type of sites that people from outside the region visit. Hamilton residents most often visited locations in or near Hamilton.

Aucklanders more often visited the lower Waikato (close to Auckland), Lake Karapiro and Lake Taupo and Bay of Plenty residents more often visited the upper Waikato catchment.

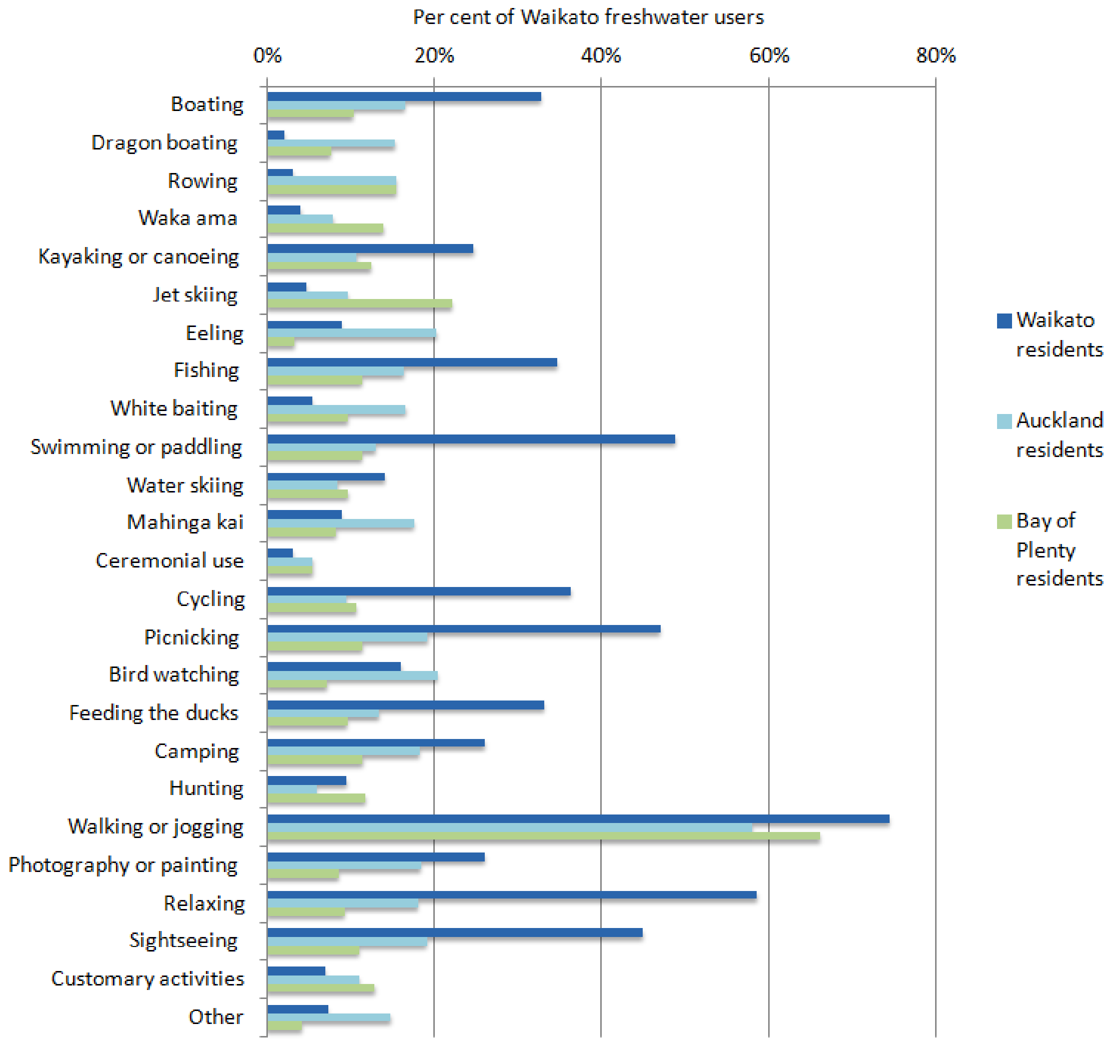


Figure 17 - Activities at Waikato freshwater sites

4.3.7 Kilometres travelled

Participants made a total of 20,578 trips to Waikato fresh water sites in the past year, travelling 597,000 kilometres in total. Waikato residents account for 93 per cent of all trips but only 50 per cent of kilometres travelled (Figure 18).

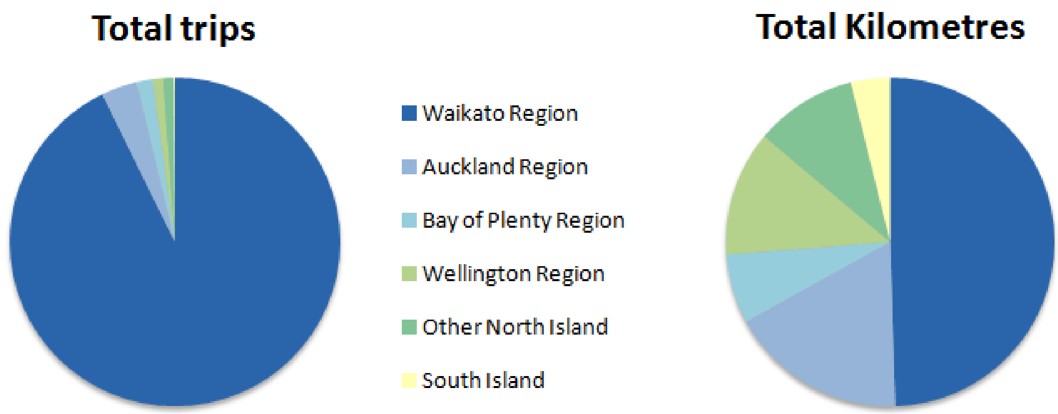


Figure 18 - Number of trips and total kilometres travelled in 12 months by region of origin

The *average* user from within the Waikato region made 42 trips to Waikato fresh water sites and travelled 647 kilometres. Visitors from other regions made fewer trips but travelled more kilometres on average.

4.3.8 Sites visited

Sites were categorised by calculating the closest water body to each set of coordinates that individuals identified on the map. The following Figure 19 shows the relative intensity of freshwater visit locations around the region. It is weighted by number of visits in the past 12 months. Red coloured areas had the most visits. Hot areas with the most visits were Hamilton City, Lake Karapiro and Lake Taupo.

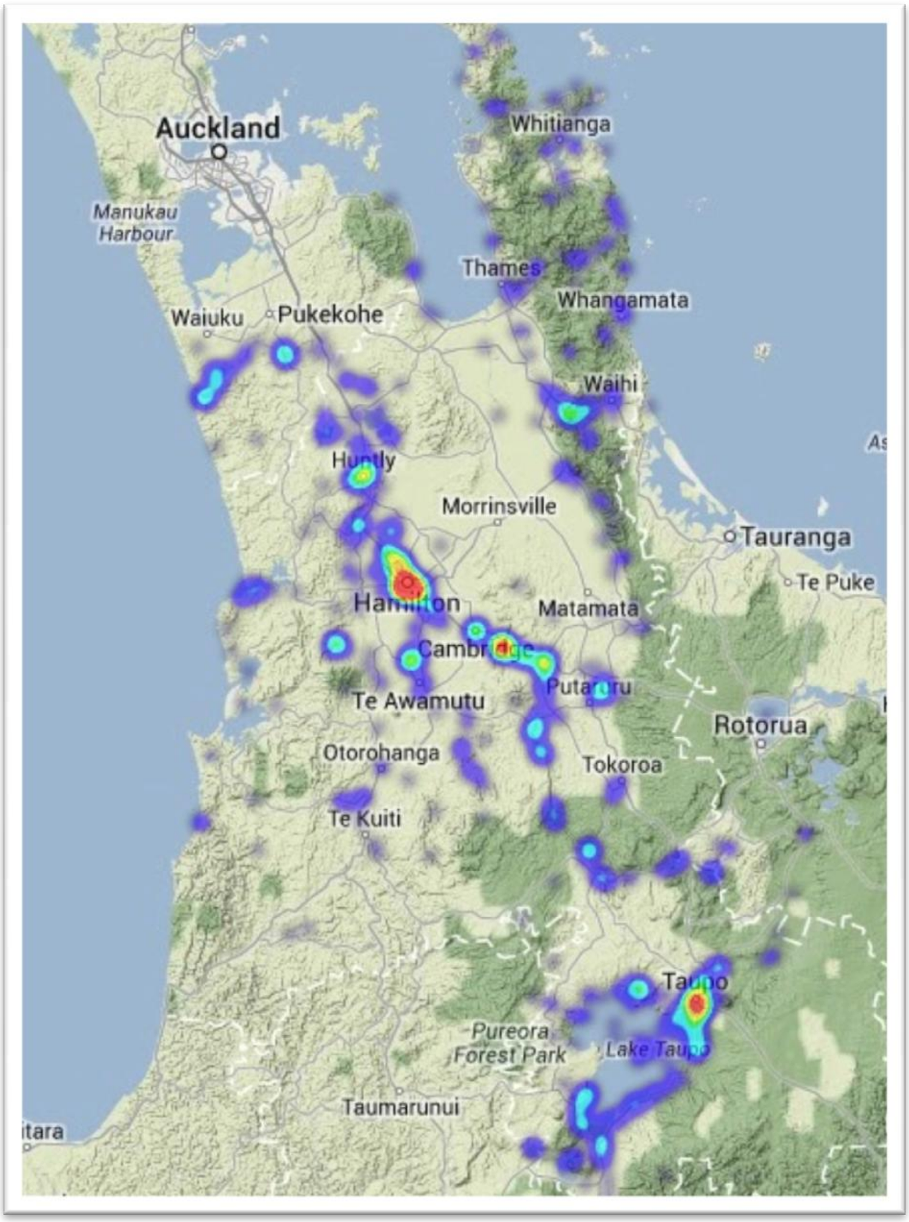


Figure 19 - Heat map of sites visited (weighted by number of visits)

Figure 20 shows a breakdown of sites by catchment management zone and water body type. The central Waikato zone had the largest number of sites identified (27 per cent) and the vast majority of these are within the Hamilton urban area. 190 people visited the Waikato River within the Hamilton urban area and 133 people visited Lake Rotoroa. The remaining 31 sites were small urban streams and lakes such as Horseshoe Lake on the West side of Hamilton and the un-named lakes on Waikato university campus.

In the Upper Waikato management zone the majority of sites visited were hydro lakes on the Waikato River. Lake Karapiro was visited by 93 people, followed by Lake

Arapuni (35 people). Other areas of the Waikato River were visited by 27 people. There were also a variety of streams and other non-hydro lakes visited by only one or two people each.

In the Lower Waikato zone most people visited the Waikato river (56 people) or one of several lakes near Huntly. The most popular lake was Hakanoa (16 people).

In the Waipa zone only 16 people visited the main stem of the Waipa River. The most popular steam was the Kaniwhaniwha stream (visited by 12 people). The most popular lake was Lake Ngaroto (18 people).

In the Lake Taupo management zone most people visited Lake Taupo itself (196 people). A small number of people visited Tongariro river (18 people) and the Waikato River near Taupo gates (15 people).

Sixteen per cent of sites visited were outside the Waikato/Waipa catchment management zones. The most popular sites included Ohinemuri river (33 people), Waihou river (28 people) and Wainui stream (11 people). Other sites included a large number of streams in the Kaimai ranges, and some small, un-named lakes.

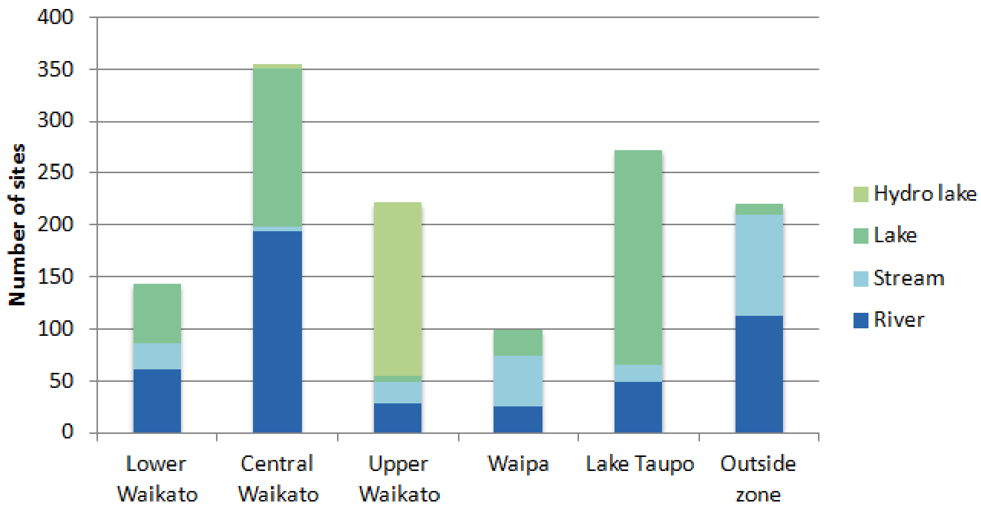


Figure 20 - Visited sites by location and water body type

4.3.9 Perceptions of water quality

For each site that they visited, participants were asked about their perceptions of clarity, human health risk and ecosystem health of the water. Participants rated each on a five-point scale with five being the best. The following table shows average ratings for each management zone. Water quality in Lake Taupo zone was rated the highest (good to excellent), and most of these ratings were for Lake Taupo itself. Lower Waikato zone was rated the lowest (poor to adequate).

There was a “don’t know” option available to participants. Four per cent of participants said they didn’t how good the clarity was, while 22 per cent said they did not know the level of risk to human health and 14 per cent did not know about the ecosystem health.

The five-point scales cannot be directly compared with objective water quality measurements even for sites where monitoring data exists. However, we can compare the correlation between perceived water quality and perceived health risk and ecosystem health (94-94 per cent) with correlations in objective monitoring data (only 70-80 per cent). People appear to assume clear water means low levels of bacteria and contaminants and vice-versa but the monitoring data tells us this is not always the case.

People who lack information about a water quality indicator could not have based their choice of destination on that indicator. This is probably why water clarity was the only significant quality variable in the destination choice model (see section 4.4.1).

Table 8 - Average quality ratings of each management zone

Management Zone	Count of visits	Clarity rating	Human health	Eco health
Lake Taupo	272	4.3	4.3	4.2
Upper Waikato	221	3.6	3.5	3.6
Central Waikato	354	2.7	2.6	2.8
Lower Waikato	143	2.5	2.5	2.7
Waipa	99	3.2	3.1	3.2
Other	219	4.0	3.9	3.9
Grand Total	1308	3.4	3.4	3.4

Figure 21 shows average perceived quality scores on a map. The highest scoring waterways are light blue, with decreasing scores grey down to red.

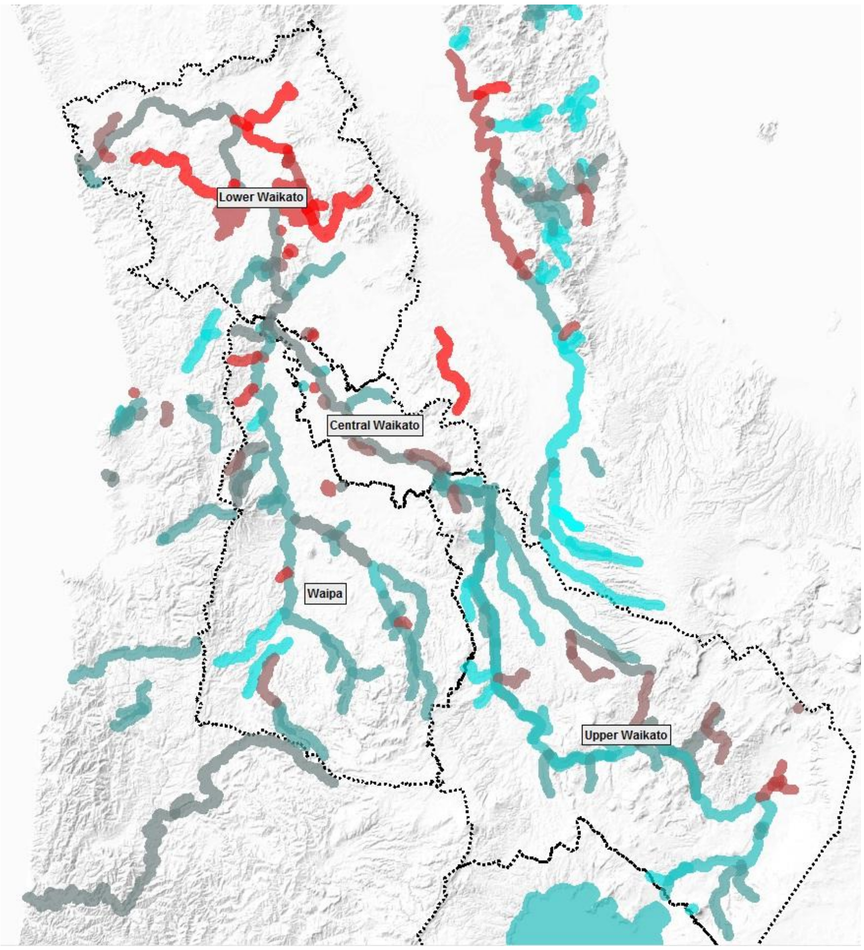


Figure 21 - Map of perceived water quality

4.3.10 Positive and negative features of sites

Participants were asked what they liked or disliked about each site. The most common positive feature identified was “habitat for wildlife”, selected by 52 per cent of visitors. “Trees”, “clean water”, “safe source of food” and “good access” were also commonly selected options.

Figure 22 shows the proportion of visitors to each management zone in the Waikato/Waipa catchment who selected each of the positive features. Half of visitors to the Upper Waikato zone said they liked the clean water there, compared with only 12 per cent of visitors to the Lower Waikato zone. Visitors to the Waipa zone were more likely to appreciate "safe source of food" and "good access".

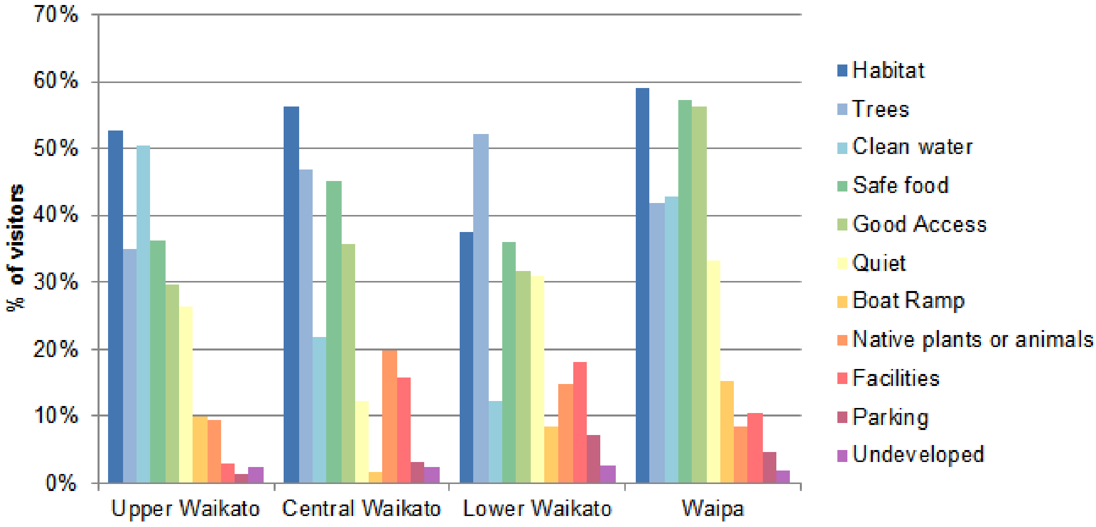


Figure 22 - Reasons for liking a site by management zone

The most common negative feature of a site identified was "dirty water" (68 per cent of visitors). "High flows or flooding" was also identified by more than half of all visitors. This doesn't necessarily mean that the site was flooded at the time they visited, but perhaps people have experience of the river or stream flooding. "Poor access" and "unsafe food" were identified almost as often as "good access" and "safe food" but generally for different sites.

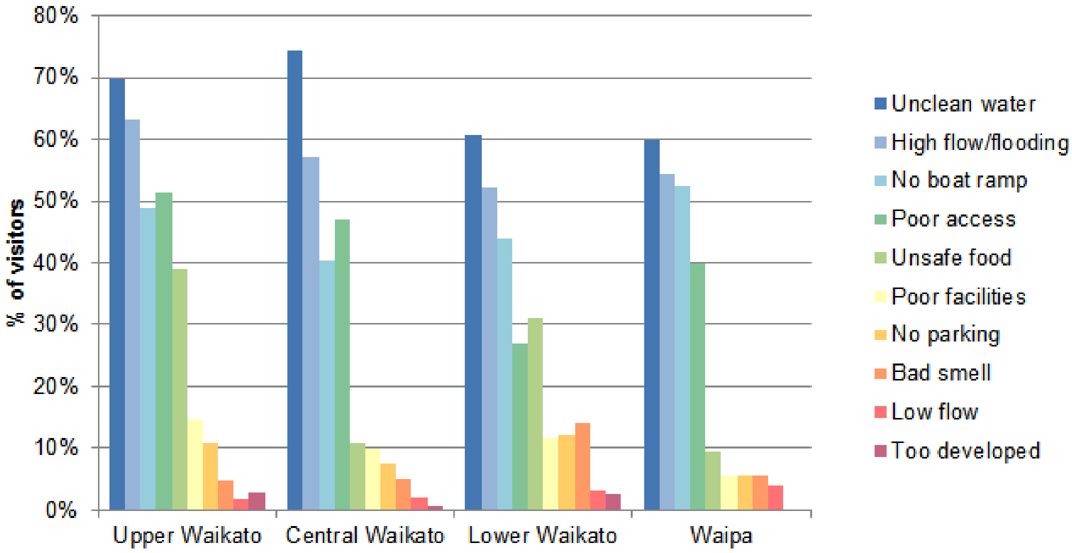


Figure 23 - Reasons for disliking a site by management zone

4.3.11 Detailed maps

The following maps are a pictorial representation of individual visits to fresh water sites and the type of activities (in water, on water or near water) that people did there. If there was more than one type of activity at the site only the top-most icon is visible (i.e. "near water" will be hidden behind "in water").

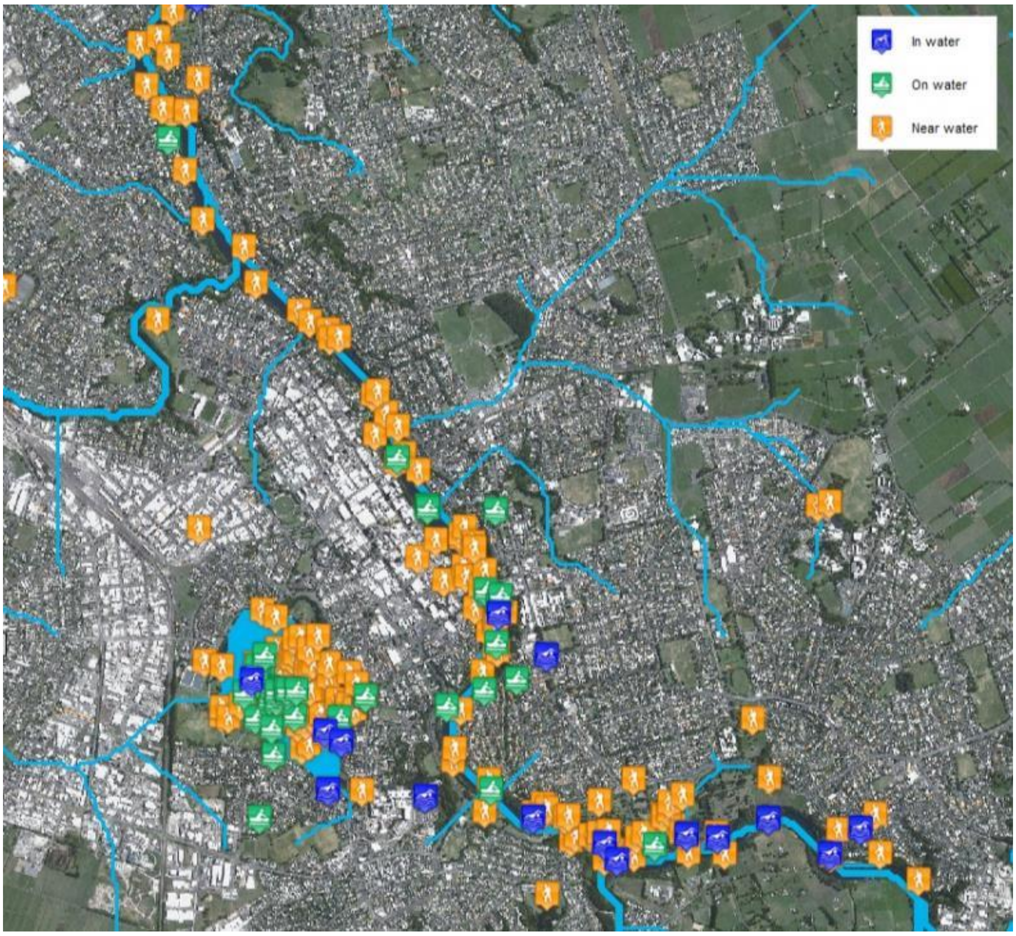


Figure 24 - Map of fresh water visits in Hamilton

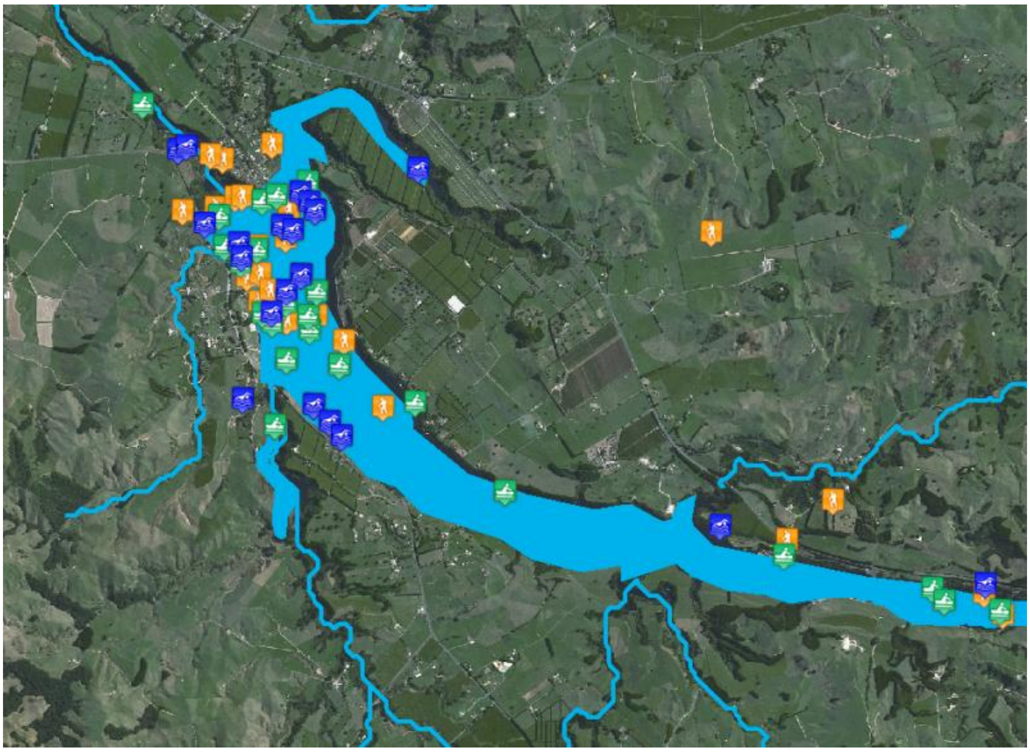


Figure 25 - Map of fresh water visits around Lake Karapiro

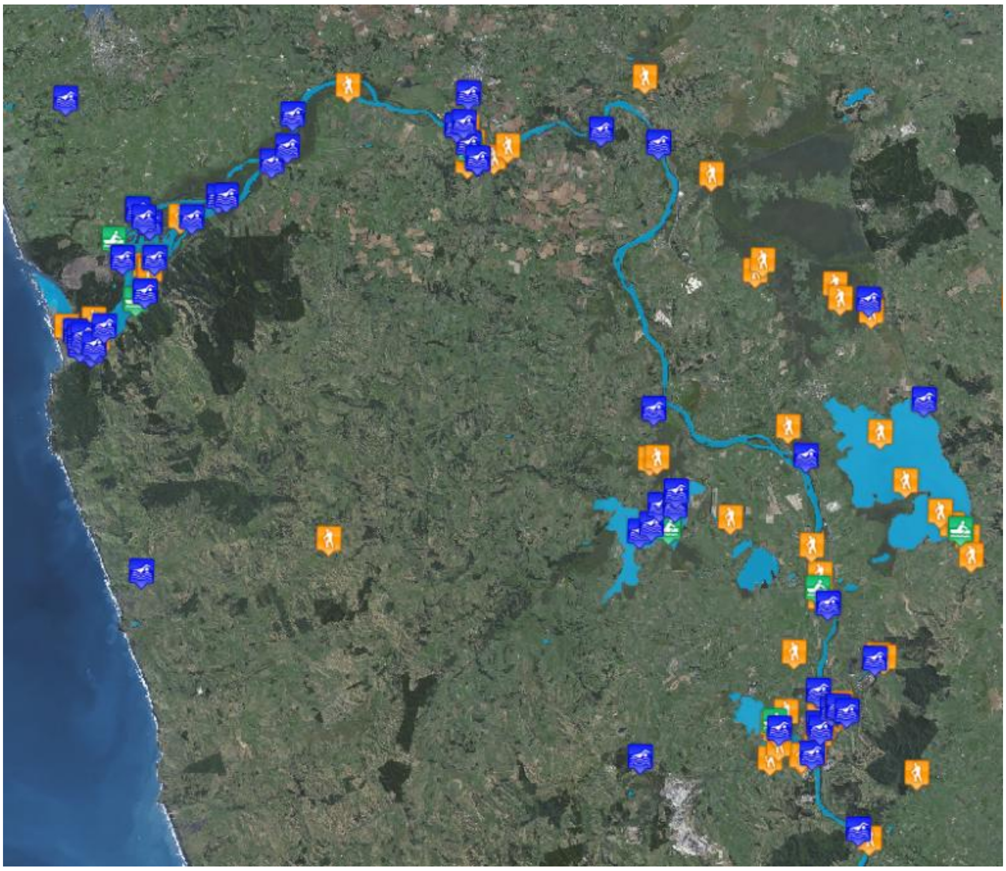


Figure 26 - Map of fresh water visits around in the Lower Waikato zone

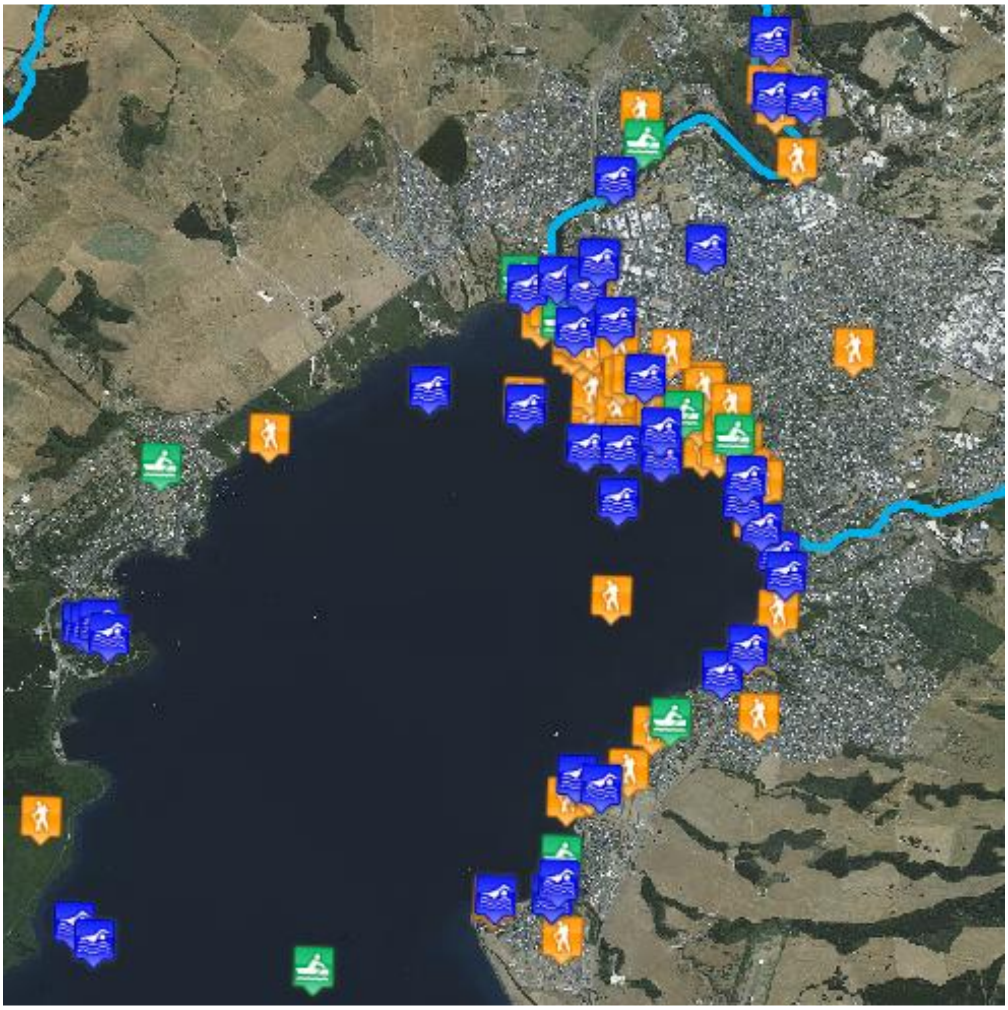


Figure 27 - Map of fresh water visits around Taupo

4.3.12 Sites of significance

In addition to mapping trips, people were asked to identify any other fresh water locations they felt were significant for either cultural, economic, environmental or personal reasons. The following map shows the locations of these significant sites but no further analysis has yet been done.

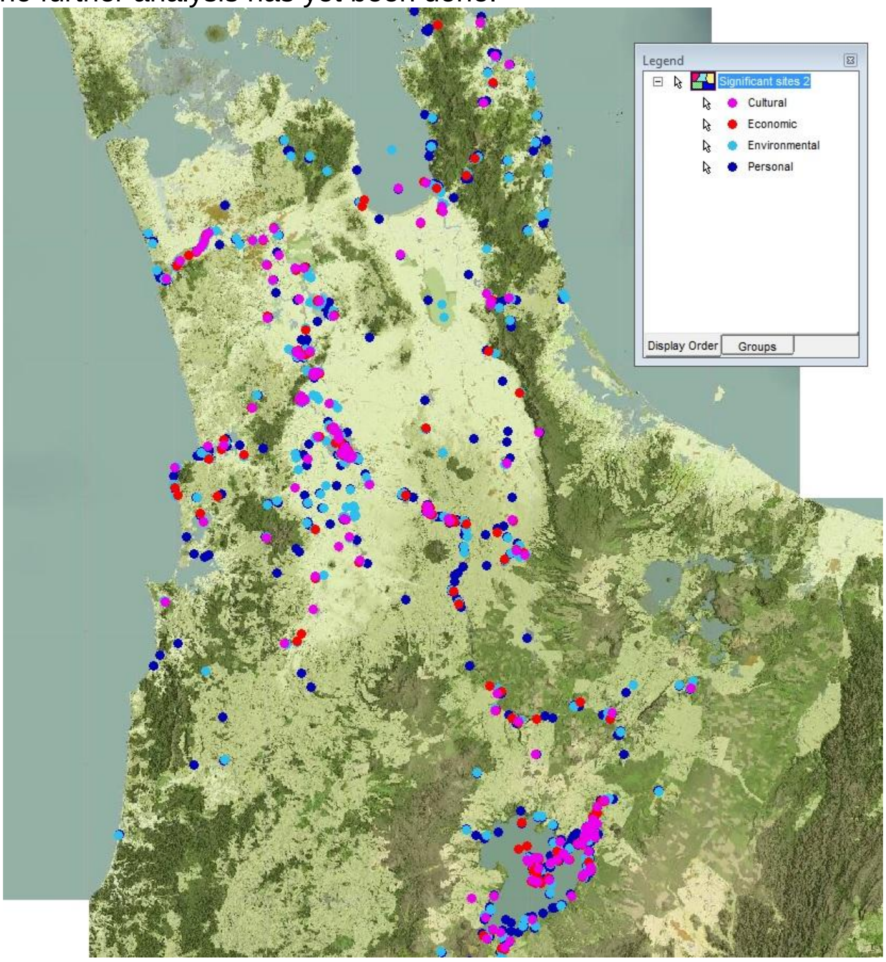


Figure 28 - Sites of significance

4.3.13 Travel costs

The following figure shows the distribution of distances travelled (one-way) to reach each site visited. The majority of trips are relatively short. The median is 49km and the average is 106km.

The peaks in travel distance around 180km and 300-350km reflect the distances between Auckland, Hamilton and popular destinations like Lake Taupo and the hydro lakes. It is approximately 180km from Auckland to Lake Karapiro and 280km to the closest edge of Taupo.

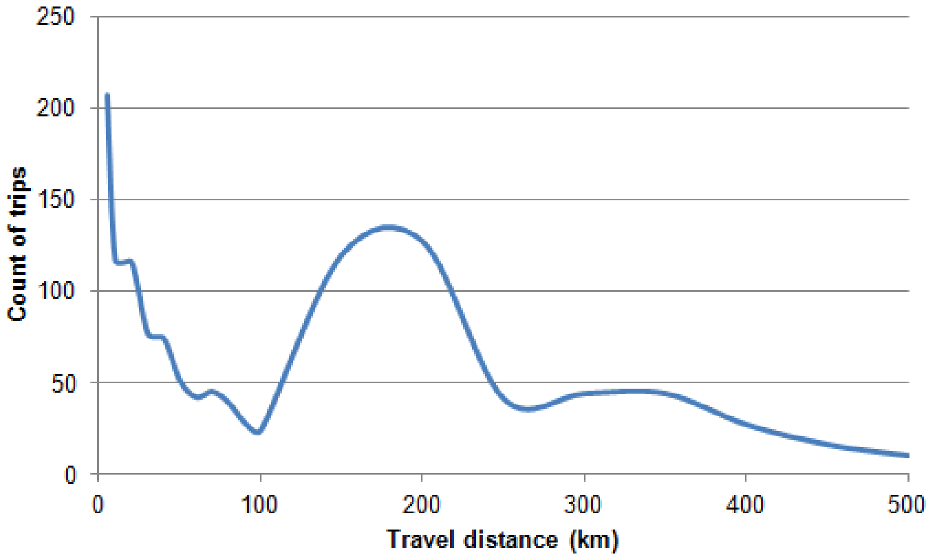


Figure 29 - Distribution of travel distance (km) per site visited

Travel cost is calculated using a per-kilometre cost of $0.20 for vehicle expenses and an opportunity cost of time equal to 25 per cent of the individual's hourly wage. Travel cost analysis relies on the assumption that visiting the site was the primary purpose of the trip rather than being incidental to a trip for another purpose (such as visiting family in the region). This assumption is less realistic for longer trips. The literature suggests that 290km is an appropriate cut-off point for day recreational trips (McConnell & Strand, 1994) so we exclude longer trips from further analysis.

The median travel cost is $24 and the average is $44 per round trip. After multiplying by the number of trips per year for each individual the median cost is $101 per year and the average is $270.

In the marginal benefit analysis we estimate that the number of users in the population may range from 105,000 (low estimate) to 340,000 (high estimate). The total value (in terms of willingness to pay to access the site) of fresh water recreation trips is therefore in the order of $28 to $91 million per year.

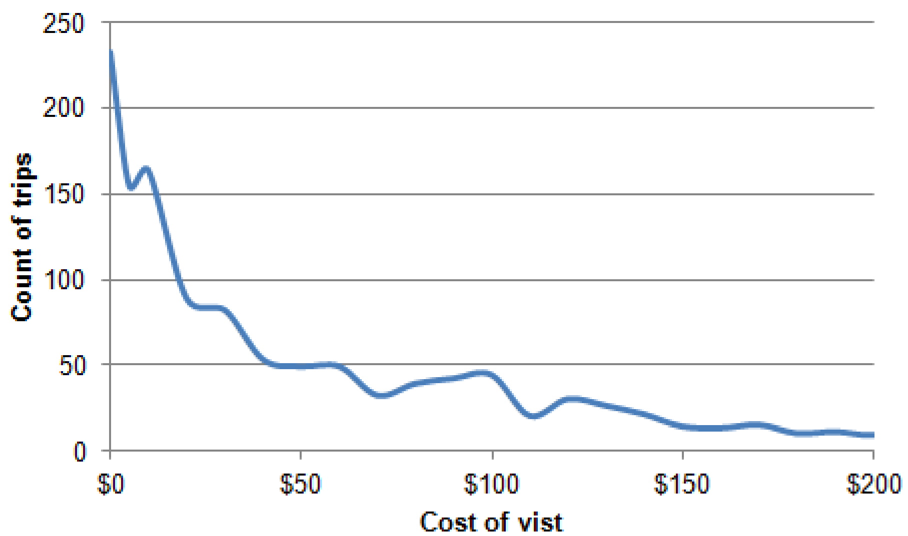


Figure 30 - Distribution of travel cost including opportunity cost

4.3.14 Non-users

Data was collected from 450 non-users of Waikato freshwater. The proportion of non-users to users is probably not representative of the population due to the potential for selection bias in this survey. In the marginal benefit analysis (section 6.5) we compare estimates of fresh water use with other studies.

The survey asked these non-users if they would start using any Waikato freshwater site if water quality there improved and 63 per cent of non-users answered "yes". Table 9 shows that people who live in Auckland or Waikato regions were more likely to say yes than people further away (who would face higher travel costs).

Table 9 – Per cent of non-users by region who might become users

Region of residence	Answered "yes"
Auckland	68%
Waikato	69%
Bay of Plenty	59%
Other North Island	50%
South Island	35%

The survey asked people who answered "yes" to becoming users which measure(s) of water quality would need to improve for in-water, on-water, or near-water recreation. Figure 31 shows that water clarity was the most commonly selected improvement for each type of recreation. Almost half of participants said they would want a lower infection risk before doing in-water recreation, but only a third required lower infection risk for on-water or near-water recreation.

A third of people said none of these water quality indicators (clarity, infection risk or contaminants) affect whether they would do near-water recreation. Only 14 per cent said these indicators have no effect on their decision to do in-water recreation.

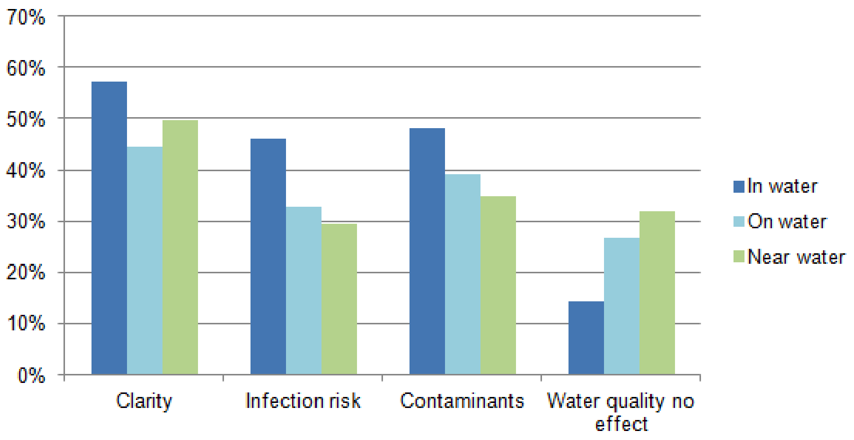


Figure 31 - Improvements required for different types of recreation

These questions would perhaps be more illuminating if they were asked about specific sites but this would have introduced a new level of complexity and was out of scope. In any case, the literature says that people tend to overstate the likelihood that their behaviour will change (i.e. become freshwater recreational users) so these figures should be considered the upper end of a reasonable estimate.

4.4 Revealed Preference model

A travel cost random utility model is used to assess factors that influence individuals' choice of freshwater bodies for recreational and cultural use in the Waikato Region. The recreational use value of environmental resources such as freshwater bodies is inferred indirectly through what people are willing to pay to get to the site for recreational activities. See appendix 9.1 for the technical details of the model.

For this model we need to define the alternative sites available to each individual. To keep the number of alternatives manageably small we include the eight most popular "sites" (which may be a lake or a stretch of river) and aggregate the rest by management zone and type of water body. The following table shows the number of visits and visitors (in the past 12 months) to each alternative in the sample.

Table 10 – Alternatives and number of visits

Destination	Type	Unique visitors	Number of visits
Lake Arapuni	hydro lake	25	130
Central Waikato River	river	190	4820
Lake Karapiro	hydro lake	97	1026
Lower Waikato River	river	56	1574
Lake Rotoroa	lake	133	2592
Lake Taupo	lake	196	2690
Upper Waikato River	river	45	383
Waipa River	river	18	157
Central Waikato Mngt Zone	lake	20	690
Central Waikato Mngt Zone	stream	4	34
Lower Waikato Mngt Zone	lake	58	1418
Lower Waikato Mngt Zone	river	4	45
Lower Waikato Mngt Zone	stream	25	230
Other Mngt Zone	lake	9	42
Other Mngt Zone	river	112	939
Other Mngt Zone	stream	98	1017
Lake Taupo Mngt Zone	lake	12	52
Lake Taupo Mngt Zone	river	33	624
Lake Taupo Mngt Zone	stream	16	277
Upper Waikato Mngt Zone	hydro lake	46	595
Upper Waikato Mngt Zone	lake	6	20
Upper Waikato Mngt Zone	stream	21	484
Waipa Mngt Zone	lake	26	122
Waipa Mngt Zone	river	10	419
Waipa Mngt Zone	stream	48	198

There are two parts to the revealed preference analysis, a site choice model to explain site choices and a trip count model to explain the number of trips taken per individual.

4.4.1 Site choice model

For this analysis we include all trips (under 290km) to rivers, streams and lakes in the region. Variables tested in the model included travel distance and travel time to each site, opportunity cost of travel (25 per cent of hourly wage), visitor activities, demographic variables and site characteristics (both objective and user-rated).

Many variables were either not useful for explaining destination choice or were too highly correlated with other variables to be able to include them all in the model

The final model that provides the best fit includes variables for travel cost, clarity, land cover (urban and forest) and perceived ratings for facilities, access, development, cleanliness, safety of food gathered, and flow adequacy.

More detail on the model coefficients is presented in Appendix 9.1.2 Figure 32 below is perhaps more useful for understanding the importance of each variable on destination choice. The bar chart shows the average influence of each factor (averaged across all choice situations). The absolute size of the coefficients is irrelevant so the scale of the x-axis is not shown.

Travel cost is a significant negative effect and means that sites further away are less likely to be visited, all else being equal. Clarity has just as large a positive effect. Human health risk and ecosystem health measures were insignificant when clarity was also included in the model. However, user-perceived cleanliness has the largest impact overall and is significant even after including clarity in the model. This has two important implications: a) the objective measures of clarity, E.coli and ecosystem health are insufficient to explain perceived cleanliness and b) perceived cleanliness is more important for explaining site choice than objective measures.

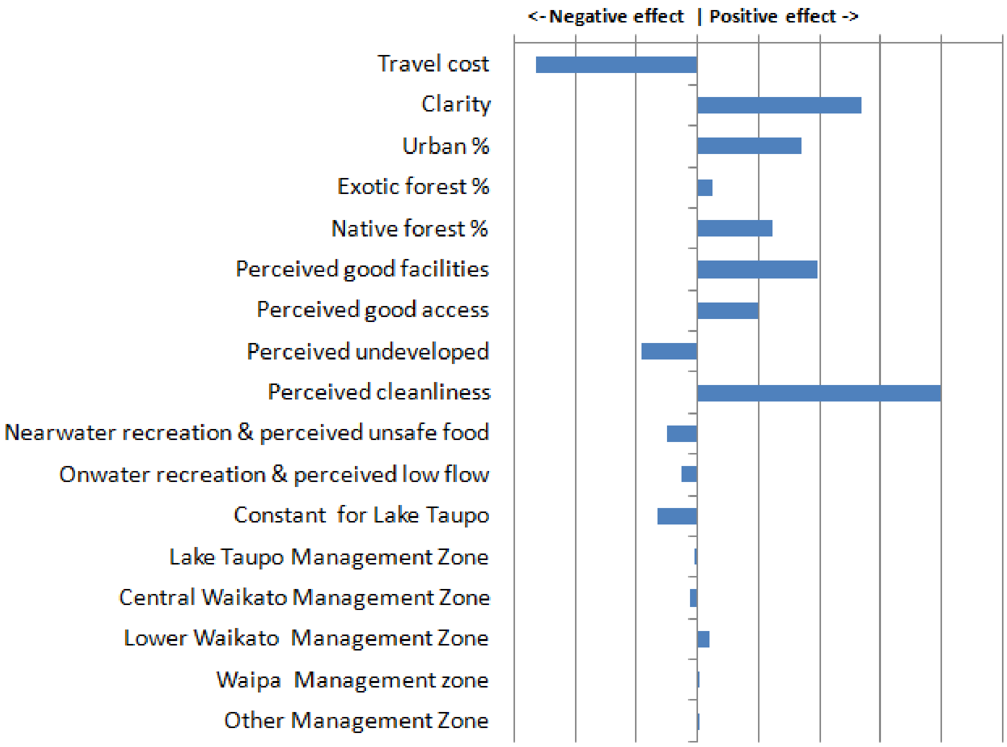


Figure 32 - Relative impact of coefficients at average levels of each variable

4.4.2 Trip count model

While the site choice model attempts to explain site choices, the trip count model (negative binomial) seeks to explain the number of trips taken per individual.

The results (appendix 9.1.3) show that older and more highly educated people take more trips for fresh water recreation. Other demographic variables such as age squared, income, education and household composition are not statistically significant predictors of how many trips a fresh water user makes, or the total distance travelled.

The multinomial site choice model is linked to the negative binomial count data model through a parameter called the *inclusive value index*. This is a measure of maximum level of satisfaction people get from the chosen sites and is derived from the site choice model above. It includes the effect of travel distance. This inclusive value parameter is insignificant in the trip count model. This implies that **changes** affecting recreation sites are more likely to lead to **substitutions among sites** rather than a change in the overall number of trips.

4.5 Application of findings

The information obtained from the revealed preference analysis is useful to help understand the *total* non-market use value of fresh water visits (or at least a lower bound on this value). The model also helps us to understand how visits may be redistributed if water clarity improves.

For analysis of non-use values and other quality attributes (human health risk and ecosystem health) we need to use the additional information obtained from the stated preference survey discussed in section 5.

4.6 Scenario analysis using revealed preference model

The site choice model can be used to estimate the effect of a change in any parameter in the model (see appendix 9.2 for details of this process). However, water clarity is probably the only useful parameter for scenario analysis. As an example, we simulate the effect on site choice and welfare from improving the water clarity at each site to a minimum level of 1.6 metres. This is considered the minimum desirable level for swimming. Sites that are already above this minimum are not altered. The following Figure 33 shows which sites would be affected.

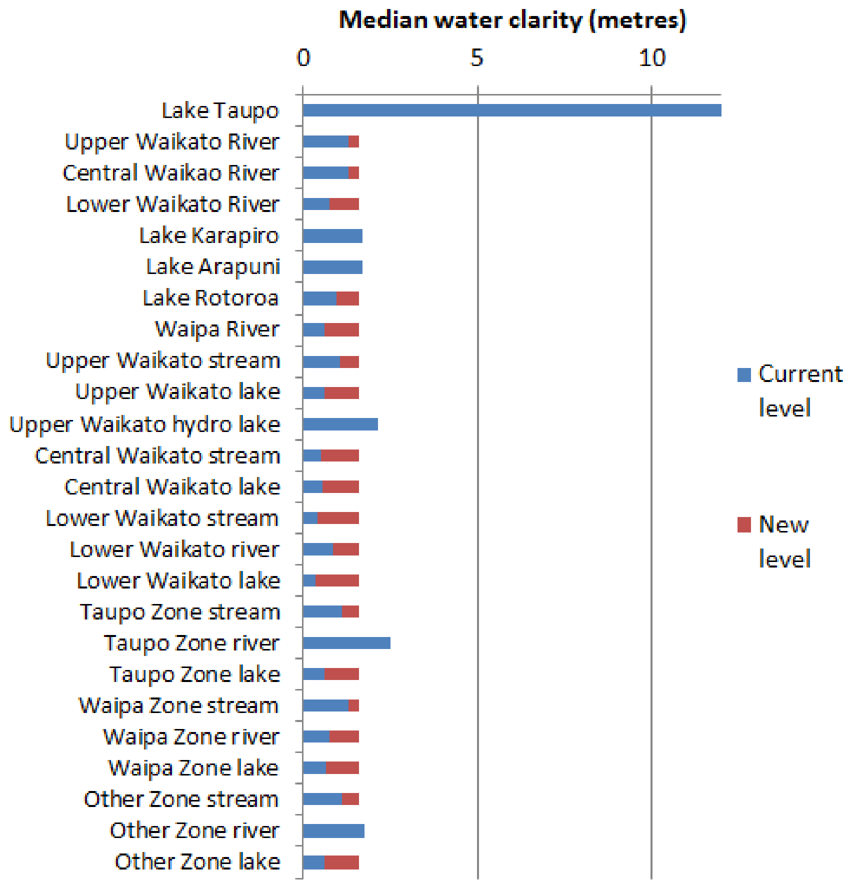


Figure 33 - Simulated changes to water clarity

We input these new values for clarity into the model and calculate the adjusted site choice probabilities. The following Figure 34 shows the increase in visit probability to each site if clarity changed for that site only. It does not show the substitution effects on other sites. Lake Rotoroa shows the largest increase because it currently has very poor clarity but is still a relatively popular destination (at least for near-water recreation).

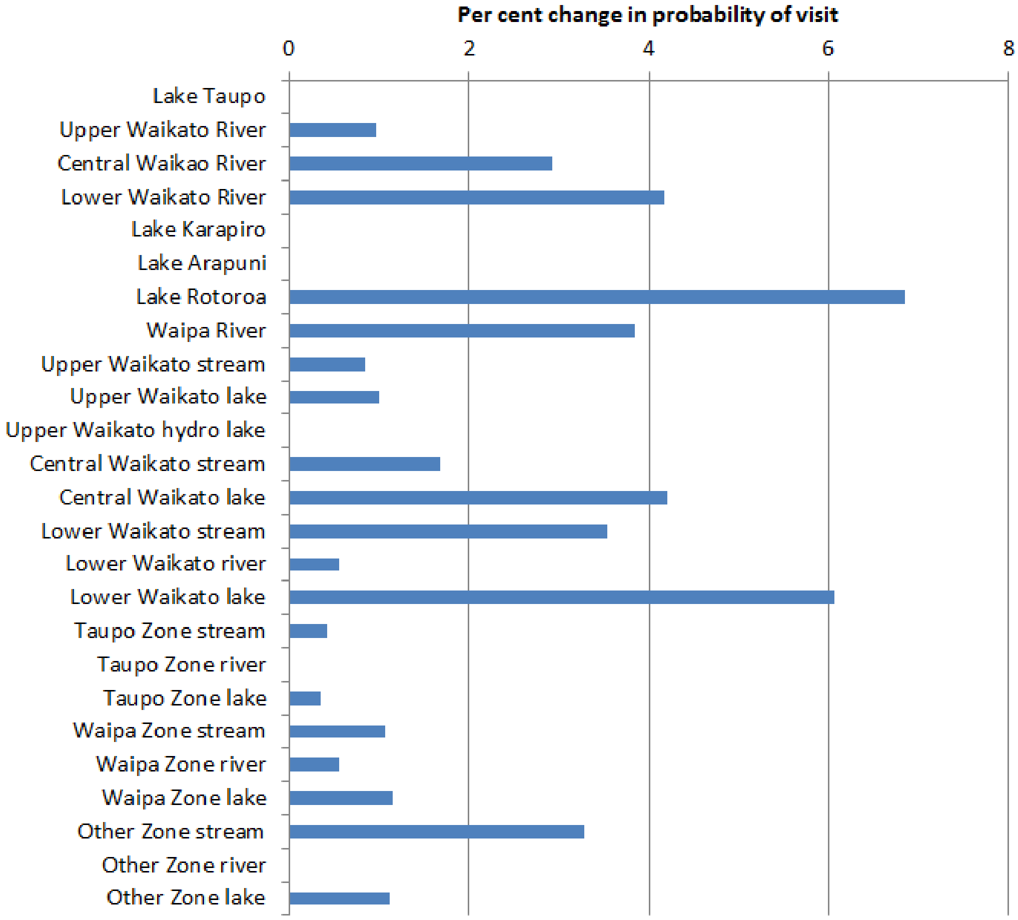


Figure 34 - Change in own probability resulting from clarity change at individual site

Figure 35 illustrates the effects of substitution between sites and shows the effects of simultaneously improving clarity at all sites below the 1.6 metre threshold. Sites where there is no increase in clarity (such as Lake Taupo and Lake Karapiro) show the largest declines as users switch to improved sites that are closer to home. The central Waikato River also shows a decrease. This is because the relative clarity increase is smaller than for other sites and people visit the other sites instead. Aucklanders in particular are more likely to visit sites in the lower Waikato zone because they are closer.

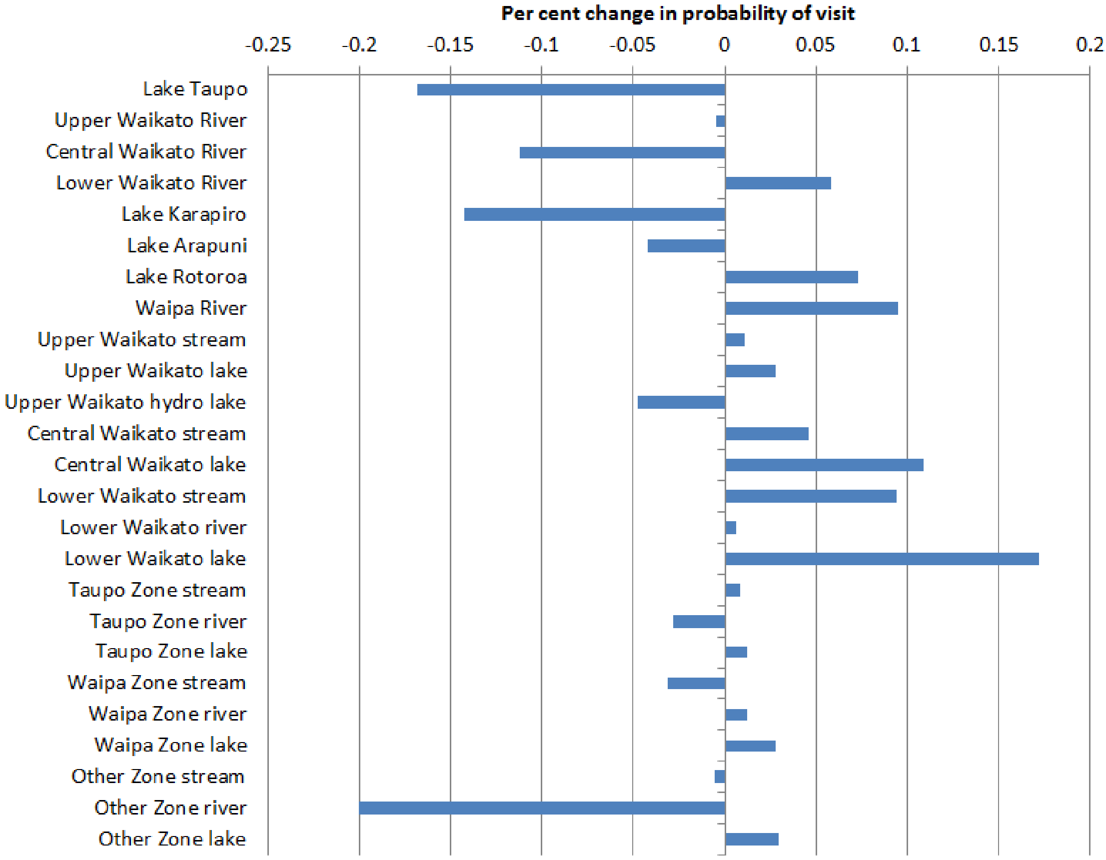


Figure 35 - Change in visit probabilities including site substitution effects

4.6.1 Non-market benefit of improving clarity to 1.6 metres

This value is divided by the total number of individuals in the sample to obtain the average welfare gain/loss per individual over the recreational season. The following Figure 36 shows the welfare change resulting from an improvement in clarity **only at that site**.

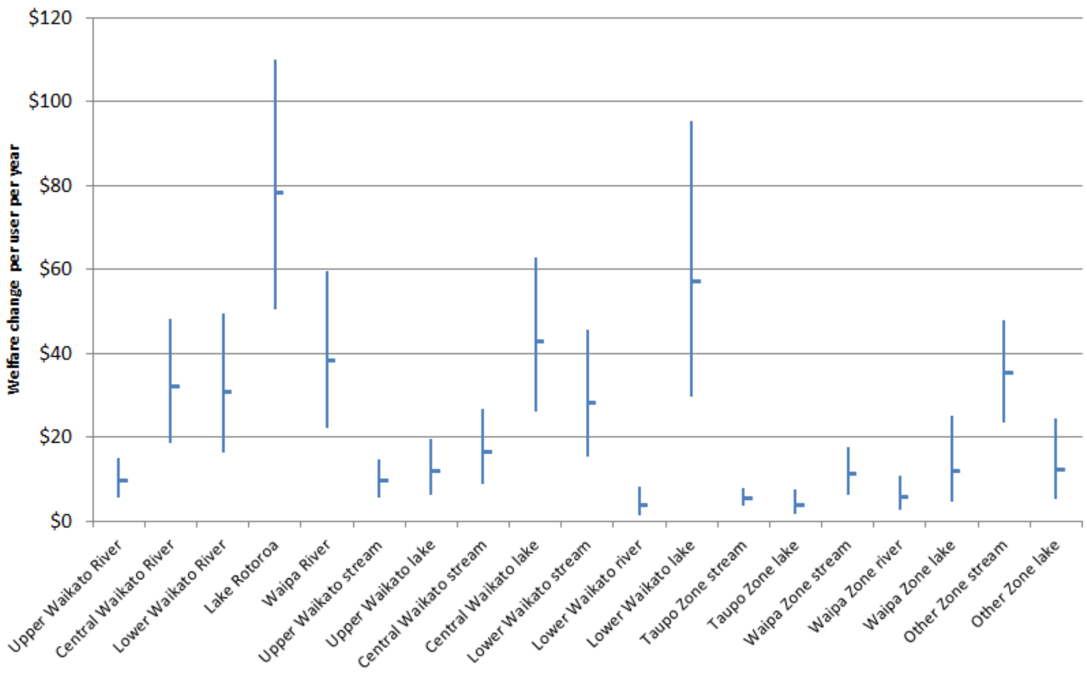


Figure 36 - Welfare change (mean and 95% confidence) resulting from water clarity improvement at site

Lake Rotoroa shows the largest benefits to welfare (average $79 per user per year) because current water clarity is so poor and it is conveniently located for Hamilton residents. Lower Waikato Lakes (e.g. Hakanoa near Huntly) also have large potential welfare gains ($58 per year). However, the changes resulting from improvements to river and stream water quality are likely of more interest from a policy point of view. Clarity improvements in the lower or central Waikato river result in modest welfare gains of $31-$32. The welfare gain from improving the upper Waikato river is only $10 because clarity is not far below the scenario minimum of 1.6 metres.

4.7 Limitations of the revealed preference analysis

4.7.1 Coverage of non-market value

Revealed preference destination choice analysis estimates non-market value based only on the travel cost people are willing to incur to travel to a site of particular quality. The benefit to the user may well be higher than this travel cost. In addition, revealed preference studies do not capture passive or non-use values. This is why we conducted a stated preference choice experiment as well. These two limitations mean that the welfare effect will tend to be *understated* by the revealed preference analysis alone.

4.7.2 The subjective nature of quality

Revealed preference studies capture the effects of subjective quality – features that people *see* or *believe to be true*. This is a large part of the reason why indicators for contact health risk and ecosystem health did not help explain site choice.

4.7.3 Usefulness of scenario

The scenarios we can analyse are limited to those that alter variables used in the model. Water clarity is the only variable in the model that is likely able to linked to a water quality policy scenario. The advantage of extending this study to include stated preference data is that we estimate the marginal effects of infection risk and ecosystem health as well.

4.7.4 Substitutability

The model form used above assumes that sites are perfect substitutes for each other, after controlling for the variables included in the model (also known as the Independence of Irrelevant Alternatives assumption).

We tested a model with different decision “branches” for different site types (river, lake etc) but this worsened the model fit. There may be variables that we did not or cannot include that would prevent people from changing sites (including habits and imperfect information). This means that the benefits deriving from substitution may be overstated.

We find no evidence (from the trip count model) that the overall number of recreational trips would increase if quality increased so we assume that changes result in substitutions between sites only. However, a lack of evidence for something does not prove the opposite is true.

A method called contingent behaviour analysis might help answer this question but literature has found that people are poor predictors of their own behaviour in response to a quality change. The issue remains an area of uncertainty that probably can only be answered reliably after a real quality change occurs.

5 Stated Preference Analysis

5.1 Purpose

The purpose of the stated preference analysis is to allow us to estimate the non-use portion of non-market values and quantify marginal values for human health risk and ecosystem health that could not be identified from the revealed preference analysis.

To achieve these objectives we designed a second survey named “the Waikato water quality survey”. The two surveys could have been delivered as one longer survey but there were advantages in having the recreation visit information already available when designing the second survey.

Information collected for the stated preference analysis consisted of choice experiment questions, some attitudinal questions and standard demographic questions.

5.2 Method

5.2.1 Design

5.2.1.1 Sites

The choice experiment included a whole-catchment choice task and choice tasks for individual sites. Including a lot of individual sites would have provided more site-specific data but also increase the survey length and burden for participants.

Based on the results of the first survey we selected the highest-use areas of the Waikato and Waipa rivers as “sites”. Lakes were not included because they are not a primary area of policy focus at present. Lake Karapiro is the third highest-used stretch of the Waikato river but was not included because it has already been the subject of choice experiments (e.g. Marsh et al., 2011). From water quality monitoring data we also selected a degraded lowland stream (Komakorau) and a stream with very good water quality (Mangauika) to cover a range of quality conditions.

The five sites are as follows:

1. *Waikato River at Hamilton*

This stretch of river has the highest use of any river or stream in the Waikato region, due to the high population density in the area

2. *Waikato River at Tuakau*

The lower Waikato is also highly used but has significantly worse water quality

3. *Waipa River at Whatawhata*

The Waipa River is an important part of the Waikato-Waipa catchment and the vicinity of Whatawhata is the most highly used stretch

4. *Komakorau stream*

The Komakorau stream near Taupiri has the lowest water quality of any monitored stream in the catchment

5. *Mangauika stream*

The Mangauika stream near Pirongia has water quality amongst the best of any monitored site in the catchment. Part of it flows through private farmland so there is potential for water quality to decline in future. This site was included to elicit the effect on welfare of a decline in water quality, as opposed to improvements in the other sites.

5.2.1.2 Attributes and levels

The first row of each choice card specified the cost of the alternative in terms of change in annual rates (or taxes, for non-ratepayers). Appendix 9.3 provides more detail about how the water quality attributes and levels were derived for each site.

The following tables show the attribute levels for each site and the images or colour codes used. The current situation is the *lowest* quality level for every site except Mangauika, where the current quality is the *highest* level.

Table 11 - Clarity levels used in choice tasks

Lower Waikato		0.6m (Poor)	1.1m (Poor)	1.6m (Fair)		
Mid Waikato				1.6m (Fair)	2.5m (Good)	
Waipa		0.6m (Poor)	1.1m (Poor)	1.6m (Fair)		
Mangauika				1.6m (Fair)	2.5m (Good)	3.5m (Very good)
Komakorau	0.2m (Very Poor)	0.6m (Poor)	1.1m (Poor)	1.6m (Fair)		

Table 12 - Health risk (infections per thousand) levels used in choice tasks

Lower Waikato		**100** (Very poor)	**50** (Poor)		
Mid Waikato					**1** (Good)
Waipa		**100** (Very poor)	**50** (Poor)		
Mangauika			**50** (Poor)	**10** (Fair)	
Komakorau	**300** (Very poor)	**100** (Very poor)			

Table 13 - Ecosystem health levels used in choice tasks

Lower Waikato	**Very Poor** Very high levels of nutrients and algae. Unsuitable for sensitive species	**Poor** High levels of nutrients and algae. Sometimes unsuitable for sensitive species		
Mid Waikato		**Poor** High levels of nutrients and algae. Sometimes unsuitable for sensitive species	**Fair** Moderate levels of nutrients and algae. Usually suitable for sensitive species	
Waipa	**Very Poor** Very high levels of nutrients and algae. Unsuitable for sensitive species	**Poor** High levels of nutrients and algae. Sometimes unsuitable for sensitive species		
Mangauika			**Fair** Moderate levels of nutrients and algae. Usually suitable for sensitive species	**Good** Low levels of nutrients and algae. Very suitable for sensitive species
Komakorau	**Very Poor** Very high levels of nutrients and algae. Unsuitable for sensitive species	**Poor** High levels of nutrients and algae. Sometimes unsuitable for sensitive species		

The following figure shows a sample choice card. Appendix 9.3.3 describes how the levels and alternatives were selected for each card. The order of alternatives and water quality attributes was randomised for each participant.

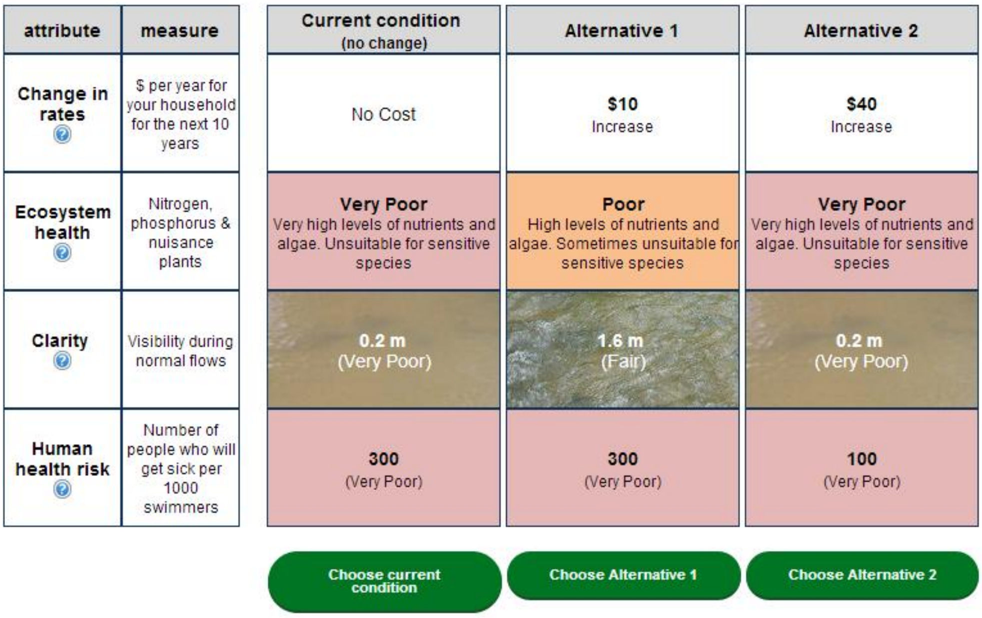


Figure 37 - Sample choice card for individual site

5.2.1.3 The whole-catchment choice card

The purpose of including a choice task for the whole catchment is to put an upper bound on stated WTP for the most inclusive geographic scope of potential water quality policies, avoiding a potential problem with part-whole bias. See appendix 9.3.2 for more detail about this and how the whole-catchment attributes and levels were derived.

The three water quality attributes for the whole-catchment cards are the proportion of monitored sites achieving 1.6 metres clarity, and infection risk of less than 0.1 per cent and "good" ecosystem health.

The following figures show a sample whole-catchment choice card with and without the pie-chart presentation. Participants were randomly assigned one version or the other.

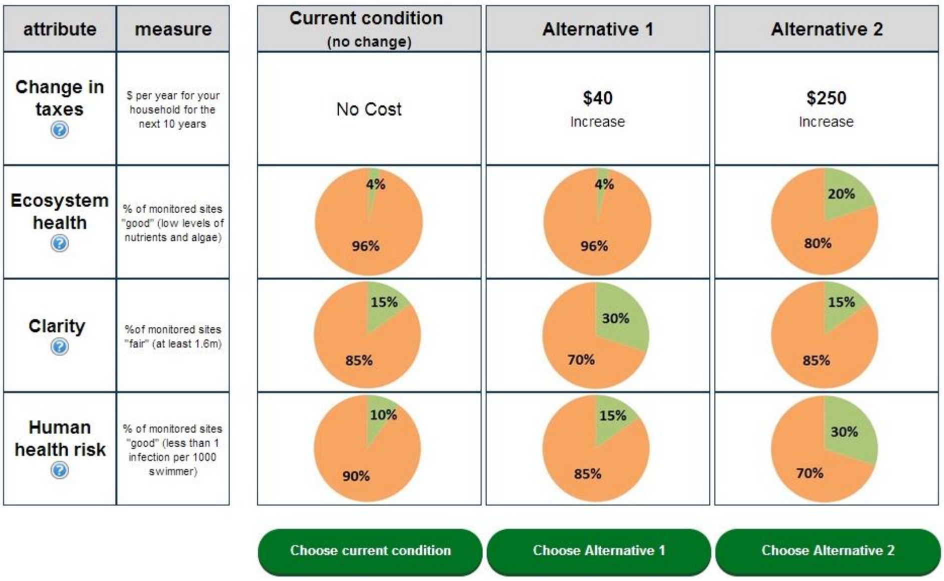
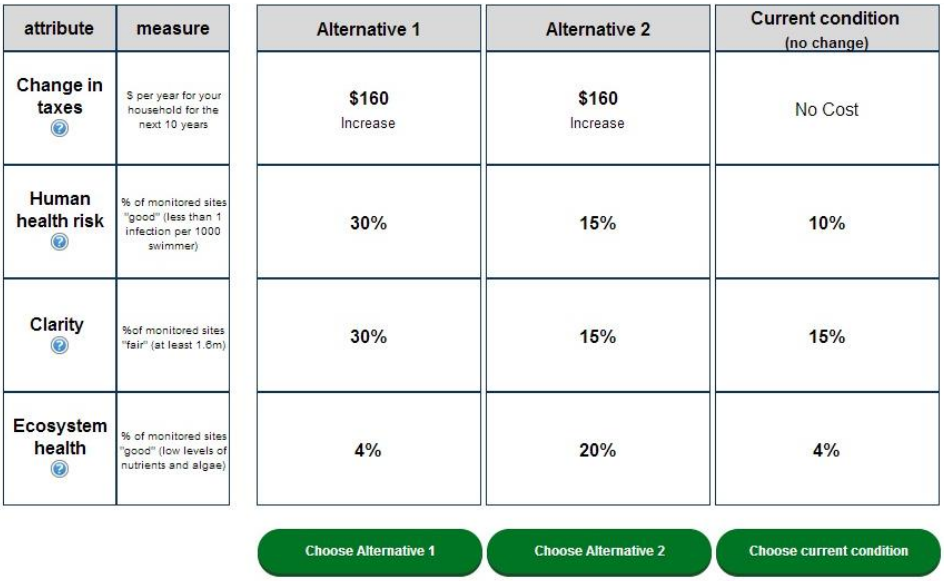


Figure 38 - Catchment choice card with pie charts



attribute	measure	Alternative 1	Alternative 2	Current condition (no change)
Change in taxes	$ per year for your household for the next 10 years	$160 Increase	$160 Increase	No Cost
Human health risk	% of monitored sites "good" (less than 1 infection per 1000 swimmer)	30%	15%	10%
Clarity	%of monitored sites "fair" (at least 1.6m)	30%	15%	15%
Ecosystem health	% of monitored sites "good" (low levels of nutrients and algae)	4%	20%	4%
		Choose Alternative 1	Choose Alternative 2	Choose current condition

Figure 39 - Catchment choice card without pie charts

5.2.2 Development

The online survey was programmed by the same developer who did the recreation survey. As part of the process there was an internal workshop to test the survey and two focus groups to get feedback from members of the public.

5.2.3 Delivery

The second survey required a broadly representative sample of the population rather than focussing on fresh water users as in the first survey. For this reason we purchased a panel of participants from the market research company Research Now and they delivered the survey by emailing the link to a stratified, random selection of individuals in their database.

Participants from the first survey were also invited by email (if they provided an email address) to participate in the second survey. Descriptive statistics are provided separately for the two sources of participants

5.3 Descriptive Statistics

Data was collected over a three-week period from 3/2/2014 to 23/2/2014. Table 14 shows the numbers of participants from each sampling frame who started and completed the survey. The "Re-contact" sample frame consists of 627 individuals who agreed to be contacted again upon completing the recreation survey and provided a valid email address. The response rate from re-contacts was 37 per cent. Of the 1684 people who started the survey, 1177 (69 per cent) completed it.

Table 14 - Completed surveys by participant type

Participant type	Started Survey	Completed Survey	Minutes (average)	Minutes (median)
Panel	1451	999	27	15
Re-contact	233	178	36	17
Total	1684	1177	28	15

The following Table 15 shows a number of summary measures for the sample. The "previous participant" measure shows how many individuals remembered filling in the recreation survey. The majority of the re-contact sample (93 per cent) remembered the first survey. The remaining 7 per cent were perhaps due to different individuals sharing an email account, or they may simply not recall the doing the survey. Three per cent of the panel sample also did the earlier survey even though the earlier survey did not recruit from the same panel. This overlap suggests that the total population of willing online participants may be relatively small and there is potential for sampling bias.

Females are over-represented in the panel participants but this is not a concern because the sampling unit is the household, not the individual. Beharry-Borg et al (2009) report that women are slightly more likely to provide a response that is representative of the entire household than are men. Recreational survey participants were more likely to be men so the re-contact sample is biased towards men.

People aged 30-50 and with higher education are overrepresented in both sub-samples. People of Māori ethnicity are underrepresented. These sample biases are corrected by re-weighting data for the final model. However, there may be sources of sample bias that are not related to simple demographics and cannot be measured or corrected.

A third of the overall sample pays rates in the Waikato region (excluding people who did not want to answer). Of the participants who live in the Waikato region, 69 per cent are rate payers. This is higher than the home ownership rate of around 50 per cent, but is consistent with the sample being older and having higher incomes than the general population. The average amount of Waikato regional rates paid by participants is $1039 per year. The median, however, is in the $250-$500 range which is typical of a single residential dwelling. The question about total rates (regional plus district) was included in case some people did not know the regional portion of their rates but also serves as a consistency check. Two percent of ratepayer participants answered that their regional rates are higher than total rates – clearly an inaccurate response.

The final two measures relate to how difficult participants said they found the choice tasks, and whether they fully understood them. People who find choice tasks difficult are likely to have a higher random component to their choice, and/or display lexicographic preferences (they ignore some features of the alternatives). Including these variables in the choice model generally improves the model fit significantly (Beck et al., 2013).

Table 15 - Summary statistics

Measures	Panel	Re-contact	Total
Count	999	178	1177
Previous participant	3%	93%	18%
Waikato residents	40%	37%	40%
Auckland Residents	27%	29%	28%
Bay of Plenty Residents	32%	12%	29%
Female	64%	43%	61%
Age (average)	37	42	38
Māori	5%	5%	5%
Post-school education	67%	74%	68%
Income < $30k	18%	13%	18%
Income > $100k	17%	26%	19%
WRC ratepayer	34%	35%	34%
WRC rates	$1,026	$1,116	$1,039
Total rates	$3,009	$2,770	$2,973
Rates inconsistent	2%	2%	2%
Choices difficult	40%	34%	39%
Didn't understand choices	13%	8%	12%

5.3.1 Perceived importance of rivers, lakes and streams

The survey included questions about how people perceive the importance of fresh water quality in relation to other general public issues. Table 16 shows that most people consider the condition of fresh water to be important, with most people giving it a rating of 4 out of 5. However, the other issues all rated as very important. The re-contact sample rated freshwater more highly than the panel sample. This is unsurprising considering the re-contact sample are all recreational users and subject to self-selection bias. A counter-intuitive result is that people rated fresh water quality more highly than the overall condition of the natural environment.

Table 16 - Importance of general public issues where 1 = least important and 5 = critical

Issue	Panel	Re-contact	Total
Economic growth	3.9	3.8	3.9
Crime safety	4.2	4.0	4.1
Child welfare	4.2	4.1	4.2
Quality and affordability of health care	4.2	4.1	4.2
Quality and affordability of education	4.0	4.1	4.0
The condition of rivers, lakes and streams	4.0	4.3	4.0
Overall condition of the natural environment	3.9	4.2	4.0

Participants were also asked to pick the top 3 most important issues, which forced a trade-off. Freshwater scored the lowest for panel participants with only 20 per cent including it in the top three. Re-contact participants rated freshwater higher with 38 per cent including it in their top three, apparently at the expense of crime safety. Re-contact participants were also much more likely to include the overall environment in their top three (55 per cent versus 34 per cent for panel participants).

Participants who are male or have higher education were more likely to include freshwater in their top three issues. Parameters for age, Māori ethnicity and ratepayer were not statistically significant.

The order of the issues was randomised for each participant to mitigate potential order effects (earlier items are more likely to be selected in surveys). Position is not a statistically significant variable in regression results.

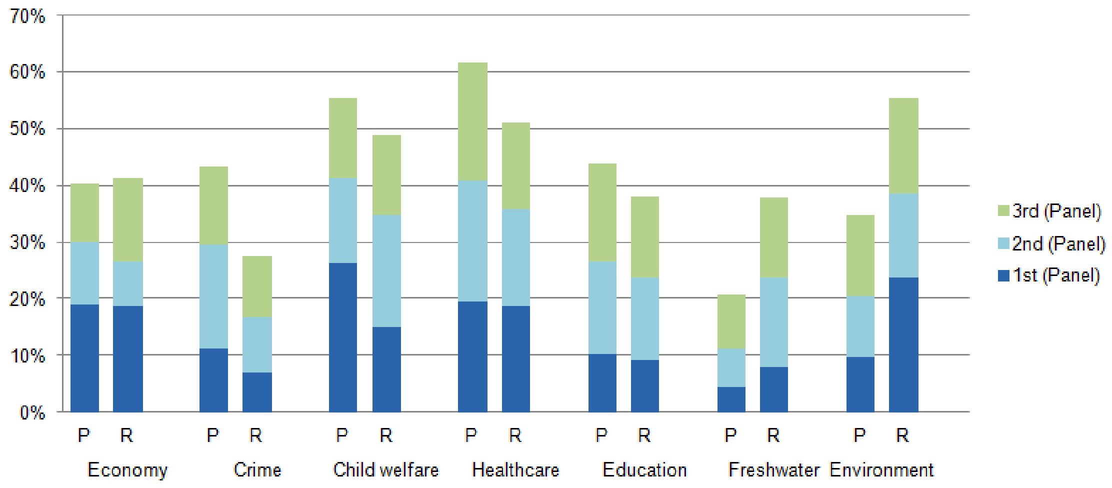


Figure 40 - Top 3 public issues by sub-sample

5.3.2 Sites

Participants were asked whether they had seen each of the five sites in the choice experiment, and whether they had used the site for recreation or cultural activities. These are important variables for estimating use and non-use components of stated value, and as explanatory variables heteroscedasticity in the choice model.

The following Figure 41 shows that 80-90 per cent of participants have seen the Waikato River at Hamilton, while a much smaller proportion have seen the Mangauika and Komakorau streams. Members of the re-contact sample were more likely to say they had seen each site, and more recently than members of the panel sample.

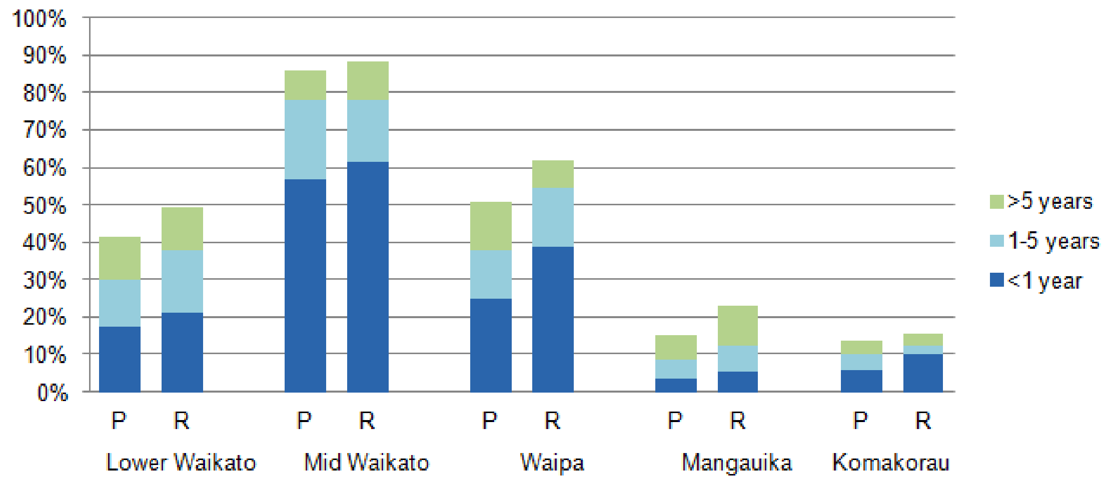


Figure 41- Sites seen by participants in the past year, 1-5 years, or more than 5 years ago

The following Table 17 shows the proportion of participants who indicated they had used each site for recreation or cultural activities. Similar to the first survey, the activities are differentiated depending on whether they occur in, on or near the water. The Waikato River at Hamilton was the most used site, and re-contact participants were more likely to be users of all sites. Because the panel sample is a broadly representative and arguably subject to less selection bias than the Recreation & Cultural Use survey, these results are useful for estimating the overall number of users in the population for the purpose of value aggregation.

Table 17 - Recreation & cultural use of sites

Sub-sample	Site	In Water	On Water	Near Water
Panel	Lower Waikato river	3%	2%	7%
	Mid Waikato river	5%	7%	33%
	Waipa river	2%	2%	8%
	Mangauika stream	2%	0%	7%
	Komakorau stream	1%	1%	2%
Re-contact	Lower Waikato river	4%	5%	14%
	Mid Waikato river	8%	15%	44%
	Waipa river	3%	5%	14%
	Mangauika stream	5%	1%	10%
	Komakorau stream	0%	0%	4%

Participants were asked whether they believed the choice cards accurately portrayed current water quality conditions at each site, and whether they thought the proposed improvements were feasible. Even if we ignore subjective components of water quality, objective measurements vary widely depending on season or rainfall. The choice cards presented median measures of clarity, contact health risk and ecosystem health but these are not necessarily consistent with users' experiences. Model results may be biased if participants do not believe the status quo (Marsh et al., 2011) so we include a variable to control for this.

Table 18 below shows that approximately a quarter of participants believed the status quo is accurate. Only 1-6 per cent believed the sites were better than stated. A slightly higher proportion believed the sites are worse than stated. The majority of participants said they didn't know. People who had seen or used the sites were less likely to say they didn't know.

The final two columns show whether participants believed the proposed changes were feasible or not. We did not delve into the reasons why people might disbelieve because they are largely irrelevant to the valuation exercise. The results show that almost half of participants believed the changes were feasible. Less than a quarter believe they are not feasible and the remainder did not know. The re-contact sample was slightly more pessimistic in belief of feasibility. Belief is also included as a variable in the model to control for potential bias.

Table 18 – Perceived accuracy of status quo and believability of scenarios

Sub-sample	Site	Accurate	Site Better	Site Worse	Believe	Not Believe
Panel	Lower Waikato river	23%	5%	10%	42%	15%
	Mid Waikato river	38%	6%	13%	51%	14%
	Waipa river	26%	5%	9%	43%	15%
	Mangauika stream	24%	4%	3%	51%	9%
	Komakorau stream	19%	2%	9%	43%	15%
Re-contact	Lower Waikato river	27%	4%	13%	38%	25%
	Mid Waikato river	39%	5%	13%	51%	20%
	Waipa river	35%	4%	10%	40%	19%
	Mangauika stream	30%	4%	1%	50%	13%
	Komakorau stream	23%	1%	8%	42%	18%

The choice card for each site was followed by a question asking how certain they are that this is the option they would prefer in real life, if the tax/rate increases were real. This is called a "certainty scaling" question and is currently considered best-practice for mitigating hypothetical bias in stated preference studies (Blomquist et al., 2009). People who are very certain of their choice are less prone to overstating their willingness to pay. The data can be weighted to reduce the influence of people who are less certain. Stated certainty is also effective for explaining choice randomness and the inclusion of this variable tends to improve model fit (Beck et al., 2013).

The following Figure 42 shows that less than half of participants were "probably" or "definitely" sure of their choice. The re-contact sample was more certain on average which is consistent with the higher proportion of users and pro-environment participants. There is negligible difference between the sites.

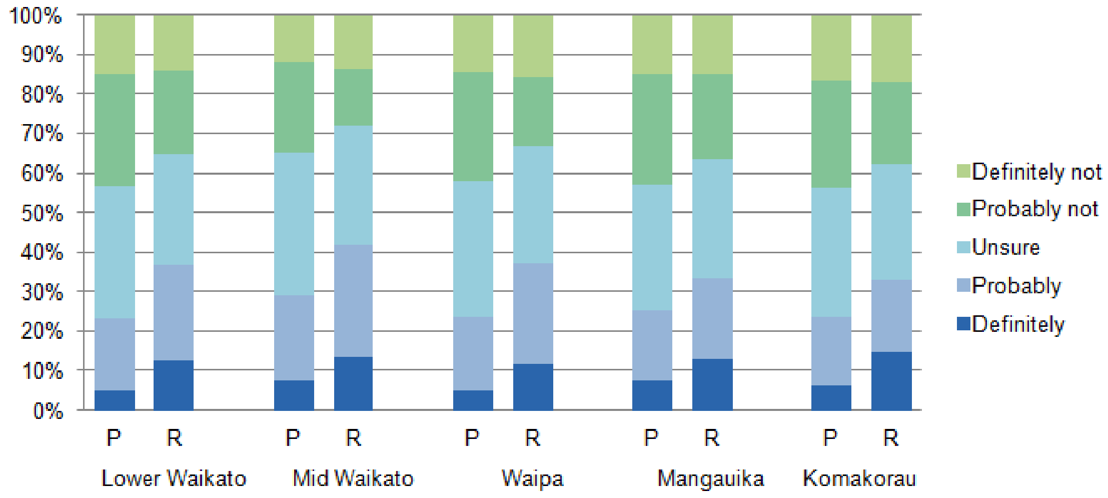


Figure 42 - Stated choice certainty by site and sub-sample

5.3.3 Choice balance

If individuals consistently chose the zero-cost or highest cost option their true WTP may be below or above the range of values used in the experimental design. The following table shows that 6 per cent of individuals always chose the zero cost option and only 1 per cent always chose the highest cost. This implies that the range of costs used was appropriate for most people.

Table 19 - Zero-cost and high cost choices by individuals

Choice type	Individuals	Per cent
Always chose $0	74	6%
Sometimes chose $0	793	67%
Never chose $0	310	26%
Always chose highest cost	16	1%
Never chose highest cost	265	23%

The zero-cost option meant no quality change for every site except Mangauika, for which the highest cost option meant maintaining the current level of quality and zero cost meant a decline. Figure 43 shows the proportion of individuals who chose current quality, highest cost and zero cost options per site. Note that current quality and zero cost is the same alternative for every site except Mangauika.

People were much more likely to choose current quality for Mangauika than the other sites, indicating an aversion to letting water quality decline. Asymmetry between improvements and declines is a common finding in environmental economics literature and is consistent with the theory of loss aversion. People were also more likely to choose a zero-cost option for Mangauika than the other sites but there were two zero cost options for Mangauika and only one for each of the other sites so this may be simply a design effect. Interaction parameters between status quo, cost and the Mangauika site were tested in the model but these were not actually statistically significant.

People were more likely to choose the highest cost option for Komakorau. This could reflect the fact that cost levels were set lower for the streams than the rivers, in anticipation of a stream having lesser value than the rivers. Or it could be because Komakorau has the lowest current water quality of all the sites.

People were slightly more likely to choose the current condition, zero cost option for the whole catchment. The difference is insignificant after controlling for the higher level of randomness in whole-catchment choices.

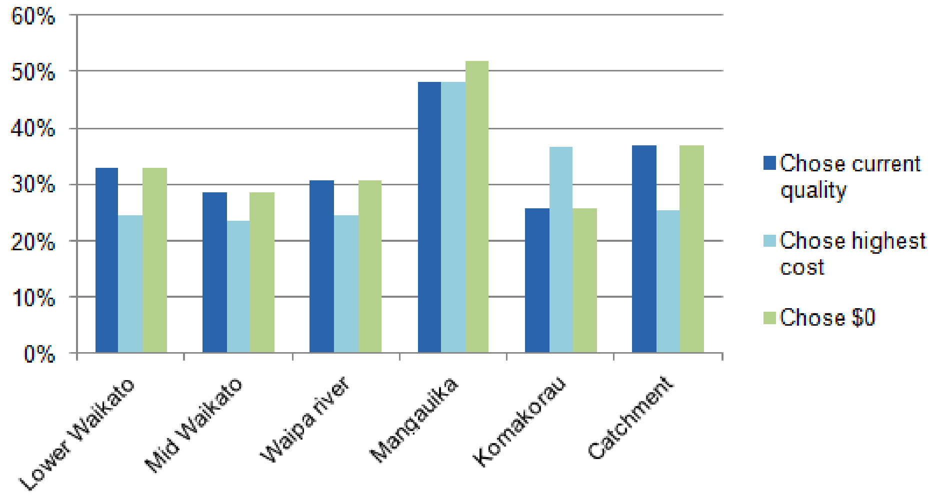


Figure 43 - Choices by site

5.4 Stated Preference Model

5.4.1 Weights

Older, more highly educated individuals were over-represented in the sample (compared with 2013 census figures). Appendix 9.4 describes how this was corrected by re-weighting the sample.

5.4.2 Model Results

The final model used is a G-MNL model with cost interaction and scale variables and a random parameter for the non-status-quo option. See appendix 9.5 for a discussion of the advantages and disadvantages of different model specifications tested.

Appendix 9.6 presents the estimated model and explains the purpose of each parameter. The absolute size of the model coefficients is unimportant. What is important is the relative magnitude and sign (positive or negative) of the cost and water quality attributes.

Cost has a significant negative effect, as expected. Water clarity is positive and non-linear so it is worth more at higher levels of clarity (at least up to the maximum of 3.5 metres used in the experiment). The coefficient for human infections is negative and also non-linear, flattening out at more than 100 infections per thousand. The coefficients for “poor”, “fair” and “good” ecosystem health are all positive (when compared with the base case “very poor”) and increasing magnitude as expected.

Site-specific constants are insignificant which means there is little difference in values for different sites after controlling for the different current quality levels and amount of recreational use.

5.4.3 Willingness to pay

Marginal willingness to pay (WTP) for a quality change is calculated by dividing the attribute coefficient by the cost coefficient including all relevant interaction terms. The scale parameters and random parameter do not affect WTP so are largely irrelevant beyond improving model fit.

There are several significant cost interaction variables which affect WTP. Fresh water users are willing to pay more than non-users. People who said they were very certain of their choices are willing to pay more than people who were unsure. Māori participants and people who said water quality is one of the top three important issues are also willing to pay more. Waikato ratepayers are willing to pay less than non-ratepayers, perhaps because they believe a rates increase is a very realistic scenario. Individuals with high income also have higher WTP but the difference is not significant after controlling for user status.

The following charts show WTP calculated using the stated preference model. See section 6.4 for combined revealed and stated preference model results which include an adjustment for hypothetical bias.

5.4.3.1 Generic WTP

The following charts illustrate marginal WTP including the squared terms and the impact of different interaction variables. Each interaction variable is changed in turn, while holding the others constant at (weighted) sample mean values. Parameters such as use which are specific to a site are averaged across the five sites.

Figure 44 shows WTP for an improvement in clarity from the lowest level 0.2 metres. Stated certainty is associated with significantly higher WTP. People who said they would “definitely” or “probably” want rates/taxes to increase to fund water quality are willing to pay $450 for an improvement to 3.5 metres, while the weighted sample average is only $138. People who said “definitely not” or “probably not” were only willing to pay $88. Since their answer suggests they would not support any increase, perhaps we should assume true WTP is $0. The interaction effects with recreational use, Māori ethnicity and water as a top three issue are also positive although the effect is not as large.

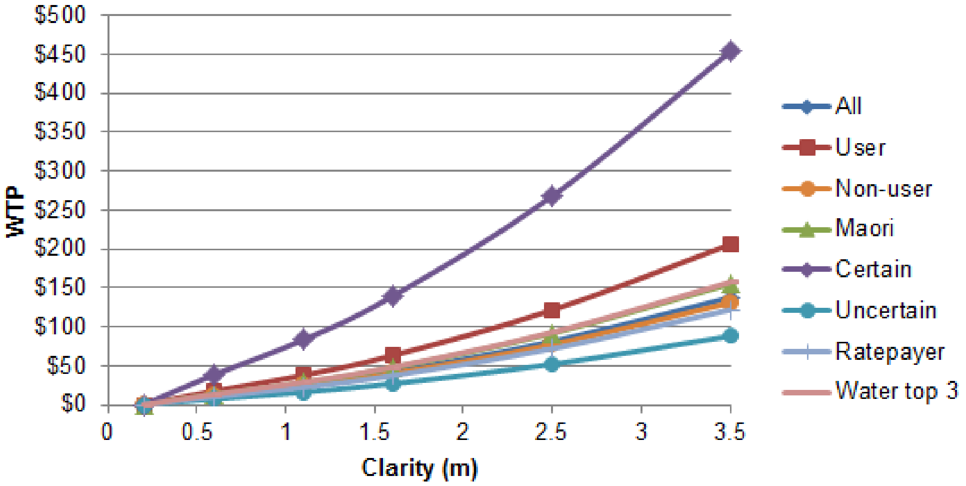


Figure 44 - Generic WTP for clarity including interaction effects

Figure 45 shows a similar chart for infection risk, using a baseline of 300 infections per 1000 bathers. Figure 46 shows ecosystem health.

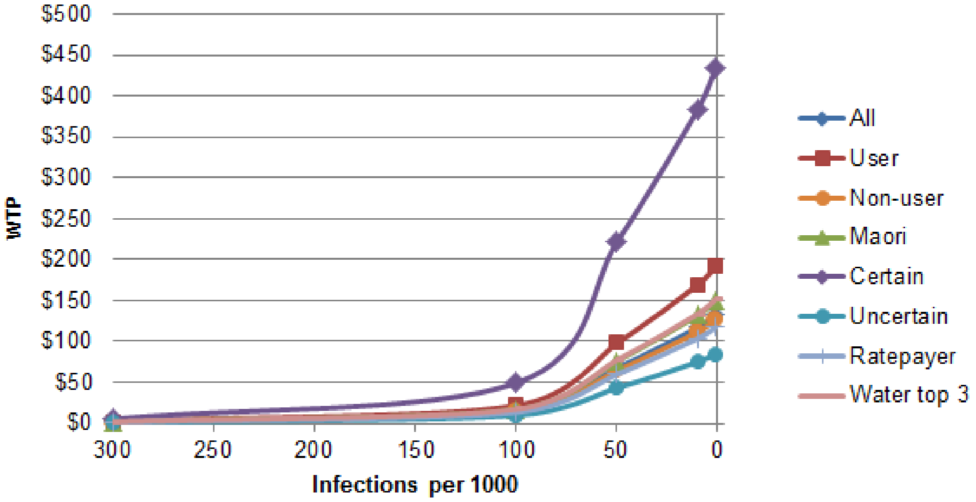


Figure 45 - Generic WTP for infection risk including interaction effects

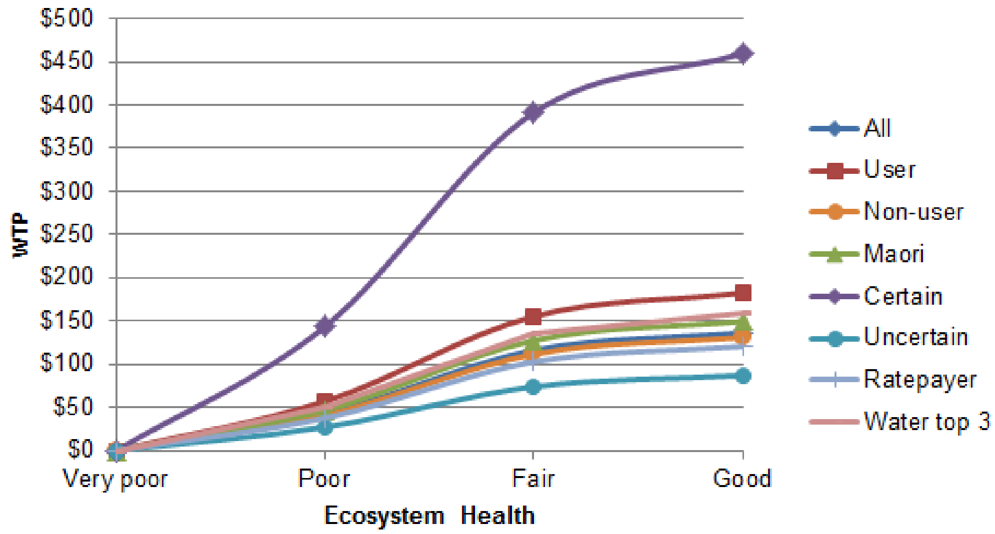


Figure 46 - Generic WTP for ecosystem health including interaction effects

5.4.3.2 WTP over distance

Another significant effect on WTP is travel time. WTP declines with increasing travel time from the individual's home to the site, and use value declines faster than non-use value. The following chart illustrates the effect of travel time on WTP for a clarity improvement from the baseline 0.2 metres to 1.6 metres. The second axis shows the distribution of travel distance within the sample. The majority of the sample live within 3 hours of any site and user WTP declines by approximately a third over this distance, compared with a 9 per cent decline in non-user WTP.

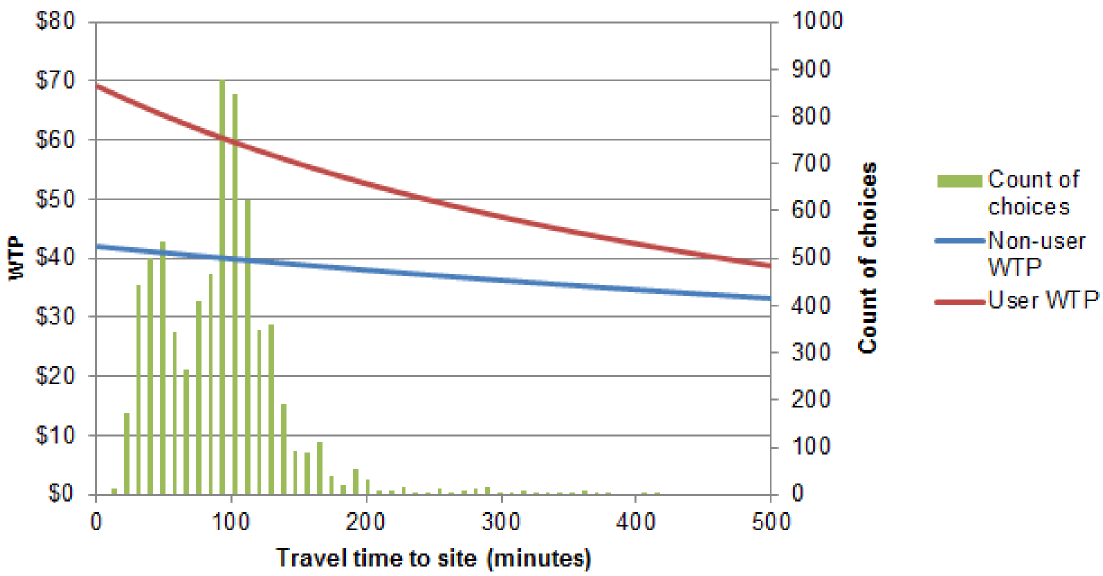


Figure 47 - WTP for clarity 1.6m versus distance

5.4.3.3 WTP for specific sites and changes

Although the site-specific interaction variables are not significant, each site varies in terms of current water quality, use and travel time. This results in variation in WTP for quality changes at each site. Figure 48 illustrates calculated WTP for each quality change used in choice cards (indicated by the markers). The dotted lines illustrate an extrapolation of the WTP functions for levels that did not appear in the choice experiment because they were not considered feasible or relevant.

Current clarity is approximately 1.6m in middle Waikato River so the value of 1.6m is subtracted from each WTP for this site. The WTP for an improvement to 2.5m is therefore the difference between 1.6 and 2.5m ($43), including the effects of interaction variables. The lower Waikato, Waipa and Komakorau sites currently have worse clarity so the intercepts for these sites are correspondingly lower. The levels for Mangauika represent a decline in quality so the values are all negative.

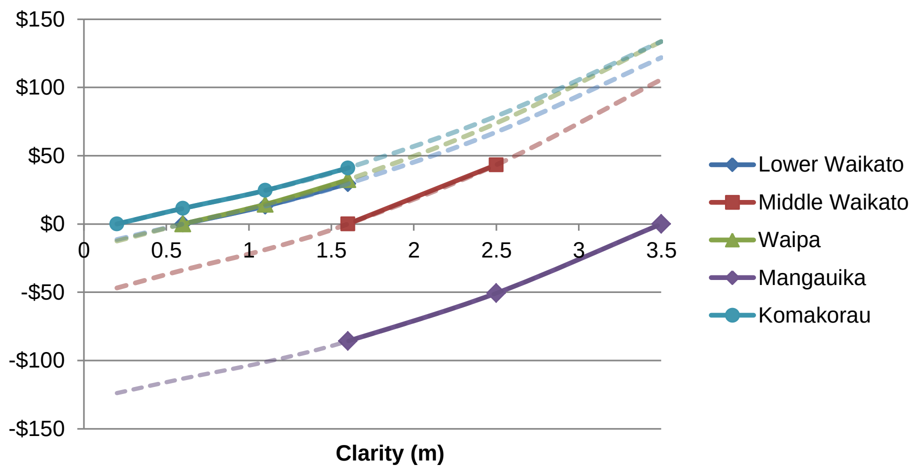


Figure 48 - WTP for clarity for each site

Figure 49 shows WTP for changes in infection risk. An improvement at Komakorau from 300 infections to 100 is worth $15, while an improvement in lower Waikato or Waipa rivers from 100 to 50 infections is worth approximately $50. The middle Waikato River is already at the lowest level (1 infection) so no other level was included in the choice card for this site.

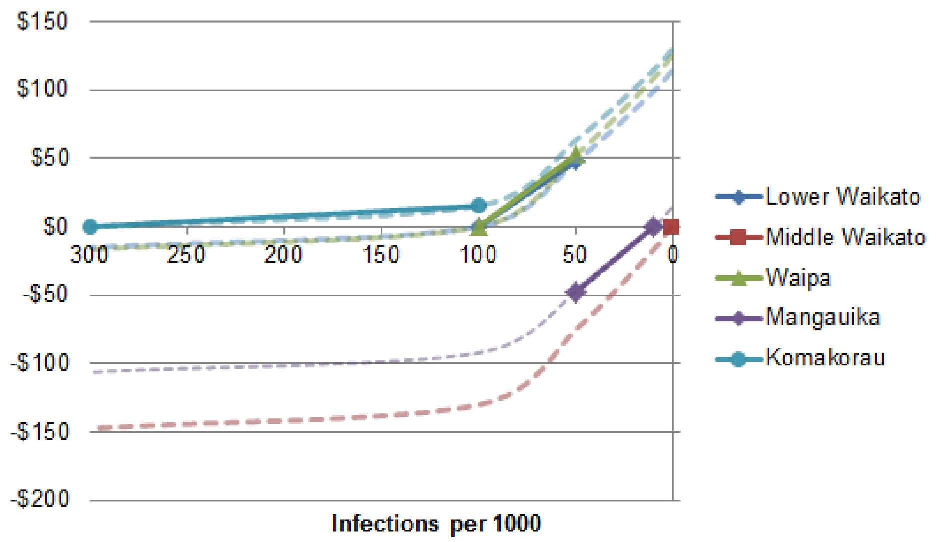


Figure 49 - WTP for infection risk for each site

Figure 50 shows WTP for ecosystem health. The s-shaped function estimated by the models implies that an improvement from “poor” to “fair” at the middle Waikato site is worth more than the changes from “very poor” to “poor” or “good” to “fair” at the other sites.

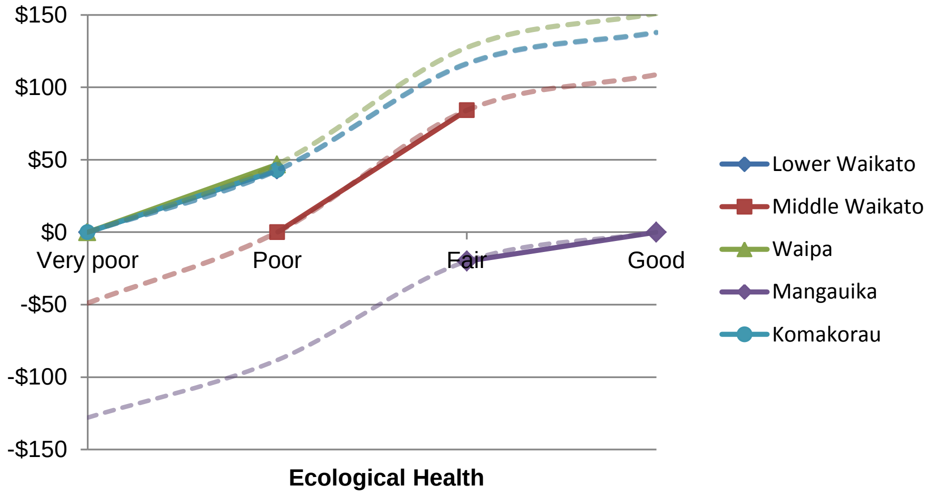


Figure 50 - WTP for ecosystem health at each site

5.4.4 Single site versus whole catchment

The whole-catchment attribute levels represent the proportion of monitored sites that meet the specified target (1.6 metres for clarity, 1 or fewer infections per thousand, and "good" ecosystem health). The range from status quo to the maximum feasible improvement was 15-16 per cent for each site. There was no evidence of a significant non-linear effect over these ranges so there is only one variable for each of the three quality measures. The following Figure 51 shows WTP for the specified proportion of sites meeting each target. The current level is where WTP equals zero.

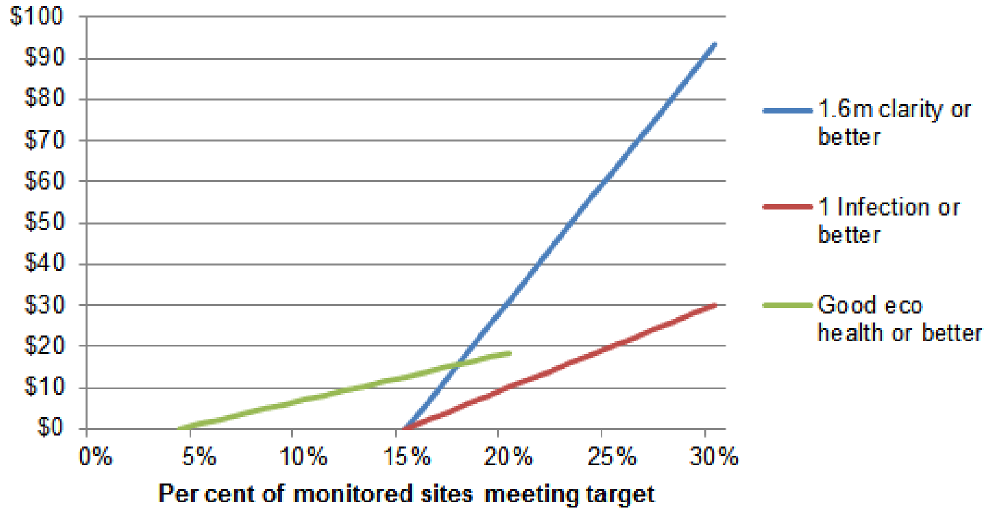


Figure 51 - WTP for whole catchment water quality

Table 20 shows a comparison of WTP for individual sites and the whole-catchment attributes. If the proportion of sites meeting a target were to increase, we assume it would be the sites at the next lower quality level that would be affected. The estimated WTP to improve a site from 1.1 to 1.6 metres clarity is $16. This is 17 per cent of the WTP for the largest improvement across the catchment.

It is difficult to define what an individual site *should* be worth in comparison with the whole catchment. One site is approximately 2 per cent of around 60 monitored sites in the catchment. But sites are neither independent nor of equal significance. If a scenario involves quality changes to multiple sites the catchment WTP values should be used as a reality check for total WTP.

Table 20 - Comparison of catchment and site WTP

Quality change	WTP	% of max catchment improvement
Improve a site from 1.1 to 1.6m	$ 16	17%
Improve a site from 10 infections to 1	$ 15	50%
Improve site to "fair" to "good"	$ 20	109%

5.5 Application of findings

The stated preference model results can be used to analyse welfare effects of various scenarios that involve a change in quality for individual sites, multiple sites, or the whole catchment. The scenario must be framed in terms of changes to clarity, E.coli or nitrogen and phosphorus (ecosystem health). Section 7 of this report provides a marginal benefit analysis of an example scenario.

The demographic, geographic and attitudinal variables in the model also allow the estimated of willingness-to-pay by different groups in the population.

5.6 Limitations

As stated in section 7, stated preference studies are sensitive to framing of attributes and scenarios, geographic scope, and hypothetical bias. We used consultation with water quality scientists and consultation with members of the public (in focus groups) in an attempt to derive attributes that would be meaningful both for science and for fresh water users. A small minority of people still found the scenarios difficult to understand or not believable (see section 5.3.2) but this is probably inevitable.

We addressed sensitivity to geographic scope by including whole-catchment choice cards. One limitation is that we could not obtain specific values for every possible site because this would have required far too many different choice cards. There were no site-specific constants for the five sites that were used, but other sites (or site definitions) might have unique features that make them more or less valuable than average.

The issue of hypothetical bias (overstating willingness to pay) is addressed by comparing use values with the revealed preference study in section 5 and using the stated certainty question.

6 Combined revealed and stated preference model

6.1 Purpose

The purpose of combining the two data sources in one model is to improve on the separate models by taking advantage of the different strengths of both methods.

Combining revealed and stated preference data can solve the problem of correlation of quality attributes in revealed preference data; extend the model beyond the range of existing quality levels, and ground stated preferences with real choice data.

6.2 Methodology

There are different types of combined data studies in the literature (see Whitehead et al., 2008 for an overview). One method is to simply compare the WTP from the two different models. If the choices involve similar variables the data may alternatively be stacked and estimated as a pooled model. If the data includes SP and RP choices for each individual then correlated errors may be used to recognise the panel nature of the study.

In this study the revealed and stated preference attributes have quite different meanings. The RP cost attribute is a per-trip value, while SP cost is an annual payment. The water quality attributes use the same measures but potentially have different impacts depending on whether the choice is framed as a recreation visit or a general preference for water quality. The attributes are therefore not constrained to be equal.

However, preferences for water recreation and water quality improvements are expected to be motivated by the same underlying (unobserved) preferences within individuals. The two sets of data are therefore linked by including individual-specific random parameters with correlations between the RP and SP attributes. There were 200 participants who completed both surveys, allowing the estimation of panel effects.

This approach is similar to that used by Eom and Larson (2006), who combined river use data with contingent valuation questions about improvement of water quality for a river in South Korea.

For this joint model only river/stream visits within the Waikato/Waipa catchment are included in the RP data. The RP choice alternatives consist of the five sites specified in the SP choice experiment, plus an “other” alternative for all other river or stream sites. For the SP data the alternatives represent different levels of quality for a given site.

The whole-catchment choice data is excluded from this model because it is yet another type of choice that would have required another set of attributes and covariances with no obvious usefulness.

6.3 Model results

See appendix 9.7 for the model specification and estimated coefficients. Including SP and RP attribute covariances significantly improve model fit compared with the SP-only model, and improve the significance of RP attributes. The covariance coefficients are positive and significant, which supports the theory that the same underlying preferences for water quality affect both destination choice and stated willingness to pay.

6.4 Willingness to pay comparison

The following table compares the WTP figures calculated from the joint and SP-only models respectively. The final two columns show the percentage difference between the two models. The values are relatively consistent considering the models are quite different.

The RP part-worths are not directly comparable with the RP-only model in section 4.4 because it included lakes and sites outside the catchment.

Table 21 - Comparison of stated WTP from joint and SP-only models

		Joint model[4]		SP-only model		Difference	
		User	Non-user	User	Non-user	User	Non-user
Clarity	0.2	$4.47	$3.54	$3.98	$2.86	12%	24%
	0.6	$15.37	$12.17	$14.18	$10.19	8%	19%
	1.1	$32.64	$25.85	$31.12	$22.37	5%	16%
	1.6	$53.98	$42.75	$52.73	$37.90	2%	13%
	2.5	$102.64	$81.28	$103.36	$74.29	-1%	9%
	3.5	$172.15	$136.33	$177.33	$127.45	-3%	7%
Infections	1	$169.15	$133.95	$172.94	$124.30	-2%	8%
	10	$163.13	$129.19	$152.72	$109.77	7%	18%
	50	$94.91	$75.16	$88.25	$63.43	8%	18%
	100	$21.12	$16.72	$19.55	$14.05	8%	19%
	300	$2.16	$1.71	$2.00	$1.44	8%	19%
Eco health	Poor	$46.12	$36.52	$56.90	$40.89	-19%	-11%
	Fair	$208.84	$165.38	$155.35	$111.65	8%	19%
	Good	$227.18	$179.91	$182.30	$131.02	-5%	4%

6.4.1.1 Use versus non-use value

Use value in this context is the value obtained from any type of recreation or cultural use of fresh water. Non-use value includes option or existence value and exists even for people who do not visit any sites.

Similar to Eom and Larson (2006) we use a recreational use parameter to split the use and non-use components. Users are assumed to include **both** use and non-use values in their statements of WTP for a particular improvement. Therefore, the non-use value is the magnitude of the systematic difference between WTP by users and non-users.

This systematic difference is captured by the user/SP cost interaction variable, which implies that non-use value comprises 79 per cent of stated value. This is higher than the proportion reported by Eom and Larson (2006), which was around 38 per cent. Non-use value is thought to be more affected by hypothetical bias. We don't know if this is the case for this study, but the marginal benefit analysis section reports a sensitivity analysis based on different proportions of non-use value.

6.4.1.2 Comparison of SP and RP willingness to pay

As stated earlier, the RP and SP costs are in different time units because the RP cost is per trip while SP cost is per year. However, we can make a rough comparison by multiplying the RP WTP by number of trips taken in the past year for each individual and site (the average being 17 trips).

The following three figures compare SP use value (user minus non-user WTP) with the corresponding RP use values. The WTP values are relative to the lowest quality level for each attribute (0.2 metres clarity, 300 or more infections and "very poor" ecosystem health). The figures show that there are differences between the use values obtained from stated and revealed preferences, but they are at least the same order of magnitude.

[4] Conditional WTP

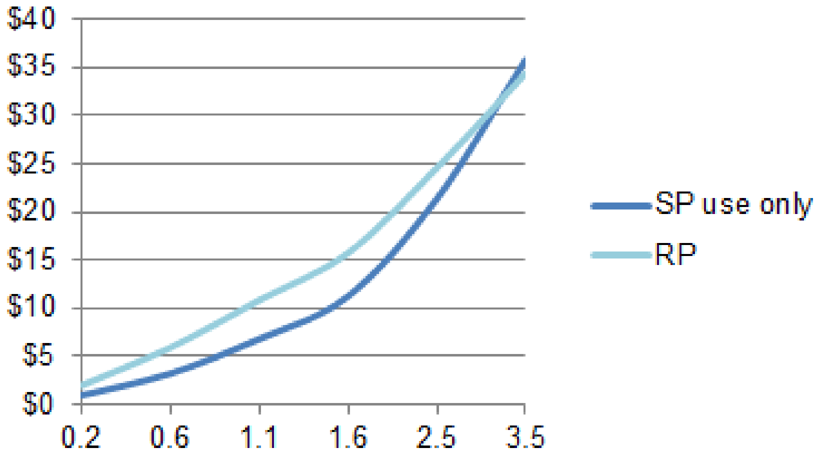


Figure 52 - SP and RP use values for clarity

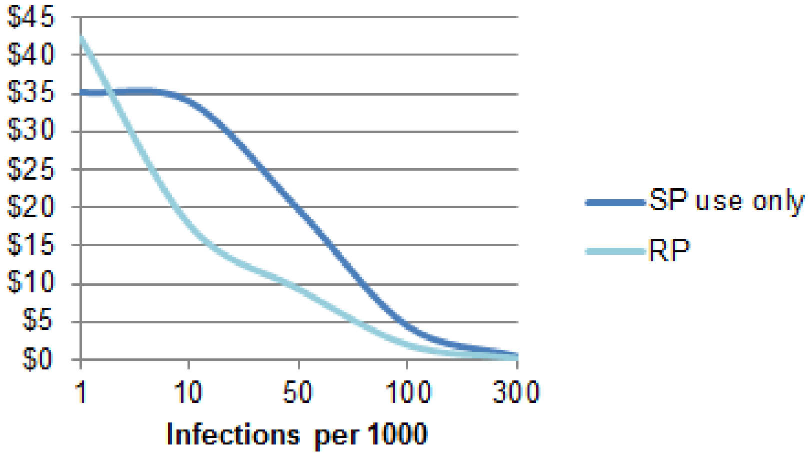


Figure 53 - SP and RP use values for infection risk

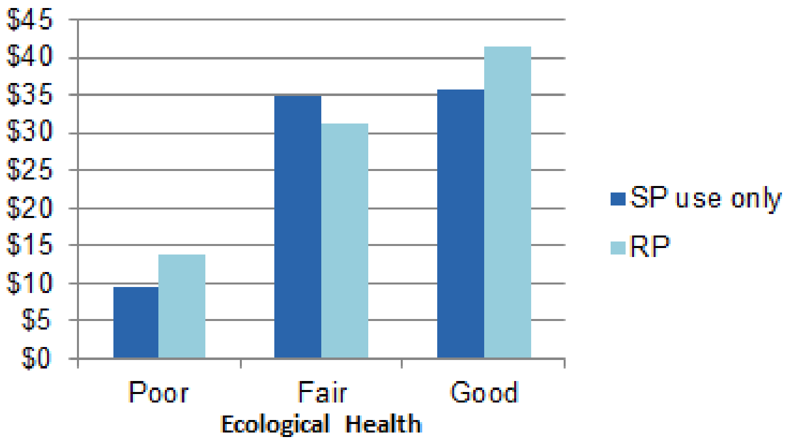


Figure 54 - SP and RP use values for ecosystem health

6.5 Application of results

The main purpose of this model is to provide confidence that estimate use values are broadly consistent using either data source. The model may be used for a marginal benefit analysis of a single site, similar to the stated preference model. The two models will provide slightly different values but both are equally valid.

6.6 Limitations

The attributes in the RP and SP data are not directly comparable because the choices are framed differently. The joint model therefore cannot provide a single set of values for use in a marginal benefit analysis.

7 Marginal benefit analysis

7.1 Purpose

The purpose of this section is to use model results to estimate the total welfare effect of a change in water quality (the "hypothetical scenario"). The two steps necessary to this process consist of 1) defining the population over which to aggregate values and 2) framing the scenario in terms of changes to model parameters.

7.2 Bias adjustments

There are two important sources of bias to consider in an analysis of non-market values. The first is hypothetical bias, which is where people overestimate their willingness or ability to pay in reality. Following the recommendations in recent literature (Blomquist et al., 2009; Ready et al., 2010) the stated certainty answers (Figure 42) were used to adjust for hypothetical bias. Participants who answered that they would "probably not" or "definitely not" want the rates increase in reality are assumed to have a true WTP of zero. This reduced user WTP by an average of 24 per cent and non-user WTP by 49 per cent across the three regions.

The other source of bias is non-response bias. This arises when people who respond to and/or complete a survey are different to those who don't. The email invitations for survey participants did not specify the topic so there was no opportunity for self-selection by people interested in fresh water. However, only 68 per cent of people completed the survey after starting it. Some people may have dropped out due to having no interest in fresh water quality. As per Mitchell and Carson (2013) I use the most conservative adjustment and assume that all non-completers have a true WTP of zero. This reduces WTP by 42 per cent (after the hypothetical bias adjustment).

If a policy passes a benefit-cost test after this adjustment then non-response bias is irrelevant. If it passes before the adjustment but not after, then non-response bias needs closer scrutiny.

7.3 Scenario 1: improvement across the catchment

This hypothetical scenario is based on a 30 per cent reduction in median nitrogen and total phosphorus across the entire catchment. The following two charts show the effect on distributions of median N and P levels for all monitored sites.

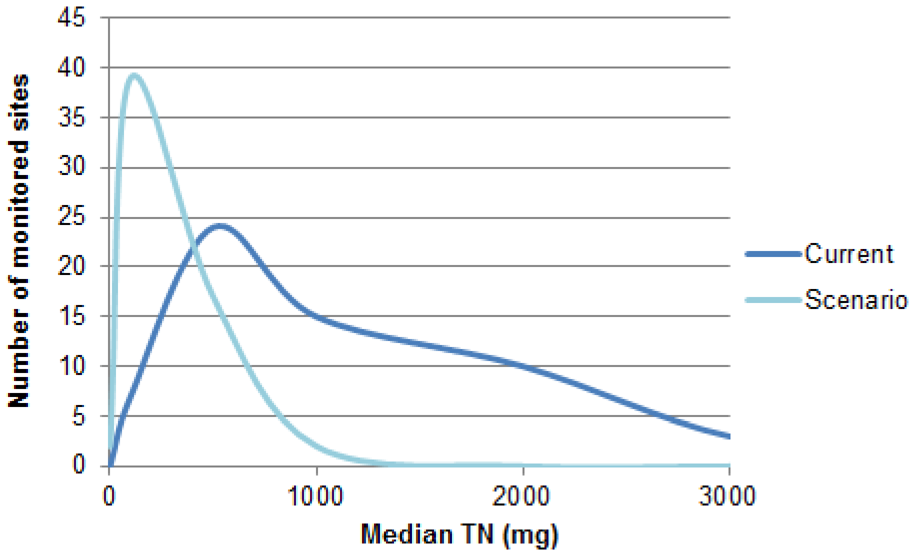


Figure 55 – Median Total Nitrogen across all monitored sites

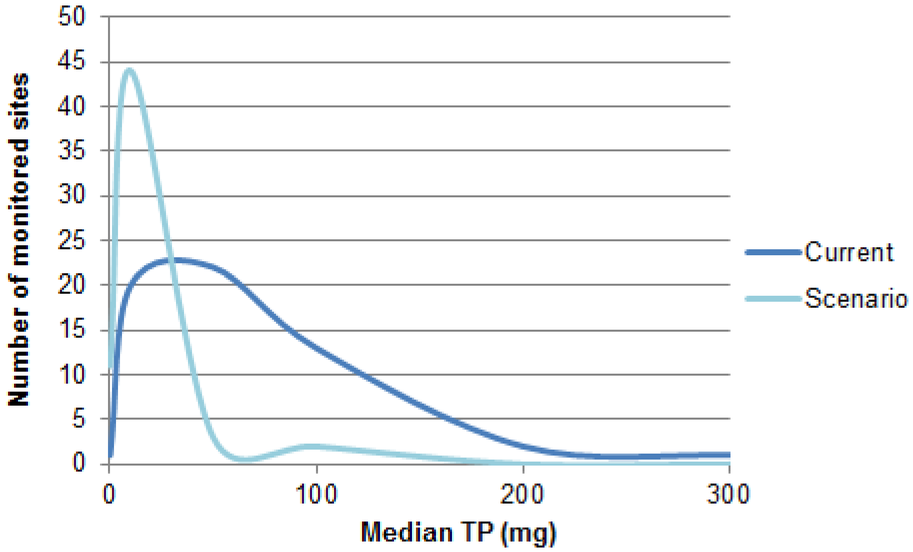


Figure 56 – Median Total Phosphorous across all monitored sites

N and P are directly related to the "ecosystem health" attribute used in the whole-catchment choice cards. The 30 per cent reduction in N and P would result in the proportion of sites defined as "good" ecosystem health increasing from 4 per cent to 15 per cent.

Reductions in N and P would also affect water clarity by reducing suspended chlorophyll levels. There is currently no information available about how significant the improvement would be so the value of clarity is ignored for this analysis. This means the benefit is likely to be understated.

7.3.1 Welfare effect per household

The change in welfare resulting from a change in the attributes is known as compensating variation (CV). See appendix 9.2 for the formula. The following table shows the CV users and non-users in each region for the quality changes in this scenario. The differences between regions are due to differences in characteristics of users from these regions. Users who travel from Auckland and Bay of Plenty have higher incomes and are less likely to be Waikato ratepayers (ratepayers have lower WTP). These figures have been adjusted for hypothetical and non-response bias as discussed in section 7.2.

Table 22 - Compensating variation by region and user/non-user household

	Waikato		Auckland		Bay of plenty	
	User	**Non-user**	**User**	**Non-user**	**User**	**Non-user**
Clarity	$0	$0	$0	$0	$0	$0
Infection	$0	$0	$0	$0	$0	$0
Eco Health	$59	$14	$77	$19	$95	$21
Total	$59	$14	$77	$19	$95	$21

7.3.2 Population use estimates

Recreational and cultural users of Waikato fresh water have higher non-market values than non-users so we need to estimate the proportion of users in the general population for a marginal benefit analysis. Appendix 9.7 describes the approach used to derive these estimates. The following table presents low, medium and high estimates for number of Waikato fresh water user households in the Waikato, Auckland and Bay of Plenty regions. There is no reliable information available about the number of users in other regions.

Table 23 – Estimates of users in the general population

Region	Dwellings	User % (low)	User % (med)	User % (high)	Users (low)	Users (med)	Users (high)
Waikato	152,496	45%	59%	65%	69,000	91,000	99,000
Auckland	473,448	7%	14%	30%	34,000	67,000	142,000
Bay of Plenty	103,500	8%	15%	30%	8,000	16,000	31,000
Total	729,444				111,000	174,000	272,000

7.3.3 Aggregated welfare effect

The household-level welfare effects are multiplied by the number of users and non-users in each region from Table 23 to calculate the total for each population. The following table shows the estimated non-market benefit of this scenario under different assumptions about the total number of users in the population. The total ranges from $18.9 to $28.3 million. The medium overall non-market value is $22.4 million. As mentioned above, this does not include any effects of N and P reductions on clarity.

Table 24 - Total WTP per year for different estimates of the total number of users

Region		Low use	Medium use	High use
Waikato	User	$4,100,000	$5,300,000	$5,800,000
Waikato	Non-user	$1,200,000	$900,000	$800,000
Waikato	Total	$5,300,000	$6,200,000	$6,600,000
Auckland	User	$2,600,000	$5,200,000	$11,000,000
Auckland	Non-user	$8,300,000	$7,600,000	$6,200,000
Auckland	Total	$10,900,000	$12,800,000	$17,200,000
Bay of plenty	User	$800,000	$1,500,000	$2,900,000
Bay of plenty	Non-user	$2,000,000	$1,900,000	$1,500,000
Bay of plenty	Total	$2,800,000	$3,400,000	$4,500,000
All 3 regions	**User**	**$7,400,000**	**$12,000,000**	**$19,700,000**
All 3 regions	**Non-user**	**$11,500,000**	**$10,400,000**	**$8,600,000**
All 3 regions	**Total**	**$18,900,000**	**$22,400,000**	**$28,300,000**

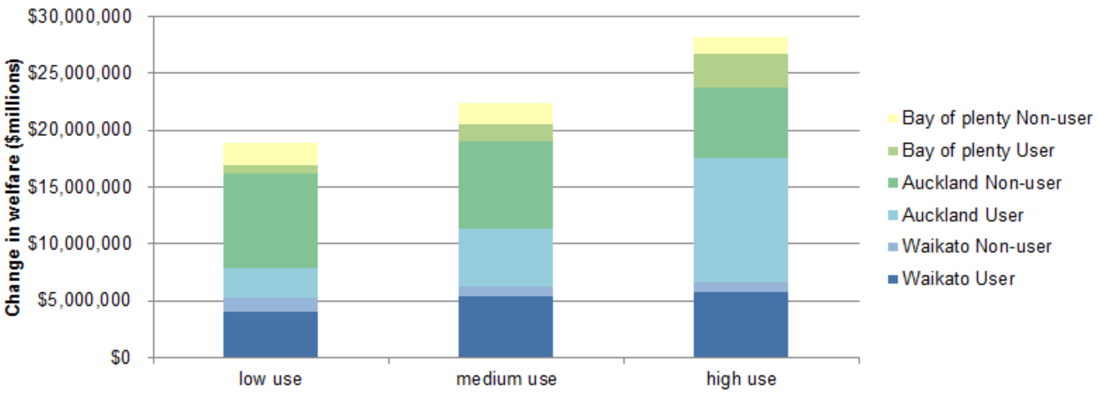


Figure 57 - Total welfare effect for scenario 1 for low, medium and high use estimates

7.3.4 Limitations of scenario 1

As mentioned above, this particular scenario does not include any effect of N and P reductions on clarity. It includes conservative adjustments for hypothetical and non-response bias so the total benefit is therefore likely to be understated.

Another limitation of this is that we do not include values from the rest of New Zealand. This is because we did not purchase a representative panel for the rest of New Zealand and have no reliable information about the total number of Waikato fresh water users in the rest of the country. We could extrapolate the distance-decay function for non-use values which would add another $6.3 million to the total non-use value for New Zealand but extrapolation is not a reliable method.

In conclusion, these various uncertainties include both positive and negative effects but the values provided in the table above represent the best estimate of marginal non-market value given the information currently available.

7.4 Scenario 2: prevent the decline in quality in the Waikato river from the upper to central zone

The central zone of the Waikato river (from Karapiro dam to Ngaruawahia) is the most commonly visited fresh water site in the Waikato-Waipa catchment, accounting for 24 per cent of in-catchment visits reported in the recreational use survey.

Fresh water quality in the upper Waikato river is superior to the water that flows through Hamilton, some 150km downstream. Nutrient levels increase significantly between Taupo and Karapiro and the ecosystem health category changes from “fair” to “poor” as per our definitions (see section 9.3.1). Average water clarity between Taupo and Karapiro is around 2.5 metres, compared with 1.6 metres in Hamilton. The human health risk does not change because the river at Hamilton is still grade “A” in terms of E.coli levels. For this scenario we evaluate the WTP to improve water quality in the middle Waikato river to be at least as good as the upper Waikato river.

7.4.1 Population recreational use estimates

The following table shows the estimated number of users for the middle zone of the Waikato river. The “medium” estimate is based on the proportion of people in the web panel sample who said they have used this part of the river for recreation or cultural activities in the past 5 years. The number of users (117,800) is 33 per cent fewer than for all fresh water sites in the Waikato-Waipa catchment (174,000).

Table 25 – Estimates of number of recreational users of the Waikato river, middle zone

Region	Dwellings	User % (low)	User % (med)	User % (high)	Users (low)	Users (med)	Users (high)
Waikato	152,496	30%	43%	56%	45,700	65,800	85,900
Auckland	473,448	5%	9%	17%	23,700	41,400	82,800
Bay of Plenty	103,500	6%	10%	20%	6,200	10,600	21,100
Total	729,444				**75,600**	**117,800**	**189,800**

7.4.2 Predicted change in visits and welfare impact using revealed preference model

The revealed preference model predicts that the number of visits to the central Waikato river would increase by 12 per cent in this scenario. There would be a corresponding decrease in visits to other sites, particularly Lake Rotoroa (-2 per cent), Lake Taupo (-1.2 per cent) and Lake Karapiro (-1.1 per cent).

The estimated welfare effect is a net benefit of $5.16 per trip. The estimated number of users is 214,000 and the average fresh water user makes 15 trips per year so this implies a total benefit of $16 million per year.

7.4.3 Welfare effect per household using stated preference model

The following table shows average WTP per household for users and non-users (of the middle stretch of the Waikato river) in the three regions. These figures have been adjusted for hypothetical and non-response bias as discussed in section 7.2. Bay of Plenty users have the highest stated WTP on average but there are fewer of them, as shown in the next section

Table 26 - Compensating variation by region and user/non-user household

	Waikato		Auckland		Bay of plenty	
	User	Non-user	User	Non-user	User	Non-user
Clarity	$36	$8	$41	$12	$49	$15
Infection	$0	$0	$0	$0	$0	$0
Eco Health	$72	$16	$81	$24	$98	$30
Total	**$108**	**$23**	**$122**	**$37**	**$146**	**$45**

7.4.4 Aggregated welfare effect

The household-level welfare effects are multiplied by the number of users and non-users in each region from Table 23 to calculate the total for each population. The medium overall WTP is $22.7 million.

The WTP for users only (medium use estimate) is $13.7 million. This is lower than the $16 million given by the revealed preference model, which suggests that the bias adjustments may be too conservative. This should be kept in mind when considering the benefits alongside the potential costs of freshwater management scenarios.

Table 27 - Total WTP for different estimates of the total number of users

Region		Low use	Medium use	High use
Waikato	User	$4,900,000	$7,100,000	$9,300,000
Waikato	Non-user	$2,500,000	$2,000,000	$1,600,000
Waikato	Total	$7,400,000	$9,100,000	$10,800,000
Auckland	User	$2,900,000	$5,000,000	$10,100,000
Auckland	Non-user	$16,500,000	$15,900,000	$14,300,000
Auckland	Total	$19,400,000	$20,900,000	$24,400,000
Bay of plenty	User	$900,000	$1,600,000	$3,100,000
Bay of plenty	Non-user	$4,400,000	$4,200,000	$3,700,000
Bay of plenty	Total	$5,300,000	$5,700,000	$6,800,000
All 3 regions	**User**	**$8,700,000**	**$13,700,000**	**$22,400,000**
All 3 regions	**Non-user**	**$23,400,000**	**$22,100,000**	**$19,600,000**
All 3 regions	**Total**	**$32,100,000**	**$35,700,000**	**$42,000,000**

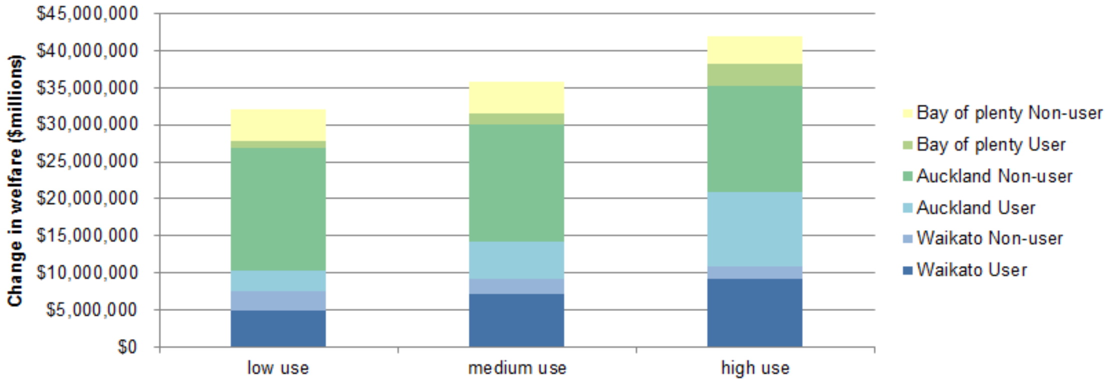


Figure 58 - Total welfare effect of scenario 2 for low, medium and high use estimates

7.4.5 Limitations of scenario 2

The limitations of scenario 2 are similar to those of scenario 1. We only have data for the three regions with the highest number of users of Waikato fresh water, but there are likely to be people with non-zero values outside of this area.

The benefit of looking at a specific area is that we can compare values from both the revealed and stated preference models and gain confidence from the fact that the use values are broadly consistent. However, it may not be so simple to define the effect and geographic scope of a real policy scenario.

8 Discussion and conclusion

In this report we have introduced the total economic valuation framework and presented the results of a study to estimate non-market values for recreation and cultural use of fresh water and non-use.

We explained the differences and relative advantages between revealed and stated preference methods and presented results derived from both methods. Then we defined two hypothetical scenarios for water quality improvements and estimated the total non-market value of that improvement.

8.1 Areas for further work

8.1.1 Development of scenarios

Other work streams such as hydrological modelling or policy development will identify other scenarios for which non-market values can be estimated. These scenarios will need to be framed in terms of the quality attributes and geographic scopes used in the models in this report.

For scenarios that focus on the upper Waikato catchment it may be appropriate to use the WTP values from previous studies of Lake Karapiro and Arapuni.

8.1.2 Other non-market valuation methods

One method that has not been discussed in this report is hedonic analysis. This is where the value of a landscape feature is estimated based on the effect of surrounding property values. This type of analysis may be worth investigating in future to provide additional information about the non-market value of visible characteristics such as water clarity or riparian planting.

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9 Appendix

The purpose of this appendix is to provide additional information about methods and models results that may not be of interest to the general reader.

9.1 Revealed preference model specification

To specify the model, it is assumed that on each recreational trip, an individual is faced with a choice of J possible freshwater sites to visit. Each individual is assumed to choose the site that gives them the highest level of satisfaction. A number of factors can influence an individual's choice of which freshwater sites to visit. These factors include the cost of accessing the site, freshwater site attributes and social-economic covariates. The choice of site for recreation is also affected by the characteristics of substitute sites. There are also factors that affect the decision but were not measured in the survey. These unobserved factors form the random component of the model.

Assuming that utility is additive, and further that an individual chooses freshwater site j over all other J sites in the choice set on a particular choice occasion, the total utility that an individual would derive from choosing site j is given by:

$$U_{nj} = V_{nj}\left(C_{nj},\ Q_j\ , Z_n\ \right) + \varepsilon_{nj} \qquad (1)$$

Where V_{nj} is representative part of utility that can be observed by the researcher which depends on the cost of accessing the site, freshwater site attributes and social-economic covariates which are further outlined below.

C_{nj} is the implicit price of accessing freshwater site j for individual n which includes fuel expenses and the opportunity cost of travel time;

Q_j is a vector of freshwater site attributes;

Z_n is a vector of individual social-economic covariates;

ε_{nj} represents other factors influencing individual's choice of freshwater sites that are unknown to the researcher.

Travel cost random utility models are most appropriate for day recreational trips (Parsons, 2003). To ensure that day trips are used in the analysis, we use a cut-off point of 150 – 180 miles or (241 – 290 km) which is a commonly used distance measure for day recreational trips (McConnell & Strand, 1994; Parsons & Kealy, 1992). A 241 km benchmark is used for aggregated sites while 290 km is applied to individual sites. In general, we expect people to be willing to travel longer distances to popular recreational sites especially those outside their home regions. A brief description of the other variables used in estimation is given in the subsequent section.

9.1.1 Specification of alternatives

Estimation of travel cost random utility models requires the determination of the appropriate substitute sites for each individual in the sample. A number of approaches have been proposed in the literature. In this analysis a combination of partial aggregation and distance measure is used. Under partial aggregation, the most popular recreational sites and sites of policy interest enter choice sets as individual sites and less popular sites are aggregated (Lupi & Feather, 1998; Parsons, Plantinga, & Boyle, 2000). The distance measure approach is explained in the subsequent paragraphs.

9.1.2 MNL model

This multinomial site choice model models attempts to explain the (log) likelihood that a person will choose to visit a particular site at any choice situation. A positive and statistically significant coefficient means the variable is associated with a higher likelihood of the site being visited.

The results show that travel cost has a negative effect, as expected. Water clarity has a positive effect. The other water quality variables (swimmability, ecosystem health and trophic state) were too highly correlated with water clarity to have any explanatory power. The clarity variable by itself provided the best model fit. In revealed preference analysis it is generally the most noticeable features that explain choices. People can see how clear the water is but they can't see bacteria levels or ecosystem health so we would not expect these variables to have a large impact on choice.

Being in an urban area has a positive effect. This may be because urban sites tend to have better facilities and be close to services and shops. It may also be capturing a familiarity effect – if people drive past a river on a regular basis it may seem like an obvious choice for freshwater recreation. Being surrounded by native or exotic forest also has a positive effect.

In the earlier Water Values survey (Versus Research, 2012) people stated that they prefer waterways to have a natural appearance but the negative coefficient on "undeveloped" in this model suggests that they are less likely to visit sites in undeveloped areas – perhaps due to a lack of facilities or difficult access.

Several interaction effects were tested but the only two that were significant were near-water recreation at sites unsafe for food gathering, and on-water recreation at sites prone to low flows. Both interactions were negative.

The alternative-specific constants indicate that there are variables missing from the model that are also important for explaining site choices. The constant for Lake Taupo is negative (Upper Waikato is the base case) which means that although it is a very popular destination, it should be even more popular if the variables in this model were the only predictors. Water clarity at Lake Taupo is higher than any other site, and there are both urban areas and forest nearby. One possibility is that the attributes do not have a strictly additive effect as the model assumes – for example, cleanliness may have no value if there are no facilities. Various interactions of this type were tested but it is infeasible to try every possible combination of every variable. Another possibility is that water clarity has diminishing benefits at higher levels. There are not enough sites with high water clarity to verify this but it would conform to the general principle of economic satiation.

There is a negative constant for central Waikato management zone and positive for lower Waikato management zone. However, the following table shows that these constants only have a very minor adjustment effect on choice probabilities.

Table 28 - MNL model of site choice

Variable	Coefficient		95% Confidence Interval	
Travel cost (one-way)	-0.030	***	-0.035	-0.025
Water clarity (metres)	0.904	***	0.641	1.167
Urban (% of land in a 1km radius of the sites)	5.854	***	4.315	7.392
Exotic forest (% of land in a 1km radius of the sites)	1.521		-1.476	4.518
Native forest (% of land in a 1km radius of the sites)	4.661	***	1.343	7.979
Perceived good facilities	3.363	***	1.770	4.956
Perceived good access	0.863		-0.598	2.325
Perceived Undeveloped	-1.966	***	-3.210	-0.722
Perceived cleanliness	2.280	***	0.621	3.939
Nearwater recreation & unsafe food interaction	-4.845	***	-7.880	-1.810
Onwater recreation & low flow interaction	-5.576	**	-9.832	-1.320
Constant for Lake Taupo (compared with Upper Waikato)	-8.163	***	-10.941	-5.385
Constant for Lake Taupo Management Zone	-0.390		-1.205	0.425
Constant for Central Waikato Management Zone	-1.551	***	-2.614	-0.488
Constant for Lower Waikato Management Zone	2.324	***	1.583	3.065
Constant for Waipa Management zone	0.485	*	-0.071	1.041
Constant for Other Management Zone	0.478		-0.375	1.330
Log-likelihood	-1740.41			
Log-likelihood (Alternative specific constants model only)	-2898.54			
McFadden R-squared	0.40			

9.1.3 Trip count model

Table 29 - Results of Negative Binomial Count Model

Variable	Coefficient	z	95% Confidence Interval	
Constant	2.90163***	49.93	2.78773	3.01553
Inclusive Value	-0.001	-0.72	-0.00372	0.00172
AGE (1 if 60 year and over)	-0.17084**	-2.4	-0.3102	-0.03149
MALE (1 if Male and 0 if female)	-0.00032	-0.22	-0.00314	0.0025
CHILDREN (1 if children in the household)	0.00027	0.54	-0.00071	0.00125
Post-school educated (1 if post school educated)	0.00100**	2.2	0.00011	0.0019
Dispersion parameter for count data model				
Alpha	2.05512***	14.12	1.76994	2.3403
Log-likelihood	-3606.88			
McFadden R-squared	0.87			

9.2 Scenario analysis using revealed preference model

These changes were simulated using the log-sum formula procedures by Hanemann (1982) given below.

$$CV = \frac{ln\left[\sum_{j=1}^{J} e^{V_j\left(Q_j^{w^0}\right)}\right] - ln\left[\sum_{j=1}^{J} e^{V_j\left(Q_j^{w^1}\right)}\right]}{\alpha_m} \quad (3)$$

where CV is the expected per trip welfare measure.

V_j represent the deterministic component of utility evaluated based upon the estimated coefficients from the multinomial site choice model and α_m is the marginal utility of income, which is equal to the negative of the cost of travel cost coefficient.

We change the values for site quality and then use the Nlogit software package to simulate the adjusted site choice probabilities using the attribute coefficients previously estimated.

9.3 Choice experiment design

9.3.1 Attributes and levels

Water quality attributes of interest consisted of clarity, contact health risk (swimmability) and ecosystem health. We needed objective indicators that may be easily linked to monitoring data and hydrological models so there is less of a focus on invertebrate biodiversity than in other freshwater choice experiments assessed in the literature review. The ranges had to be wide enough to include existing quality levels and realistic improvements.

Individual site attributes
For clarity we used the black-disc measure widely used in Waikato freshwater monitoring (the median of the past 5 years). The levels used in the design are based on current water quality at the 5 sites, the lowest being 0.2 metres in Komakorau and the highest being 3.5 metres in Mangauika. The level 2.5 metres was also included because otherwise the jump between 1.6 and 3.5 metres would have been too large to be a realistic improvement.

It would not be realistic to use every level with every site (some waterways are naturally higher in sediment) so a reasonable range was developed in consultation with water quality scientists[5]. Note that the ranges are not *proven* to be feasible but they provide enough variation to estimate welfare effects without being obviously unrealistic. Clarity and health risk are continuous variables so any value within the range can be interpolated.

The following Table 11 shows the clarity levels for each and corresponding images used to represent the levels. The images were appreciated by focus group participants and preferred to colour codes but clarity was the only attribute for which we could provide corresponding images

The current situation is the lowest quality level for every site except Mangauika, where the current quality is the highest level.

Table 30 - Clarity levels used in choice tasks

Lower Waikato		0.6m (Poor)	1.1m (Poor)	1.6m (Fair)		
Mid Waikato				1.6m (Fair)	2.5m (Good)	
Waipa		0.6m (Poor)	1.1m (Poor)	1.6m (Fair)		
Mangauika				1.6m (Fair)	2.5m (Good)	3.5m (Very good)
Komakorau	0.2m (Very Poor)	0.6m (Poor)	1.1m (Poor)	1.6m (Fair)		

For health risk we used 95^{th} percentile E. coli counts (averaged over 5 years) and converted this to expected number of infections from primary contact and a label from “very poor” to “good” based on suitability for recreation grades. Table 12 shows the levels used for each site. The alternative levels were simply created by shifting each site up (or down, for Mangauika) one suitability grade. The middle Waikato river site already achieves the best grade in terms of infection risk so the attribute did not vary for this site.

[5] Bill Vant and Ton Snelder

Table 31 - Health risk (infections per thousand) levels used in choice tasks

Lower Waikato		**100** (Very poor)	**50** (Poor)		
Mid Waikato					**1** (Good)
Waipa		**100** (Very poor)	**50** (Poor)		
Mangauika			**50** (Poor)	**10** (Fair)	
Komakorau	**300** (Very poor)	**100** (Very poor)			

Ecosystem health was the most problematic attribute because there are many different understandings and measures of the concept. The indicators of most interest to policy makers are nitrate toxicity and chlorophyll A. Nitrate toxicity is not an issue for the majority of Waikato waterways because levels are too low to be toxic. We lacked chlorophyll data for most sites but chlorophyll is dependent on levels of nitrogen and phosphorus nutrients in the water so these were used instead. However, focus group testing revealed that people found the terms “nitrogen” and “phosphorus” too technical and abstract to be useful in making choices. For the final survey we constructed levels which are based on total nitrogen and phosphorus but the text and labels are derived from trophic state descriptions[6].

Table 13 shows the levels used for ecosystem health for each site. Similarly to health risk, the alternatives to current conditions were derived by shifting up or down a grade.

Table 32 - Ecosystem health levels used in choice tasks

Lower Waikato	**Very Poor** Very high levels of nutrients and algae. Unsuitable for sensitive species	**Poor** High levels of nutrients and algae. Sometimes unsuitable for sensitive species		
Mid Waikato		**Poor** High levels of nutrients and algae. Sometimes unsuitable for sensitive species	**Fair** Moderate levels of nutrients and algae. Usually suitable for sensitive species	
Waipa	**Very Poor** Very high levels of nutrients and algae. Unsuitable for sensitive species	**Poor** High levels of nutrients and algae. Sometimes unsuitable for sensitive species		
Mangauika			**Fair** Moderate levels of nutrients and algae. Usually suitable for sensitive species	**Good** Low levels of nutrients and algae. Very suitable for sensitive species
Komakorau	**Very Poor** Very high levels of nutrients and algae. Unsuitable for sensitive species	**Poor** High levels of nutrients and algae. Sometimes unsuitable for sensitive species		

[6] http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Lakes/Water-quality-glossary/

The final attribute was change in annual rates (or taxes, for non-ratepayers). The following Figure 59 shows a sample choice card. The order of the water quality attributes was randomised but cost always appeared at the top of the card to maximise the likelihood of people paying attention to it. Alternative order was also randomised, so the "current condition" (status quo) option could be on the left, right or middle of the table.

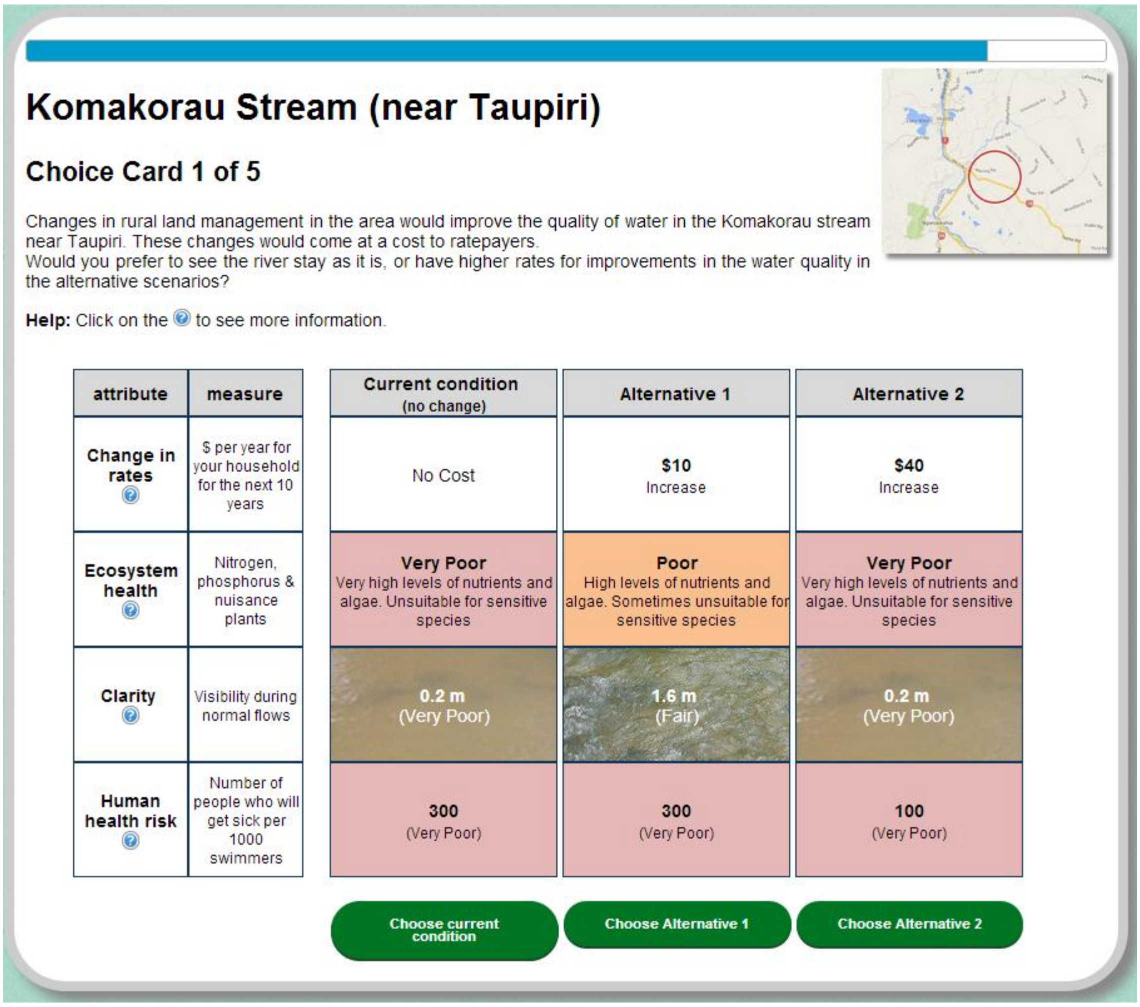

Figure 59 - Sample choice card for individual site

9.3.2 Part-whole bias and whole-catchment attributes

Part-whole bias is a discrepancy in individual valuations of goods that are part of a larger good. If the component goods (e.g. streams and rivers) are evaluated separately, the sum may exceed the value for the whole (e.g. a whole catchment) (Carson and Mitchell, 1995). There is evidence part-whole bias also exists for private goods and real transactions (Bateman et al., 1997). Causes for this phenomenon may include substitutability, budget constraints, or the "warm glow" effect where people value contributing to a cause rather than the economic outcome.

Whole-catchment water quality indicators

It is more difficult to represent and communicate the overall level of water quality in a catchment compared with individual waterways. In focus groups we tested reporting the median water quality, infection risk and nutrient levels but people found these measures difficult to comprehend on a whole-catchment basis. For the final version we set a target for each indicator and reported the percentage of monitored sites meeting these targets. The target for clarity was 1.6 metres, representing the level considered suitable for swimming. The human health risk target was the highest grade for recreation suitability, 1 or fewer infections per thousand. The target for ecosystem health was the level described as "good".

An alternative representation could have been to report the total length or volume of freshwater meeting these targets. However, it was deemed too complicated to determine what area or volume each monitoring point represents.

Pie chart versus per cent representation
We tested two slightly different visual presentations of the levels and randomly selected a version to show participants. The first presentation was simply a table stating the percentage of sites that meet the target. The alternative presentation was pie charts showing the per cent achieved in green and the rest in orange. Figure 38 shows a sample choice card with the pie charts. The results (section 5.4.2) show that the pie charts are associated with lower choice error but make no difference to WTP.

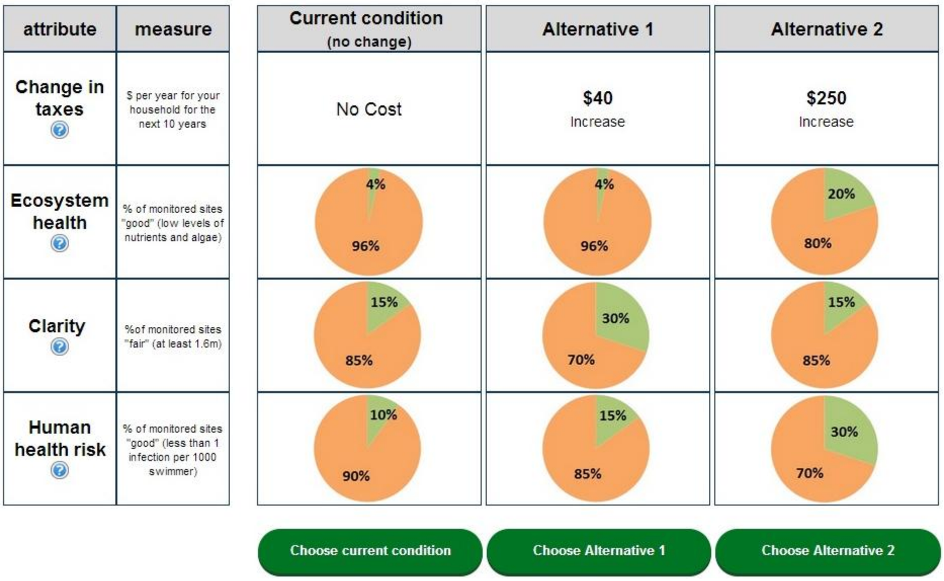

Figure 60 - Catchment choice card with pie charts

attribute	measure	Alternative 1	Alternative 2	Current condition (no change)
Change in taxes	$ per year for your household for the next 10 years	$160 Increase	$160 Increase	No Cost
Human health risk	% of monitored sites "good" (less than 1 infection per 1000 swimmer)	30%	15%	10%
Clarity	%of monitored sites "fair" (at least 1.6m)	30%	15%	15%
Ecosystem health	% of monitored sites "good" (low levels of nutrients and algae)	4%	20%	4%
		Choose Alternative 1	Choose Alternative 2	Choose current condition

Figure 61 - Catchment choice card without pie charts

9.3.3 Experimental design

The design (combination of attributes and levels for each card) was optimised for each site using Ngene[7] software. The initial design was D-efficient with wide Bayesian prior values for each attribute. Values obtained from the pilot test were used to refine the design. The design was split into ten blocks per site so each participant received one

[7] ChoiceMetrics (2012) *Ngene 1.1.1 User Manual & Reference Guide*, Australia

choice card for each site. Estimated design D-error (the determinant of the asymptotic variance-covariance matrix) ranged from 4 to 14 per cent for the different sites.

9.4 Weighting of stated preference data

Sampling and non-response bias arise when sub-groups of the population have a different probability of being selected for, or responding to a survey. The data is pre-weighted to adjust age and education to conform to census 2013 counts. These variables were chosen because the sample was skewed towards an older, more highly educated demographic and the census data is conveniently available as a two-way table. The 15-19 age group was excluded from the census counts because the sample is supposed to be 18 or older. There were a small number of 15-19-year-olds (2 per cent) in the sample and these were not re-weighted.

Adding the weights to the model had the effect of reducing WTP by approximately 5 per cent but did not affect significance of the estimates or overall model fit. Variables that appear in the final model (such as Māori ethnicity and attitudinal variables) may be used to do further ex-post weighting of WTP as required.

The chart below compares the means of other variables before and after weighting. Average choice certainty, ratepayers, users and water-as-a-top-3-issue decrease after weighting. People with Māori ethnicity and those with low understanding of the task have increased weight. The high income variable is not significantly affected by the weighting, even though income is correlated with education level. Census income data is scheduled for release in October 2014 so not currently available to compare with the sample income distribution.

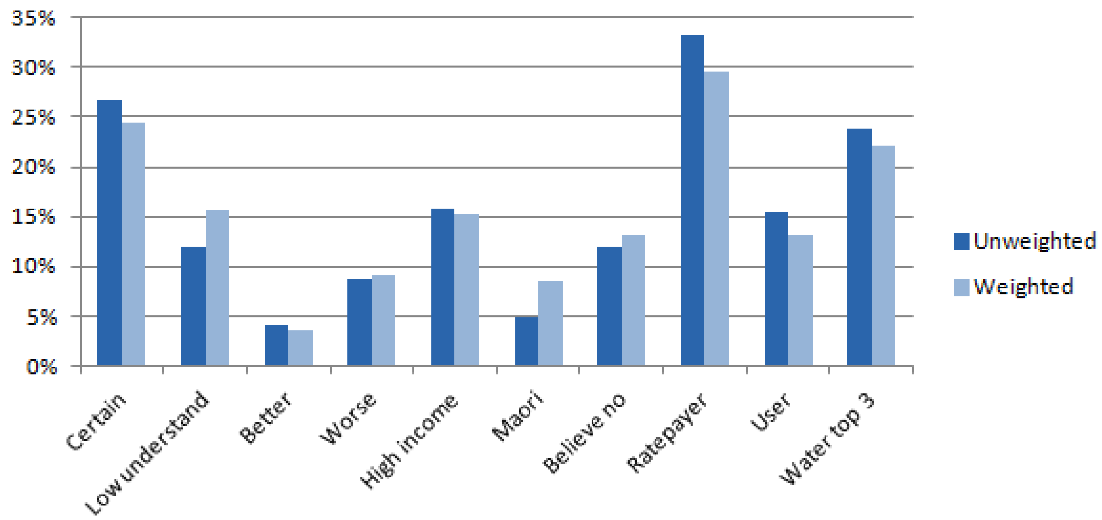

Figure 62 - Demographic and attitudinal variables before and after weighting

9.5 Stated preference model specification

It is well known that people exhibit substantial heterogeneity in how they make choices, both in choice experiments and in real life. This heterogeneity may take the form of taste variation (people more strongly prefer different attributes) or variation in the random, unobserved component of choice. Both forms of heterogeneity have the potential to bias welfare estimates if not controlled for.

Approaches to deal with taste variation include interacting attribute coefficients with demographic variables or a mixed logit model with random parameters for one or more attributes. If the parameters are specified with discrete mixing distributions the model is known as a latent class model.

Heterogeneity in the random component of choice (the scale factor) means observations with systematically larger random variance will receive less weight in estimating the coefficients for the observed variables. Welfare estimates may be biased (in either direction) and parameter distributions may be confounded with unobserved variation (Louviere et al., 2002). Recent literature cautions that mixed logit models may be misspecified because much of the heterogeneity in choice models is actually in scale not taste (Meyer, 2008). Latent classes do allow for variation in scale but may understate the extent of heterogeneity in choice data (Fiebig et al., 2010). Correlated errors can be incorporated in a mixed logit model but if the main source of heterogeneity is in the scale factor then a heteroscedastic MNL model is a much more parsimonious approach.

Several authors have used parameterized heteroscedastic MNL (S-MNL) models where the scale factor is allowed to vary for different individuals or choice tasks. Parameters found to be significant in explaining this heteroscedasticity include design factors (e.g Caussade et al., 2005) and factors relating to individual cognitive ability or effort (Swait and Adamowicz, 2001).

Recent literature has demonstrated it is possible to accommodate both taste and scale heterogeneity in a single model by nesting S-MNL and mixed logit models. Known as “generalized multinomial logit model” or G-MNL (Fiebig et al., 2010), this is a very flexible specification that can accommodate a wide range of individual choice behaviours. We test the G-MNL specification for this analysis and find that very good model fit is achieved with a combination of fixed effects and just one random parameter.

9.5.1 Independence of Irrelevant Alternatives

The standard multinomial logit model requires an assumption that errors (the random component) are identically and independently distributed. This results in a property known as independence of irrelevant alternatives (IIA) which means that if the quality of an alternative changes, the probabilities of choosing other alternatives will adjust so that the probability ratios between sites stay the same. This assumption may not hold in reality, if some alternatives are closer substitutes than others. If IIA does not hold then using the model for scenario analysis will give incorrect results.

The S-MNL model was tested for IIA violation using the Hausman-McFadden test and a log-likelihood test with additional variables for two out of three alternatives. Both test statistics were highly significant, indicating the IIA assumption is not valid for this dataset even though it is an unlabelled choice experiment.

Models which allow correlation between alternatives relax the IIA assumption. These include nested logit, heteroscedastic extreme value (HEV), mixed logit, latent class and G-MNL which nests mixed logit. A nested logit specification was tested with a separate branch for the status quo alternative, but the IV parameter was not significantly different to one. An HEV specification was tested by including an alternative-specific constant or random parameter in the scale function but neither was significant. The mixed logit and latent class models did not provide as good a fit as the S-MNL. The final model chosen was therefore a G-MNL combining the S-MNL model with a single alternative-specific random parameter.

An attribute-non-attendance latent class model was also tested but this model had significantly worse fit then the more flexible G-MNL. A G-MNL model is capable of accommodating a wide variety of choice behaviour including attribute non-attendance.

9.6 Stated preference model estimates

The following Table 33 shows estimated parameters for the stated preference model including individual sites and the whole-catchment choice cards. The table is arranged with alternative-specific constants first then single-site attribute coefficients, whole-catchment attribute coefficients, interaction variables and scale parameters.

Table 33 - Stated Preference estimated model

Parameter	Value	Std Error	p-value
Constant for leftmost alt	0.0476	0.00896	0
Constant for middle alt	0.025	0.00906	0.01
Status quo constant	-0.0554	0.0139	0
Cost	-0.00192	0.000242	0
Clarity (m)	0.0529	0.0226	0.02
Clarity squared	0.0247	0.006	0
Infection risk per 1000	-0.00553	0.000437	0
Infection squared	0.0000131	0.00000111	0
Ecosystem health poor	0.164	0.0134	0
Ecosystem health fair	0.441	0.0296	0
Ecosystem health good	0.516	0.0359	0
Per cent of all sites clarity > 1.6m	2.18	0.337	0
Per cent of all sites with <=1 infections	0.72	0.296	0.01
Per cent of all sites good eco health	1.91	0.327	0
Interaction cost * user	0.00123	0.000961	0.2
Interaction cost * ratepayer	-0.000717	0.00016	0
Interaction cost * high income	-0.0000781	0.000171	0.65
Interaction cost * Māori	0.000294	0.00023	0.2
Interaction cost * certainty = "definitely"	0.00142	0.000239	0
Interaction cost * certainty = "probably"	0.000985	0.000189	0
Interaction cost * certainty = "probably not"	-0.00195	0.000246	0
Interaction cost * certainty = "definitely not"	-0.00775	0.000497	0
Interaction cost * site better than sq	-0.000433	0.000391	0.27
Interaction cost * site worse than sq	0.000868	0.000237	0
Interaction cost * infeasible improvements	-0.000657	0.00023	0
Interaction cost * water top 3 issue	0.000652	0.000146	0
Interaction cost * travel time	-1.93E-06	0.000000878	0.03
Interaction cost * travel time * use	-4.12E-07	0.00000201	0.84
Interaction cost * Mid Waikato	-0.000368	0.000213	0.08
Interaction cost * Waipa	0.000257	0.000197	0.19
Interaction cost * Mangauika	-0.000457	0.00045	0.31
Interaction cost * Komakorau	0.000172	0.000348	0.62
Interaction cost * whole catchment	-0.000174	0.000273	0.52
Scale shifter - high certainty	0.889	0.0656	0
Scale shifter - didn't understand	-0.121	0.0888	0.17
Scale shifter - pie charts	0.569	0.14	0
Scale shifter - whole catchment choice card	-0.872	0.118	0
Scale shifter - minutes	0.0134	0.00583	0.02
Random parameter standard deviation	0.249	0.02106599	0
Log-likelihood			**-6588.06**
Adjusted psuedo r-square			**0.167**

9.6.1 Alternative-specific variables

The model includes two constants to indicate the position of the alternative chosen. These are to account for left-right bias, which is a common finding in choice experiments and surveys in general. The order of alternatives was randomised for each participant. The coefficients are both positive and significant indicating the right-most alternative was less likely to be chosen, all else being equal.

The status quo is negative and significant, indicating the “no change” option was less preferred, all else being equal.

9.6.2 Water quality attributes

Water clarity is a continuous variable in reality, but only had five discrete levels in the choice experiment. Linear, dummy coded and polynomial specifications were tested. The dummy coded coefficients displayed a convex curve indicating that the difference between 2.5 and 3.5 metres is valued more highly than the difference between 0.6 and 1.6 metres, for example. A second-order polynomial fits this curve very well and requires fewer variables so the final model includes clarity and clarity squared instead of the dummy-coded variables. Care should be taken not to extrapolate this curve beyond the bound of the clarity range used in the choice experiment (0.2 to 3.5 metres) because the law of diminishing returns implies that the function would probably be concave at higher levels.

The infection risk attribute was similarly dummy coded but the resulting curve is concave. The value of the difference between 300 and 100 infections is almost the same as between 10 and 1 infection. Again, a second degree polynomial fits well enough within the range 1 to 300. Number of infections has a negative coefficient, and infections squared is positive.

Ecosystem health is a categorical variable so can only be dummy coded. The three coefficients for “poor”,”fair” and “good” (base case being “very poor”) are all significant, positive, and increasing in magnitude as expected.

The water quality attributes for the whole-catchment choices are coded differently. They represent the percent of monitored sites that meet the target specified for clarity, infection risk and ecosystem health. All three variables are positive and significant and are compared with individual site attributes in section 5.4.4.

9.6.3 Interaction variables

An interaction variable shifts the coefficient of an attribute such as clarity or cost to account for discrete differences in preferences between different groups of people. Interaction variables are not as flexible as fully random parameters but are a lot more parsimonious and are often sufficient to explain an effect. Interaction variables are also useful for examining differences within subgroups of the population. To do the same with a random parameter or latent class one would need to identify the relationship between the subgroup and parameter distribution or class probability, requiring a much more complex model that may not even converge.

A range of interaction variables were tested including demographic, attitudinal and site specific factors. There were no significant interaction effects found for water quality attributes, only cost. The pie-chart treatment was not significant as an interaction variable.

Demographic interaction variables
An income effect is a generally expected finding in WTP because people with more disposable income are able to pay more. However, income in this dataset is correlated with choice certainty. The high income interaction is positive as expected but not statistically significant. The low income interaction is insignificant even when choice certainty is not in the model. There could be larger hypothetical bias amongst low income individuals because they may (quite rightly) believe that little of the public cost will fall on them anyway.

People who identified as being of Māori ethnicity are willing to pay more on average. Waikato ratepayers are willing to pay less (after controlling for level of use). Ratepayers might be less prone to hypothetical bias because they think the prospect of a rates increase to pay for water quality is more likely that a general tax increase.

Other variables such as age, gender and education level were insignificant after controlling for use and attitudinal variables.

Attitudinal interaction variables
People who believe that the site is in worse condition than stated are willing to pay more, on average, and people who believe the site is better are willing to pay less. This is an intuitive result because the perceived current condition affects the expected utility change for these people. People who believe that the suggested improvements are infeasible are willing to pay less. People who ranked water quality as one of the top 3 issues are willing to pay more.

Site-specific interaction factors
People who said they had used a site for recreation or cultural activities are willing to pay more. Having seen a site recently has a smaller effect and is insignificant after including the use variable so it is not included in the final model. Interactions between types of use and the different water quality attributes (e.g. clarity and in-water recreation) were tested but none were significant.

Travel time from participants' homes to each site was included in the model and the significant and negative coefficient means that willingness to pay declines with distance, as expected. Travel time squared was not significant, indicating the effect is approximately linear over the sample range. The three-way interaction between travel time, use and cost was included to test whether use value declines faster than non-use value, as the literature suggests it should. The coefficient is the expected sign but not statistically significant from zero.

There are also interactions between cost and a constant for each site, to determine if willingness to pay varies from site to site after controlling use, current quality and other variables. The reference is site 1, lower Waikato River. Only middle Waikato river has a significant constant. The negative coefficient for middle Waikato river could caused by non-linear effects on other variables that the model does not account for. The WTP charts in section 5.4.3.3 show that the impact of this variable is small in any case.

It was expected that the streams would have lower WTP than the river sites but the interaction variables show no statistically significant evidence of this.

The whole-catchment cost interaction variable is positive and significant. The whole-catchment and individual site choices only have the cost attribute in common because aggregate and site-specific quality measures are not directly comparable.

9.6.4 Scale parameters

The choice probabilities are specified by:

$$(1)\quad P(j|X_{nt}) = \frac{1}{D}\sum_{d=1}^{D}\frac{\exp(\sigma^d\beta+\gamma\eta^d+(1-\gamma)\sigma^d\eta^d)X_{njt}}{\sum_{k=1}^{J}\exp(\sigma^d\beta+\gamma\eta^d+(1-\gamma)\sigma^d\eta^d)X_{nkt}}$$

(Fiebig et al., 2010). The parameterized scale factor is required to be positive, and so is specified as an exponential function of a sum of explanatory variables to increase or decrease the scale, which is normalised to one. The specification of the scale factor is:

$$(2)\quad \sigma_{tn} = exp(1 + \sum\gamma_k V_{ktn})$$

where V is a vector of parameters relating to choice task t for individual *n*. The scale factor is proportional to the inverse of the variance of the random component so parameters with a positive coefficient are associated with *lower* choice error, and vice versa.

The design parameters we tested included a dummy variable indicating the choice card is for the whole catchment and a dummy variable for the pie chart treatment. The whole-catchment scale parameter is negative, indicating the whole-catchment choices were more random. This perhaps illustrates the difficulty of communicating and/or comprehending a catchment-wide change in water quality. The pie chart coefficient is positive and significant, indicating that using the pie charts instead of percentages helped reduce choice error.

The remaining scale parameters relate to the measures of effort and or the ability-complexity gap for each individual. Stated choice certainty is the most significant variable, with people being more certain of their choice displaying lower choice error. People who said they did not understand the choice tasks had higher choice error, as expected. Higher education was a weaker explanatory variable and not significant after including stated understanding so is not included in the final model.

Choice card order was tested as a scale parameter because learning and fatigue affects can affect the scale factor. However, there were no significant order effects found in this data and the order variables are left out of the final model.

Time taken to complete the choice task is a significant positive scale parameter. The rationale is that people who spend more time on the task make more thoughtful choices, after controlling for cognitive ability or understanding. We cannot know if a person was actually focussing on the task for the whole time the page was open but time is still highly significant regardless. Time squared was tested as a scale parameter and was negative but insignificant, indicating that the time effect is close enough to linear over the sample range. The following Figure 63 illustrates the distribution of times (cut off at 5 minutes - the 97.5th percentile) and the corresponding scale effect.

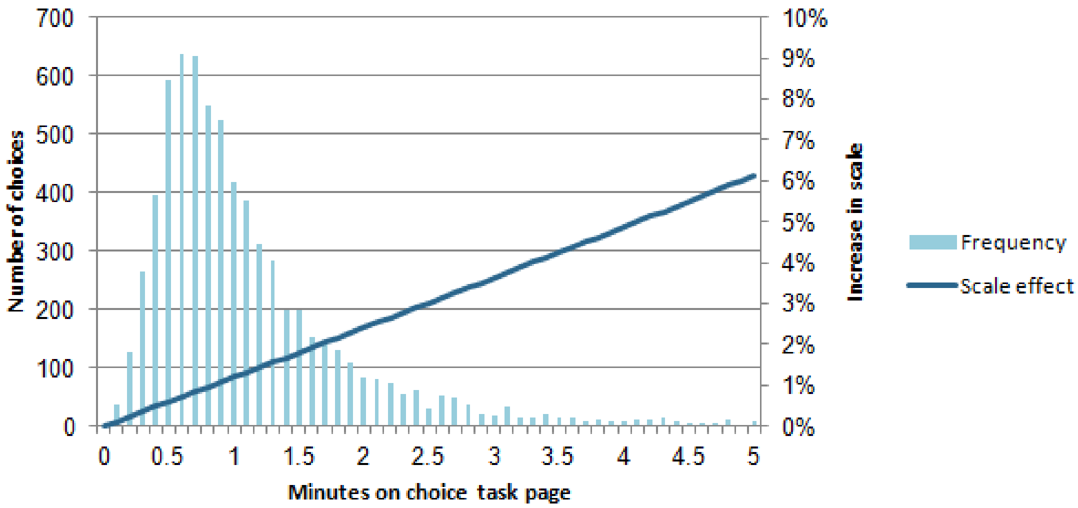

Figure 63 - Time to complete choice card and related change in scale

9.6.5 Random parameters

The G-MNL specification allows for random or individual parameters both in the scale and linear utility specification. A variety of random parameters were tested but the model suffered from convergence issues when multiple random parameters were included, or random parameters for attributes were included in the same model as fixed scale parameters and interaction variables. A mixed logit model with no scale parameters was not as good a fit as a heteroscedastic model with cost interaction variables. The final (preferred) model has only one alternative-specific random parameter for the non-status quo alternatives. This parameter does not add much to model fit but neatly solves the issue of IIA discussed below.

9.7 Combined model specification and results

To allow for correlation across attributes and alternatives we specify the vector of attribute coefficients (β) as random variables with a mean $\bar{\beta}$ and variance σ^2. The utility (benefit) that an individual obtains from a choice is specified as:

$$U_{ni} = (\bar{\beta} + \sigma \eta_n) X_{ni} + \varepsilon_{ni} \qquad (1)$$

Where x is a vector of explanatory variables (e.g. cost and water quality), *i* is the choice situation and *n* is an individual. The error term is independently and identically distributed similar to a standard MNL model[8]. The covariance between the RP and SP attributes is:

$$Cov(e_{ni}^{RP}, e_{ni}^{SP}) = \sigma^2 (X_{ni}^{RP}, X_{ni}^{SP}) \qquad (2)$$

The choice probability across *j* alternatives, conditional on β_{ni} is:

$$L_n(\beta_n) = \frac{e^{\beta_n X_{ni}}}{\sum_j e^{\beta_n X_{nj}}}$$

To obtain the unconditional choice probabilities we integrate over all values of β.

9.7.1 Parameters

Aside from the random parameters, the parameters in the joint model have the same meaning as those in the separate models presented in sections 4.4 and 5.4.

The inclusion of random parameters means that several parameters used in the separate models are no longer needed or identifiable. The joint model does not include scale parameters and only has a subset of interaction variables. Heterogeneity between individuals is adequately captured by the random parameters rather than scale parameters or interactions. An SP/RP scale parameter is not required because the attributes are not constrained to be equal.

9.7.2 Model Results

The joint model has McFadden r-square value of 0.209, which represents a significant improvement in fit over the SP-only model (0.149). An RP-only model had a better fit of around 0.4, but most of the individual parameters were insignificant which made it not particularly useful.

The estimated model is presented below in Table 34. The first set of parameters are alternative-specific constants (ASCs) for RP sites and the SP “no change” alternative. The ASCs capture all the unobserved factors that influence site choice. The central Waikato river parameter is positive and significant which means that this site is more popular compared with the lower Waikato river (the base case) than can be explained by the water quality and travel cost variables alone. The two streams have negative values but they are not significantly different from zero. A dummy variable for streams was tested but this was also insignificant.

Of the RP attributes only cost, clarity and infection risk were statistically significant. This represents a large improvement over a model including only RP data for rivers and streams in the catchment, in which only travel cost was significant.

The SP water quality attributes are all significant and a similar sign and magnitude to the SP-only model.

[8] See Hensher and Greene (2003) for a more detailed explanation of mixed logit and error component models

The only significant random parameter for the RP attributes is cost. In contrast, all of the SP random parameters are significant except for poor ecosystem health.

The final section shows the estimated covariances, which are significant only for clarity and infection risk.

Table 34 - Joint RP-SP model estimates

Parameter	Coefficient	t-test	p-value	
ASC for Waikato river central	2.08	2.68	0.01	**
ASC for Waipa river	0.424	0.12	0.90	
ASC for Komakorau stream	-1.46	-0.19	0.85	
ASC for Mangauika stream	-3.51	-1.65	0.11	
ASC for other	6.41	1.32	0.20	
ASC for SP status quo	0.0621	1.64	0.10	
RP attributes				
RP cost	-0.408	-3.24	0.00	***
Clarity	0.236	2.19	0.04	**
Clarity squared	0.000000284	0.00	1.00	
Infections	-0.00468	-1.79	0.08	*
Infections squared	0.00000431	0.00	1.00	
Eco Poor	0.333	0.08	0.93	
Eco Fair	0.749	0.42	0.68	
Eco Good	0.994	0.60	0.55	
Māori * RP cost	-0.0105	-0.05	0.96	
SP attributes				
SP cost	-0.0113	-21.44	0	***
Clarity SP	0.1515	2.80	0.01	***
Clarity squared SP	0.0594	2.54	0.02	**
Infections SP	-0.0189	-13.50	0	***
Infections squared SP	0.000048	12.63	0	***
Eco Poor SP	0.337	7.01	0	***
Eco Fair SP	1.226	13.76	0	***
Eco Good SP	1.26	16.56	0	***
Stated certainty * SP cost	0.0125	19.72	0	***
Māori * SP cost	0.0048	3.38	0	***
Travel time * SP cost	-0.0000164	-5.05	0	***
Site user * SP cost	0.00192	2.46	0.02	**
Random parameters				
Cost RP	-0.004296	-5.51	0	***
Cost SP	-0.00904	-11.59	0	***
Clarity RP	0.118	0.08	0.94	
Clarity SP	0.4	2.06	0.05	**
Infection RP	0.00379	0.53	0.60	
Infection SP	0.00288	2.17	0.04	**
Eco poor RP	0.0000997	0.00	1.00	
Eco poor SP	0.0284	0.23	0.82	
Eco fair RP	0.000776	0.00	1.00	
Eco fair SP	0.0689	4.62	0	***
Eco good RP	0.00081	0.00	1.00	
Eco good SP	0.432	3.46	0	***

Covariances				
Cost RP/SP covariance	0.442	0.32	0.75	
Clarity RP/SP covariance	0.643	4.66	0	***
Infections RP/SP covariance	0.1882	1.73	0.09	*
Eco poor RP/SP covariance	0.0356	0.26	0.80	
Eco fair RP/SP covariance	0.0833	0.45	0.66	
Eco good RP/SP covariance	0.439	0.75	0.46	

9.8 Population use estimates

The process of aggregating values across the population is arguably the largest source of error in a non-market value study. The two important pieces of information required are: what is the relevant population and is the sample representative of that population?

For this study we define the population as household units in the Waikato, Auckland and Bay of Plenty region. The majority (87 per cent) of Waikato freshwater users recruited for the recreation survey live in one of these three regions. People in other areas of the country may also have positive values but we did not attempt to obtain representative panels from other regions for the SP survey. The distance decay parameter identified in the SP model could be used to extrapolate values for other regions but with higher uncertainty.

An important parameter in the models is the concept of a "user" of freshwater in the Waikato/Waipa catchment because users have significantly higher values. The following table shows user proportions identified in three different samples.

The Water Values phone survey (Barns et al., 2014) was a geographically stratified random sample of a thousand Waikato region residents. Two-thirds of this sample identified themselves as being "regular" users of rivers or streams in the Waikato/Waipa catchment. The definition of "regular" was open to interpretation by participants. In this study we define a "user" as someone who has used a fresh water site in the past year so the figures are not directly comparable. The authors note that young adults aged 18-34 were under-represented in the Values survey.

The following table shows the different figures obtained from each survey. The SP panel (after re-weighting to correct for education level) had the lowest proportions of users. The RP sample had the highest proportion of users but this is not surprising because it specifically targeted users.

Table 35 – Proportion of people who used fresh water in the past year by survey

Sample	Region of residence	Waikato river users	Waipa river users	Catchment users
Water values phone survey	Waikato	52%	8%	69%
SP Panel Participants (re-weighted)	Waikato	45%	3%	N/A
	Auckland	11%	0.5%	N/A
	Bay of Plenty	11%	1%	N/A
RP participants	Waikato	54%	2%	91%
	Auckland	32%	1%	60%
	Bay of Plenty	34%	0%	76%

We use the SP Panel figures to generate a "medium" estimate of the number of users of the five SP sites in the populations of Waikato, Auckland and Bay of Plenty regions.

Table 36 – Estimated number of users of each site in the general population

Site	Region	User % (low)	User % (med)	User % (high)	Users (low)	Users (med)	Users (high)
Lower Waikato	Waikato	2.5%	3.8%	8%	3,800	5,700	11,500
Lower Waikato	Auckland	2.0%	3.4%	7%	9,500	16,000	32,000
Lower Waikato	BOP	1.0%	2.2%	4%	1,000	2,300	4,600
	Total				**14,300**	**24,000**	**48,100**
Central Waikato	Waikato	30.0%	43%	56%	45,700	65,800	85,900
Central Waikato	Auckland	5.0%	9%	17%	23,700	41,400	82,800
Central Waikato	BOP	6.0%	10%	20%	6,200	10,600	21,100
	Total				**75,600**	**117,800**	**189,800**
Waipa river	Waikato	7.0%	14%	28%	10,700	21,100	42,200
Waipa river	Auckland	0.9%	1.8%	4%	4,400	8,800	17,500
Waipa river	BOP	0.7%	1.4%	3%	700	1,500	2,900
	Total				**15,800**	**31,400**	**62,600**
Mangauika	Waikato	1.3%	2.6%	5%	2,000	3,900	7,800
Mangauika	Auckland	0.2%	0.5%	1%	1,100	2,100	4,300
Mangauika	BOP	0.3%	0.5%	1%	300	600	1,100
	Total				**3,400**	**6,600**	**13,200**
Komakorau	Waikato	0.4%	0.8%	2%	600	1,200	2,300
Komakorau	Auckland	0.5%	0.9%	2%	2,100	4,300	8,600
Komakorau	BOP	0.4%	0.8%	2%	400	800	1,700
	Total				**3,100**	**6,300**	**12,600**

The whole catchment estimate is calculated by adding 33 per cent to the number of Waikato river users (the difference between the whole catchment and the Waikato river only, in the Water Values survey).

Table 37 – Estimated number of catchment users in the general population

Region	Dwellings	User % (low)	User % (med)	User % (high)	Users (low)	Users (med)	Users (high)
Waikato	152,496	45%	59%	65%	69,000	91,000	99,000
Auckland	473,448	7%	14%	30%	34,000	67,000	142,000
Bay of Plenty	103,500	8%	15%	30%	8,000	16,000	31,000
Total	729,444				111,000	174,000	272,000