The valuation of estuary services in South Africa specifically regarding changes to estuary services as a result of reductions to fresh water inflows

- Main report

Report to the Water Research Commission

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This is the main report of WRC Project K5/1413/2. There is also a sub report which is available on the enclosed CD.

This report forms part of a series of two reports. The other report in the series is *Estuaries, Economics and Freshwater: An Introduction* (WRC Report No TT 463/10).

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Dr GR Backeberg	Water Research Commission (Chairman)
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In particular the support of Drs Backeberg and Mitchell is acknowledged. This report is a product of their belief in the aims of this project. Several of the parts of this report have already been shared with the public – either in scientific journals or in conference presentations. These early ‘part-releases’ are cited at the beginning of each chapter as a footnote to the chapter heading.

This report is the main one of three deliverables of this project. The sub-report appears on the enclosed CD and the report by Hay and McKenzie is published as a standalone reports (WRC Report TT 463/10). The enormous efforts put into compiling the subsidiary reports are also gratefully acknowledged.

If there is someone in the project team who deserves special mention in connection with this project it is Professor Tristan Wooldridge, whose invitation to the economics department to share his passion to conserve South Africa's estuaries led to our involvement. We have learned a lot from him (and Prof Janine Adams) and thank him for the tolerance he has shown toward our ignorance and application of valuation methods which often did not yield pleasing results.

Many people contributed to the collection of the data – students, friends, family and Bridget Zietkiewicz. The data on which the results generated in this study are based are stored at the Department of Economics, Nelson Mandela Metropolitan University, and may be accessed through Prof Stephen Hosking. The interpretation of this data was led by Mr Gary Sharp of the Department of Statistics. He was kind enough to instruct a series of our students in applying estimation methods that were within their capability to apply. Jessica and Gaye Hosking were of great assistance in the compilation and editing of the final document.

Last but not least, this report is the product of the students of the Nelson Mandela Metropolitan University. It was uplifting watching them develop the skills required and I take this opportunity to congratulate them on their achievement!

The following students participated and contributed dissertations (in one case a treatise) on this basis:

Moses Mlangeni
Marzanne Potgieter
Henri van der Westhuizen
Johane Dikgang
William Akoto
Jedidah Chege
Denis Nyaboga (forthcoming)
Chatelle Oliver (forthcoming)

Executive Summary

The two main research objectives WRC project K5/1413 set out to achieve were to generate information that would be useful in guiding the efficient allocation of river water to South African estuaries and to test selected hypotheses on factors that explained willingness to pay for river inflows into South African estuaries. In pursuing these objectives this project followed on and extended some of the findings from WRC project K5/1304, entitled *The valuation of changes to estuary services in South Africa as a result of changes to freshwater inflow* (WRC Report No. 1304/1/04).

The research objectives of this project were formulated as hypotheses. The five primary hypotheses tested were that:

- a theoretically and practically appealing approach to the efficient managing of the allocation of South Africa's river water between estuaries and other uses is to do so with reference to marginal values – comparing the value the water abstracted and that of the flowing into the estuary
- the contingent valuation method is a credible method by which to value the flows of river water into estuaries
- the primary value of South African estuaries lies in the recreational services they yield
- the main recreational demand for estuary recreational services is that of white male fishermen
- the more highly developed the region in which the estuary is located, the greater the opportunity cost will be of water flowing into it.

These hypotheses were derived from a mixture of conventional economic wisdom and consideration of the findings of WRC Project 1394, being the one that preceded this project.

Two secondary objectives of WRC Project K5/1413 were to provide education to the public on the value of conserving estuaries and to build up capacity in applying environmental valuation techniques. The first of these secondary objectives was pursued by the handing out of booklets on estuaries (Breen and McKenzie, 2002) and through discussions held with the public during the administration of the surveys. At an intermediate stage in the project the interaction and feedback with estuary managers was initiated by members of the project team, especially, Mr Duncan Hay and Ms Margaret McKenzie (see Appendix H). The second of the secondary objectives was pursued by involving students in the application of the methods. Table 1 shows the 6 Nelson Mandela Metropolitan University (NMMU) students who obtained degrees for their application of the relevant techniques during the course of WRC Project

K5/1413 and 2 others whose work had not yet been submitted for examination at the time of writing up this report. In addition there were also other students who were trained (and remunerated) in the administration of the surveys – from NMMU and also from Rhodes University and the University of Cape Town.

Table 1: Capacity building

Student name	Degree (year awarded)	Title of treatise/dissertation
Moses Mlangeni	MCom (2006)	A contingent valuation of river inflows into the Swartkops, Kariega, Mngazi and Mngazana estuaries in the Eastern Cape
Marzanne Potgieter	Honours in Statistics (2005)	Valuing preferences for freshwater inflows into the Mngazi and Mngazana estuaries
Henri van der Westhuizen	MCom (2007)	Valuing preference for freshwater inflows into the Bira, Bushmans, Kasouga, Keiskamma, Kleinemonde East, Nahoon and Tyolomnqa estuaries
Johane Dikgang	MCom (2007)	A comparison of the values of water inflows into selected South African estuaries: the Heuningnes, Kleinmond, Klein, Palmiet, Cefane, Kwelera and Haga-Haga
William Akoto	MCom (2008)	Valuing preferences for freshwater inflows into selected western and southern Cape estuaries
Jedidah Chege	MA (2009)	Valuing preferences for freshwater inflows into five Eastern Cape and KwaZulu-Natal estuaries
Denis Nyaboga	MCom (not yet complete)	Valuing preferences for freshwater inflows into the Gqunube, St Lucia and Uilkraalsmond estuaries
Chatelle Oliver	MSc (not yet complete)	Eliciting willingness to pay preferences for various public policy options with respect to estuary management: a choice modeling pilot study

The main normative economic objective for generating values of environmental goods is to provide information to guide their (public) management, but the usefulness of this type of information is still a matter of debate. Project K5/1413 estimated the economic value of river water inflows into South African estuaries with the purpose of guiding the management of these inflows toward efficient levels. The latter flows improve estuary habitats and thereby their recreational appeal, *inter alia,* and have been identified as a natural resource in South Africa under threat (see Chapter 1). In South Africa the Minister of the Department of Water and Environmental Affairs (DWEA) is required to ensure a portion of the mean annual runoff be set aside for the (users of the) environment by the National Water Act (Number 36) in 1998.

The management of river inflows into estuaries advocated by this report is one based on the comparison of the marginal benefit and marginal opportunity cost of such flows (see Chapter 2). It is consistent with the approach advocated in the recently completed draft report for WRC Project K5/1644: ‘A framework and manual for the valuation of goods and services of aquatic ecosystems for resource directed measures’.

The valuations reported in this report (Project K5/1413) aim to help guide this management. The values were derived by applying the contingent valuation, travel cost and choice experiment methods and relate to information collected from 7 768 people between 2000 and 2008 and to 40 estuaries known to be vulnerable to changes in river inflows. The report outlines the way the contingent valuation method was applied (Chapter 3) as well as the thinking that led to the selection of the forty estuaries (Chapter 4).

For each of the 40 estuaries researched an environmental change scenario was identified and valued. The scenario was a change in recreational services induced by a change in annual river water inflow into the estuary. The relevant scenario was a consensus opinion formulated by a panel of estuarine experts on the consequences of specified hypothetical changes to water inflows into estuaries. The experts covered various aspects of estuarine functionality (see Part 2 of this Report – attached in electronic format). The fact that the scenario was linked to a specific volume change in river inflow made it possible for the per cubic metre value of this water to be estimated.

The sample design and elicitation of bids was delegated to 9 different survey teams and covered a 9 year period. In addition to the natural differences in style by which the surveys were administered, the questionnaire was also improved upon and added to during this period. A travel cost component was added half way through the project, and along the way a few problematic questions were dropped and the clarity improved of the wording made simpler. As is true for many other applications of the contingent valuation method, this one was vulnerable to all the standard biases and challenges, such as:

- embedding bias
- information asymmetry
- moral and strategic rather than budget motivated bidding
- addressing questions with long run implications to people whose primary interest is short run survival

- interpreting the implications for management and policy from their answers (values).

Sample design proved to be such an overwhelming challenge in this project that the target population (those people in whose demand the 9 teams were interested) had to be restricted to those using the estuary in the year the survey was administered (and non-users excluded). Even drawing up a sample frame for this part of the target population (the per annum users for the relevant year) proved to be beyond the capacity of the research team – because there are no records on which to base such estimates (and there are unlikely ever to be). The target population (complete sample frame) from which the annual visitors to estuaries originated come from far and wide. The estimates of the size of the sample frame were mostly estimated from information supplied by local authorities and from GIS information on the residential population.

Passive use demand was incorporated into the contingent valuations, that is, the demand of people coincidentially stopping by the estuary in cars and those seeing the estuary from permanent homes purchased principally for their proximity to other amenities (not the estuary). The passive demand for estuary functionality is a complementary demand for these people. It is coincident to that for other goods and services that these people have.

For each user population predictive Tobit models were generated, and from these models median and mean estuary user willingness to pay bids were predicted. The product of the predicted median willingness to pay and the per annum user population was deemed to be the estimate of the change in consumer surplus that would result from the specified change in the estuary services. The latter product, divided by the specified change in river water inflow, was in turn deemed to be the estimate of the (environmental) consumer surplus per cubic metre of river water. Chapter 5 outlines the results of applying the contingent valuation method to the forty selected estuaries.

All of the findings of the values per cubic metre (environmental) river water and results of validation assessments are shown in the tables 2 to 6 below (contingent, travel cost and opportunity cost).

Table 2: Estimated price level adjusted values of water at each estuary*

Estuary	Mean predicted value of water (Rands/m^3)	Median predicted value of water (Rands/m^3)
Keurbooms	0.0129	0.0125
Groot Brak HB	0.1485	0.1048
Swartkops HB	0.1141	0.0904
Kowie HB	0.0809	0.0721
Kariega HB	0.1027	0.0570
Klein Brak HB	0.0136	0.0126
Knysna HB	0.0168	0.0126
Kromme HB	0.0158	0.0122
Mngazana	0.0697	0.0231
Mngazi	0.0089	0.0063
Bira	0.2049	0.1016
Bushmans	0.2952	0.1377
Kasouga	0.5329	0.3503
Keiskamma	0.0113	0.0006
Kleinemonde East	2.9063	0.0469
Nahoon	0.0430	0.0222
Tyolomnqa	0.0743	0.0027
Heuningnes	0.0120	0.0022
Kleinmond	0.0503	0.0044
Klein	0.0915	0.0546
Palmiet	0.0416	0.0394
Cefane	0.0218	0.0129
Kwelera	0.0609	0.0048
Haga-Haga	0.0188	0.0128
Olifants	0.0044	0.0021
Great Berg	0.0033	0.0015
Breede	0.0133	0.0109
Duiwenhoks	0.0051	0.0011
Swartvlei	0.0100	0.0061
Kleinemonde West	4.3404	2.7676
Mlalazi	0.0044	0.0036
Mhlathuze	0.0033	0.0023
Gqunube	0.0324	0.0075
St Lucia	0.0002	0.0000
Uilkraals	0.1034	0.0270
Gamtoos	4.7278	0.4472
Sundays	0.2562	0.0261
Mgeni	0.0373	0.0008
Mvoti	0.0127	0.0068
Mdloti	0.0551	0.0193

* Values adjusted to 2008 price levels. The estuaries are listed in the order they were surveyed.

The mean, median and standard deviation respectively of the median predicted consumer surplus value of water per cubic metre in cents are reported in Table 3.

Table 3: Water value summary statistics

Predicted Values		**Mean predicted value of water (cents/m^3)**	**Median predicted value of water (cents/m^3)**
All 40 estuaries	Average	36.395	11.317
	std dev	107.318	43.964
37 estuaries (excl. high est.)	Average	6.982	3.419
	std dev	6.684	3.785

Also shown in Table 3 are the mean and median when the three estuaries yielding outlier estimates are excluded from the sample, viz. Gamtoos, Kasouga and Kleinemonde West.

Not all of the estimates reported in Table 2 have credibility – some were assessed to lack validity or reliability. The latter assessment was undertaken in terms of a plausibility (expectations) criterion, a convergence criterion and a reliability criterion. The results of part of the convergence assessment are shown in Table 4 and the list of all estimates on which there were credibility queries raised is provided in Table 5.

The validity of the valuations was assessed in terms of the plausibility of the predictive model and on the basis of comparisons of other similar valuations. As could be expected, some models were more plausible than others. Other valuations that were calculated for comparative purposes were:

- per annum user travel cost valuations at 23 estuaries
- a per annum user marginal valuation of inflow into the Bushmans Estuary generated through a choice experiment

The travel cost valuations were calculated using both the zonal and the individual travel cost methods. Chapter 6 outlines the results of the validity assessments.

Table 4: Comparing unadjusted (for price levels) CV and TC consumer surplus values per m^3 river inflow

Estuary	CV estimate value cents/m^3	Net TC estimate cents/m^3
Heuningnes	.2	2.1
Kleinmond/Bot	.4	88.2
Klein	5.5	5.7
Palmiet	3.9	28.1
Cefane	1.3	.5
Kwelera	.5	1.1
Haga-Haga	1.3	.9
Olifants	.2	35.3
Great Berg	.1	7.8
Breede	1.1	15.3
Duiwenhoks	.1	11.3
Swartvlei	.6	12
Kleinemonde West	277	271.5
Mlalazi	.4	16
Mhlathuze	.2	8.4
Gqunube	.1	53.4
St Lucia	0	.6
Uilskraalsmond	.1	90.9
Gamtoos	25	1
Sundays	1.2	.5
Mgeni	.2	1.9
Mvoti	0	.4
Mdloti	1.6	.1
Average	**14**	**28**

For the purpose of guiding river inflow allocations, validity testing raised concerns over 14 of the estuaries (Table 5).

Table 5: Median estimates of consumer surplus per m^3 over which there are queries

Estuary	**Reason to query validity**
Keurbooms	No validity assessment
Swartkops	Poor predictive model
Kowie	Poor predictive model
Klein Brak	Poor predictive model
Klein	Poor predictive model
Kwalera	Poor predictive model
Uilskraalmond	Poor predictive model + divergent TC estimate
Kleinmond/Bot	Divergent TC estimate
Olifants	Divergent TC estimate
Mlalazi	Divergent TC estimate
Gqunubie	Divergent TC estimate
Gamtoos	Divergent TC estimate + reliability doubtful
Kleinemonde West	Reliability doubtful
Kasouga	Reliability doubtful

When the three estimates that are of doubtful reliability are excluded, the average of the mean and median respectively of the sample (of 37 estuaries) decline to 7 percent and 3.5 percent, and the standard deviations are approximately of the same magnitude (see Table 3).

In order for the marginal values to be used to guide river allocations they must be compared to the per annum user opportunity costs of inflows into estuaries. One was available for the Keurbooms (Du Preez, 2002) and one was estimated for river water abstracted from the Mngazi River for consumption (Chapter 7).

Table 6: Opportunity costs of river inflows into two estuaries

Estuary	**Marginal Value of river inflow into estuary (consumer surplus in cents per m^3 – calculated from median WTP)**	**Marginal Cost of River inflow into estuary (willingness to pay in cents per m^3 estimate)**
Keurbooms	1.3	13 (demand for agriculture)
Mngazi	.7	-122 (stated WTP – prod costs)

The comparisons in Table 6 show the marginal value of water flowing into the Mngazi and Keurbooms estuaries to be similar (about 1 cent), but the marginal (opportunity) cost to be very different. Due to the high state of development in the region of the Keurbooms River, the demand for fresh water is high (about 13c per m^3), and due to the low state of development in the region of the Mngazi River, the demand (but not need) for fresh water is negative (about negative122c per m^3). The opportunity cost of abstracting water from the Mngazi Estuary and treating it for consumption was found to be less than zero.

The results reported in Table 6 are consistent with the hypothesis that the value of water abstraction upstream of the estuary will typically exceed that of the water flowing into the estuary when this estuary is located in highly developed region, and be less than that of the water flowing into the estuary when this estuary is located in an undeveloped region.

There are a number of conclusions drawn with respect to the various hypotheses about what explains willingness to pay for river inflows into South African estuaries (Chapters 8 and 9). Chapter 8 analyses selected hypotheses by means of linear model estimation. It shows that user characteristics such as gender and race are highly significant in determining a user's mean willingness to pay (*WTPM)* for estuary services. These results support many of the individual findings of the surveys conducted at the estuaries (see Table 1). In addition, the analysis shows that important estuary factors for determining user *WTPM*s are the climatic zone in which the estuary falls and the time the estuary mouth is open.

When user and estuary characteristics are considered simultaneously, the users characteristics dominate in influence. The results of this analysis show little support for the *a priori* expectation that fish population maintenance is important, despite the fact that many users are active recreational fisherman.

Chapter 9 concludes that:

- it is efficient to allocate South Africa's river water with reference to its value at different points along the river.
- the contingent valuation method is a credible method by which to determine these values, albeit not without problems.
- there are many people who have an <u>interest</u> in using estuaries, but the primary <u>demand</u> is for their recreation services they yield. The survey teams reported finding two different user populations at the estuaries – people engaging in recreation activity and people engaging in subsistence activity. The former tended to be wealthy and the latter poor. The latter derived much of their value indirectly; by supplying services to those engaged in recreation activity. The collective response of the two populations typically yielded a skewed and bi-modal distribution of bids.
- the recreational demand is mainly from White males, but not necessarily fishermen. Demand is positively correlated with the length of time the estuary mouth is open, and

climatic location of the estuary, but it is not correlated with the conservation status of the estuary.

- the opportunity cost of water flowing into the estuary increases the more highly developed the region in which the estuary is located.

There is no doubt that better analytical methods may resolve some of the credibility challenges encountered in this attempt to use economic values to guide policy on the environment (see Chapter 6), but even in applying these improved methods there will be serious challenges confronted.

One of these challenges will be determining credible opportunity costs of river water inflows into estuary habitats from the information available (see Chapter 7). This information consists of (difficult to obtain) records of transactions in the current imperfect publicly administered markets that relate to water use rights in South Africa. These factors undermine the merit of using actual (administrative) water service charges levied as references for opportunity costs.

Another challenge is the normative economic appeal of employing efficiency arguments to guide water allocations where there are significant distributional consequences of alternative allocations (estuary recreational use versus freshwater abstraction use) and many unresolved related economic rights issues. These perspectives should also be taken into account along with efficiency criteria, such as the comparison of marginal or total benefits and costs. It is not simply values and efficiency that are important to South Africans and other people interested in our river systems. The field research of this project focussed its attention on this aspect, but we were constantly being made aware that they have many other interests and views on our estuaries and rivers that cannot be captured into two marginal monetary values.

The report concludes that:

- some form of government intervention is justified to manage the problem of malfunctioning estuaries
- efficiency is a relevant criterion for guiding this intervention, but has no claim to prioritisation above other criteria like welfare or sustainability
- the contingent valuation method can be a credible method by which to estimate the marginal value of river inflows into estuaries, but the results are highly vulnerable to challenge
- the unit value of river inflow into estuaries is increased where a small change in this flow causes a large change in the services the estuary yields and where there is a high number of users.

In addition to Part 1 there is also a Part 2 of this report (see enclosed CD for Part 2). It more fully details the background underlying the specification of the plausible changes in environmental service and identifies the baseline information about the estuaries selected.

The final report output of this project is a standalone WRC report on the relevance of this research (Part 1 of this Report) to estuary managers (*Estuaries, Economics and Freshwater: An Introduction*, co-authored by Hay, Hosking and McKenzie [WRC Report TT 463/10]).

A number of publications and conference presentations were made of the material covered during the course of this research project.

(1) Part of the material in Chapter 2 appears as an article: Hosking (2008) 'An Economic Approach to Allocating River Water to Estuaries in South Africa', *Coastal Management Journal* 36 (1): 35-46.

(2) Part of the material in Chapter3 appears as an article: Hosking (2007) 'Is there a need to audit CVM applications to the environment?" *South African Journal of Economic and Management Sciences*, 10 (4) :482-489.

(3) Parts of the material in Chapter 5 have been presented as papers at conferences or published in scientific journals, namely:

(a) Sharp GD, Hosking SG and Van der Westhuizen H (2009). 'Valuation of freshwater inflows using a mixed log-linear model', International Conference on Implementing Environmental Water Allocations, 20-24 February 2009, Port Elizabeth.

(b) Sale, M, Hosking, SG and Du Preez, M (2009) 'Application of the contingent valuation method to estimate a recreational value for freshwater inflows into the Kowie and Kromme estuaries', *Water SA* 35 (3):261-270.

(c) Sharp, G.D., Friskin, D.G, Hosking, S.G., Logie, C.B., Nasila, M. and Van der Westhuizen, H. (2009). 'The Determination of an Environmental Service for a Contingent Valuation Study – Using R to Compute Estimates', The R User Conference 2009, July 8-10, Agrocampus-Ouest, Rennes, France.

(d) Hosking SG, Van der Westhuizen H and Sharp GD (2009) 'The value of water inflows into six estuaries between East London and Bushmans River, Eastern Cape, South Africa', Resource and Environmental Economics Conference, Cape Town, 20-22 May 2009.

(e) Hosking SG and Hosking JG (2009) 'The value of river water inflows into South African estuaries' WIOMSA Conference, St Denis, La Reunion 24-29 August 2009.

(4) Part of Chapter 6 has been presented as a conference paper:

Oliver, C, Hosking, SG and Sharp, G. (2009). 'Comparing choice experiment with contingent values for water inflows into the Bushmans Estuary', International Conference on Implementing Environmental Water Allocations, Port Elizabeth, 20-24 February 2009.

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AA	Automobile Association
CE	Choice Experiment
CMAs	Catchment Management Agencies
CPI	Consumer Price Index
CS	Consumer Surplus
CV	Contingent Valuation or Value
CVM	Contingent Valuation Method
DEAT	Department of Environmental Affairs and Tourism
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWEA	Department of Water and Environmental Affairs
EDUC	Education
GIS	Geographic Information Systems
GLM	Generalised Linear Model
HPM	Hedonic Price method
IDP	Integrated Development Plan
ITCM	Individual Travel Cost Method
KM	Kilometres
KZN	KwaZulu-Natal
ML	Maximum Likelihood
MLE	Maximum Likelihood Estimator
MV	Marginal Value
MWTP	Marginal Willingness to Pay
NMMU	Nelson Mandela Metropolitan University
OLS	Ordinary Least Squares
PDI	Previously Disadvantaged Individual
RUTCM	Random Utility Travel Cost Method
TC	Travel Cost or Total Cost
TCM	Travel Cost Method
TWTP	Total Willingness to pay
UCT	University of Cape Town
UKZN	University of KwaZulu-Natal
WMAs	Water Management Agencies

WRC	Water Research Commission
WTA	Willingness To Accept
WTP	Willingness To Pay
WTPM	Mean Willingness To Pay
WTPMd	Median Willingness To Pay
ZTCM	Zonal Travel Cost Method

Chapter 1

A rationale for allocating river water to South African estuaries

1 An estuarine demand for river water

South Africa has a coastline of about 3 000 km (Baird, 2002:37) and along this coastline there are a large number of estuaries – 289 by some counts (Hattingh *et al.,* 2002:5), 465 by others (Baird, 2002:37). The status of an increasing proportion of the 255 South African estuaries, classified as "functioning" (Lamberth and Turpie, 2003:1), is being threatened by a number of factors. These include insensitive use and settlement of the banks of the estuaries, industrial, agricultural and domestic emissions into rivers that feed into the estuaries and the construction of recreation and transport infrastructure in the estuaries (Hay, 2006). The factor that appears to have had the most severe impact is reduced freshwater inflows, especially on those estuaries classed as temporary open/closed (Schalacher and Wooldridge, 1996). The main cause of the reduced freshwater inflow is increased abstraction to satisfy upstream freshwater demand, but another well documented cause of reduced inflows is the displacement of indigenous vegetation by higher water consuming alien vegetation within the river catchments (Hosking *et al.,* 2002).

Estuaries are reliant on uninhibited access to marine and freshwater links in order to function properly (Adams, 2001; Lamberth and Turpie, 2003:2) but because less water is reaching them they are yielding less services (Whitfield and Wood, 2003), for instance, smaller areas available for recreational boating and losses of habitat for species of fish, birds and vegetation.

These consequences, unfortunate as they are, do not necessarily indicate that the freshwater in South African rivers is being misallocated, with too little being received by estuaries. River water yields value to many users in South Africa – to households, industrialists, farmers, foresters and government organisations. The demand for water inflows into estuaries by people wishing to use the services of these estuaries for recreation, is but one of many. Given the limits of supply, it is inevitable that some demand will not be satisfied. In fact this is a problem that is most likely to get even worse in the future. At current rates of growth in demand it has been estimated that by the year

2025 South Africa will have a population of 70 million, and all its exploitable freshwater resources will be fully exploited (Schalacher and Wooldridge, 1996).

Nevertheless, concerns have increased in South Africa during recent years, especially among government agencies charged with environmental conservation, that there may be a misallocation problem, with too little river water reaching the estuary, i.e., being allocated to the recreation users of estuary services (Adams, 2001). The economic rationale underlying these concerns is not so much that there has been a deterioration in estuary service levels as that the services yielded by the estuaries have strong public good properties and that key relevant public policy makers have seemed, up until recently, to have been largely ignorant of the close connection between the river inflows and levels of service yielded by estuaries. Public good characteristics are well known to render the market deficient as a mechanism for signalling the demand, causing market failure. Ignorance of relevant information by public decision makers would most likely result in this information failing to be taken into account in public decisions, causing government failure (and hence a double failure).

Recent actions by South Africa's Department of Water Affairs and Forestry (DWAF) and Department of Environmental Affairs and Tourism (DEAT) reflect this concern. These two departments have now been combined into the Department of Water and Environmental Affairs (DWEA). The water affairs section of the ministry (DWA) has been and still is in the process of re-examining the basis by which river water is allocated in South Africa, particularly with a view to incorporating conservation demand. The National Water Act of 1998 requires catchment management agencies to be established. One of its functions is to ensure that demand for freshwater inflows into estuaries is taken into account in the management of catchments. DWA also regulate emissions into rivers and estuaries.

Similarly, South Africa's Directorate of Marine and Coastal Management (which fell under DEAT) and local authorities have actively sought to formulate policies aimed at countering the degradation of estuaries, but their scope was largely constrained to the marine elements of the estuary, including regulation of the fish and bait stocks. One of the requirements imposed upon local authorities is that they integrate into their development planning sensitivity to the ways estuaries work and the services and goods they deliver (see also Hay, 2006).[1] The relevant legislation making this a requirement is

1 In addition to stipulating how much freshwater they will permit to be removed from the inflow into the estuary, local authorities

the Municipal Systems Act No. 32 of 2000. Provincial and Local authorities play a key role in the land use that the estuary banks are put to, and together with the National Department of Transport regulate what infrastructure is erected in the estuaries.

2 The statutory requirement for allocating river water to the environment

The National Water Act No. 36 of 1998 is the legislative framework by which South Africa's water resources must be managed. The Act was based on 28 fundamental principles (Hirji and Davis, 2009b: 31). These principles stress the need for public participation, creating greater access to allocations of water be given to previously disadvantaged people and improving water use efficiency, *inter alia*. Principles 9 and 10 prioritise water use for the basic human needs (listed first) and water for long term environmental needs (of humans) – as *the reserve* – to be satisfied before water is used in any other way (Hirji and Davis, 2009b: 31-32).

The National Water Act covers all water uses, including allocations for consumption and any activity affecting the availability of water. It covers stream flow reducing activities, and relates to water both on the surface and below the ground. All allocations are governed by the Act. The Act requires relevant stakeholders to be consulted in the establishment and implementation of any decision on water resource management (Hirji and Davis, 2009b: 32).

The management of the demand for and supply of water has various components. On the demand side there is reserve setting, licence issuance and price regulation through market creation, while on the supply side there is the building and operation of dams, increasing use of groundwater, reuse of water, desalination, cutting back alien vegetation, reallocating water and inter-basin water transfers.

The reserve setting component of demand management falls under the heading of resource directed measures (Turpie *et al.,* 2000; Turpie *et al.,* 2002). They entail establishing a national classification system for all water resources, determining a class for each significant water resource and the setting aside a reserve portion and quality objective for each class of water resource. The reserve portion is intended to maintain the ecological health of the wetlands system. The Act requires the reserve to be

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are required to formulate plans to guide what emissions they will allow into the estuary, what land uses they will permit on the banks and what resources (like fish, bait and mangrove trees) they will allow to be extracted from the estuary.

managed by the Minister of Water Affairs and Forestry. This requirement must be met before other allocations are made. Part of this reserve is a constitutional right for basic human needs – approximately 25 litres per person per day. The latter allocation does not require authorisation, but all human demand above this does. The Act specifies that this additional demand be regulated by means of a system of licences, and that the Department of Water Affairs and Forestry (but now DWEA) will administer this system on behalf of the minister. Provision is made for the Department to delegate these functions to Catchments Management Agencies (CMAs). DWAF created 19 Water Management Areas (WMAs) to be managed with the assistance of these CMAs. Each CMA must include representation from all stakeholders in the catchment, including government, civil society, communities, agricultural water users and industries. Once the CMA has developed a Catchment Management Strategy (CMS), it will be given the power to licence water use.[2]

The extent of the direct involvement of the DWAF in the final determination of who receives the licences is partly dependent on the degree to which the relevant catchment is stressed. In unstressed catchments the Act envisages complete delegation of DWAF ministerial authority for licence issuance to the CMAs. On the other hand, where a catchments is stressed, that is, already more water is allocated to human demand than is consistent with meeting the reserve requirement, the Act envisages a more direct involvement the Department of Water Affairs and Forestry (on behalf of the Minister), aimed at progressive reallocation toward meeting the reserve requirement.

The Act requires that reallocations are to be managed through interaction between the CMAs and the DWAF at the national level. The mandate of both parties is the same – meeting the reserve requirement at each catchment.

The National Water Act of 1998 prioritises a river flow allocations for river ecosystems functionality above satisfying agricultural and (non-basic right) urban demand, but it does not do this in a way that secures scientifically desirable allocations for the environment. The latter may have been its intention, but it is not the ultimate result, because the Act

2 The Inkomati CMA (ICMA) was the first to be established. This catchment is drained mainly by the Sabie, Crocodile and Komati rivers (none of which were covered in this research project). In addition to urban settlements the Inkomati catchment supports intensive agricultural activities (sugarcane, subtropical fruits and citrus) and forestry, as well as the animals of the Kruger National Park. Since this time five other CMAs have been established: the Mvoti-Mzimkulu, Gouritz, Olifants-Doorn, Thukela and Usutu to Mhlathuze (Hirji and Davis 2009b: 34).

implicitly subjects the allocation outcomes to a condition, that they be collective choices and that the economic benefit to society be considered (Hirji and Davis, 2009b: 32).

This condition makes it unavoidable that the relevant economic tradeoffs be taken into account; the reason being that collective choice and not science defines the minimum acceptable level of functionality. Given that collective choice determines the minimum acceptable level of functionality, it also determines the acceptable river flow allocation into the estuary, because the two are linked. The river inflow allocation is determined with reference to the chosen minimum level of functionality, *inter alia*.

By similar reasoning it follows that urban and agricultural demand will necessarily be taken into account in the determination of the minimum level of estuarine functionality – because urban and agricultural users of water also are constituents of the collective choice.

The reality imposed by the collective choice requirement, then, is that the economic tradeoffs will have to be taken into account in catchments allocation management. For this reason, it is not sensible to approach the problem of how much water to allocate to estuaries, by grouping a set of estuarine scientists together and calling for them (alone) to deduce a minimum river inflow allocation, for adoption by the relevant components of government.

The latter group's proposals may well be very useful inputs into the decision making, but they represent too narrow an interest base to be acceptable as a guide to how river water should be allocated. Their input is *ex ante* (before) the consideration of all of society's interests. The approach of the current study proposes the river water allocation decision is made *ex post* (after) the consideration of a broad a cross-section of the current members of society's interests.

The so-called Building Block Methodology (BBM) for determining ecological flow requirements (the reserve) for South African estuaries is one based on the considered views of a group of estuarine scientists (aquatic scientists, hydrologists and managers). It has been applied to major water resource projects in 14 South African rivers (Hirji and Davis, 2009b: 34). A variant of this approach is the Downstream Response to Imposed Flow Transformation (DRIFT). It was used in the Lesotho Highlands project.

The problems with the current reserve setting approach are that it is poorly equipped to manage the economic trade-offs with which it is tasked, many of the CMAs lack the required information to properly execute their mandate, the circumstances are continuously changing (due to climate change and economic development, *inter alia*) and the most challenging allocation tasks are typically ones where the water is already over-allocated (making reserve setting more a theoretical than practically relevant exercise).

This study (reported below) aims to contribute to understanding the trade off issues. It adopts the *status quo* as its reference point and addresses itself to the question of what reallocation would improve social welfare or efficiency. It is a situation not unlike that facing the set of managers of estuaries (DEAT, DWAF and local government development planners). They have to decide if they are going to leave things as they are or make some changes. This way of looking at the trade off issue was also advocated in the draft report of WRC Project K5/1644 presented in June 2009, entitled 'A framework and manual for the valuation of goods and services of aquatic ecosystems for resource directed measures'.

3 How much river water is allocated to South Africa's estuaries?

South Africa received about 611 600 million m^3 of water in rainfall in the year 2000 (Statistics South Africa, 2008: 13). Of this only about 105 528 million m^3 was retained on the land – not used by natural vegetation, or lost in evaporation and deep seepage before reaching rivers. Of the 105 528 million m^3 about 49 040 million m^3 found its way into rivers as natural mean annual runoff (about 8% of the MAR) and about 1 088 million m^3 was added to ground water reserves (some authorities estimate a higher recharge figure). Of the natural mean annual runoff only 19 785 million m^3 (19%) is subject to allocation control. The total available for allocation was 19 785 million m^3 in the form of a surface yield plus 1 088 million m^3 in addition to groundwater – making a grand total of 20 873 million m^3.

This 20 873 million m^3 was estimated by Statistics South Africa to be allocated as shown in Table 1.1 in the year 2000.

Table 1.1: The allocation of South Africa's surface and ground water yield in the year 2000

Allocation destination	Millions of m^3 of water	% of total that may be allocated
Agriculture plantations	428	1.9
Irrigation Boards –agriculture*	7 920	34.8
Domestic consumption	1 959	8.6
Industry and Business	2 251	9.9
Livestock and game	313	1.4
Exported to other countries	170	.7
Ecological Reserve	9 545	41.9
Losses in evaporation	186	.8
Total with return flows included	22 772	100
Minus return flows: from municipalities (1223 mil m^3) and agriculture (676 mil m^3)	-1 899	
Total excluding return flows	20 873	

Note: * The Department of water Affairs estimate a much higher allocation for agriculture, above 60% of that available (DWA, 2009:11)

South African Statistics argue that the largest single discretionary allocation of South Africa's water resources is to the environment (about 42%), but this allocation is very uneven – mostly it is allocated to the environment in the region stretching from the Mzimkulu to the Kei rivers (Statistics South Africa, 2008: 10). The Department of Water Affairs contend the largest allocation is to agriculture (60% of that available, see DWA, 2009:11). The country faces a situation where there are surpluses in some water catchment areas and deficits in others (Statistics South Africa, 2009:3). Many of the river catchments considered in this report could be argued to be in deficit, all be this concept (a deficient inflow) a controversial and complex one (Hirji and Davis, 2009a:3).

4 Aims of the project

The two main research objectives of WRC project K5/1413 were to generate information that would be useful in guiding the efficient allocation of river water to South African estuaries and to investigate the hypotheses that explain willingness to pay for river inflows into South African estuaries. This project follows on and incorporates some of the findings from WRC project K5/1304, entitled *The valuation of changes to estuary services in South Africa as a result of changes to freshwater inflow* (WRC Report No. 1304/1/04, 2004).

Two secondary objectives of WRC Project K5/1413 were to provide education to the public on the value of conserving estuaries and to build up capacity in applying environmental valuation techniques. The first of these secondary objectives was pursued by the handing out booklets on estuaries (Breen and McKenzie, 2002) and through discussions held with the public during the administration of the surveys. At an intermediate stage in the project the interaction and feedback with estuary managers was initiated by members of the project team (see Appendix H). The second of the secondary objectives was pursued by involving students in the application of the methods. Six Nelson Mandela Metropolitan University (NMMU) students obtained degrees for their application of the relevant techniques during the course of WRC Project K5/1413 and a further two were in the process of doing so at the time of writing this final report (see Appendix I). In addition there were also other students who were trained (and remunerated) in the administration of the surveys – from NMMU, Rhodes University and the University of Cape Town.

The values that the current study generates are intended to assist in indicating to management the direction of potential efficiency, as measured by marginal recreation values. These are measured by the stated willingness to pay responses of current estuary users. They need to be compared to the marginal opportunity cost in order to indicate the direction of efficiency. In terms of their mandate (The National Water Act and the implementers of collective choice), we argue that managers of estuaries and catchments are required to take these values into account. They can only do this to the extent that they are available.

Another secondary objective pursued was the exploitation of the benefit of multi-disciplinary perspectives. Members of the Departments of Zoology, Statistics and Economics of the Nelson Mandela Metropolitan University contributed to this report and the research it describes.

Initially, it was planned to value changes in environmental allocations of river water to 57 estuaries, but during the project it was decided to reduce this number to ones where significant changes of freshwater inflow were forecast in terms of the information available within the management period set as a guideline, viz. up to 2025 (see Chapter 4). There was considered to be little management relevance in valuing changes to recreation services that were forecast to be trivially small.

The decrease in number of estuaries to 40 made it possible to introduce other dimensions into the project. The most important other dimension was introducing convergence tests at selected estuaries.

5 Conclusion and overview of the other chapters making up the report

The point has repeatedly been made by estuarine scientists that estuaries are reliant on uninhibited access to marine and freshwater links in order to function properly (Adams, 2001; Lamberth and Turpie, 2003:2), and that because less water is reaching them than used to in the past, they are yielding less services (Whitfield and Wood, 2003). This reduction of services diminishes the quality of recreational experience made available by estuaries. It causes there to be less area available for recreational boating and losses of habitat for species of prawns, fish and birds and induces changes in estuarine vegetation. The loss of habitat, in turn, reduces the local populations of these species. All this has prompted calls for government to intervene and do something to prevent the situation from worsening still further (Whitfield and Wooldridge, 1994; Schalacher and Wooldridge, 1996).

This report is part of the response to this call. It comprises nine chapters and nine appendices. The second chapter outlines the role that value of marginal benefits play in guiding the efficient environmental allocations of river water. The third reflects on the appropriateness of the contingent valuation method by which to generate the relevant values. The fourth identifies a sample of vulnerable estuaries of different types and plausible changes to environmental service to which they may be exposed. The fifth chapter describes the results of applying the contingent valuation method to value these changes. The sixth describes the results of assessing the validity of the estimates. It includes applying the travel cost method of valuation to the changes in a sub-sample (23 of them) of the selected 40 estuaries and compares these results to the contingent valuation estimates. It also includes comparing the marginal value of river water inflow into the Bushmans Estuary found in a choice experiment with the contingent value estimate for that estuary. The seventh chapter estimates the willingness of users of potable water to pay for the abstraction of water from the Mngazi River. The eighth chapter analyzes the factors that could be expected to explain society's demand for river inflows into estuaries, and the ninth (final) chapter draws conclusions and makes recommendations. The appendices include selected key supplementary material, such as an example of the questionnaire administered, some supplementary information and matters relating to estuarine managers. Part 2 of the report (see CD in cover for Part 2) more fully details the background underlying the specification of the plausible changes in environmental service (referred to briefly in Chapter 4 of Part 1 of the Report). A final element of the research is captured in a related WRC report on the relevance of the research reported in Part 1 to estuary managers (co-authored by Hay, Hosking and McKenzie).

Chapter 2

Using marginal values to guide the efficient allocation of river water[3]

1 Introduction

It is generally accepted that sound water resource management requires the benefits and costs of different water allocations be compared and an optimum determined (Loomis, 1998). The same principle applies to the current allocation of river water (freshwater) inflow into estuaries. The efficient management of the allocation of river water to estuaries requires the marginal social costs of the inflows to be brought into equivalence with the marginal social values of the inflows. These values may be estimated but there are the challenges in this estimation and in linking these estimates to the welfare of the people in whom the managers of river systems are (presumed to be) interested.

Chapter Two is organised in the following way: an optimum current inflow is defined in terms of marginal values and some complications are considered of using these marginal values for the purpose of allocating river water to estuaries (and away from other uses).

2 An economic optimum freshwater inflow into estuaries

2.1 Optimising conditions

The optimum freshwater (river) inflow (Q*) into a given estuary at any given time is defined where the positive difference between the total social value and the total social cost of this inflow is maximised, or put differently, where the marginal social value of the inflow equals the marginal social cost. The services generated from river inflow into estuaries are yielded and consumed mainly in the form of public goods, for instance, in areas suitable for boating, swimming and fishing.[4] Total value is what the public would

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3 Part of the material in this chapter appears as an article: Hosking (2008) 'An Economic Approach to Allocating River Water to Estuaries in South Africa', Coastal Management Journal 36 (1): 35-46.

4 Public goods provide nonexclusive benefits to everyone in a group and can be provided to one more user at zero marginal cost.

be willing to pay to consume the services, and the marginal value is what they would be willing to pay for an increment or decrement of the service, that is the sum of each individual's (i = 1….n people) marginal value for this change ($\sum MVi$). The willingness to pay concept employed here is a composite one, including payments made directly and those made indirectly, for instance, through government. It specifically includes willingness to pay of the current cohort of recreation users of the estuary, a scarcity cost component and an external cost component. The scarcity cost component is the present discounted value of future willingness to pay for services foregone in the future as a result of the water reallocation being considered – where there is long term damage done to the estuary service yield potential. The external cost component is the payment that user groups, other than the estuary recreation group, would be willing to make for water that is allowed to flow to the estuary, below the point at which abstraction is being considered.

The total cost referred to above is the opportunity cost of the water flowing into the estuary, that is, the value of the water in its best alternative use, for example, in irrigating agricultural crops. It too is a composite value. It includes not only the willingness of the current user to pay, but also an external cost component. The external cost component refers to the net willingness to pay of users, other than the abstractors, of the facilities built to abstract the water, e.g., the dams, canals and regulation/redirection of river water flows. There may be a positive net willingness to pay for using these facilities. There is considerable recreational use made in South Africa of these constructed water facilities, but in some cases this infrastructure also has undermined other recreational uses (like fly fishing).

2.2 A model for allocating river water

The concepts relevant to a model for allocating freshwater inflow into the estuary are defined below.

Q = Freshwater inflow into estuary in m^3

Q*= Optimum freshwater inflow into estuary in m^3

ΔQ = Change in freshwater inflow into an estuary in m^3

P1 = Social value per m^3 of a specified quantity of freshwater in the best alternative use to the estuary

P2 = Social value per m^3 of a specified quantity of freshwater inflow into the estuary to all users (including passive) of the estuary

TC = Total opportunity cost per m^3 of freshwater inflow into the estuary (for all people)

= $f(P1; Q)$

MC = Marginal social cost of an incremental freshwater inflow into an estuary

= dTC/dQ

= $P1.\Delta Q$

TV = Total value of freshwater inflow into an estuary (for all people)

= $f(P2; Q)$

MV = Marginal social value of freshwater incremental inflow into the estuary (for all people)

= dTV/dQ

= $\sum MVi$ (because of the public good nature of the services generated by the inflow)

= $P2.\ \Delta Q$

where

$i = 1........n$

people deriving utility from the freshwater inflow into the estuary.

$MC = P1$ if $\Delta Q = 1$ and

$MV = P2$ if $\Delta Q = 1$.

Optimisation takes place at the level of Q where the excess of TV over TC is maximised. A necessary condition for this optimisation to take place is that:

$$MC = MV \tag{2.1}$$

which implies

$$P1 = P2. \tag{2.2}$$

It follows that

if $P1 > P2$,

then (the current inflow of freshwater into the estuary) $Q > Q^*$ (the optimum inflow)

and if

$P1 < P2$,

then $Q < Q^*$.

A priori:

$$P1 = f(Q) \text{ and } dP1/dQ > 0 \tag{2.3}$$

$$P2 = f(Q) \text{ and } dP2/dQ < 0 \tag{2.4}$$

The P1 and P2 functions would be expected to change over time and, for this reason, the optimising conditions (Equations 1 and 2) would be expected to yield different values at different moments in, or periods of, time. Given the nature of P1 and P2 functions (Equations 3 and 4) it would be expected that at Q^*:

$TC < TV$

3 The marginal social value and marginal social cost functions

The expected nature of the marginal value and marginal cost functions (also see Equations 2.3 and 2.4) are shown in Figure 2.1.

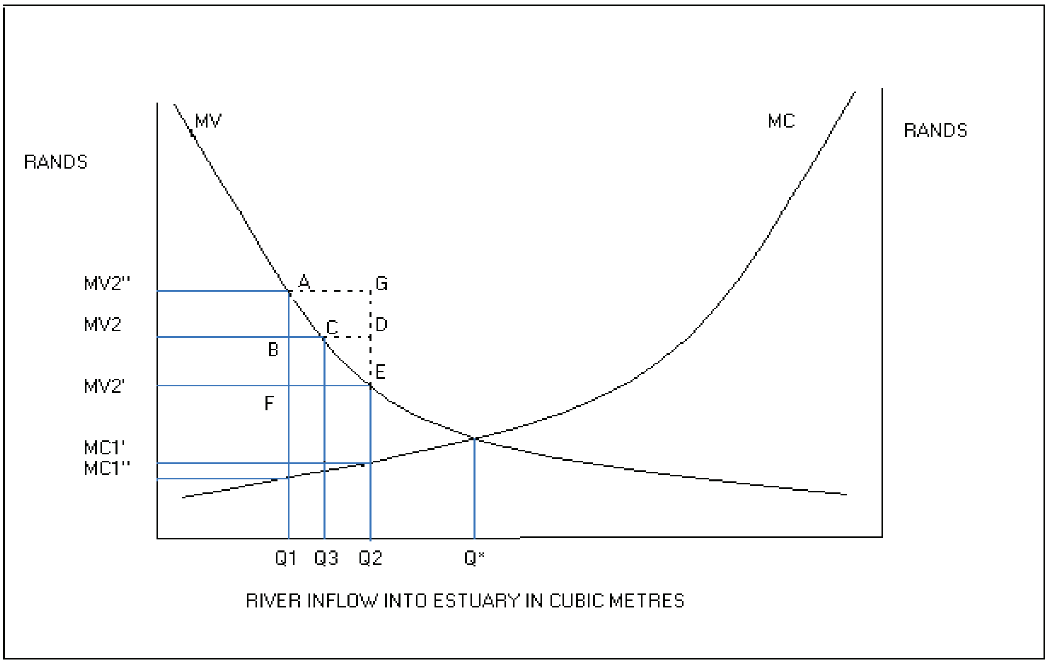

Figure 2.1: Expected Marginal Social Value and Marginal Social Cost functions

In Figure 2.1 the river inflow into the estuary is shown in m³ on the horizontal axis and the marginal value and marginal cost of it in Rand is shown on the vertical axis. As freshwater inflow into the estuary increases, the marginal value of this inflow decreases (by Equation 2.4), but the marginal costs associated with securing more freshwater increases (by Equation 2.3).

At the intersection of MV and MC the optimal freshwater inflow (Q*) is identified. At this level the excess of TV over TC is maximised. At any given time the actual freshwater inflow (Q) may, and most probably will, differ from the optimal inflow (Q*). Such a situation, for instance, would be where Q = Q1.

At Q1:
MV2” > MC1” and net TV (or TV – TC) can be increased by increasing Q.

For instance, if an increase of Q1Q2 is brought about, net TV increases by the vertical area between Q1 and Q2 and the MC and MV functions. After the increase, MV would have declined from MV2” to MV2’ and MC would have increased from MC1” to MC1’.

As it happens, in this case, further increases of Q would also be efficient. The optimum inflow into the estuary is Q*.

4 The optimal inflow guide versus the environmental Reserve guide for managing freshwater inflows

One alternative to the optimal efficient inflow approach to guiding the allocation of freshwater inflows into estuaries is the environmental reserve approach. In terms of this approach a certain amount of the mean annual runoff is set aside for the estuary and may not be abstracted. This amount is set with reference to the minimum freshwater inflow needed to sustain a desirable level of environmental services and with reference to historical levels of environmental service delivery for that estuary (Adams, 2001).

It could be expected that for many cases the two guidelines (efficient optimum and minimum reserve requirement) would coincide in their recommendation, even though there are fundamental differences between the two. There are at least two reasons to expect some measure of overlap between the two guidelines – a step like feature in the marginal value function where the minimum is defined, and the effect on the efficiency calculus of incorporating future generation demands (scarcity costs).

Where the environmental services of the estuary are in demand, it stands to reason that if there is a precipitous fall in these services, their marginal value would increase, perhaps dramatically. As a result, declines in freshwater allocation below an ecologically determined minimum would most likely be sub-optimal – because marginal values would become markedly higher (in a step like way) for freshwater inflows at base levels less than this ecologically defined minimum. Moreover, if the consequent decline in service yields were expected to be enduring, a fall below an ecologically defined minimum inflow of freshwater would be very difficult to justify in terms of multi-generational efficiency criteria, unless suitable compensation could be determined, and this is difficult to conceive (Holland, 2002).

Notwithstanding there being many cases where the conclusions and recommendations yielded from these two guidelines converge (namely the environmental reserve requirement and efficiency criteria), there may be many other cases where the two guidelines yield conclusions and recommendations that diverge. In the latter cases the question will arise of what is most important to society – the efficiency of the economy or the conservation of the environment. Economics has tended to favour the former.

5 Measuring the relevant marginal values

5.1 Methods

Efficient allocation of river water in South Africa requires management to be informed on both the MV and MC. There have been numerous attempts to estimate (or infer) values for MC in South Africa – using a mixture of marginal and average cost reference values (Hosking *et al.,* 2002) – but there has been less work undertaken on estimating (or inferring) values for the MV in South Africa.

Given the relative lack of work done on estimating P2 there would appear to be a strong case currently for devoting a bit more attention to doing so. In order to generate an estimate for P2, the first question one is faced with is which MV2 should be targeted for its estimation? The question is whether MV2” or MV2’ or MV2 should be targeted (see Figure 1)? Ideally the MV gained through the increase in inflow of Q1Q2 is estimated by MV2, where the excess valuation of Q3Q2 (value area CDE) is exactly offset by the undervaluation of Q1Q3 (value area ABC). The alternative of MV2” would yield too high an estimate of the MV (by value area AGE), while MV2’ would yield too low an estimate (by value area AFE).

In practice it is one of MV2” or MV2’ that is likely to be identified by empirical research – the value prior to an increment in freshwater inflow or a decrement. It follows that for a decrement of freshwater inflow, the price identified is likely to be MV2’, that is too low, but for an increment it is likely to be MV2”, that is too high. It would be expected that the error will be greater the greater the derivative of the P2 function with respect to Q exceeds zero (see Equation 4) and the greater the change in Q being considered.

The second question one is faced with in estimating P2 is which method of valuation to employ. In principle there are several methods by which MV2 may be identified, for instance, hedonic price method, travel cost method and the contingent valuation method (CVM). Of these the latter is the one most amenable to the required fine-tuning (see Chapter 3). This method may be used to generate average WTP per annum for a specified ΔQ at a given estuary. The estimated (or inferred) P2 (viz. $\underline{P2}$) is defined as the product of this average and the total number of people with a demand for the services derived from the ΔQ, divided by the ΔQ:

$$\underline{P2} = TWTP/\Delta Q \qquad (2.5)$$

where total willingness-to-pay (TWTP) is defined as follows:

$TWTP = \sum MVi = n(AWTP)$,

where,

$i = 1\ldots n$ people with a demand for estuary services.

and

AWTP = a before-the-ΔQ average WTP for a specified change in water inflow into the estuary, as estimated by the CVM (either MV2' or MV2" in Figure 1, depending on the direction of the specified change)

and

ΔQ = specified change in freshwater inflow measured in m^3.

Related to this second question is a credibility issue – in what sense the measure generated for P2 (in the case of CVM it is a stated preference measure) is indeed an acceptable estimate of the marginal social value of freshwater flowing into the estuary. This problem is three-fold. One aspect relates to the use of a response to a hypothetical question on willingness to pay as equivalent to a market generated value based on what people actually do pay – the contingent valuation debate (covered in Chapter 3). Another aspect relates to the omission of scarcity and external costs components (see Section 5.2 below). Yet another aspect relates to the plausibility of these responses reflecting social values, taking into account welfare complications that could be anticipated (see Section 5.3 below).

5.2 Omissions of marginal scarcity and marginal external costs

The estimated value, P2, is a valuation of willingness to pay for freshwater inflow by recreation users of the estuary. It is only part of the complete social benefit of water being allowed to flow into the estuary. Other potentially important components of the social benefit are the scarcity cost of any future estuary services foregone as a result of abstraction of the freshwater upstream, and the willingness to pay of groups beside the estuary recreation users, for the water not to be abstracted upstream.

Plausible reasons for discounting these omissions are that the values of these components would be expected to be negligible or that there are exact equal offsetting external benefits derived through the infrastructure built to abstract the water upstream. It may be reasonable in some cases to argue cases along these lines, but clearly it cannot be assumed to be generally true. The researcher seeking to provide guidance on the issue of water allocation to the decision makers will have to consider the merits of each case with respect to the marginal scarcity and external costs.

5.3 Welfare complications in applying the equivalent pricing rule as a guide to efficiency

One additional way of checking the efficiency analysis results for credibility is through the direct consideration of social welfare issues. If the social efficiency analysis is accurate a welfare analysis should yield results that are consistent with it.

For the purpose of considering the welfare implications relevant to the efficient allocation of river water it is convenient to define social welfare in terms of the utility derived from two groups of water users – the upstream abstractors and the estuary recreation users. The social welfare (W) implications of changes in river inflows may then be considered in terms of the utility (U_1) derived by those abstracting water upstream (-Q) and the utility (U_2) derived by those using services dependent on river inflow into the estuary (Q):

$$W = W[U_1(-Q); U_2(Q)] \tag{2.6}$$

It would be expected that the respective utilities would be increasing functions in –Q and Q, and welfare an increasing function in the respective utilities.

Assuming a linear welfare function in the respective utilities and equal welfare weighting, a first order condition for a welfare optimum of the constrained maximisation problem is:

$$MU1 = MU2 \qquad (2.7)$$

where MU1 and MU2 are the partial derivatives of user groups 1 and 2 with respect to m^3 water allocations.

The main implication of this condition is that under the relevant assumptions, welfare optimality requires MU1 to equal MU2. For this reason, if the estimated prices ($\underline{P1}$ and $\underline{P2}$) are brought into equivalence through appropriate management actions, welfare analysis would require that this allocation also make MU1 to equal MU2. However, it may not do so. There are many factors that may prevent this marginal utility condition from being met. For instance, if one group are using the water as a necessity and the other as a luxury, or if one group enjoys high incomes and the other low incomes, this MU equivalence may not be met, *a priori*. These factors will now be considered.

6 Differences in use of the water allocation

Marginal utilities in the consumption of water will differ widely among the users of upstream river water. Individuals in South Africa are constitutionally entitled to a minimum of 25 L of fresh water (as a basic human right), but many have yet to receive this right, and among those that have, there is wide variation in consumption levels. Similarly in production, some firms are more productive with the water they use than others, and the goods the water is used to produce vary from luxury type goods to necessities.

The relevance of this variation is that marginal utility foregone (and marginal output foregone) through reallocations of water will differ widely. For this reason, there may be welfare reasons for re-allocating water even when estimated water prices are brought into equivalence, or alternatively, not re-allocating water even where estimated prices suggest that it would be efficient to do so. For instance, the finding that $\underline{P2}>\underline{P1}$ would suggest that efficiency could be improved by re-allocating water from upstream users to the users of estuary services. However, if the upstream abstraction of water under consideration is targeted at satisfying basic needs for water in poor households and the estuary service users are mainly ski boat fishermen on holidays, a welfare analysis would suggest the exact opposite to be the preferred management action in terms of the efficiency analysis. In this case it would seem likely that the marginal utility of the upstream water users would be higher than the marginal utility of the estuary service recreation users, and welfare would not be increased by allocating more water to the recreation users of estuary services.

On the other hand, if the upstream abstraction of water being considered is targeted at sustaining gardens of alien vegetation, topping up private swimming pools, etc., i.e., at facilitating the consumption of luxury goods, *a priori* there would be no marginal utility complications corresponding with a finding that it would be efficient to allocate more water from upstream abstractors to users of estuary services, because <u>P2</u> > <u>P1</u>. For this reason, in addition to estimating P1 and P2 it would seem prudent for those aiming to provide guidance to decision makers on water allocations to include consideration of what change in usage of this water will be entailed through a reallocation, and if the marginal utility implications of that reallocation yield welfare results that are consistent with the efficiency implications. Due to the diverse nature of consumption patterns within the relevant user groups, identification of the appropriate users may be difficult.

7 Differences in income between the user groups

There are many factors that influence willingness to pay values, besides expected marginal utility, for instance, income levels and the prices of related goods. That the value of water should be influenced by the prices of related goods is important from an efficiency perspective. However, the fact that higher levels of income will generally induce higher willingness to pay, *ceteris paribus*, is problematic from a welfare perspective.

The relation between income and utility/welfare is indirect and controversial, but to the extent that there is any consensus on the relation, it is that diminishing marginal utility from income is more likely to be experienced by people than constant or increasing marginal utility from income. If one accepts this proposition one is led to the conclusion that where income levels differ between the two users, the relative prices paid by people will not correspond with the relative respective relative marginal utilities. In terms of the theory of diminishing marginal utility of income the price being paid by the user group with the lower income should correspond with a higher marginal utility than the equivalent price paid by the higher income group.

It follows that those seeking to provide guidance to decision makers on the allocation of river water need to carefully consider whether there are significant differences in income levels between the two water using groups. For instance, it would be relevant if the income levels were higher of the recreation users of estuary services than were those targeted for the water upstream. Once again, due to the diverse spread of incomes within the relevant water user groups, identification of the income of the appropriate users may be difficult.

8 Concluding remarks

That there are adverse consequences for estuaries in South Africa of freshwater deprivation has been widely documented (Lamberth and Turpie, 2003:2; Whitfield and Wood, 2003). As could be expected, the government has acted to address the problem with legislation that creates catchment management agencies to take estuary freshwater needs into account, *inter alia*, and compels local authorities to incorporate sensitivity to estuary services in their development planning (where this is applicable). The current state of thinking within catchment management agencies and local development planners about how to incorporate the required sensitivity is still at the formative stage. Much of the discussion has been orientated around the idea of setting aside freshwater reserves for estuaries in order attain target estuary quality standards (Adams, 2001).

This chapter has advocated that management of freshwater allocations to estuaries should be guided by the idea of an optimal freshwater inflow rather than the idea of a freshwater reserve. The allocations of freshwater inflow into South African estuaries are optimal when the marginal social values of the inflow are brought into equivalence with the marginal social costs. For this reason catchment management may be guided towards optimal allocation of freshwater inflow into estuaries, by reference to estimates of the relevant marginal social costs and marginal social values.

However, there are notable complications in attempting to employ this apparently simple decision rule for the purpose of allocating river water to estuaries. Estimates of these marginal values may be generated in controversial ways (see Chapter 3), and for this reason need to be qualified. Secondly, irrespective of the method of valuation employed, there are checks that should be made for relevant value omissions and for welfare inconsistencies. In order to address some of the complications associated with the latter, there may be advantage in guiding management decision making by simultaneously (in the same analysis) presenting several other appraisal criteria together with the efficiency criterion (of bringing the relevant prices into equivalence) – a multi-criteria mapping approach (such as is advocated by Stirling, 2002).

These qualifications and complications need to be borne in mind when using the values reported in later chapters for the purpose of managing current river inflows into the estuaries of South Africa.[5]

5 The optimum flows over time are not discussed in this report.

Chapter 3

Using the contingent valuation method to determine the marginal benefit values of river inflows into estuaries[6]

1 Introduction

Chapter Two demonstrated that efficient management of the freshwater inflows required the marginal social costs of the inflows into estuaries to be brought into equivalence with the marginal social values of the inflows. Chapter Three addresses an issue related to one of the methods by which (at least) one of these values may be estimated, the marginal social value of the inflow. The method discussed is the contingent valuation method and the specific issue discussed is the use of appropriate statistical models with which to administer the expectation test for validity of the household willingness to pay estimate. The discussion of the relevant statistical models is preceded by an outline of the context within which the contingent valuation method is applied and the steps entailed in applying the method.

2 Controversy over the contingent valuation method

The CVM is a widely applied but controversial valuation technique (Azevedo *et al.,* 2003). It is widely used because it is very flexible and may be used to assess the values of a wide variety of non-market goods and services (Carson *et al.,* 2001). In particular, it has advantages in incorporating passive use and non-use values into the total value estimate. Its credibility depends on there being a close correspondence between expressed answers given to hypothetical questions (stated willingness to pay) and voluntary exchanges in competitive markets that would be entered into if money did actually change hands.

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6 Part of the material in this chapter was published as a paper: Hosking (2007) 'Is there a need to audit CVM applications to the environment?" South African Journal of Economic and Management Sciences, 10 (4) :482-489.

The fact that it has proved very difficult to establish this correspondence has led to CVM being subject to criticism. At the empirical level some authors have argued that it is much better not to generate any numbers at all than the misleading ones that some authors have published (Diamond and Hausman, 1994). At the theoretical level some authors have argued that those researchers applying the CVM make 'category' mistakes by attempting to value (moral) judgements as if they were (economic) preferences (Keat, 2002).

Many aspects of the 'obvious' errors in the ways the CVM has sometimes been applied, have been addressed – in the form of using standard methods to reduce biases, the adoption of conservative elicitation formats and the reporting of tests for consistency with economic theory. Subject to these checks and balances being taken into account many feel that the results should be taken seriously by decision makers (Carson *et al.,* 2001). One of the common checks is for consistency with economic theory. Recommended guidelines for applying the method have emerged during the past 25 years, e.g., those drawn up by the Blue-Ribbon panel and Arrow *et al.* (1993). These guidelines are ideals, but are frequently not fully adhered to – often because budget limitations preclude this, for instance, that relating to sample size, and often because it is impossible, for instance, that relating to random selection.

3 Choosing an appropriate method of valuation

There are two main ways of valuing environmental goods with strong public good characteristics: by analysis of values revealed in actual markets or by analysis of values elicited in constructed markets (Folmer *et al.,* 1995). The former technique observes values of the environmental benefits and costs associated with the goods or services as indirectly reflected in the markets. The latter technique generates values in the form of willingness to pay (WTP) responses elicited from people who are placed in hypothetical valuation positions. The responses are to questions on what a specific change of the current status of an environmental service is worth to the person selected for interviewing (Turner *et al.,* 1990). The people surveyed are those expected to have a demand for the good/service. Being based on verbal (expected) responses it is a stated preference (SP) technique.

The most widely used SP technique is the contingent valuation method (CVM). The empirical roots of CVM may be traced back to a study by the US National Park Service in the Delaware River basin area (Hanemann. 1992). The method rapidly gained popularity during the 1970s (Wattage, 2001:5). By the 1980s it was being widely applied in North America, Europe and many other parts of the world, and it has continued to be widely applied since then. One of the reasons for its rise in popularity is its capacity to measure both passive use and existence values of environmental goods (Breedlove, 1999:5). These values are not as easily captured in two other prominent environmental good/service valuation methods, the hedonic pricing model (HPM) and travelling cost method (TCM). In addition, with these other methods, it is often difficult to identify the value of the specific feature in which one is interested because of the strong public good characteristics and composite nature of many environmental goods/services (Field, 1994; Kahn, 1995).

This rise in the popularity of applying the technique has occurred despite CVM being very sensitive to many discretionary elements, and its validity being challenged on the grounds of implausible results (Bateman and Wallis, 1999:4). Part of the reason for its ongoing popularity is that there have been the many advances made in reducing the discretionary elements and increasing use made of recommended tests for validity (Arrow *et al.,* 1993; Bateman and Wallis, 1999; Carson *et al.,* 2001). For instance, it is common to use pilot studies to reduce information biases generated in the way questionnaires are drawn up and administered. Similarly, it has become standard practice to justify the way the willingness to pay question is phrased. It should be phrased so as to limit the scope for misunderstanding of what is being bid for and how payment would be effected. The importance of the sample design is now also widely recognised (Wattage, 2001) – predicted WTP is very sensitive to population estimation and sample size selection.

It has also become widely recognised as desirable to administer as many tests as possible for the validity of WTP observations. Prominent among the various tests that may be administered for validity is that for the credibility of the estimated coefficients of the bid function fitted to the CV survey data.

The remainder of this chapter describes the way CVM was applied to predict the value of recreational use of estuary services dependent on freshwater inflow, the different statistical models that were used to estimate the relevant bid functions, and how these estimates were used for the purpose of administering one of the standard validation tests – *a priori* consistency of the data collected with economic theory and experience.

4 Steps in applying CVM

The application of CVM can be broken down into six steps or stages (Hanley and Spash, 1993). All of these steps were followed in the applications of the CVM reported in Chapters 5 and 6.

(1) Questionnaire and sample design

<u>Questionnaire design</u>

The CVM questionnaire must be clear to its purpose and set up so that the respondents understand the context (hypothetical scenario) accurately and fully. The interviewers must be well trained in order to secure the respondents' cooperation and allow the respondents to participate in an informed manner. The context of the questionnaire must be realistic and encourage truthful responses.

Care should be exercised to value a defined set of goods and services rather than a moral position. For instance, in the case of estuaries, it is not whether the health of estuaries matters that is being valued (a moral position) but a specified change in the services yielded by estuaries that is being valued (a specific service package). When moral positions rather than packages of goods are valued the CV is said to incorporate a category valuation error (Keat, 2002).

In order to minimise what is known as respondent fatigue, the amount of information provided to the respondents and number of questions asked should not be excessive. Respondent fatigue causes the respondent to provide responses aimed first and foremost at bringing the interview to an end. It can easily become a problem in the application of CVM to freshwater inflows into estuaries because there is a lot of explaining required. The link between freshwater inflows and the levels of estuary services is complicated and often qualifications have to be made to cover relevant uncertainties.

The way the payment for the good is to be made (the payment vehicle) must be credible, realistic, relevant and acceptable to the respondents. In some cases the appropriate payment vehicle may be a national tax. In others it may be a local tax or a user fee – perhaps linked to other payments for public services or access. In others it may be in the form of a price increase. Least appealing would be a payment in the form of a voluntary contribution/donation. Given the free-rider problems associated with public good provision this is not a credible means of payment. Ideally, the way the payment is to be made, in the event of charges really being introduced, should have been decided upon by the responsible collecting authority prior to the survey being undertaken. In South Africa it has not yet been decided upon by the relevant authorities as to how the estuary services linked to freshwater inflows will be paid for. User fees are charged at many estuaries.

It is highly recommended that focus groups and a pilot study be used before administering the questionnaire in order to discover and rectify inadequacies and improve the accuracy of the responses.

This study attempted to incorporate many of these lessons in its design – clarity, truthfulness, credible good being valued and a realistic payment vehicle (see example of a questionnaire in Appendix A). Furthermore, a pilot study at the Keurbooms Estuary preceded the other surveys.

Sample design

At the sample design stage of a contingent valuation the sample population (or sample frame) is identified and a method is formulated by which to select a sample that is representative of this population.

The identification of the estuary user population is fraught with difficulty. There are two groups of users – residents and visitors – but these groups are mixed into larger resident populations in ways that make it virtually impossible to identify all of their elements, *ex ante*. Many of the members making up the group are themselves unaware that they will become users of the estuary in the future. Their decision to use the estuary will only be made at some future time.

From this population a certain number of its members are targeted to elicit bids for a change in estuary service. The sample size is defined by number of the population targeted for interviewing and the sample selection by those interviewed. The significance of statistical inference is improved as the sample size increases, but so too does the cost of administering the survey. Sample size was benchmarked against Cochrane's (1977) guidelines; further details of which are provided in Appendix B.

The actual selection of users from whom to elicit bids for estuary service changes is a sample selection choice. Only if the sample is representative of the whole population is it legitimate to deduce information about the whole user population from analyses of the sample. Sample selection was endogenously stratified in this study – that is, based on who was present at the estuary during the period the survey was administered and reflective of the dispersion (geographically and in other ways) of those members of the population present. Such sample selection tends to over select frequent visitors relative to infrequent ones (Martinez-Espineira and Amoako-Tuffour, 2005).

Satisfying the representative criterion proved to be a major challenge, especially with respect to the non-user population. In the initial surveys bids were elicited from people who were thought to be potential non-users, but the dominance of disinterest and zero bids within this class led the teams to abandon the practice in later surveys.

For this reason populations were redefined to exclude non-users and the samples were selected from direct and passive users – both visitors and residents. The nature of the sample design challenge of extracting a representative sample from an estuary user population is shown in Figure 3.1 below.

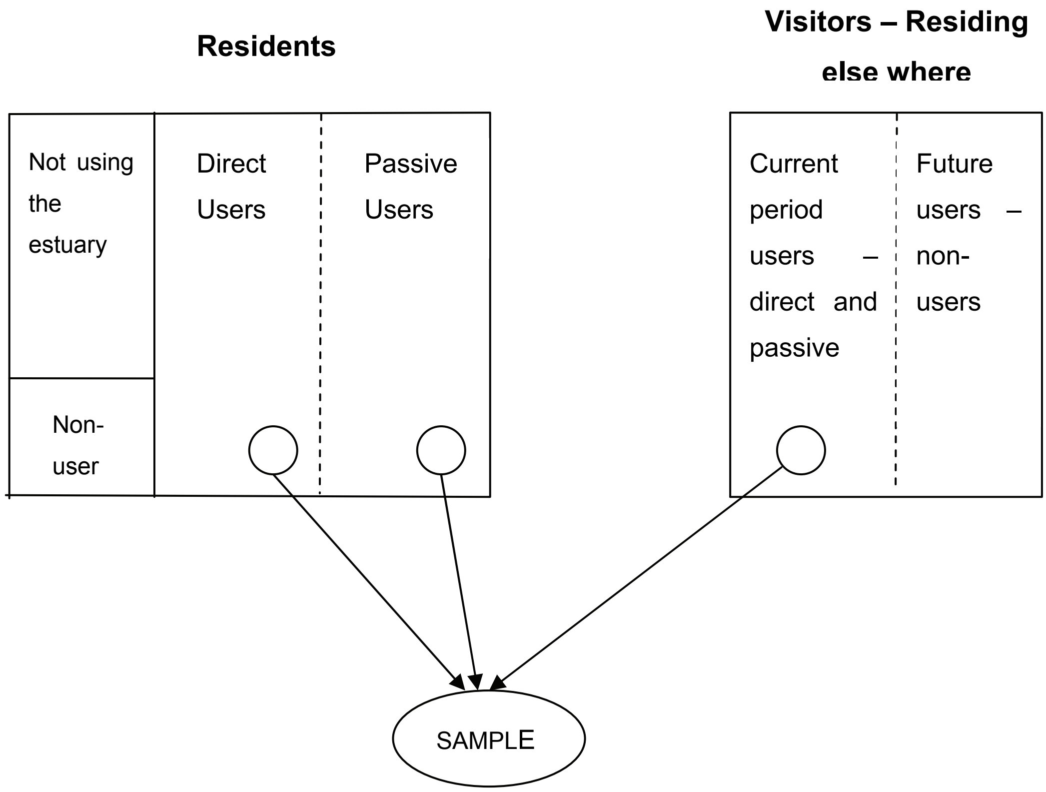

Figure 3.1: Sample design for an estuary user population

In Figure 3.1 the various classes of users are defined as follows. **Direct users** of estuaries are those who enjoy the estuary through some activity in the estuary or on its immediate banks, like swimming, fishing, bait collection and bird watching. **Passive users** of estuaries are those who enjoy the estuary as a by-product of some other activity, for instance, as a view while passing in a car, or resident in the area of the estuary. They were anticipated mainly to be made up of local residents. It was recognised that both visitors and local residents contribute to the direct and passive user populations.

Following convention, **non-users** of estuaries are defined to be a potential user class. In this study they are defined as non-current, future users of estuaries. These people may or may not anticipate that they will use the estuary at some point in the future. They may be visitors or local residents. Those who have an anticipation that they will use the estuary at a future time period have a defined demand for its services (a discounted present value of the future value to them). This project did not include 'theoretical' non-user demand, that is, people apparently willing to pay who never will visit the estuary. The project leader believed that their inclusion would constitute a so-called category mistake (Keat, 2002). The project leader argued that these people would presumably state being willing to pay for every noble intervention to conserve the environment, and that as the number of feasible interventions in the world will approaches infinity, they would need infinitely large budgets to honour all of these bids.

(2) Administering the survey

Surveys can be administered by face-to-face interview, telephonic interview or mail surveys. A face-to-face interview is more efficient in terms of response rates and avoiding misinterpretation of the questionnaire by the respondents, but is also the most expensive approach. Face to face interviews were employed in this study.

The key question in a CVM study is the WTP question. The respondents are asked what their maximum willingness to pay is for a particular good or service. The other questions asked aim at generating information relevant to understanding and predicting the particular WTP response, e.g., the income earned by the respondent.

It is the obligation of the person conducting the interview to inform the respondents that they should keep in mind their budget constraints and the availability of substitutes. The respondents need to make compensating mental adjustments to other expenditures they would otherwise have made in order to accommodate their declared WTP answers. The set of substitutes with respect to the demand for estuary services is quite broad. It includes not only other estuaries but also all other facilities (natural and manmade) that can serve to satisfy recreational demand.

A key concern at the second stage of the CV is that the questions and responses be limited in their scope only to the goods and services being valued. In surveys of the WTP for specific changes the service yields of specific estuaries, it would be a mistake if the response elicited was for something more than this, e.g., to a permanent closure of the estuary or to changes to all South African estuaries known to the respondent. Where the scope of the question/response is too broad it will probably give rise to what is called the part-whole bias or embedding problem.

The types of WTP question formats most frequently used to elicit responses from respondents are open-ended, closed-ended and payment card ones. These formats are described below:

- Open-ended elicitation is where respondents are asked to state their maximum WTP and no guides to an answer are provided.
- Closed-ended dichotomous choice (DC) is where specific bid values are put to the respondents for them to accept (yes) or reject (no). The closed-ended format is preferred over to the open-ended format because it simplifies the decision required of the respondents and it is closer to the way deals are struck in real markets. Where only one bid value is put to the respondent the format is known as single-bounded DC. Where two bid values are put to the respondent it is known as double bounded DC.
- Bidding game elicitation is an extension of the DC method to elicit the maximum value within a pre-defined set of options. If the respondent accepts the bid, another higher bid is put to the respondent, and the process is repeated until he/she rejects the bid. If the respondent rejects the first bid other lower bids are offered until he/she accepts the bid. In both cases the highest accepted bid represents the respondent’s maximum WTP.
- Payment card elicitation is where a range of values on a card are presented visually to the respondents and the respondents are themselves asked to circle a value that represents their maximum WTP.

A combination of payment card and limited bidding game elicitation was used in this study.
An assessment of the appropriateness and acceptability of the CVM stages 1 and 2 are part of tests for content validity (see stage 6 below).

(3) Estimating the mean and median of WTP.

Once the surveys have been administered and data captured, both the mean and median WTP are normally reported. Data clearings are required at this stage. The data that are discarded include unrealistically high bids (outlier), zero bids (protest bid) without reasons, refusals to participate and data where critical explanatory information has not been given, e.g. annual income. If a mean bid is used, outliers must be excluded (Jones-Lee *et al.,* 1985). The norm for the exclusion of outliers is three standard deviations from the mean. The problem of deciding on exclusions does not occur if the median bid is used because outliers do not distort the central tendency of the median. Three different types of means and medians may be identified: before data clearing sample means and medians, after data clearing sample means and medians and predicted means and medians. The latter are predicted using independent variable observations (after data clearing) and preferred statistical models of predictive WTP (bid) functions. Typically the latter are preferred in later stage analysis, e.g., in aggregation (the fifth stage).

(4) Estimating bid functions (curves) using WTP as the dependent variable and other responses revealed in the questionnaires as independent variables.

Bid curves are used to predict the WTP variations expected as a result of changing the independent variables, and to examine for coherence and consistency the relationship predicted between the non-WTP responses and the WTP ones. Estimating bid curves can be a one stage or a two stage process. The most important task (first stage) is estimating a bid function in which all the relevant explanatory variables for WTP, for which data have been collected, are included, that is the estimation of the complete model. Following an analysis of the significance of the coefficients in the complete model, another model may be estimated in which only coefficients significant in the complete model are incorporated. The significance of the coefficients and overall explanatory power of this reduced model may shed further insight into the relations being explored. The reduced model would typically be the preferred one by which to predict WTP in the event of there being an interest in how changes to the explanatory variables would affect WTP. Typically, the complete model bid functions take the following form:

$$WTP_i = f(S_i, C_i, O_i) \qquad (3.1)$$

where: WTP_i = Willingness-to-pay

S_i = Socio-economic characteristics of the respondent.

C_i = Characteristics of the environmental goods.

O_i = Other relevant characteristics of the respondent.

(5) Calculating the societal (total) WTP – the aggregation stage

The predicted societal (total) WTP is the product of the predicted household mean or median WTP and the predicted number of households estimated to have a demand for the relevant environmental goods/services (N). The degree to which the sample represents the target population must be considered. If the sample design is improperly determined this will lead to biases. Failure in sample design undermines the legitimacy of the aggregation step. Sample size determination is a crucial aspect of any empirical research. Too small a sample undermines the power of the statistical test's significance (Hair et al., 1998) as argued previously.

Similarly the accuracy of the prediction of N is of vital importance. If the estimate (prediction) of N is incorrect, the societal WTP will be incorrect. If N is badly wrong the resultant societal WTP is likely to be absurd – a situation where it would probably be better not to generate any value at all, because what is generated serves more to mislead than to inform (Diamond and Hausman, 1994). To sum up, the aggregation stage is one where the issues are assessed of how representative the sample is and how confident one is in the predicted population size.

The problem of predicting N is great with respect to estuary service demand because most of the user population is transient and it is rare for there to be any records kept of them. For this reason most researchers of estuary recreational user populations are forced to resort to macro-estimation methods for predicting N.

(6) Assessment of the credibility of the CVM application.

The credibility of the WTP is assessed in terms of reliability and validity tests. Reliability refers to being able to replicate the results by executing the same method under the same circumstances. Validity, on the other hand, measures how well a valuation method generated the observed values (construct validity) and whether the results consistently accord to the economic theory (expectations- based/ theoretical validity) (Hanley and Spash, 1993). Theoretical validity can be tested by using multivariate analyses to identify the determinants of households' WTP (Lauria et al., 1999).

Besides the correspondence, or lack of it, between the predictions of the bid function and economic expectations and theory, there are also many other 'construct' factors to consider with respect to validity, for instance:

Internal consistency of responses (no contradictions)

The scope and clarity of the WTP question

Whether or not the respondents were clear about the proposed exchange

The nature of the biases in the results that could be expected

Whether the lessons learned in the pilot study were adequately addressed in the main study.

Ideally, the societal WTP deduced, using the CV method, should also be compared to equivalent service valuations generated with the aid of other methods, like the travel cost method or the hedonic pricing method. Any assessment of the validity of the CV based on this type of comparison is said to be a test for convergence (of value findings). Tests for convergence are desirable and can substantially add credibility to a CV finding.

5 Bid function estimation

The appropriate use of statistical method is particularly important when applying CVM in two main areas: sample design and bid curve estimation. The need for the sample to be representative of the entire user population has already been stressed (see step 5 above). The contribution statistical method can make to proper bid function estimation will be described below.

5.1 WTP estimation

Bid curves have a predictive purpose and are useful for the validation of the CVM study. For the latter purpose, WTP amounts are used as the dependent variable and regressed on a range of explanatory variables (Hanley and Spash, 1993). The signs and significance of the coefficients are then examined for plausibility.

One or more of four estimation models are typically utilised for this purpose: Ordinary Least Square (OLS), Tobit, Logit and Probit models. They are assigned accordingly into two sets of information on the individual's WTP:

(a) The OLS and Tobit models are used to explain the variation of WTP amount in monetary terms. They are continuous dependent variable models (Lauria *et al.,* 1999).

(b) The Logit and Probit models are used to explain the WTP probabilities. They are binary response dependent variables models (Buckland *et al.,* 1999). The probability of being willing to pay is calculated from these models.

5.1.1 Continuous dependent variable models

A multiple linear regression model (Ordinary Least Square)

Ordinary Least Square (OLS) models are classical models that use a least square estimation procedure. They define the best fitted straight line that relates a dependent variable to several independent variables while the sum of squares of the residuals (SSR) is minimized (Bowerman and O'Connell, 1990). The standard equation takes the form:

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_p x_{ip} + \varepsilon_i \qquad (3.2)$$

where: y_i = the ith observation of the dependent variable

x_{ij} = the ith observation of the jth independent variable for $j = 1, 2, \ldots, p$

β_0 = the intercept

β_j = the parameter of the jth independent variable

ε_i = the ith residual observed

A multiple censored regression model (Tobit)

In some cases, it is necessary to 'limit' or 'restrict' the information that is gathered about the targeted population, i.e. censor the data. The Tobit model, also known as a limited dependent variable regression model (it was first proposed by Tobin in 1958), employs the same classical regression model framework of the OLS model but divides the data into two groups (Gujarati, 2003). The first group includes all the data that have values of the dependent variable above the censoring value. The second group consists of the censored observations, i.e., those observations that fall at or below the censoring value. The general form of the Tobit model is shown below (Green, 2003),

$$
\begin{aligned}
y_i^* &= x_i'\beta + \varepsilon_i \\
y_i &= a \quad \text{if } y_i^* \leq a \\
y_i &= y_i^* \quad \text{if } y_i^* > a
\end{aligned}
\tag{3.3}
$$

where: *a* = censoring point (value)

x_i' = a row vector whose first element is 1 followed by *p* independent variables, x_j, j = 1, 2, …,*p*

β = a column vector of parameters β_i, i = 0, 1, 2, …, *p*

The parameters for this model are obtained by maximising the log-likelihood function. The log of the likelihood function (ln *L*) in the censored Tobit regression model takes the following form (Green, 2003:767):

$$
\ln L = \sum_{y_i>0} -\frac{1}{2}\left[\log(2\pi) + \ln\sigma^2 + \frac{(y_i - x_i'\beta)^2}{\sigma^2}\right] + \sum_{y_i=0} \ln\left[1 - \Phi\left(\frac{x_i'\beta}{\sigma}\right)\right]
\tag{3.4}
$$

The first part of the equation (Equation 3.4) is the linear regression model for the unlimited observations that uses the maximum likelihood estimator (MLE) procedure, and the second part of the equation indicates the relevant probabilities for the limited observations (Green, 2003). As a result the estimators ($\hat{\beta}$) have a several desirable distributional asymptotic properties (Green, 2003). They are normally distributed, unbiased and have minimum variance.

Both the OLS and Tobit models have direct interpretations. Each coefficient measures the value change of the dependent variable for a unit change in the value of an independent variable, where other independent variables are held constant (Gujarati, 2003).

The main criticism of the OLS model applied to the WTP case is that some of the predicted WTP values are negative, which of course, is illogical because they can only be non-negative. In addition, OLS models become awkward with respect to the zero WTP responses at the specification stage. These zero WTP responses pose a dilemma – should they be treated like other positive observations, or should they be left out altogether (Hill *et al.,* 2001)? The Tobit model avoids these problems, and as a result, is preferred to the OLS model from a statistical theoretic point of view.

Due to its desirable statistical properties most of the willingness to pay models selected for prediction purposes employed the Tobit model. A notable exception was Lin (2005) who also employed the Logit and Probit models (described below).

5.1.2 Binary response dependent variable models

A multiple Logistic regression model (Logit)

The Logit model is an appropriate estimation model when a dependent variable is measured by discrete choices. In this case the dependent variable takes the values of either 0 or 1 (absence or presence of an attribute) and the model predicts the outcome in terms of probability of occurrence (Hanemann and Kanninen, 1999). Due to the nature of the dependent variable in this model the relationship between the dependent variable and independent variables it describes is always nonlinear.

The Logit cumulative distribution function (c.d.f.) is expressed as follows (Gujarati, 2003):

$$\mathrm{G}\left(Z\right) = \mathrm{P}\left(\mathrm{Z} \leq \mathrm{z}\right) = \frac{1}{1+e^{-Z}} = \frac{e^{z}}{1+e^{z}} \qquad (3.5)$$

where Z = a continuous random variable with a logistic distribution.

A multiple Probit regression model (Probit)

In the application of the dichotomous dependent variable estimation, the Logit (based on logistic cumulative function) is not the only suitable c.d.f.. An alternative, and in some cases preferred model, is the Probit model (Gujarati, 2003).

The Probit cumulative distribution function (c.d.f.) is expressed as follows (Hill *et al.,* 2001):

$$F(Z) = P[Z \leq z] = \int_{-\infty}^{Z_i} \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}u^2} du \qquad (3.6)$$

Where: Z = a continuous random variable with a standard normal probability distribution.

Both the Logit and Probit functions have the characteristic of an S-shaped c.d.f., whose probabilities approach zero when the independent variables are at low levels and one when the independent variables are at high levels. All predicted probabilities fall between zero and one.

The coefficients of the variables in both the Logit and Probit models take different meanings from the coefficients in the OLS and Tobit models. The partial coefficients of the Logit and Probit models have no direct interpretations (Verbeek, 2000). A meaningful interpretation of the estimated coefficient of an independent variable requires determining the slope relation between $\hat{P}$ (the estimated probability of WTP) and X (the independent variable), $\partial \hat{P} / \partial X$ (Mirer, 1995).

This determination must be obtained when $\partial \hat{P} / \partial X$ is equal to zero. For both Logit and Probit models this occurs at the point where: $\hat{Z} = 0$, that is, when the probability density functions (p.d.f.), of the logit and probit, denoted *g(Z)* and *f(Z)* respectively, are maximised. This occurs when $g(Z)$ = 0.25 and $f(Z)$ = 0,399.

It can be shown that in the Logit model

$$\frac{\partial \hat{P}_i}{\partial X_i} = g(\hat{Z}_i) \times \hat{\beta}_i \qquad (3.7)$$

and in the Probit model that

$$\frac{\partial \hat{P}_i}{\partial X_i} = f(\hat{Z}_i) \times \hat{\beta}_i \qquad (3.8)$$

It follows that $\partial \hat{P} / \partial X$ describes the effects on the probabilities of a unit change in the value of an independent variable, where other independent variables are held constant. In regression cases, both Logit and Probit models can be extended to a multiple regression framework (Mirer, 1995).

There is no theoretical reason to prefer the Logit over the Probit model, or *vice-versa*. The choice made is a matter of convenience (Gujarati, 2003; Hill *et al.,* 2001) and on how well the data fits the model.

The contribution of individual parameters to explain WTP is typically done with either a *t*-test or *z*-test (for the models using the method of MLE). If the null hypothesis that the relevant coefficient is equal to zero is rejected (the *t*-test statistic value falls within the critical *t* value region) it can be concluded that the relevant coefficient makes a significant contribution to explaining WTP.

To compare the predictive qualities of the complete and reduced models, provided one is nested within the other, an *F*-test may be used for the OLS model and a log-likelihood ratio statistic may be used for the Tobit, Logit and Probit models. The test of the null hypothesis is that none of those variables excluded in the reduced model are significant and therefore equal to zero.

The measurements of the overall significance of the regression models can be explained by R^2 (multiple coefficient of determination) or adjusted R^2 (adjusted multiple coefficient of determination). These measures indicate how well a model fits a set of data. A R^2 value equal to 0 implies a complete lack of fit of the model to the data and a R^2 value equal to 1 implies a perfect fit (Mendenhall and Sincich, 1996). The adjusted R^2 is preferred to the R^2 as it adjusts the observed value for each additional independent variable included in the model. In addition to the R^2 or adjusted R^2, the applicable significant measurement for the binary response models are the McFadden R^2 and the count R^2 (Gujarati, 2003:605). These values are ranged between 0 and 1.

6 Administering the expectation validation test

Typically the adjusted R^2 found for bid functions are quite low. Based on a survey of CVs, Hanley and Spash (1993) argue that an adjusted R^2 value of the estimated model of at least 0.15 (15%) is acceptable. Some studies have utilised their argument as the benchmark for the assessment of construct validity of the CV (Hosking et al., 2004).

Arguably the overall explanatory power of the bid function is the less important of the expectation validation tests. Much more important is the consistency or lack of it found between the coefficient signs and values of the bid function and what one would expect from economic theory and experience. Typical theoretical principles are, other things being equal, that people pay more if they use more of a good/service or earn more or are wealthier, and pay less the more abundant and perfect the substitutes and the harder it is for them to access the amenity. Findings that conflict with these theoretical expectations call into question the survey results and therefore the validity of the household WTP finding.

In addition to the bid function expectation test, there may well be other 'construct' validation checks built into the questionnaire, e.g., ones aimed at testing for part-whole bias problems in the responses and plausibility of the share of budget allocated to the good in the form of the bid.

7 Concluding comments

The demand for freshwater inflows into South African estuaries is a derived demand – derived from the demand for the recreational use of the estuaries. For this reason this inflow is valuable, and from a management perspective, the issue that needs to be addressed is whether this value exceeds or is less than the value of river water in other uses. It is in this context that a CVM of the recreational use of estuary services has direct relevance for decision making on the allocation of South Africa's river water.

This chapter finds CVM to make a particularly useful contribution to the valuation technology available to economists with respect to guiding public decision making on the management of environmental goods and services. It also finds the method to be highly suitable for the specific valuation needs of management with respect to freshwater inflows into South African estuaries.

Notwithstanding this suitability, it acknowledges that the method has many critics and if applied improperly could yield misleading results. Undoubtedly the method will continue to be modified in the light of ongoing experience, and what will constitute acceptable CV practice will continue to change over time.

Current practice in applying CVM entails at least six steps to be followed. Many of these steps are challenging, especially when applied to value the indirect recreational demand for freshwater inflows into estuaries. An important step is that of assessing the credibility of the household WTP finding in terms of theoretical validity. The test for theoretical validity entails comparing the estimated bid function coefficients with the values they would be expected to take in terms of economic theory and experience.

The findings derived from the theoretical validity test should be combined with those of all the other validation tests conducted in the form of an expression of a degree of confidence or otherwise in the WTP predicted. This expression can take the form of a subjective assessment based on a summary of all the validation test results reported or it can be based on an *ex ante* declared weighting formula – as done in Hosking *et al* (2004). Either approach would seem to be an acceptable way by which to draw a conclusion on the overall credibility of the predicted societal WTP (see also Chapter 6, Table 6.1).

Chapter 4

River inflow scenarios for forty South African estuaries[7]

1 Introduction

During the period from 2001 to 2008 contingent valuations of the service impact of changes in fresh water inflows were undertaken among recreational user populations at 40 South African estuaries. The estuaries were selected from 57 options for which the relevant information was generated by a team of estuarine scientists gathered by the project team. The options were in turn identified on the grounds of representing the broad cross-section of estuaries to be found along South Africa's coastline and the belief that these particular estuaries were vulnerable to changes (reductions) in river water inflows.

The relevant information on the 57 estuaries and the forecast reductions in river water inflows they considered are published by the WRC as part 2 of this report (see CD included in cover). Chapter 4 identifies the estuaries that were included in the sample and describes selected features of the changes to estuarine service forecast by a panel of South African estuarine scientists.

2 The estuaries selected (and their features)

Initially 57 estuaries were selected for valuation by means of the contingent valuation method, based on their perceived vulnerability to changes in freshwater inflow, representativeness of the broad cross-section of South African estuaries and conservation importance. These estuaries are listed in Table 4.1 below. Of this sample of estuaries (notwithstanding initial perceptions) no change in inflow was forecast for 17 of them for the period up to 2025, and consequently no valuations were undertaken for these estuaries (see Column 7 of Table 4.1 and Table 4.2). The attention of this project was focussed on the valuation of changes to river water inflow into South African estuaries. Twenty five of the estuaries listed in Table 4.1 were ranked in the top fifty of South African estuaries in terms of their Conservation Importance (Column 4).

7 The content of this chapter form the basis of Part 2 of this report.

Table 4.1: Summary of key features of the fifty seven estuaries covered in the main report (Part 2 of Report).

	Region	Mouth type	Scientific Info	Conservation importance	Condition	Size	Estuaries valued
Olifants	Cool Temperate	Permanently Open	Moderate	2	Good	>100	x
Great Berg	Cool Temperate	Permanently Open	Good	3	Moderate	>100	x
Palmiet	Warm Temperate	Permanently Open	Good	78	Good	10-100	x
Bot (Kleinmond)	Warm Temperate	Estuarine Bay / Lake	Good	8	Good	10-100	x
Klein	Warm Temperate	Estuarine Bay / Lake	Good	9	Good	>100	x
Uilskraals	Warm Temperate	Permanently Open	Moderate	49	Moderate	>100	x
Heuningnes	Warm Temperate	Permanently Open	Moderate	24	Good	>100	x
Breede (Breë)	Warm Temperate	Permanently Open	Moderate	19	Good	>100	x
Duiwenhoks	Warm Temperate	Permanently Open	Moderate	23	Good	>100	x
Klein Brak	Warm Temperate	Temporary Open/Closed	Poor	93	Moderate	10-100	x
Groot Brak	Warm Temperate	Temporary Open/Closed	Good	47	Moderate	>100	x
Swartvlei	Warm Temperate	Estuarine Bay / Lake	Good	7	Good	>100	x
Knysna	Warm Temperate	Estuarine Bay / Lake	Good	1	Good	>100	x
Keurbooms	Warm Temperate	Permanently Open	Good	18	Good	>100	x
Kromme	Warm Temperate	Permanently Open	Good	20	Moderate	>100	x
Gamtoos	Warm Temperate	Permanently Open	Good	16	Moderate	>100	x
Swartkops	Warm Temperate	Permanently Open	Good	12	Moderate	>100	x
Sundays	Warm Temperate	Permanently Open	Good	41	Good	>100	x
Bushmans (Boesmans)	Warm Temperate	Permanently Open	Moderate	35	Moderate	>100	x
Kariega	Warm Temperate	Permanently Open	Good	28	Moderate	>100	x
Kasouga	Warm Temperate	Temporary Open/Closed	Poor	84	Good	10-100	x
Kowie	Warm Temperate	Permanently Open	Good	32	Moderate	>100	x
Kleinemonde West	Warm Temperate	Temporary Open/Closed	Moderate	54	Good	10-100	x
Kleinemonde East	Warm Temperate	Temporary Open/Closed	Moderate	55	Good	10-100	x
Great Fish Estuary	Warm Temperate	Permanently Open	Good	13	Good	10-100	
Bira	Warm Temperate	Temporary Open/Closed	Poor	59	Good	>100	x
Keiskamma	Warm Temperate	Permanently Open	Moderate	17	Moderate	>100	x
Tyolomnqa	Warm Temperate	Temporary Open/Closed	Poor	63	Good	>100	x
Nahoon	Warm Temperate	Permanently Open	Moderate	61	Moderate	10-100	x
Gqunube	Warm Temperate	Permanently Open	Poor	79	Good	10-100	x
	Warm Temperate	Permanently Open	Poor		Good	10-100	
Kwelera	Warm Temperate	Permanently Open	Poor	86	Good	10-100	x
Cefane	Warm Temperate	Temporary Open/Closed	Poor	74	Good	10-100	x
Haga-haga	Warm Temperate	Temporary Open/Closed	Poor	228	Good	<10	x
Great Kei	Warm Temperate	Permanently Open	Moderate	40	Moderate	>100	

Column 1 – Region (Whitfield, 2000)
- Cool Temperate
- Warm Temperate
- Subtropical

Column 2 – Mouth type (Whitfield, 2000)
- River mouth
- Permanently Open
- Temporary Open/Closed
- Estuarine Bay / Lake
- Canal / Other

Column 3 – Scientific information (Whitfield, 2000)
- Good
- Moderate
- Poor

Column 4 – Conservation importance in terms of national ranking (Turpie et al., 2004)

Column 5 – Condition (Whitfield, 2000)
- Good
- Moderate
- Poor

Column 6 – Size in ha (Turpie et al., 2004)
- >100
- 10-100
- <10

Table 4.1 (continued)

	Region	Mouth type	Scientific Info	Conservation importance	Condition	Size	Estuaries valued
Nqabara				75			
Mbashe				25			
Mtata				26			
Mngazana				15			x
Mngazi				146			x
Mzimvubu				31			
Mzintlava				114			
Mbotyi				72			
Mtentu				50			
Mtamvuma				83			
Mzimkulu				38			
Mkomazi				52			
Umgababa				116			
Durban Bay				11			
Mgeni				51			x
Mdloti				53			x
Tongati				81			
Mvoti				89			x
Thukela				56			
Mlalazi				21			x
Mhlatuze				10			x
St Lucia System				6			
Kosi system				5			x

3 The forecast changes in environmental service (the scenarios valued)

Estuarine biodiversity changes in response to shifts in freshwater flow patterns. River inflow also influences mouth condition (along a continuum of an open mouth to fully closed). The degree of freshwater abstraction therefore, influences the estuary in various ways that ultimately influences the estuarine biota. Based on the degree of change in freshwater inflow, predicted biodiversity responses in the sample of estuaries are summarized in Table 4.2 below. The details of the impact on recreational services are reported in Part 2 of this report.

Table 4.2: Summary of basic impact on estuary of forecast reduced river water inflow (also see Table 8.4 later)

Estuary	% reduction in inflow	Main Forecast change in estuary service
Olifants	2	No major shift predicted.
Great Berg	100	Increase in marine species, loss of floodplain area.
Palmiet	20	Reduction in biodiversity.
Bot (Kleinmond)	20	Considerable loss of biodiversity.
Klein	20	Considerable loss of biodiversity.
Uilskraals	20	Possible increase in biodiversity.
Heuningnes	75	No major shift predicted.
Breede (Breë)	5	No major shift predicted.
Duiwenhoks	5	Already a significant change in biodiversity.
Klein Brak	100	Considerable loss of biodiversity.
Groot Brak	-	Previously completed in independent report.
Swartvlei	100	No major shift predicted, unless moth closes for longer.
Knysna	-	Previously completed in independent report.
Keurbooms	-	Previously completed in independent report.
Kromme	-	Previously completed in independent report.
Gamtoos	1	Some biodiversity loss.
Swartkops	-	Previously completed in independent report.
Sundays	-	10% biodiversity loss predicted.
Bushmans	2	No further shift in biodiversity predicted.
Kariega	-	Previously completed in independent report.
Kasouga	50	Considerable loss of biodiversity.
Kowie	-	Previously completed in independent report.
Kleinemonde West	50	Moderate loss of biodiversity – endemic pipefish present.
Kleinemonde East	50	Moderate loss of biodiversity – endemic pipefish present.
Great Fish Estuary	21	No major shift predicted.
Bira	67	Significant loss in biodiversity.
Keiskamma	67	Considerable loss of biodiversity.
Tyolomnqa	67	Significant loss in biodiversity.
Nahoon	67	Significant loss in biodiversity.
Gqunube	62	No major shift predicted.
Kwelera	67	Significant loss in productivity (water column).
Cefane	67	Significant loss in biodiversity.
Haga-haga	67	Moderate loss in biodiversity.

Table 4.2 (continued)

Estuary	% reduction in inflow	Main Forecast change in estuary service
Great Kei	10	No change
Nqabara	-1 (increase)	No change
Mbashe	-1 (increase)	No change
Mtata	1	No change
Mngazana	1	Significant loss in biodiversity.
Mngazi	1	No change
Mzimvubu	1	No change
Mzintlava	0	No change
Mbotyi	0	No change
Mtentu	0	No change
Mtamvuma	0	No change
Mzimkulu	1	No change
Mkomazi	1	No change
Umgababa	100	No change
Durban Bay	100	No change
Mgeni	118	Significant loss in biodiversity.
Mdloti	15	Moderate loss in biodiversity.
Tongati	15	Moderate loss in biodiversity.
Mvoti	15	Moderate loss in biodiversity.
Thukela	22	Significant loss in biodiversity.
Mlalazi	30	Considerable loss in biodiversity.
Mhlatuze	30	Moderate loss in biodiversity.
St Lucia System	3.5 (but with connection to Mfolozi River)	Significant increase
Kosi system	0	No change

4 Conclusion

The selection of estuaries for which to value inflows of river water was led by Prof Wooldridge and a team of estuarine experts assembled by him. Initially 57 were identified. Later this was trimmed down to 40. The next chapter (Chapter 5) reports the marginal benefit estimates made of the river inflows into these estuaries.

Chapter 5

Generating the marginal benefit estimates for forty estuaries[8]

1 Introduction

Chapter 4 and Part 2 describe the scenarios that were valued at the forty selected estuaries, while Chapter 5 describes key measures that were used to generate the marginal benefit estimates. Selected aspects of the sample design are identified (per annum user populations and sample size and selection processes), the mean and median predicted bids for the relevant change are reported, and the mean and median willingness to pay per estuary for the change per cubic metre of water and the change in total estuarine user consumer surplus per cubic metre of water per estuary are calculated. The predicted median willingness to pay is adjusted for changes to price levels (so they may be compared).

These valuations were drawn from the following 10 manuscripts, a conservation study and the deliberations of a panel of estuarine experts. The manuscripts are:
Du Preez (2002), Lin (2005), Dimopoulos (2004), Mlangeni (2006), Potgieter (2005), Van der Westhuizen (2007), Dikgang (2008), Akoto (2009), Chege (2009), Nyaboga (2009).
Copies of all of these manuscripts may be obtained from the Nelson Mandela Metropolitan University library. The conservation study is that of Turpie, Adams, Joubert, Harrison, Colloty, Maree, Whitfield, Wooldridge, Lamberth, Taljaard and Van Niekerk (2002), and the panel deliberations are reported in Part 2 of the Report.

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8 Parts of this chapter have been presented as papers at conferences or published in scientific journals:

Sharp GD, Hosking SG and van der Westhuizen **H (2009). 'Valuation of freshwater inflows using a mixed log-linear model', International Conference on Implementing Environmental Water Allocations, 20-24 February, Port Elizabeth.**

Sale, M, Hosking, SG and du Preez, M (2009) 'Application of the contingent valuation method to estimate a recreational value for freshwater inflows into the Kowie and Kromme estuaries', Water SA 35 (3):261-270.

Sharp,G D., Friskin, D.G, Hosking, S.G., Logie, C.B., Nasila, M. and van der Westhuizen, H. (2009). 'The Determination of an Environmental Service for a Contingent Valuation Study – Using R to Compute Estimates', The R User Conference 2009, July 8-10, Agrocampus-Ouest, Rennes, France.

Hosking SG, vd Westhuizen H and Sharp GD (2009) 'The value of water inflows into six estuaries between East London and Bushmans River, Eastern Cape, South Africa', Resource and Environmental Economics Conference, Cape Town, 20-22 May.

Hosking SG and Hosking JG (2009) 'The value of river water inflows into South African estuaries' WIOMSA Conference, St Denis, La Reunion 24-29 August.

2 Sample design

The sample design and elicitation of bids was administered by 9 different survey teams and during a period spanning 9 years (from 2000-2009). There were differences in style between the survey teams, the questionnaire was changed and the time of the year during which surveys were administered was not always the same – mostly during the December/January recess period. The teams administering the surveys believed that many of the standard complications associated with the application of the contingent valuation method were present to some degree, such as, embedding bias, information asymmetry and the strong possibilty of moral and strategic rather than budget motivated bidding.

The target population (those in whose demand we were interested) was defined to be those using the estuary in the year the survey was administered. Estimating this population (the per annum users for the relevant year) proved to be a major challenge because there are no records on which to base such estimates. The estimates were mostly generated from local authorities and GIS information on the residential population.

The population (complete sample frame) from which the annual visitors to estuaries originated could not be defined (they came from far and wide). As a result of these complications the demand for non-use was excluded and attention was focused on per annum demand for use. The latter includes the demand for passive use, that is, of people coincidentially stopping by the estuary in cars and those seeing the estuary from permanent homes purchased principally for their proximity to other amenities. This type of demand for the estuary functionality is as a complementary service to their demand for other goods and services. The survey teams sought the current users of the estuary within a 10 km radius of the mouth of the estuary.

Over the nine year period from 2000 to 2008 a total of 7768 face to face questionnaires were administered, of which 6397 were deemed valid. The valid response rate of 82.4% was within the target range (see Chapter 6, Table 6.1). Table 5.1 identifies the 40 estuaries that were evaluated and lists the year of survey chronologically. The column labelled *analyst* shows the specific estimates that the students were involved in generating (see Appendix I for more details on the work of the analysts).

Table 5.1: Estuary and analyst database (listed in order estuary surveyed)

Estuary	Analyst	Year	Sample	Valid	Users
Keurbooms	Du Preez	2000	150	120	3312
Groot Brak HB*	Dimopolous	2002	151	151	2730
Swartkops HB	Lin	2002	200	200	5200
Kowie HB	Lin	2002	150	100	3234
Kariega HB	Lin	2002	100	100	2000
Klein Brak HB	Dimopolous	2002	101	101	1178
Knysna HB	Dimopolous	2002	201	201	3891
Kromme HB	Lin	2002	150	150	3200
Mngazana	Mlangeni/Potgieter	2003	107	107	2500
Mngazi	Mlangeni/Potgieter	2003	143	103	7000
Bira	vd West	2004	83	68	1250
Bushmans	vd West	2004	300	229	2800
Kasouga	vd West	2004	151	135	1875
Keiskamma	vd West	2004	251	220	2800
Kleinemonde East	vd West	2004	151	128	1875
Nahoon	vd West	2004	294	270	2800
Tyolomnqa	vd West	2004	150	150	1875
Heuningnes	Dikgang	2005	216	187	1325
Kleinmond	Dikgang	2005	250	212	4482
Klein	Dikgang	2005	249	187	4482
Palmiet	Dikgang	2005	293	258	3878
Cefane	Dikgang	2005	62	42	1250
Kwelera	Dikgang	2005	101	63	2500
Haga-Haga	Dikgang	2005	112	100	2573
Olifants	Akoto	2006	95	80	500
Great Berg	Akoto	2006	268	248	2000
Breede	Akoto	2006	180	161	1328
Duiwenhoks	Akoto	2006	30	28	100
Swartvlei	Akoto	2006	352	337	4000
Kleinemonde West	Akoto	2006	150	132	1250
Mlalazi	Akoto	2006	344	340	1500
Mhlathuze	Akoto	2006	292	286	725
Gqunube	Nyaboga	2007	301	212	5661
St Lucia	Nyaboga	2007	300	261	3218
Uilskraals	Nyaboga	2007	150	103	2168
Gamtoos	Chege	2007	260	141	5000

Table 5.1 (continued)

Sundays	Chege	2007	210	136	8300
Mgeni	Chege	2007	210	113	4414
Mvoti	Chege	2007	300	95	1500
Mdloti	Chege	2007	210	142	2730
Total count			**7768**	**6397**	**114404**

* HB = High benefit scenario (in cases where HB is indicated two scenarios were valued)

Two types of user population found

The survey teams reported finding two different user populations at the estuaries – people engaging in recreation activity and people engaging in subsistence activity. The former tended to be wealthy and the latter poor. The latter derived much of their value indirectly; by supplying services to those engaged in recreation activity.

The collective response of the two populations typically yielded a skewed and bi-modal distribution of observations, and revealed one of the dominant features found in the population using estuaries in South Africa – dualism. Dualistic economies were first studied as sociological dualism in Indonesia by Boeke (1953) and were further made famous by the Nobel prize winner Arthur Lewis (1954). A "dual economy" is when two distinct economies exist within the same region (Hagen, 1986). The dual model proposes that the economy can be split into two halves, a traditional sector and a modern sector. The modern sector has an expanding capitalist nucleus, while the traditional sector economy is based on low-productivity farming and petty commodity production. This economic phenomenon is especially common in less developed countries (Boeke, 1953; Lewis, 1954; Fei and Ranis, 1964).

Dual economies are also prevalent in the southern African region (Barnes, 2002; Blignaut and de Wit, 2004). This same phenomenon may be observed at many of South Africa's estuaries[9]. There are two economies – one based around the (relatively affluent) holiday

9 An examination of the survey data found that there was a large difference in the distribution of different race groupings income levels. Whites made up most of the middle- to upper- class income respondents and Blacks made up most of the lower income respondents. The finding of income inequality between the race groupings in this sample was consistent with findings at national level. The measure often used to calculate income inequality is the Gini coefficient. The Gini coefficient is defined as a ratio with values between 0 and 1. Zero corresponds to perfect income equality, and one corresponds to perfect income inequality (Blignaut & de Wit, 2004). The Gini coefficient for a random sample (S), consisting of values yi (i = 1 to n) that are arranged in an increasing order (yi ≤ yi+1), is defined by the Equation 5.1 (Wikipedia 2006).

recreational users and the other based around (relatively poor) subsistence users. The latter often have strong links to the rural economy and communities and seek employment from the recreation users as domestic workers, builders, river guides, boat pushers and bait collectors. The level of remuneration from this employment is typically higher than the alternative agricultural or subsistence options, inducing migrations and economic dependencies of the sorts reported in other dualistic economies (Fei & Ranis, 1964; Barnes, 2002).

3 Predicted median and mean willingness to pay

3.1 Questionnaire design

A pilot study for this application was administered by Du Preez (2002) among the users of the Keurbooms Estuary, and a modified version of the questionnaire developed and applied until the end of 2005. In each succeeding study attempts were made to improve clarity and omit unnecessary questions. A major addition was incorporated into the questionnaire in 2006, in the form of eliciting travel cost and visit information.

3.2 Administration of the questionnaires – management of the surveys

Each year new students were provided with training on how to administer the questionnaires. Initially, this was provided in the form of a workshop (29 November, 2004) led by Prof Hosking, Prof Wooldridge and Prof Adams. These presentation/discussion sessions were followed by practical sessions on administering the questionnaires. Later student to student training was used.

3.3 Data management

The data for selected groups of estuaries was allocated between the students who participated in the project. These students were responsible for checking up on the

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$$G(s) = \frac{1}{n-1}(n+1-2(\frac{\sum_{i=1}^{n}(n+1-i)y_i}{\sum_{i=1}^{n}y_i})) \tag{5.1}$$

South Africa has one of the highest Gini coefficients in the world of 0.60 (Woolard and Klasen 2005), compared to developed countries which range between 0.30 and 0.40 (Muradzikwa et al. 2004: 278). The Gini coefficient for a combined sample (867 observations) of seven estuaries was estimated at 0.57.

accuracy of the data entered and cleaning or screening the data for validity. Screening included deciding on what to include when there was missing data and adjudicating outliers and protest bids. The responses that remained after this phase was deemed valid and the associated bids were deemed valid bids.

3.4 Modelling

Tobit models were employed for prediction (see Chapter 3 for more detail). In some models the functional relationships estimated were linear and in others logarithmic. Both complete and reduced form models were estimated and the selected predictive model rationalised on statistical grounds.

3.5 Results

To describe user willingness to pay (*WTP*) for the survey results, two central measures of location were determined, the mean willingness to pay (*WTPM*) and the median willingness to pay (*WTPMd*). The results summarised in Table 5.2 include data collected for the years 2000 to 2008 (both inclusive) with *WTPM* and *WTPMd* data adjusted for consumer price index (CPI). The selected models were used to predict mean and medium household willingness to pay per estuary (Table 5.2). The extension *pr* and *cpi* (to WTP) refer to predicted value and consumer price index adjusted value. Both an unadjusted and adjusted predicted mean and a predicted median willingness to pay were calculated.

Table 5.2: Predicted WTP in Rand – unadjusted and adjusted for inflation

Estuary	WTPM Rand	WTPMd Rand	WTPM pr (R)	WTPMd pr (R)	WTPM cpi (R)	WTPMd cpi (R)	WTPM prcpi(R)	WTPMd prcpi (R)
Keurbooms	316	350	305	297	476	527	459	447
Groot Brak HB	225	75	272	192	294	98	355	251
Swartkops HB	280	150	308	244	366	196	402	319
Kowie HB	256	75	325	290	334	98	424	379
Kariega HB	364	75	380	211	475	98	496	275
Klein Brak HB	108	75	129	120	141	98	168	157
Knysna HB	189	150	199	149	247	196	260	195
Kromme HB	360	350	373	287	470	457	487	375
Mngazana	270	15	296	98	336	19	368	122
Mngazi	108	5	180	128	134	6	224	159
Bira	362	150	236	117	443	183	289	143
Bushmans	452	150	253	118	553	183	309	144
Kasouga	223	75	108	71	273	92	132	87
Keiskamma	273	20	77	4	334	24	94	5
Kleinemonde East	284	150	186	3	347	183	227	4
Nahoon	130	75	58	30	159	92	71	37
Tyolomnqa	246	15	111	4	301	18	136	5
Heuningnes	58	25	25	5	70	30	29	5
Kleinmond	109	15	47	4	130	18	57	5
Klein	204	75	82	49	244	90	98	58
Palmiet	249	40	42	39	299	48	50	47
Cefane	339	150	236	139	406	180	283	167
Kwelera	454	350	411	32	543	419	492	39
Haga-Haga	107	113	113	77	128	135	135	92
Olifants	123	0	4	2	143	0	5	2
Great Berg	136	15	125	55	158	17	145	64
Breede	303	75	211	172	352	87	245	200
Duiwenhoks	421	75	26	5	489	87	30	6
Swartvlei	174	40	14	8	202	46	16	10
Kleinemonde West	296	40	347	221	344	46	403	257
Mlalazi	108	40	25	21	125	46	29	24
Mhlathuze	111	25	45	32	129	29	52	37
Gqunube	297	40	30	7	329	44	33	8
St Lucia	113	15	65	9	125	17	72	10
Uilskraals	329	75	104	27	364	83	115	30
Gamtoos	582	75	340	32	644	83	377	36
Sundays	299	58	67	7	330	64	74	8

Table 5.2 (continued)

Mgeni	290	75	227	5	321	83	251	6
Mvoti	182	75	76	41	202	83	84	45
Mdloti	298	40	42	15	329	44	46	16

Note: M = mean, Md = median, pr = predicted, cpi = adjusted for consumer price index (base year = 2008). Estuaries are listed in the order they were surveyed.

Adjustment for inflation and real growth of incomes were made in order to make the estimates comparable – as WTP was elicited in different years.[10]

Although the *WTPM* (mean) exceeds the *WTPMd* (median) for most estuaries, this pattern is not definitive. Seven of the forty estuaries have *WTPMd*s exceeding the *WTPM*s. This lack of conformity is an illustration of the difficulty modelling the user *WTP*s.

The marked difference between the mean and median predicted WTPs provided an opportunity to explore an alternative, more robust, measure of central tendency. In the case of the Bushmans Estuary, the 25% trimmed mean was used as an estimator for the predicted WTP estimates. In order to obtain interval estimates for the three central

10 The indices used to adjust the values to base year ones (2008). During the period from 2000 to 2008 the CPI increased by 51 % and spending power as measured by real GDP by 20%. However, the latter was negated in per capita terms by about a 17-20% increase in the population.

Table 5.3: Yearly weight adjustments

Year	CPI (Base year: 2008 = 100)	Real growth (Base year: 2008 = 100)
2000	**66.4**	**83.2**
2001	**70.2**	**85.2**
2002	**76.6**	**86.7**
2003	**80.4**	**87.7**
2004	**81.8**	**90.2**
2005	**83.5**	**92.9**
2006	**86.1**	**95.8**
2007	**90.4**	**98.8**
2008	**100.0**	**100.0**

measures of location, a bootstrapping re-sampling method was followed. The results of applying this bootstrapped method are shown in Table 5.3.

Table 5.4: Predicting means and medians using the bootstrapping method

	Bootstrapped predicted WTPs (Rand)	Bootstrapped sample std. dev. (Rand)
Mean	245.2	49.4513
Median	120.69	55.7742
Trimmed Mean	145.13	35.5806

The trimmed mean, with the smallest bootstrapped standard deviation, provided a compromise measure of central tendency between the median and mean. Further research in this direction may provide useful results. As can be seen, the use of the bootstrapping statistical technique for the Bushmans Estuary yielded a compromise result (Sharp et al., 2009) – between the two for that case, but there is no reason, *a priori*, for preferring the compromise.

Tables 5.5 and 5.6 highlight important features of the findings reported in Table 5.2. Table 5.5 shows the unadjusted mean and median *WTP*s, as well as the predicted mean and median *WTP*s, while Table 5.6 shows these predictions revised with adjustments for inflation. An important feature of the results is that the mean values are higher than the median values – evidence that the distributions of the responses are asymmetrical. Under these circumstances the median is often the preferred measurement of central location. After the CPI adjustment the median WTP prediction increases from R84.20 to R106.80.

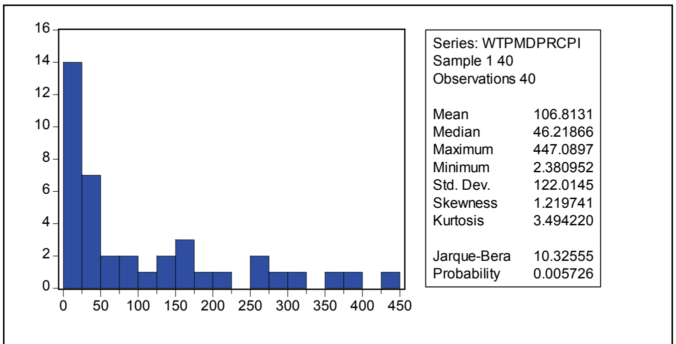
Table 5.5: Mean and median willingness to pay in Rand

WTP	Sample Mean (R)	Predicted Mean (R)	Sample Median (R)	Predicted Median (R)
Average	250.7	162.4	87.1	84.2
Std. Dev. of	116.7	122.7	87.8	91.4
No. Estuaries	40	40	40	40

Table 5.6: Willingness to pay in Rand adjusted for inflation

WTP	Mean CPI_{adj} (R)	Mean Pred. CPI_{adj} (R)	Median CPI_{adj} (R)	Median Pred. CPI_{adj} (R)
Mean	302.1	200.5	108.7	106.8
Std. Dev.	140.2	156.8	118.1	122.0
Observations	40	40	40	40

The standard deviation of the inflation adjusted median predicted adjusted estimate exceeds the predicted median value (see Table 5.6). This finding is in no small measure due to the skewness of the distribution of estimates – see Figure 5.1. Despite the skewness of the distributions, there is overwhelming evidence that estuary users are willing to pay for the necessary freshwater inflow to maintain or improve recreational services.



Median predictions adjusted for inflation

Figure 5.1: Histograms of inflationary adjusted median predictions

4 Values of changed recreational service per cubic metre of river water

The final step taken in predicting WTP was the calculation of the predicted change in total consumer surplus per cubic metre change in river inflow caused by the changed quality of estuary service. The total consumer surplus or total willingness to pay was calculated by multiplying the mean and median predicted WTP by the estimated per annum number of estuary users. This total willingness to pay (at 2008 price levels) for the change in river inflow (consumer surplus lost) is reported by estuary in ascending order of value in Table 5.7. This total was divided by the change in volume (millions of m^3 per annum) of water inflow required to bring about the change in the estuary conditions to calculate the consumer surplus per cubic metre change in river inflow (see Table 5.8).

Table 5.7: Estimated total willingness to pay (consumer surplus) in Rand at 2008 price levels

Estuary	Total WTP mean (R)	Total WTP median (R)
Duiwenhoks	2965157	616725
Olifants	2526132	1190476
Kleinemonde East	426344743	6876528
Heuningnes	38877246	7156587
Tyolomnqa	254431540	9168704
Keiskamma	263569682	13691932
Kleinmond	254319952	22222132
Mgeni	1109847566	24316062
Mhlathuze	38018293	26524390
St Lucia	231275951	31539248
Mlalazi	44041812	36062718
Swartvlei	63832753	39070848
Gqunube	187472754	43205144
Mdloti	125507522	44090708
Sundays	612216814	62341814
Uilskraals	248264779	64728230
Mvoti	125691372	67931416
Kwelera	1231077844	97185629
Nahoon	198533007	102689487
Great Berg	290360046	127758420
Kasouga	247555012	162744499
Gamtoos	1882743363	178097345
Bira	360635697	178789731
Palmiet	193249796	182846539
Klein Brak HB	198383812	184543081
Cefane	353188623	208652695
Haga-Haga	347000635	237116587
Klein	438162467	261673653
Breede	324827875	265954750
Mngazana	920398010	304726368
Kleinemonde West	504108595	321443089
Bushmans	866014670	403911980
Kariega HB	992167102	550010444
Groot Brak HB	969399478	684281984
Knysna HB	1010847258	756865535
Mngazi	1567164179	1114427861
Kromme HB	1558224543	1198955614
Kowie HB	1372127937	1224360313
Keurbooms	1520646862	1480761042
Swartkops HB	2090861619	1656627676

Table 5.8: Estimated price level adjusted values of water at each estuary*

Estuary	Change in inflow of water (millions m^3/annum)	Mean predicted value of water (rand/m^3)	Median predicted value of water (rand/m^3)
Olifants	0.50	0.0044	0.0021
Great Berg	74.9	0.0033	0.0015
Palmiet	3.88	0.0416	0.0394
Kleinmond (Bot)	4.22	0.0503	0.0044
Klein	4.00	0.0915	0.0546
Uilskraals	2.17	0.1034	0.0270
Heuningnes	2.70	0.0120	0.0022
Breede	21.10	0.0133	0.0109
Duiwenhoks	0.50	0.0051	0.0011
Klein Brak HB	11.20	0.0136	0.0126
Groot Brak HB	5.00	0.1485	0.1048
Swartvlei	5.50	0.0100	0.0061
Knysna HB	46.00	0.0168	0.0126
Keurbooms	78.5	0.0129	0.0125
Kromme HB	75.50	0.0158	0.0122
Gamtoos	0.36	4.7278	0.4472
Swartkops HB	14.04	0.1141	0.0904
Sundays	2.16	0.2562	0.0261
Bushmans	2.40	0.2952	0.1377
Kariega HB	7.40	0.1027	0.0570
Kasouga	0.38	0.5329	0.3503
Kowie HB	13.00	0.0809	0.0721
Kleinemonde West	0.10	4.3404	2.7676
Kleinemonde East	0.12	2.9063	0.0469
Bira	1.44	0.2049	0.1016
Keiskamma	19.08	0.0113	0.0006
Tyolomnqa	2.80	0.0743	0.0027
Nahoon	3.78	0.0430	0.0222
Gqunube	5.23	0.0324	0.0075
Kwelera	16.88	0.0609	0.0048
Cefane	13.50	0.0218	0.0129
Haga-Haga	15.44	0.0188	0.0128
Mngazana	10.62	0.0697	0.0231
Mngazi	14.14	0.0089	0.0063
Mgeni	26.90	0.0373	0.0008
Mdloti	2.06	0.0551	0.0193
Mvoti	8.97	0.0127	0.0068
Mlalazi	8.70	0.0044	0.0036
Mhlathuze	9.90	0.0033	0.0023
St Lucia	891.0	0.0002	0.0000

* Values adjusted to 2008 price levels. Estuaries are listed from West to East.

The findings reported in Tables 5.7 and 5.8 reveal a positive WTP for river inflows at most of the forty estuaries in South Africa included in this study. The difference between the values reported in the two tables is the correction for the change in river inflow. Table 5.7 shows that the five most highly valued river inflows into estuaries along the coast of South Africa are the Swartkops, Keurbooms, Kowie, Kromme and Mngazi estuaries. The mean, median and standard deviation respectively of the median predicted consumer surplus value of water per cubic metre in cents are reported in Table 5.9.

Table 5.9: Mean and median willingness to pay per m3

		Mean predicted value of water (cents/m^3)	Median predicted value of water (cents/m^3)
All 40 estuaries	Mean	36.4	11.3
	std dev	107.3	44

The average mean and median predicted consumer surplus per m^3 for the forty estuaries were 36 and 11 cents respectively. The standard deviations about average of the mean and median predicted values respectively, were 107 and 44 cents.

5 Conclusion

There is sufficient empirical evidence to support the expectation that recreational users are willing to pay for estuarine water inflow services. Expected willingness to pay is dependent on the estuary, with mean willingness to pay ranging between R58 and R582 per annum, whilst median willingness to pay ranges between R0 and R350 per annum. Collectively the mean predicted willingness to pay was estimated as R162.45 with a median predicted willingness to pay of R84.18. When using these results for decision making, caution is advised, as the asymmetrical nature of the data makes estimation and modelling difficult.

The findings show there to be considerable variability in the results. The water inflow required for the St Lucia Estuary is so great relative to the total WTP that the consumer surplus per m^3 is reduced to negligible levels; both the mean and median predicted water values are less than R0.00 per m^3. On the other hand the water inflow required to change the Kleinemonde West estuary is small, leading to mean and median predicted water values exceeding R2.50 per m^3. Given this wide dispersion, the assessment of the validity of these estimates assumes particular importance – see Chapter 6.

The consumer surplus values found for changes in river inflow are particularly high for the estuaries located in the Eastern Cape and eastern coast of the Western Cape of South Africa, especially those located within well developed areas – such as the Swartkops, Keurbooms and Kromme.

Chapter 6
A validity assessment of the estimates[11]

1 Introduction

Chapter 3 pointed out that the credibility of the WTP estimates may be assessed in terms of tests for validity and reliability. There are two types of validity assessment that may be made – content and construct (see Table 6.1). Both aspects are covered in the source references cited in Chapter 5. Construct validity incorporates two elements – the plausibility of the predictive model, especially the consistency of its predictions with economic expectations, and the consistency of the estimates the model yields with others generated independently for the same good or service. Chapter 6 reports selected assessments made of the construct validity of the estimates generated and reported in Chapter 5 For this purpose 23 travel cost valuations were generated of the same service and compared to those generated for these estuaries using the contingent valuation method. The two estimates may be compared because both methods calculated the change in consumer surplus induced by changed quality of recreational experience, where the latter was a consequence of reduced inflow of river water into estuaries. This change in consumer surplus was interpreted as the marginal benefit of allocating river water to estuaries.

2 Construct Validity

The assessment of construct validity is part of an assessment of the credibility of an estimate (see Table 6.1a and 6.1b over the next two pages). Construct validity is considered after content validity and reflects problems in the way the information was elicited.

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11 Parts of this chapter have been presented as a paper – see Oliver, C, Hosking, SG and Sharp, G. (2009). 'Comparing choice experiment with contingent values for water inflows into the Bushmans Estuary', International Conference on Implementing Environmental Water Allocations, Port Elizabeth, 20-24 February.

Table 6.1a: Content validity criteria for assessing the credibility of applying the contingent valuation method

Criteria – content validity	**Project leader's overall assessment**	**Compliance effort**
Assess whether the study employed a feasible hypothetical scenario.	✓	The scenario was feasible as similar projects do exist in the study area, e.g., the National Working For Water Programme.
Accurate information on the valuation situation must be presented to and received from respondents (integrity of communication exchange).	✓	All data on the changes in freshwater flowing into estuaries are from the scientific study conducted by Papadopoulos (2009). Responses from drunks, pranksters, etc. were discarded.
Acceptable and independently verified sample design. The determination of population, sample size and selection, must be best practice and its implementation verified externally/independently. If this 'first choice' is not possible, the total sample size must be at least 1000 respondents.		The size of the user population was estimated from local opinion, but GIS figures on population were also considered. The population size could not be independently verified. The determination of sample size was guided Cochran's (1977) specification of the requirements for random sampling.
Pre-testing of survey – did the survey ask the right questions in a clear and appropriate manner.	✓	A pilot study was administered at the Keurbooms and subsequent other studies conducted revealed improvements that could be made to the questionnaire.
Minimize high non-response and missing data – allow "no-answer" option (protest bid) and do not set questions that there are good reasons not to answer.	✓	Typically 10-20 % of the bids could not be used, which is acceptable. The income question was frequently not answered – more at some estuaries than at others.
Personal interviews conducted.	✓	The study opted to use face-to-face interviews to reach the users of the estuaries.
WTP format should be employed. The bid vehicle should be carefully considered and realistic. If uncertain, a single dichotomous question should be employed.		These studied employed WTP to estimate value and did not ask WTA questions. More than one type of bid vehicle was applied. User fees are not collected at South African estuaries as a standard practice.
Cross-tabulation – survey should include questions that help interpret respondents' WTP (for instance, to enable soundly based predictive models to be estimated).	✓	The questionnaire elicited information on many of the variables recommended by Arrow (1993), but there is a trade-off between greater inclusivity and respondent fatigue (there is a time constraint on administration of questionnaires).
Remind respondents of their budget constraints (i.e. alternative expenditure possibilities) to reduce embedding bias, strategic and "warm glow" bids/responses – that indicate vote or moral (what one thinks one should pay) preferences rather than real bids (what one would actually pay) towards the environment.		The surveys were administered by students – they were not experienced surveyors. This reminder could not be verified in all instances.

Source reference: Arrow *et al.* (1993)

Table 6.1b: Construct Validity and Reliability as criteria

Criteria	Project leader's overall assessment	Compliance effort
Construct Validity		
i. Expectation (plausibility of predictive model) Validity		
Conservative design – a model likely to underestimate WTP is preferred to one likely to overestimate WTP.	✓	Residual analysis showed an improvement in the models by using a log-linear functional form. The predicted mean and median WTP for these models were also lower, as there was less variation in the models. Predicted medians were favoured because they yielded more conservative results.
Different models produce similar results when modelling same data.	✓	Logit and Probit models yielded consistent results where they were applied (about 13 cases) – in almost all of these cases the same variables were significant.
Analysed whether bids can be explained in terms of characteristics of sample.	✓	Further interpreted for each individual estuary through regression modelling – overall significance not satisfactory in all cases. An *adjusted* R^2 of 15% was deemed satisfactory (Hanley and Spash, 1993).
Results were consistent with prior expectations of coefficients.		Most, but not all, of the coefficients did conform to expectations.
ii. Convergence (of estimates with those derived from other methods) Validity		
Different methods for valuing a given environmental change produce similar results.	✓	Travel cost estimates generated for 23 estuaries – see chapter 6.
Cross-study analysis showed similar results.	✓	The results were compared with results of the previous estuaries surveyed and it was found that results were similar (overlap with the reliability criterion).
Reliability (when repeatedly applied to the same population are the same predictions generated?)		
Replicate results by running method under same circumstances and conduct temporal averaging – eliminate time dependent "noise" by independently drawn samples.	×	No follow-up surveying has been done yet at the estuaries, but there were comparable valuation circumstances (so a type of convergence/reliability assessment was feasible).

Source reference: Arrow *et al.* (1993)

The project leader assessment of the overall content validity compliance in the project (see second column of Table 6.1) was about 6/9 (or 66%), and construct validity at 4/7 (57%), making the overall compliance self assessment of 10/16 (or 63%). The overall assessment content validity is weighted slightly higher than construct validity. The assessment of content and construct validity took the form of (subjective) self-assessment in terms of the criteria set out in Tables 6.1a and 6.1b. The individual researchers' self-assessments per estuary are reported in Table 6.2. These self assessments of validity were made by the different researchers who administered the surveys and modelled the estimation of the river inflows into the different estuaries.

Table 6.2: Self assessments of expectations validity

Estuary	Analyst	Year	Self -Validity assessment of support for model*
Keurbooms	Du Preez	2000	Not done
Groot Brak HB	Dimopoulos/Lin	2002	Moderate[1]
Swartkops HB	Mlangeni/Lin	2002	Weak[1]
Kowie HB	Sale/Lin	2002	Weak[1]
Kariega HB	Mlangeni/Lin	2002	Moderate[1]
Klein Brak HB	Dimopoulos/Lin	2002	Weak[1]
Knysna HB	Dimopoulos/Lin	2002	Strong[1]
Kromme HB	Sale/Lin	2002	Moderate[1]
Mngazana	Mlangeni/Potgieter	2003	Moderate[2]
Mngazi	Mlangeni/Potgieter	2003	Moderate[2]
Bira	vd Westhuizen	2004	Moderate[3]
Bushmans	vd Westhuizen	2004	Moderate[3]
Kasouga	vd Westhuizen	2004	Strong[3]
Keiskamma	vd Westhuizen	2004	Moderate[3]
Kleinemonde East	vd Westhuizen	2004	Strong[3]
Nahoon	vd Westhuizen	2004	Strong[3]
Tyolomnqa	vd Westhuizen	2004	Strong[3]
Heuningnes	Dikgang	2005	Probably valid[4]
Kleinmond	Dikgang	2005	Probably valid[4]
Klein	Dikgang	2005	Probably invalid[4]
Palmiet	Dikgang	2005	Probably valid[4]
Cefane	Dikgang	2005	Probably valid[4]
Kwelera	Dikgang	2005	Probably invalid[4]
Haga-Haga	Dikgang	2005	Probably valid[4]
Olifants	Akoto	2006	Strong[5]
Great Berg	Akoto	2006	Strong[5]
Breede	Akoto	2006	Strong[5]
Duiwenhoks	Akoto	2006	Moderate[5]
Swartvlei	Akoto	2006	Strong[5]
Kleinemonde West	Akoto	2006	Moderate[5]
Mlalazi	Akoto	2006	Moderate[5]
Mhlathuze	Akoto	2006	Moderate[5]
Gqunube	Nyaboga	2007	Moderate[7]
St Lucia	Nyaboga	2007	Strong[7]
Uilskraalsmond	Nyaboga	2007	Weak[7]
Gamtoos	Chege/Sharp	2007	Moderate[6]

Table 6.2 (continued)

Sundays	Chege/Sharp	2007	Strong[6]
Mgeni	Chege/Sharp	2007	Strong[6]
Mvoti	Chege/Sharp	2007	Moderate[6]
Mdloti	Chege/Sharp	2007	Moderate[6]

Sources: [1]Hosking (2004:178), [2]Mlangeni (2005:131), [3]Van der Westhuizen (2007:135), [4]Dikgang (2007:167), [5]Akoto (2008:86), [6]Chege (2009:88), [7]Nyaboga (2009)

Notes: *Individual analyst rating system used in expectations validity assessment – there were three criteria used in the assessment of expectations validity (Hanley and Spash, 1993:116).

All models are statistically significant with an adjusted R-Squared of not less that 15% and a statistically significant F-Statistic of less than 0.05.

All reduced models contained the significant variables that they would be expected to contain.

The signs of the coefficients in the reduced models conformed to theoretical expectations.

With reference to these three criteria, four ratings were constructed:

Strong support → if all three criteria are met.

Moderate support → if any two of the three criteria are met.

Weak support → if only one of the three criteria is met.

No support → if none of the three criteria is met.

An expectation validity assessment of the estimates was undertaken at 39 of the 40 estuaries. It showed strong support for 12 estimates, moderate support for 16 estimates, support for 5 estimates and weak support (probably invalid) for 6 estimates (fourth column Table 6.2). The estimates for which weak support was found were:

Keurbooms

Swartkops

Kowie

Klein Brak

Klein

Kwalera

Uilskraalmond

3 Convergent validity

3.1 Why a convergence assessment is important

There have been thousands of other stated and revealed estimates of the consumer surplus generated by different natural resources across the world. As could be expected, the values vary widely. There are many reasons for this dispersion. One would expect the different sites people visit for recreation to also differ widely in appeal, but one would be uncertain about which value was correct if there was a wide dispersion of estimates for the same site.

For instance, consider the estimates that have been generated of the value of fishing in saltwater and beach use in Florida and Chesapeake Bay (see table 6.3 below). These results suggest that in the period 1978-80 saltwater fishing and beach use at Chesapeake Bay was more highly valued than that at Florida, but the estimate one would be least sure about would be for beach use of Chesapeake Bay – because there is a wider dispersion of results for this particular service than there is for the other environmental services. The greater the number of estimates of the same service the greater the capacity and reliability of the convergence assessment. The minimum requirement for a convergence assessment is two estimates.

Table 6.3: Selected consumer surplus estimates made in the United States of America

Activity and Site Visited	Study*	Average Consumer Surplus
Fishing in saltwater in Chesapeake Bay	Bockstael, Hannemann and Strand	\$2 054-2564 (1978 dollars) R16 163 (ave. at R7=\$1)
Fishing in saltwater in Florida by residents	Bell, Sorenson and Leeworthy	\$401-1033 (1980 dollars) R5 019 (ave. at R7=\$1)
Beach use of Chesapeake beaches	Bockstael, Strand and Hannemann	\$1080-2757 (1980 dollars) R13 430 (ave. at R7=\$1)
Beach use by Florida tourists	Bell and Leeworthy	\$203 (1984 dollars) R1421(at R7=\$1)
Beach use by Florida residents	Bell and Leeworthy	\$286 (1980 dollars) R2002 (at R7=\$1)

* Reported in Kahn (1998: 100).

3.2 Using travel cost valuations to test for convergence

If independent estimates of the value of the same good or service exist, an assessment of convergence may be done with reference to these. This study generated its own set of values against which to compare the contingent valuation estimates. Twenty-three travel cost estimates of the same service were calculated. The estimates generated by the two methods may be compared because both methods calculated the change in consumer surplus induced by the same change in quality of recreational experience.

These travel cost valuations were based on the same sample design as the contingent valuations. From an on-site sample of recreationists, responses were elicited on how visitation rates would change in response to a change in quality of estuary service. As this response allowed for non-integer changes (percent change in number of visits) the dependent variable was not restricted to a count measure (the normal case for travel cost method estimation). The sample was truncated at zero visits, since all those sampled had made at least one visit (and so were available to be selected to be interviewed), and more frequent visitors were more likely to be sampled than less frequent ones (choice based sampling bias).

A brief outline of the travel cost methods applied is provided in Appendix C. Two were applied – the zonal travel cost method (ZTCM) and the individual travel cost method (ITCM).

When the quality of the recreational good is introduced as an explanatory variable it is possible to determine the consumer surplus for the different quality of goods – by the appropriate substitution into the TGF. In effect the quality variable introduces a shift of the demand function (see Figure 6.1 below).

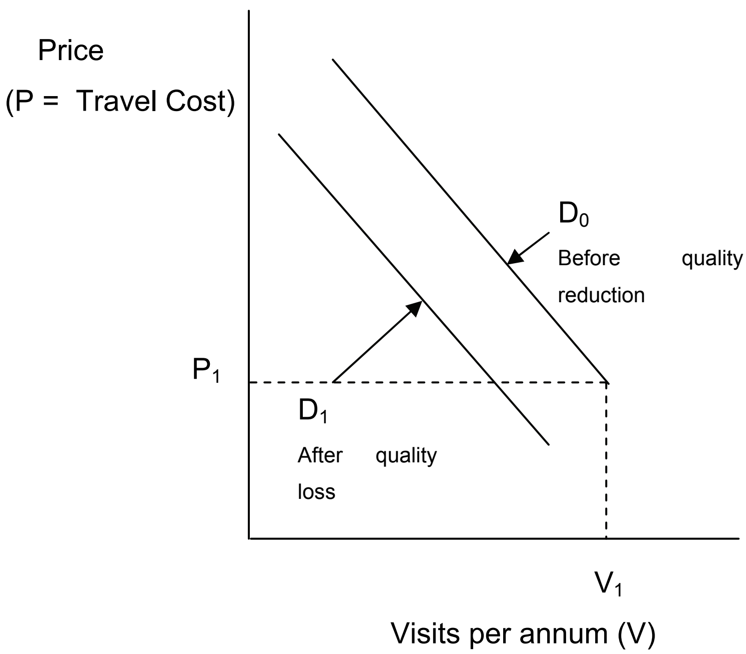

Figure 6.1: Estimating demand where there are quality differences

The consumer surplus due to quality improvement is calculated as the area between the two market demand functions above the entry fee P_1 (see Figure 6.1).

3.3 Results

3.3.1 *Applications of the ZTCM*

Example of the Heuningnes

In order to estimate the change in the gross consumer surplus associated with an increase in freshwater supply into the Heuningnes, Kleinmond, Klein, Palmiet, Cefane, Kwelera and Haga-Haga estuaries, the zonal travel cost method was applied. To determine the change in aggregate consumer surplus two demand curves were derived, one without the improvement in freshwater supply (the base case) and one with the improvement in freshwater supply. The consumer surplus under each of the abovementioned demand curves was then calculated. The difference between the two consumer surpluses was deemed to be the change in consumer surplus due to increased freshwater inflow.

In order to derive a demand curve, and hence consumer surplus, the following eight steps were applied:

(1) The set of zones around the estuaries were defined. In all seven estuary cases three zones were identified (A, B and C). The roundtrip distance for zone **A** was identified as being 1 to 10 km, zone **B** 11 to 60 km, and zone **C** 61 km and further.

(2) Information was collected on the population size of each zone and the number of visits conducted from each zone in the year leading up to the survey.

(3) The visitation rate per 1000 of the population of each zone was determined. This was done by dividing the total number of visits from each zone by its population in thousands.

An example of steps two and three for the Heuningnes Estuary is shown in Table 6.4 below.

Table 6.4: Annual visitation rates – Heuningnes Estuary

Zone	Total visits/annum	Zone population	Visits/1000
A	1119	1060	1.056
B	1533	1590	0.964
C	9	2650	0.0034

(4) The roundtrip travel cost per zone was calculated. The travel costs were determined by zone using the Automobile Association (AA) of South Africa's rates for motor vehicles. The majority of vehicles used by survey respondents had petrol engines with a capacity of between 2500 and 3000 cc. The average survey respondent travelled approximately 20 000 km per annum. The average petrol price in 2006 was used in this study and amounted to R6.06 per litre. An example of the fourth step for the Heuningnes Estuary is shown in Table 6.5 below.

Table 6.5: Roundtrip travel costs – Heuningnes Estuary

Zone	Travel cost (R)*
A	0
B	27.28
C	151.28

* Price level = 2006

(5) An equation was estimated which relates visits per 1000 population to travel costs using regression analysis. For example, the equation for the Heuningnes Estuary was estimated as:

$$V/1000 = 1888.76 - 11.31TC \qquad (6.1)$$

(6) A demand function was determined for visits to the estuaries using the regression equation estimated in the fifth step. Points on the demand curve were obtained by calculating the number of visitors with varying entrance fees – the entrance fee is viewed here as a proxy for travel cost. For example, in the case of the Heuningnes Estuary an entrance fee of R40 was substituted into Equation 6.1 above. This procedure produced the results shown in Table 6.6 below.

Table 6.6: Visitation rate at a R40 entrance fee – Heuningnes Estuary

Zone	Travel cost (in Rand) plus R40	Visits/1000	Population	Total visits
A	R40	1924	1060	2040
B	R67.28	1511	1590	2403
C	R191.28	0	2650	0
			Total visits	4443

Two more points on the demand curve were calculated in the same way – by increasing the entrance fee to R80 and R120, respectively. The results are shown in Table 6.7 below.

Table 6.7: Demand curve points – Heuningnes Estuary

Entrance fee	Total visits
R40	4443
R80	2837
R120	1231

By using these points (see Table 6.7), a recreational demand curve (Equation 6.2) was estimated for the Heuningnes Estuary:

$$TC = 150.66 - 0.025V \tag{6.2}$$

(7) The gross consumer surplus of the estuary (before adjustment for other purposes of the trip) to visitors was calculated from the area under the demand curve traced out in step six above.

(8) A similar calculation of consumer surplus was made for visitation rates at the lower quality of recreation service (due to reduced river inflows) and the two measures subtracted from each other (see table 6.8).

ZTCM results for 7 estuaries

The gross consumer surpluses calculated for seven estuaries using the ZTCM are shown in Table 6.8 below.

Table 6.8: Gross consumers surpluses calculated using the ZTCM*

Estuary	Total visits (a)	Consumer surplus BEFORE improvement (b)	Consumer surplus AFTER Improvement (c)	Change in consumer surplus (c) – (b) = (d)	Consumer surplus per visit (d)/(a)	m^3 freshwater supply change (e)	Consumer surplus per m^3 (d)/(e)
Heuningnes	2661	R343 779	R453 969	R110 190	R41.41	2 800 000	R0.039
Kleinmond	4003	R5 173 038	R13 581 068	R8 408 029	R2100.00	4 000 000	R2.10
Klein	2661	R404 595	R951 460	R546 865	R205.51	4 000 000	R0.14
Palmiet	2649	R2 453 502	R4 907 003	R2 453 501	R926.20	4 000 000	R0.61
Cefane	357	R39 341	R144 519	R105 178	R294.62	13 500 000	R0.01
Kwelera	330	R228 891	R582 002	R353 111	R1070.00	13 500 000	R0.026
Haga-Haga	1642	R189 153	R702 401	R513 248	R312.57	13 500 000	R0.038

* All Rand amounts are at 2006 price levels

Gross = equals before adjustment for other purposes or reasons for travel visits.

Source: Survey team own calculations

These gross travel cost consumer surplus estimates are converted to net estimates (where adjustment is made for other reasons for the travel cost incurred) in Table 6.14 and these are compared to the relevant contingent values reported in Chapter 5 in Table 6.15.

3.3.2 *Applications of the ITCM*

The Individual Travel Cost Method (ITCM) was used to generate consumer surplus values for a further 16 estuaries. In each case the calculations were made using predicted TGFs derived from the sample information collected.

Example of the Breede Estuary

Table 6.9 below shows the regression results for the Breede Estuary and the example which follows shows how the consumer surplus Rand/m^3 value was calculated.

Table 6.9: Travel Cost Regression Results: Breede Estuary

Dependent Variable: Visits				
Model: Reduced				
Observations: 161				
Method:	**Least Squares**			
Variable	Coefficient	Std. Error	t-statistic	Probability
C	228.2449	28.3364	8.0548	0.0000
QUALITY	0.3025	15.4606	1.6686	0.0972
RES	-118.8965	13.6951	-8.6816	0.0000
INCOME	-0.0001	3.05E-05	-3.4695	0.0007
KNOW	36.9239	17.4573	2.1151	0.0360
USE_CAT	-83.2456	27.4587	-3.0316	0.0029
TRAVEL COST	-0.0058	0.0026	-2.2226	0.0277
	R-Squared		0.4307	
	Adjusted R-Squared		0.4085	
	F-statistic		19.4195	
	Probability (F-Statistic)		0.0000	
	Sum Squared Residual		975029	

The number of trips undertaken by the median user per annum to the Breede Estuary may be calculated from the TGF coefficients estimated in Table 6.9 (see Appendix D).

ITCM results for 16 estuaries

Tables 6.10 to 6.13 show the estimated gross consumer surplus values per m^3 of freshwater inflow for a further 16 estuaries. The predictive models from which the TGFs were derived are provided in Appendix D.

Table 6.10: Predicted gross consumer surplus values per m^3 inflow – A*

Estuary	**Breede**	**Duiwenhoks**	**Great Berg**	**Swartvlei**
$TCS_{DECREASED}$	R698 369 106	R417 200	R32 680 000	R11 488 000
$TCS_{CURRENT}$	R709 139 168	R656 400	R48 328 000	R13 008 000
$TCS_{(CURRENT - DECREASED)}$	R10 770 062	R239 200	R15 648 000	R1 520 000
Water Required p.a. (million m^3)	21.1	0.5	75	0.68
Travel cost estimate (Rand/m^3)	0.51	0.49	0.21	0.28

* All Rand amounts are at 2006/7 price levels

Table 6.11: Predicted gross consumer surplus values per m^3 inflow – B*

Estuary	Kleinemonde West	Mdloti	Mgeni	Mhlathuze
$TCS_{DECREASED}$	R410 000	R84 630	R71 586 252	R63 800
$TCS_{CURRENT}$	R855 000	R90 090	R72 844 242	R2 894 200
$TCS_{(CURRENT - DECREASED)}$	R445 000	R5460	R1 257 990	R2 830 400
Water Required p.a. (million m^3)	0.1	2.06	26.9	9.9
Travel cost estimate (Rand/m^3)	4.45	0.003	0.047	0.29

* All Rand amounts are at 2006/7 price levels

Table 6.12: Predicted gross consumer surplus values per m^3 inflow – C*

Estuary	Mlalazi	Mvoti	Olifants	Sundays	Gamtoos
$TCS_{DECREASED}$	R12 834 000	R2 956 500	R17 340	R613 702	R121 850
$TCS_{CURRENT}$	R17 214 000	R3 022 200	R508 680	R633 124	R122 440
$TCS_{(CURRENT - DECREASED)}$	R4 380 000	R65 700	R491 340	R19 422	590
Water Required p.a. (million m^3)	8.7	8.97	0.5	2.16	0.36
Travel cost estimate (Rand/m^3)	0.50	0.007	0.98	0.009	0.02

* All Rand amounts are at 2007/8 price levels

Table 6.13: Predicted gross consumer surplus values per m^3 inflow – D*

Estuary	Gonubie	St. Lucia	Uilkraalsmond
$TCS_{DECREASED}$	R38 265 637.7	R35 549 426.7	R18 977 824.26
$TCS_{CURRENT}$	R50 388 966.33	R44 893 643.62	R27 550 976.38
$TCS_{(CURRENT - DECREASED)}$	R12 123 328.63	R9 344 216.92	R8 573 152.116
Water Required p.a. (million m^3)	5.23	891	2.17
Travel cost estimate (Rand/m^3)	R2.32	R0.0105	R 3.95

* All Rand amounts are at 2007/8 price levels

The conversion of gross to net travel cost and consumer surplus estimates is done in Table 6.14. It was found that on average, estuaries constituted about 40% of the reason for the trip made to the location of the estuary.

Table 6.14: Calculation of net consumer surplus values of freshwater inflows

Estuary	TC estimate value cents/m^3	Estuary as the motive for undertaking the trip (proportion)	Net consumer surplus per m^3 per estuary (cents)
Heuningnes	3.9	.54	2.1
Kleinmond/Bot	210	.42	88.2
Klein	14	.41	5.7
Palmiet	61	.46	28.1
Cefane	1	.47	.5
Kwelera	2.6	.41	1.1
Haga-Haga	3.8	.23	.9
Olifants	98	.36	35.3
Great Berg	21	.37	7.8
Breede	51	.3	15.3
Duiwenhoks	49	.23	11.3
Swartvlei	28	.43	12
Kleinemonde West	445	.61	271.5
Mlalazi	50	.32	16
Mhlathuze	29	.29	8.4
Gqunube	232	.23	53.4
St Lucia	1.1	.51	.6
Uilskraalsmond	395	.23	90.9
Gamtoos	2	.5	1
Sundays	.9	.5	.5
Mgeni	4.7	.4	1.9
Mvoti	.7	.5	.4
Mdloti	.3	.43	.1
Average	**74**	**.4**	**28**

3.4 Comparing the CV and TC estimates

The comparison of CV and TC estimates is made in Table 6.15 (below).

Table 6.15 Comparing unadjusted (for price levels) CV and TC consumer surplus values per m³ river inflow

Estuary	CV estimate value cents/m³	Net consumer surplus per m³ per estuary (cents)	CV-TC estimate (cents) *Converge = 0*	(CV estimate)/(TC estimate) % *Converge = 100*	Convergence assessment*
Heuningnes	.2	2.1	-1.9	10	Weak convergence
Kleinmond/Bot	.4	88.2	-87.8	0	Diverge
Klein	5.5	5.7	-.2	96	Converge
Palmiet	3.9	28.1	-24.2	14	Weak convergence
Cefane	1.3	.5	.8	260	Converge
Kwelera	.5	1.1	-.6	45	Converge
Haga-Haga	1.3	.9	.4	144	Converge
Olifants	.2	35.3	-35.1	1	Diverge
Great Berg	.1	7.8	-7.7	1	Weak convergence
Breede	1.1	15.3	-14.2	7	Weak convergence
Duiwenhoks	.1	11.3	-11.2	1	Weak convergence
Swartvlei	.6	12	-11.4	5	Weak convergence
Kleinemonde West	277	271.5	5.5	102	Converge
Mlalazi	.4	16	-15.6	3	Diverge
Mlathuze	.2	8.4	-8.2	2	
Gqunube	.1	53.4	-53.3	0	Diverge
St Lucia	0	.6	-.6	0	
Uilskraalsmond	.1	90.9	-90.8	0	Diverge
Gamtoos	25	1	24	2500	Diverge
Sundays	1.2	.5	.7	240	Converge
Mgeni	.2	1.9	-1.7	11	Converge
Mvoti	0	.4	-.4	0	Converge
Mdloti	1.6	.1	1.5	1600	Converge
Average	**14**	**28**			

Notes:* Converge – difference less than 2 cents or ratio is between 50-150%.

Weak convergence – difference less than 15 cents or ratio is 10-1000%.

Diverge – does not meet weak convergence criterion (shaded).

Substantial differences were found between the results of applying the contingent and travel cost valuation methods at the selected 23 estuaries. The average of the travel cost consumer surplus value is about twice as high compared to the average of the contingent value. The two methods yielded results which could be said to converge for 9 estuaries, in the sense that the difference in estimates is less than 2 cents or the ratio of CV/TC values is between 50-150%, weakly converge for 6 estuaries, in the sense that the estimates differed by less than 15 cents or the ratio of difference was between 10 and 1000%, and diverge for 6 estuaries (the shaded ones).

There were two conclusions that were drawn from the above comparison. The first was that visitation rates were more sensitive to changes in estuarine quality than stated willingness to pay. The second was that no convergence in the estimates of freshwater inflows into the following estuaries was found between those derived using the contingent and travel cost methods:

Kleinmond/Bot
Olifants
Mlalazi
Gqunubie
Uilskraalmond
Gamtoos

In total the construct validity assessments (expectation and convergence) cast doubt on 11 of the 40 estimates generated.

In addition to the expectations and travel cost convergence-in-values validity assessments reported above, one further convergence-in-value assessment was also undertaken – on the estimated value of river inflows into the Bushmans River Estuary. A comparative value for the river inflows into the Bushmans River Estuary was generated through a choice experiment (see section 4 below).

4 Comparing contingent and choice experiment values for river inflows into the Bushmans River Estuary[12]

In December 2005 one of the project team, Henri van der Westhuizen, applied the contingent valuation method to value river inflows into the Bushmans Estuary. These results were not compared to travel cost valuations, but to the results of a choice experiment over selected management interventions at the Bushmans Estuary administered by another member of the project team, Chantelle Oliver, two years later, in December 2007. This section compares the results of a contingent valuation with those of a choice experiment.

4.1 The contingent valuation estimate

The Bushmans River is linked to the sea through a permanently open estuary located on the east coast of South Africa between Port Elizabeth and East London. The immediate surrounds of the lower reaches of the estuary are developed for recreation, but the higher sections are less developed (it is a small coastal resort). Inflow into estuary has been restricted due the abstraction by farmers and residents. Due to there being no recent major floods and to a low base flow there has been an increase in sedimentation at the mouth of the estuary.

The total catchment area of the river is 2678 km^2. The inlet of the estuary is 50-60 m wide and 2-3 m deep and is constrained on one bank by bedrock outcrop. The lower reaches contain an extensive flood-tidal delta that extends over 2 km upstream. Deep, permanently submerged ebb channels dissect the inter- and supra-tidally exposed flood-tidal delta. The estuary extends for 40 km during low river flow periods. Flood-tidal currents predominate over fluvial currents.

The contingent valuation method was applied to determine the potential loss in recreational value that would accrue due to a 50 % decrease of current freshwater inflow

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12 Presented as a paper at the International Conference on Implementing Environmental Water Allocations, 23-26 February, 2009, Port Elizabeth, entitled 'Comparing results of a contingent valuation with a choice experiment on water allocation to the Bushmans River Estuary', by Hosking, S. G., Oliver, C. and Sharp, G.

into the estuary over the next 20 years – this being the forecast decrease by the DWAF (now DWEA).

Based on this decrease in river inflow, estuarine scientists forecast a 33% decline in the current (already low) biomass of angling fish in the estuary. The question was asked in December 2005 of what current recreational users of the estuary would be willing to pay, in user fees and rates on their properties, to purchase this water 'back' for the estuary. The amount of water needed to be conserved or bought in order to compensate for the additional abstraction was 2.4 million m^3.

The annual user population was estimated to be 2 800 households. A sample of 300 of these was selected to be interviewed during December 2005, less than the 364 calculated as desirable in terms of Cochrane (1977), but more than enough to generate the predictive equations. Of those interviewed, 71 had to be discarded because they fitted the definition of protest bids. This left 229 usable responses. Of these 77% were white, 53% visitors and 72% male. The median size of the households to which they belonged was 4 and their household's median pre-tax income was R200 000.

The method of eliciting the responses was face to face administration of a questionnaire. Respondents selected their level of WTP from a payment card – they circled their choice from a limited number of bracket ranges. During elicitation respondents indicated that there were many other issues affecting the recreational appeal of the estuary besides river water inflow. It was against this background that a comparative valuation of the river inflow into the Bushmans River Estuary by means of a choice experiment was deemed highly appropriate.

The predictive model applied in applying the contingent valuation method included 10 explanatory variables. The midpoints of WTP brackets were used in fitting the models. Based on results of a complete model fit, a reduced model was selected for predicting individual household WTP. The predictive model selected is shown in Table 6.16 (below).

Table 6.16: Predicting WTP for recreation services provided by the Bushmans River Estuary

Dependent Variable: LOG_WTP								
Model: Reduced								
Observation: 229								
Method:	Least Squares				Censored Normal (TOBIT)			
Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient	Std. Error	z-Statistic	Prob.
RACE	4.5132	0.6436	7.0126	0.0000	5.9709	0.8357	7.1444	0.0000
VIS	1.1440	0.4573	2.5015	0.0131	1.3017	0.5618	2.3170	0.0205
KNOW	1.0997	0.4598	2.3916	0.0176	1.4196	0.5701	2.4902	0.0128
LOG_LEV	0.2123	0.0430	4.9320	0.0000	0.2326	0.0527	4.4113	0.0000
C	-1.5878	0.4484	-3.5412	0.0005	-3.5268	0.6346	-5.5576	0.0000
	R-squared		0.5787		R-squared		0.5629	
	Adjusted R-squared		0.5712		Adjusted R-squared		0.5531	
	F-statistic		76.9212		Log likelihood		-522.7167	
	Prob(F-statistic)		0.0000		Left censored obs		50	
					Uncensored obs		179	

This reduced Tobit model was used to predict TWTP. The predicted median WTP was R117.81 and the total willingness to pay (TWTP):

TWTP = 2 800 x R117.81 = R329 868 (6.3)

Expressed as a value per cubic metre the TWTP was

TWTP per m^3 = R329 868/2 400 000 m^3 (6.4)

= R0.14 per m^3

4.2 The choice modelling estimate

Two years after this application of CVM, a pilot choice experiment (CE) was administered at the same location, with the aim of comparing these values with the other ones and to follow up on the 'other estuary issues'.

4.2.1 Experiment design

With the aid of the Bushmans River ratepayers association 5 key attributes were identified relevant to administering the estuary and its environment and 5 levels of attribute. The attributes included user levies/property taxes. The attributes and levels produced a full factorial design with 78125 possible choice set combinations. The statistical package SPSS was used to generate an orthogonal design comprising of 48 sets. The sets were paired randomly and numbered into 32 choice cards.

Each questionnaire incorporated 4 choice cards with 2 unlabelled choice alternatives on each card. Respondents were required to choose between the 4 paired alternatives. The attributes and levels are described in Table 6.17 (below).

Table 6.17: The attributes and levels between which choices were elicited

LEVELS / ATTRIBUTES	1	2	3	4	5	A priori expectation
Regulating Access / Permit Control	0%	10%	30%	60%	100%	Positive
Conservation Control	0% (No improvement)	10% (Minimal improvement)	30% (Slight improvement)	60% (Intermediate improvement)	100% (Rapid improvement)	Positive
Purchase of freshwater inflows - in million m³ (quality of the estuary)	0 (No attempt to maintain the estuary - 33% reduction in the biomass of angling fish)	1.6 (Limited attempt to maintain the estuary)	2.4 (Maintain the current situation)	3.5 (Slowly improve the quality of the estuary)	4.2 (Rapidly improve the quality of the estuary)	Positive
Improving Access	0% (Provide no access to estuary)	30% (Access to estuary by a single slipway)	50% (Access to estuary by roads and slipways)	65% (Access to estuary by roads, slipways and picnic sites)	100% (Access to estuary by roads, slipways, picnic sites and the purchase of privately held access to main attractions)	Positive
Improved Recreation Control	0% (No Control)	20% (Control of fishing access only. No control of boat sport and swimming.)	60% (Control of boat sport activity only. No control of swimming and fishing.)	90% (Control of boat sport and fishing only. No control of swimming.)	100% (Full control of fishing, boat sport and swimming.)	Positive
User Levies	0	R100	R350	R500	R 700	Negative
Additional rates levied	0	R200	R400	R500	R 700	Negative

The levels of the key estuary attribute, namely quality of estuary, were determined by the quantity of river inflow allocations made to (purchased for) the estuary – in millions of m³ water (Table 6.18 below).

Table 6.18: The levels of the quality of estuary attribute

Level of Quality attribute	Millions of m³ water purchased	Forecast impact
1	0	No attempt to maintain the estuary – 33% reduction in the biomass of angling fish
2	1.6	Limited attempt to maintain the estuary
3	2.4	Maintain the current situation
4	3.5	Slowly improve the quality of the estuary
5	4.2	Rapidly improve the quality of the estuary

4.2.2 Sample size and selection

There are a minimum number of choices required to replicate the true population proportions, within the acceptable error (Louviere *et al.,* 2000). Where the alternatives are unlabelled, all parameters are generic across all alternatives and the minimum sample size can be relaxed since the variability required is far less. It is recommended, but not prescribed (Hanley, 2001), that the least popular alternative should contain at least 50 observations (choice sets). Oliver (2009) had less, but was still able to generate estimates with a reasonable degree of confidence (but she acknowledges that the small sample size is a weakness of this study).

There were 74 household heads selected and interviewed. Of those interviewed 4 surveys were incomplete and had to be discarded. For this reason, the analysis of choices was based on the responses elicited from the remaining 70 people interviewed. The characteristics of those surveyed were as follows:
64% white
53% visitors
66% male
median size household=5
median pre-tax income = R170 000

4.2.3 Predicting choice

The recommended conditional logit model was used to analyse the choices made (Hensher et al., 2007). Four parameters were found to be significant at the 10% level: access control, conservation control, improved access and levies (but not quality). The signs of all the coefficients were positive except for levies, which was negative. These signs are as would be expected; indicating that improvements have a positive impact on a users utility, but increases in levies decreased utility. The results are shown in the Table 6.19 below

Table 6.19: Modelling preferences for management at the Bushmans River Estuary

Attributes	DF	Parameter Estimate (β)	Standard Error	Chi-Square	p-value
Access Ctrl	1	0.01165	0.0028	17.5779	<0.0001**
Conservation Ctrl	1	0.01020	0.0031	11.2222	0.0008**
Improved Access	1	0.01017	0.0031	10.6836	0.0011**
Quality	1	0.04507	0.0710	0.4032	0.5254
Recreation Ctrl	1	0.00096	0.0026	0.1374	0.7109
Levies	1	-0.00048	0.0003	3.3037	0.0691**

The odds of an individual choosing a particular option are shown in the Table 6.20 (below).

Table 6.20: The odds ratios for the Bushmans River Estuary

Attribute	Coefficient	Odds Factor
Access Ctrl	0.01165	1.011718
Conservation Ctrl	0.01020	1.010252
Improved Access	0.01017	1.010222
Quality	0.04507	1.046101
Recreation Ctrl	0.00096	1.000962
Levies	-0.00048	1.000481

The odds ratios for the Bushmans Estuary users (Table 6.20) indicate, *inter alia*, that:

An increase of 1% in access control increases the probability of respondents choosing that particular option by 1.17%.

An increase of R1 in levies decreases the probability of choosing this option by 0.04%

An increase of R200 in levies would decrease the probability of choosing this option by 10.1%.

The model was also assessed for multicollinearity and Independence of Irrelevant Alternatives. The following were found:
Access control was correlated with the remaining attributes.
The possibility of the use of a non-orthogonal design.
The validity of the parameters was questionable.
The assumption of Independence-from-Irrelevant Alternatives was tested for and upheld.

Table 6.21: Tests for overall model validity

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	51.579	6	<0.0001
Score	48.603	6	<0.0001
Wald	43.105	6	<0.0001

The tests for overall validity showed that:
All the p-values for all of the model fit statistics were found to be significant.
The null hypothesis that the attributes do not influence choice was rejected.
There was a relationship between choice and the attributes.

4.2.4 Calculation of implicit prices

The willingness to pay can be calculated from the choice predicting model (see Table 6.19) as the ratio of the two relevant parameters. The formula by which these calculations are made is shown below.

The WTP is estimated by dividing the coefficient of the relevant attribute (β_j) in which one is interested (quality of estuary) by the coefficient of the money variable (a), also interpreted as the marginal utility of money income. The result is called the implicit price of the attribute (see Equation 6.5).

$$WTP = -\beta_j/a \quad (6.5)$$

This formula was applied to generate implicit prices for all attributes in the main effects model. These prices are shown in Table 6.22 below.

Table 6.22: Implicit prices of the attributes in the main model

Attributes	Implicit Price (Rand)
Access Ctrl	24.22
Conservation Ctrl	21.20
Improved Access	21.14
Quality	93.68
Recreation Ctrl	2.00

The willingness to pay can also be defined for sub-groups of users. The WTP in Rand for the quality of the estuary for sub-groups of users is shown in Figure 6.2 (below).

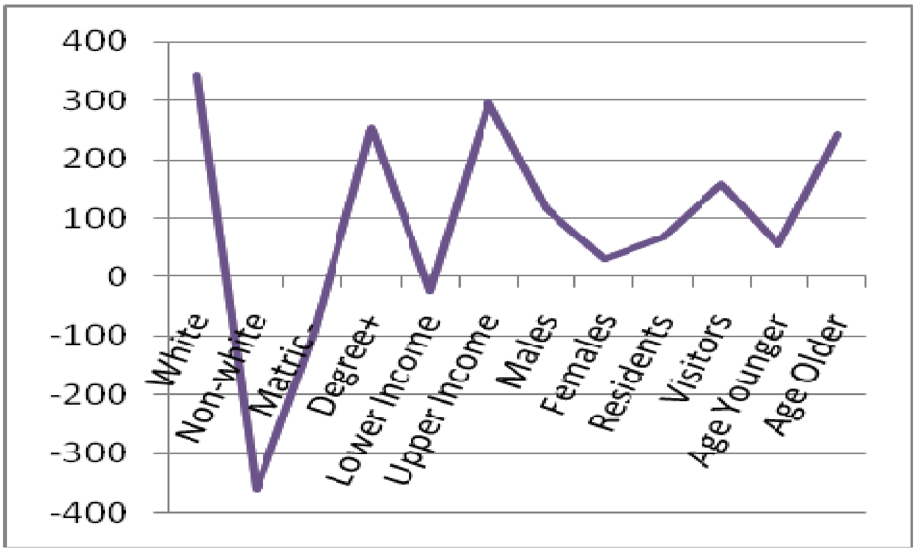

Figure 6.2: An analysis of WTP in Rand for estuary quality per sub-group of users

4.2.5 <u>Deductions about implicit WTP for quality</u>

Access Control, Conservation Control, Improved Access and Recreation Control can be considered as use values. The WTP for the quality of the estuary is considerably larger than the marginal WTP for the other attributes, but the validity of the estimate is questionable.

$$\text{TWTP} = \text{R}93.68/\text{p} \times 2800 \text{ people} = \text{R}262\ 304 \quad (6.6)$$

$$\text{TWTP/m3} = \text{R}262\ 304/2\ 400\ 00\ \text{m}^3 = 11\text{c} \quad (6.7)$$

4.3 Comparing the CV and CE estimates

Van der Westhuizen's CV study estimated use value of river water inflow into the Bushmans River Estuary to be 14c/m^3 in 2005. Oliver's CE study estimated use values of river inflows into the Bushmans River Estuary to be 11 c/m^3 in 2007. The choices presented in the two studies do not permit a direct comparison to be made between them because of differences in the elicitation method. Both studies find river inflows into the Bushmans River Estuary as holding economic value to recreation users of just over 10c/m^3. It was deduced that the application of the CE method did not generate values which could be said to diverge from those generated with a CVM derived model.

5. The reliability issue

No applications of the contingent valuation method were repeated at the same estuaries. For this reason, it is impossible to make any assessment of the margin of error in each particular application of the method, and the only basis for assessing the reliability of the estimates was in the dispersion of results across the different estuaries. Two criteria were considered in this context: the identification of outlier estimates and comparisons of estimates for similar scenarios and estuaries.

Identification of outliers

For the forty estuaries, the average respective mean and median consumer surplus per cubic metre river inflow are 36.4 cents and 11.3 cents, but the mode of both of the respective estimate types lie in the 0-2 cent bracket. The range of distribution of estimates is as shown in Table 6.23. From this perspective it appears that the estimates above 20 cents (see shaded in the table) are potentially outliers, and their reliability may be questionable.

Table 6.23: Dispersion of mean and median estimates

Range of estimate in cents per m^3	Number of mean estimates	Number of median estimates
0-2	18	25
2.1-5	5	6
5.1-10	6	3
10.1-20	4	3
20.1-40	3	1
40.1-100	1	1
100.1-200	0	0
200.1-	3	1

The relevant estimates are those for inflows into the following estuaries:
Kleinemonde West (outlier in both mean and median distributions)
Gamtoos (outlier in both mean and median distributions)
Kleinemonde East (outlier in mean distribution only)
Kasouga (outlier in both mean and median distributions)
Bira (outlier in mean distribution only)
Bushmans (outlier in mean distribution only)
Sundays (outlier in mean distribution only)

The average and standard deviation, respectively, of the mean and median predicted adjusted value consumer surplus of water per cubic metre in cents (see Table 5.7) are reported in Table 6.24.

Table 6.24: Water value summary statistics

		Mean predicted value of water (cents/m^3)	Median predicted value of water (cents/m^3)
All 40 estuaries	Mean	36.395	11.317
	std dev	107.318	43.964
37 estuaries (excl. high est.)	Mean	6.982	3.419
	std dev	6.684	3.785

Also shown in Table 3 are the average and standard deviation of the means and medians when the three estuaries yielding outlier estimates are excluded from the sample, viz. Gamtoos, Kasouga and Kleinemonde West. These three estimates distort the overall pattern of the results – dramatically increasing the average and standard deviation. These three estimates are clearly outliers in the sense that they lie further than 3 standard deviations from the mean (in the 37 estuary sample) and call into question the reliability of the samples used to generate them. When the median distribution of estimates are selected for reference purposes the outlier problem relating to mean estimates is less important. For the purpose of guiding policy these three estimates are excluded on the grounds of suspected unreliability:

Kleinemonde West

Gamtoos

Kasouga.

Selected analysis of similar scenarios

A key reliability question is whether the variation in estimates of otherwise similar scenarios can be explained. This question is briefly addressed below with respect to one class of estuaries – the 12 of the temporary open-closed type included in the sample (see Table 6.25 below). The higher the number of users per change in river inflow the higher one would expect the value of that water to be, *ceteris paribus*.

Table 6.25: An analysis of the order of estimates of river inflow values into 12 temporary open closed estuaries

Estuary	No. user Households/Change in river inflow (houses per change in mil m^3)	Median predicted consumer surplus per m^3 water (cents)	Order of reliability query	Plausible explanation
Kleinemonde East	15625	4.7	Low estimate	Predicted Mean estimate = 291c. Skewed distribution – median is wrong measure
Kleinemonde West	12500	277		
Kasouga	4934	35		
Mdloti	1325	1.9	Low estimate	Mean estimate is 5.5 cents, possibly wrong measure selected
Klein	1121	5.5		
Bira	868	10.2		
Tyolomnqa	670	.3		
Groot Brak (High)	546	10.5	High estimate	Population appear particularly sensitive to the river inflow situation
Haga-Haga	167	1.3		
Mgeni	164	.1		
Klein Brak (High)	105	1.3		
Cefane	93	1.3		

In terms of the order of estimates of values generated of river inflows into temporary open and closed estuaries three stand out as anomalous:

Kleinemonde East (too low)

Mdloti (too low)

Groot Brak (too high)

There are explanations for all of these anomalies. For the first two listed, the mean estimates are more in line with what one would expect, and for the last listed, the user population was reported to be particularly sensitive to the water inflow issue (Dimopoulos, 2005). Under these circumstances it was deemed that there was not an overwhelming case for excluding these estimates as well.

6. Conclusion

The assessment of validity is an extremely important part of applying the contingent valuation method. Not all values generated by this method merit use in policy making and management decisions. The relevant decision maker needs an indication of possible problem measurements. Chapter 6 identified 14 estimates (out of 40) where there was cause for querying their validity or reliability. They are summarised in Table 6.26

Table 6.26: Median estimates of consumer surplus per m^3 over which there are queries

Estuary	Reason to query validity
Keurbooms	No validity assessment
Swartkops	Poor predictive model
Kowie	Poor predictive model
Klein Brak	Poor predictive model
Klein	Poor predictive model
Kwalera	Poor predictive model
Uilskraalmond	Poor predictive model + divergent TC estimate
Kleinmond/Bot	Divergent TC estimate
Olifants	Divergent TC estimate
Mlalazi	Divergent TC estimate
Gqunubie	Divergent TC estimate
Gamtoos	Divergent TC estimate + reliability doubtful
Kleinemonde West	Reliability doubtful
Kasouga	Reliability doubtful

Given the substantial number of estimates that validity assessments have given rise to query it would appear that many of the standard complications associated with the application of the contingent valuation method probably were also present in this study. The students who administered the surveys agreed that it was almost impossible to exclude embedding bias, information asymmetry and moral and strategic rather than budget motivated bidding, *inter alia*, in all applications of the questionnaires.

Chapter 7

The opportunity costs of river inflows into the Mngazi Estuary

1 Introduction

When users are prevented from abstracting water from a river, so that it may flow into an estuary there is an opportunity cost to this inflow. In order to be an efficient reallocation of river water, the marginal benefit of the water inflow into the estuary (reported in Chapter 5) must exceed opportunity cost of this inflow, in the form of its value to those who would otherwise have abstracted and used it. The opportunity cost of the water is what the users of the abstracted water are willing to pay for the water minus the costs they incur in order to use the water (impoundment, transport, treatment, disposal, etc.).

With this opportunity cost in mind, the value of water abstracted from the Mngazi River before it flowed into the estuary was also estimated from the responses of a sample of freshwater users. The purpose of this exercise was very limited – to compare the median sample valuation of a cubic metre of water abstracted from the Mngazi River with the (predicted) contingent value of the water flowing into the estuary, and on this basis draw efficiency deductions. In principle one may draw efficiency deductions because the former is the opportunity cost of the latter.

The contingent value of water flowing into the Mngazi Estuary was calculated by Mlangeni (2006), while the value of water abstracted from the Mngazi was calculated by Mr Francis Wasswa and Mr Johane Dikgang (with assistance from Mr Mlangeni). The relevant questionnaires relating to the opportunity cost study at the Mngazi and Mngazana estuaries are shown in Appendices E and F. Mlangeni's (2005) estimate was based on a survey conducted from June to November 2003 and in January 2004, while Wasswa and Dikgang's estimate was based on a survey conducted during November 2006.

2 The value of water inflow into the Mngazi Estuary

A breakdown of the user population of the Mngazi Estuary is shown in Table 7.1 below.

Table 7.1: Estimated number of households using the Mngazi Estuary per year

Estuary use	No. of households (annually)
Mngazi Hotel guests	3300
Mngazi Hotel staff	250
Subsistence fishermen*	1500
Subsistence farmers	100
Subsistence crafters	100
Proximity/Viewers*	1500
Other (hiking, birding)	250
TOTAL HOUSEHOLD USERS	**7000**

Sources: Small (2004); Mngqinelwa (2004); Mkize (2004).

Note: * There was disagreement within the project team on the number of users, with some contending these were over estimates.

The majority of the user population in Mngazi Estuary consist of recreational users and subsistence fisherman. Following the approach described in Chapter 3, Mlangeni (2006) calculated the sample median and mean willingness to pay (WTP) for freshwater flowing into the estuary to be R5 and R180 respectively. About 30% of the respondents were WTP R0.00 in that study. The predicted (Tobit model) total WTP for freshwater inflow into Mngazi Estuary was found to be R175 000 and the per cubic metre value of the water to be R0.01.

3 The value of water abstracted from the Mngazi River

3.1 Sample design

The basis information for the valuation of water abstracted from the Mngazi River was generated through information elicited in a survey conducted during November 2006. The determination of the sample frame for this valuation proved almost as great a challenge than that of determining the per annum estuary user population. Many of the users of this water do not pay for water as a separate good, but as a composite good or service, e.g., the guests staying at the Mngazi River Bungalows Hotel.

The users of freshwater upstream include, among others, the villages along the Mngazi River and the town of Port St Johns. The OR Tambo municipality has some employees who are based in Port St Johns with a sole task of managing water and sanitation in this area (Port St Johns and its surrounding 30 villages).

The safe water used in Port St Johns and its surrounding areas was sourced from Bulolo dam. The dam is 6 km outside Port St Johns (Pumlile, 2007). The dam receives its supply from ground water and local streams. The water is treated at the Port St Johns water treatment and thereafter supplied to town and surrounding villages. Water that is abstracted from the Mngazi River by the municipality is treated separately at the Mzimvubu water treatment. This water was put on standby and was only used when the Bulolo dam levels were low. An average of approximately 15 Mega Litres (Ml) of water per month or 180 ml per annum is abstracted from the Mngazi River (Pumlile, 2007). Of the 180 ml of water that was abstracted from the Mngazi River during 2005 about two-thirds was consumed by the residents of Port St Johns (a total of 120 ml per annum).

The villages in rural areas receive their safe drinking water from public taps, whereas in the town of Port St Johns each household has its own tap. In 2007 there were 725 households in Port St Johns that were being supplied with safe drinking water (Fanelwa, 2007). In the rural areas, those living near the taps use this water more heavily than those who do not. The survey team estimated that 5000 rural households (with an average size of 5 people) consumed an average of 1 Kl of water a month or 12 Kl per annum (a total of 60 ml per annum for the 5000 rural households), and that town households (Port St Johns) consumed about 30 kl of water per month or 360 Kl per annum (a total of 120 Ml per annum for 333 households). The rural users' water consumption is limited by distance to the treated water source (tap) and storage vessels.

In addition, it was estimated that a further 2000 households abstracted their water directly from the river (a total of about 24Ml per annum). The Mngazi River passes through the following villages: Vukandlule, Scambeni, Mngazi, Chwebeni, Chebeni, Mgxabakazi, Tombo, Rela, Bholani, Caguba, Kwantsila, Enkonxeni, Mabhulwini, Mthalala and Nyikimeni. The population user population estimates are shown in Table 7.2 below.

Table 7.2: Population of users of water abstracted from the Mngazi River

Population	Estimates of Number of Households	Sample Size of Respondents	Sample Size as Percentage of Target Population
23375	7333	211	3.9%

Sources: OR Tambo Municipality (2007)

Given budget limitations, a sample size of just less than four percent of the direct upstream users of the Mngazi River was selected (3.9%). Although the area is inaccessible, the survey team attempted to cover the whole area in its sample selection.

3.2 Survey findings

In total 211 questionnaires were administered along the Mngazi River. All of these bids were adjudged to be valid (Table 7.2). Table 7.2 shows a breakdown of the valid bids, as well as calculated sample means, standard deviations and medians.

Table 7.3: Valid versus Protest bids

Number of Questionnaires	Mngazi Estuary
Administered	211
Valid Bids	211
Median WTP (valid bids in Rand)	10.00
Mean WTP (valid bids in Rand)	40.45
Standard Deviation (valid bids in Rand)	58.80

The mean of the valid bids was calculated to be R40.45 per annum. The median of the bids was identified as R10 and the standard deviation of the bids was calculated to be R58.80.

An analysis of the socioeconomic profiles of the respondents revealed low income, wealth and expenditure on freshwater (see Table 7.4).

Table 7.4: Socio-economic averages of respondents

Characteristic	Averages
Household size (No. of people) – see Figure 7.1 below	**5**
Household taxable income (Rands)	**49 322**
Household tariffs for healthy drinking water per kilo litre (kl) (Rands)	**0.11**
Household tariffs for water from the river for irrigation of crops and feeding of animals per kl (Rands)	**0.03**
Distance of users current accommodation from Mngazi River (km)	**6**
Distance of users current accommodation from the nearest healthy drinking water supply (km)	**10**
Approximate worth of user's house/possessions (Rands)	**54 365**

It was found that 62% of the surveyed households consisted of 5 or more household members. The average income of the household head was found to be R49 322 per annum. Many of surveyed respondents stated that government grants were their main source of income (due to lack of job opportunities in their area). A majority of those in employment were unskilled labourers and earned low wages (see Figure 7.2 below).

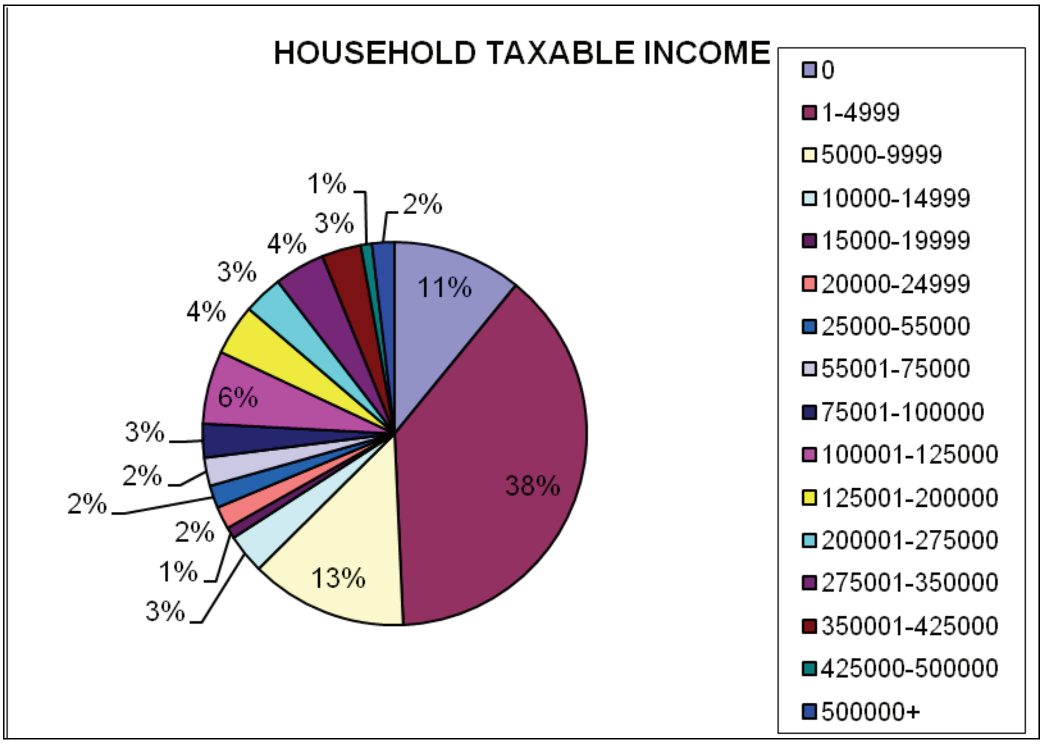

Figure 7.1: Percentage of households according to their income in Rand

A majority of 38% of the surveyed respondents earned between R1 and R4999 per annum and 13% earned between R5000 and R9999, i.e. 62% of the total respondents earned less than R10000 pa. Only 7% earned more than R350000 pa. The average total value of house possessions was consistent with the low income, namely, R54 365.

The respondents reported to be paying an average of R0.11 per Kl in tariffs for safe drinking water per annum to the municipality. The OR Tambo municipality is responsible for providing water and sanitation to the Port St Johns municipality. The respondents reported to be paying R0.03 per Kl per annum on average for water used for irrigation of crops and feeding of animals. The respondent's current accommodation was located about an average of 6 km from the Mngazi River. The closest safe drinking water supply was located about an average of 10 km from the respondent's current accommodation.

Most of the respondents were Black – 182 out of a total of 211 (86% of all respondents). The remainder (29) were White. There were slightly more female respondents than male

– 109 (or 52%) versus 102 (48%). Overwhelmingly, the majority of respondents used the freshwater abstracted upstream of Mngazi River for household consumption – 197 respondents (93%) out of the total. Those abstracting directly from the Mngazi River for consumption did so because alternative safe (potable) drinking water was relatively too far to fetch. Subsistence farmers used a small amount of river water for their crops – their scope for doing so being limited by not having irrigation infrastructure and equipment.

Table 7.5: Respondent willingness to pay analysis

Mean (Rands)	40.45
Standard Deviation (Rands)	58.80
Median (Rands)	10
Mode (Rands)	0

The mean WTP was calculated to be R40.45, the median WTP, R10, the standard deviation, R58.80 and the mode, R0. There were 74 respondents who were willing to pay R0.00 mainly because they were unemployed and therefore did not generate any income. On account of the skewed distribution of responses of WTP, the median is a better measure of central tendency than the mean (see Figure 7.3).

3.3 Mean and median WTP for water abstracted from the Mngazi River

The sample median and sample mean WTP for drinkable quality water, delivered to homes or nearby, and abstracted upstream the Mngazi River, was calculated as follows:
Mean WTP per m^3 = Mean WTP per 360 Kl/ 360 = R40.45/360 Kl = 11.2 cents per m^3
Median WTP per m^3 = Median WTP per 360 Kl/ 360 = R10.00/360 Kl = 2.8 cents per m^3

Since majority of the users received treated water, the cost of treatment has to be deducted from these measures in order to make it comparable to the contingent value of river water flowing into the Mngazi Estuary.

The costs of treating water were supplied by the Port St Johns municipal water service division (drawn for various sources, including the Mngazi). The 3 treatment plants produce a total volume of 239 m^3 per hour and run for approximately 15 hours a day, that is, 3585 m^3 per day and (ideally) for every day (Phumlile, 2008). The costs reported were:

treatment at R100 000 per month
reticulation and maintenance at R25 000 per month
electricity at R9 830 per month
The total annual cost of treating the 1 308 525 m^3 of water was therefore R134 830/month x 12 months = R1 617 960 or R1.24 per m^3, adjusted for these production costs.

It follows that the adjusted mean and median WTP per m^3 are:
Mean WTP per m^3 = 11 – 124 = -114 cents per m^3
Median WTP per m^3 = = 2.8 – 124 = -122 cents per m^3

4 Conclusion

In order for the marginal values to be used to guide river allocations they must be compared to the per annum user opportunity costs of inflows into estuaries. One was available prior to the project – for the Keurbooms (Du Preez, 2002). In addition Chapter 7 reports the willingness to pay for river water abstracted from the Mngazi River for consumption. The findings of these two pilot study cases are summarised in Table 7.6.

Table 7.6: Opportunity costs of river inflows into two estuaries

Estuary	Marginal Value of river inflow into estuary (consumer surplus per m^3 in cents – cal from median WTP)	Marginal Cost of River inflow into estuary (median willingness to pay per m^3 estimate)
Keurbooms	1.3	13 (demand for agriculture)
Mngazi	.7	-122 (stated WTP – prod costs)

The comparisons in Table 7.7 show the marginal value of water flowing into the Mngazi and Keurbooms estuaries to be similar (about 1 cent), but the marginal (opportunity) cost to be very different. Due to the high state of development in the region of the Keurbooms River, the demand for fresh water is high (about 13c per m^3), and due to the low state of development in the region of the Mngazi River, the demand (but not need) for fresh water is negative (about negative122c per m^3).

The comparisons in Table 7.6 are very limited, and it is illadvised to draw general conclusions about other esturies from them. They are consistent with the view that the value of water abstraction upstream of the estuary will typically exceed that of the water flowing into the estuary when this estuary is located in highly developed region, and be less than that of the water flowing into the estuary when this estuary is located in undeveloped region. They suggest that it is efficient to reallocate more river water away from the Keurbooms Estuary and abstract less of the Mngazi River water (so allowing more water to flow into its estuary). An important qualification to remember is that efficiency is but one consideration for the residents and visitors to that estuary. The findings of a survey of estuary user perspectives are reported in Appendix G.

This research shows that one cannot generalise about what allocations are efficient at any given point in time, let alone at different points in time. Efficiency is deduced on a case by case basis and is relevant to a limited period of time.

Chapter 8

Explaining willingness to pay for river inflows into forty South African estuaries[13]

1 Introduction

The second main question this WRC project set out to investigate was what factors explained willingness to pay for river inflows into South African estuaries. Chapter 5 reported measures found for the variable that the project sought to explain – the WTP per cubic metre of river inflows into the estuaries. Chapter 8 identifies the measures used for the explanatory variables identified to explain this WTP and analyses how well these variable perform their explanatory function.

2 The explanatory variables

2.1 Quantitative User Characteristic Variables

Information was gathered on eight user characteristic variables: the estimated number of users per estuary, the percentage of users white and non-white (White), the percentage of users male and female (Male), the percentage of users resident and visitors (Res), the percentage of users well informed of the water management issues at the estuary and uninformed (Know), the annual levies paid by users (LevM = mean vs LevMd = median), the annual gross income of users (IncM = mean and IncMd = median) and the annual value of equipment used for recreational purposes by users (EquipM = mean and EquipMd = median). The tabulated data is shown in Table 8.1, whilst summarised descriptive statistics are provided in Tables 8.2 and 8.3.

There are missing observations in several of the studies compared to the others. One of these is the Keurbooms – the first estuary surveyed. The reason for these omissions is

13 Parts presented as papers at the following conferences:

See Hosking and Hosking (2009)

that the relevant information was not elicited. In many other cases information on the income variable was not obtained, e.g., from users of the Olifants Estuary. Rather than use imputation methods to fill in the missing data, these observations were excluded from the descriptive summaries (shown below).

Table 8.1: Quantitative user characteristic variables*

Estuary	White (%)	Male (%)	Res (%)	Know (%)	LevM (Rands)	LevMd (Rands)	IncM (Rands)	IncMd (Rands)	EquipM (Rands)	EquipMd (Rands)
Keurbooms		74		48	205	150	168210	-	134380	
Groot Brak HB	62	67	52	21	100	25	106623	75000	76132	30000
Swartkops HB	73	84	48	57	194	75	114125	125000	44245	30000
Kowie HB	94	81	42	6	335	300	258500	225000	219340	300000
Kariega HB	80	67	86	55	242	150	141750	125000	72670	75000
Klein Brak HB	81	61	55	11	32	25	79951	75000	68020	75000
Knysna HB	70	69	65	30	112	25	141418	125000	105562	75000
Kromme HB	97	79	54	49	391	300	186833	175000	208173	225000
Mngazana	35	81	80	41	172	25	120093	25000	59196	0
Mngazi	21	68	80	51	114	25	68932	25000	34728	0
Bira	74	74	47	56	341	150	210172	125000	3274	500
Bushmans	77	72	48	61	340	85	288968	200000	1145	500
Kasouga	84	55	48	71	4	0	186330	175000	339	200
Keiskamma	51	61	35	77	233	100	150376	125000	1251	500
Kleinemonde East	90	69	44	98	149	85	262846	175000	414	200
Nahoon	70	74	77	75	98	0	226548	225000	857	0
Tyolomnqa	27	81	91	87	277	0	105168	20000	308	0
Heuningnes	65	63	55	53	42	0	158452	100000	145	0
Kleinmond	60	64	72	59	44	0	170957	125000	267	0
Klein	81	53	43	64	200	0	254000	175000	545	0
Palmiet	59	60	63	73	69	0	149640	75000	337	0
Cefane	95	60	19	50	75	0	310952	225000	899	100
Kwelera	97	57	49	51	53	0	211984	175000	2167	0
Haga-Haga	82	57	49	70	21	0	115793	175000	244	0
Olifants	15	69	89	64	105	87	-	-	141	0
Great Berg	51	53	87	69	755	135	114660	75000	730	0
Breede	93	64	46	83	641	300	281521	225000	925	0
Duiwenhoks	89	54	89	75	618	300	192678	125000	1311	500
Swartvlei	80	57	89	68	110	0	176104	125000	468	0
Kleinemonde West	93	61	72	67	268	250	356484	175000	1066	300
Mlalazi	20	68	90	68	61	0	141263	125000	30	0
Mhlathuze	13	50	82	68	32	0	140020	75000	1059	0

Table 8.1 (continued)

Estuary	White (%)	Male (%)	Res (%)	Know (%)	LevM (Rands)	LevMd (Rands)	IncM (Rands)	IncMd (Rands)	EquipM (Rands)	EquipMd (Rands)
Gqunube	80	54	22	41	49	0	125920	75000	455	0
St Lucia	34	62	28	84	53	0	106398	40000	509	0
Uilskraals	91	57	38	64	3	0	109951	0	157	0
Gamtoos	90	71	70	82	229	200	230390	125000	8850	250
Sundays	71	61	76	72	309	40	136400	40000	12392	100
Mgeni	29	81	88	73	277	0	129115	40000	4780	0
Mvoti	17	82	88	85	78	65	111474	125000	393	200
Mdloti	15	81	81	76	33	0	136866	20000	2385	0

* Note Listing is in chronological order from the first to last dated estimate

The mean and median results are shown in Table 8.2. They indicate that the distributions of the explanatory variables, knowledge, male White and resident are symmetric. These distributions have a beneficial property in linear modelling of reducing the requirement for transformations to improve the fit. The mean and median estimates for the equipment mean (and median) variable are noticeably different. A possible reason for this difference is that the surveys were done over an extended period and the interpretation of annual user equipment, as captured by the interviewee, may have been misrepresented. The earlier surveys included in their estimate the value of boating equipment, vehicles and fishing equipment, whilst later surveys emphasised fishing related equipment. For this reason the answers yielded by the surveys differed.

Table 8.2: User characteristic variables

	Knowledge (%)	Male (%)	White (%)	Resident (%)
Mean	61.7	66.2	64.3	62.5
Median	67	64	73	63
Std. Dev.	20.1	9.8	27.7	21.2
Observations	39	39	39	39

Table 8.3: User characteristic variables (with mean estimates in Rands)

	Equipment mean (R)	Equipment median (R)	Income Mean (R)	Income Median (R)	Levies Mean (R)	Levies Median (R)
Mean	24625	21404	171307	117368	188.3	70.0
Median	1062	0	145695	125000	113.1	25.0
Std. Dev.	52558	61927	68842	64909	182	101
Observations	38	38	38	38	38	38

2.2 Quantitative and Qualitative Estuary Characteristic Variables

Changes to four of the most likely quantitative and two of the qualitative estuary characteristic variables were used to try and predict WTP per m^3 river inflow into estuaries. All quantitative variables were captured as percentage measures and considered to be potentially important aspects of the recreational service provided by the estuaries.

Three of the qualitative variables were the percentage change of the fish population, the percentage change of the area available for boat sports activities and the percentage change of estuary viewing area. The fourth quantitative variable was the conservation importance score, as determined by Turpie et al. (2002).

The climatic classification of the estuary and the mouth functionality of the estuary were the two qualitative variables selected for hypothesis testing. Three climatic (temperate zone) classifications were used: warm temperate (WT), sub-tropical (ST) and cold temperate (CT) – see Table 8.4 below. Similarly, three mouth functionality classifications were used: the estuary was permanently open (PO), a temporary open/closed system (OC) and a combined third group of river mouths (RM), estuarine bays (EB) and estuarine lakes (EL) – see Table 8.4 below (Whitfield, 2000). It was necessary to group river mouths, estuarine bays and estuarine lakes in order to perform the statistical routines for the general linear model (*GLM*). The tabulated data is shown in Table 8.4 whilst descriptive summaries are given in Tables 8.5, 8.6 and 8.7.

Table 8.4: Quantitative and qualitative estuary characteristic variables

Estuary	Conser. Import. (Score)	Temperate class.	Mouth function	Fish (Δ%)	Boat (Δ%)	View (Δ%)
Keurbooms	88.1	WT	PO	0	0	0
Groot Brak HB	74.6	WT	OC	-100	0	0
Swartkops HB	92.0	WT	PO	-25	0	0
Kowie HB	80.3	WT	PO	25	0	0
Kariega HB	81.5	WT	PO	25	0	0
Klein Brak HB	57.9	WT	OC	-100	0	0
Knysna HB	99.8	WT	EB	-80	0	0
Kromme HB	86.4	WT	PO	25	0	0
Mngazana	84.5	ST	PO	-20	20	10
Mngazi	47.0	ST	PO	0	0	0
Bira	74.8	WT	OC	-25	5	-5
Bushmans	75.4	WT	PO	-33	0	0
Kasouga	61.0	WT	OC	-75	-38	25
Keiskamma	90.4	WT	PO	10	10	0
Kleinemonde East	72.3	WT	OC	-50	-10	10
Nahoon	70.0	WT	PO	-25	10	10
Tyolomnqa	73.5	WT	OC	-25	-10	0
Heuningnes	82.4	WT	PO	0	5	0
Kleinmond	95.6	WT	EL	-100	-50	20
Klein	95.3	WT	OC	-38	10	15
Palmiet	64.1	WT	PO	-35	-25	25
Cefane	63.8	WT	OC	-38	0	0
Kwelera	63.5	WT	PO	-25	-10	-10
Haga-Haga	25.6	WT	OC	-10	0	0
Olifants	96.0	CT	PO	0	0	0
Great Berg	97.5	CT	PO	-50	30	0
Breede	85.9	WT	PO	-5	0	-5
Duiwenhoks	79.3	WT	PO	-5	0	-5
Swartvlei	96.3	WT	EL	-50	0	0
Kleinemonde West	72.4	WT	OC	-50	10	10
Mlalazi	85.0	ST	PO	-25	0	0
Mhlathuze	93.5	ST	EB	-10	0	0
Gqunube	66.8	WT	PO	-10	0	0
St Lucia	96.6	ST	LS	90	80	80
Uilskraals	78.9	WT	PO	6	0	0
Gamtoos	90.9	WT	PO	-15	0	0
Sundays	77.4	WT	PO	-13	-10	0
Mgeni	77.6	WT	OC	50	-80	-80
Mvoti	58.4	ST	RM	-20	15	20
Mdloti	71.4	ST	OC	-50	-30	30

The summarised descriptive statistics for the estuary quantitative characteristic variables are shown in Table 8.5. The order of estuary listing is chronological – from the first to last dated estimate. The negative values indicate a mean negative change for the characteristic. The summarised results shows mean and median estimates of similar values, providing evidence of symmetric distributions; a desirable result for linear modelling.

Table 8.5: Estuary quantitative characteristic variables

	∆Fishing (%)	∆Boating (%)	∆Viewing (%)	Conservation importance (score)
Mean	-22	-2	4	78
Median	-23	0	0	79
Std. Dev.	38.7	22.9	20.2	15.5
Observations	40	40	40	40

The frequency distributions of the two qualitative variables are shown in Tables 8.6 and 8.7. Given South Africa's position relative to the warm Indian Ocean it was not surprising that 77% of the estuaries surveyed were grouped into the warm temperate group. Only two cold temperate estuaries were surveyed. A more representative sample would have allowed for better linear modelling possibilities.

Table 8.6: Biographic region characteristics

Biographic region classification (class)				
Category	**Count**	**Percent**	**Cum. count**	**Cum. percent**
Warm	31	77.5	31	77.5
Sub-tropical	7	17.5	38	95
Cold	2	5	40	100
Total	40	100	40	100

The frequency distribution of the mouth functionality variable is shown in Table 8.7. The grouping of river mouths, estuarine bays and estuarine lakes is an additional but practical limitation to the classification category. In particular the grouping of river mouths (Mvoti) and estuarine bays (Knysna) are debatable and caution is advised when interpreting these results. The representation of permanently open and temporary open/closed systems, 55% and 30% respectively, is reasonable and generalizing these results is plausible.

Table 8.7: Estuary mouth functionality

Estuary classification (open)				
Category	**Count**	**Percent**	**Cum. count**	**Cum. percent**
Permanently open	22	55	22	55
Temporary open/closed	12	30	34	85
Other	6	15	40	100
Total	40	100	40	100

3 Explaining WTP in terms of estuary characteristics

Analyses of the responses elicited show that users with a higher willingness to pay for estuary services tend to be white and male and that this group mostly use estuaries for recreational fishing and boating activities, but this hypothesis has yet to be tested across a range of estuaries. This section tests various hypotheses about what explains WTP. The results are reported of a linear modelling analysis of *WTP* as a function of user and estuary characteristic variables.

In order to avoid duplication of analysis, results and discussions, only the final results are presented of the modelling of user characteristic variables, estuary characteristic variables and <u>both</u> user and estuary characteristic variables. All models were estimated using least squares with the dependent variable being mean willingness to pay (*WTPM*).

A complete model estimating *WTPM* as a function of eight user characteristic variables is shown in Table 8.8. The results of the fitted model indicate that only two variables were significant at the 5% level of significance. The functional form of this complete model is given by the equation:

$$WTPM = \beta_0 + \beta_1\left(Equip\ mean\right) + \beta_2\left(Income\ mean\right) + \beta_3\left(Knowledge\right) + \beta_4\left(Levies\ mean\right)$$

$$+\beta_5\left(Gender\right) + \beta_6\left(Resident\right) + \beta_7\left(No.of\ users\right) + \beta_8\left(Race\right) + error \qquad (8.1)$$

where all variables were considered quantitatively.

The two significant variables, race and gender, were also estimated as a reduced model. These results of this estimation are provided in Table 8.9. Inspection of the *adjusted* R^2

indicates that the reduced model is a better fit than the complete model. This finding is consistent with those highlighted by others for specific estuaries.

Table 8.8: Complete user characteristic model

Dependent Variable: *WTPM*				
Method: Least Squares				
Included observations: 38 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-298.13	175.14	-1.7022	0.099
EQUIPM	-0.00047	0.00054	-0.8829	0.385
INCM	0.00016	0.00033	0.4827	0.633
KNOW	0.443	1.2375	0.3576	0.723
LEVM	0.136	0.1059	1.2876	0.208
MALE	4.701	2.1629	2.1735	0.038
RES	-0.06003	0.9842	-0.0610	0.952
USERS	0.00589	0.00992	0.5944	0.557
WHITE	2.398	0.9937	2.4133	0.022
R-squared	0.432	Mean dependent var		252.3
Adjusted R-squared	0.276	S.D. dependent var		117.5
Durbin-Watson stat	1.800	Prob (F-statistic)		0.0213

Table 8.9: Reduced user characteristic model

Dependent Variable: *WTPM*				
Method: Least Squares				
Included observations: 39 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-164.54	130.4	-1.262	0.2152
MALE	3.8406	1.7056	2.252	0.0305
WHITE	2.4783	0.6035	4.107	0.0002
R-squared	0.3349	Mean dependent var		249.0
Adjusted R-squared	0.2980	S.D. dependent var		117.8
Durbin-Watson stat	1.8820	Prob (F-statistic)		0.0006

Complete and reduced models of *WTPM* as a function of six estuary characteristic variables were also estimated. The estimation results of the complete and reduced models respectively, are shown in Tables 8.10 and 8.11. The functional form of the complete model was:

$$WTPM = \beta_0 + \beta_1(\Delta Fishing) + \beta_2(\Delta Boating) + \beta_3(\Delta Viewing) + \beta_4(Cons.\,importance)$$

$$+ \beta_5(Warm\ temp.\ zone) + \beta_6(Sub-trop.\ temp.\ zone)$$

$$+ \beta_7(Perm.\,open) + \beta_8(Temp.\,open/closed) + error \tag{8.2}$$

where four variables were considered quantitatively and two qualitatively.

The variable temperate zone was identified as significant at the 5% level and the mouth open variable was identified as significant at the 10% level.

Table 8.10: Complete estuary characteristic model

	sum of squares	Degrees of freedom	Mean Squared	F-stat	p-value
Intercept	1285.1	1	1285.1	0.1155	0.736
Fish	2873.9	1	2873.9	0.2583	0.615
Boat	289.3	1	289.33	0.0260	0.873
View	386.7	1	386.70	0.0348	0.853
Cons. Imp.	16057.6	1	16058	1.4431	0.239
Temp. zone	78605.5	2	39303	3.5321	0.042
Open mouth	58686.9	2	29343	2.6370	0.088
Error	344950.7	31	11127		

The parameter estimates of the complete model are shown in Table 8.11. The significant variables temperate zone and mouth open were each coded as binary predictor variables.

Table 8.11: Parameter estimates of complete model

	Level	Parameter	Std err	t-stat	p-value
Intercept		40.136	118.10	0.340	0.736
Fish		0.265	0.522	0.508	0.615
Boat		-0.165	1.024	-0.161	0.873
View		-0.216	1.158	-0.186	0.853
Cons. Imp.		1.600	1.332	1.201	0.239
Temp. zone	Warm temp.	87.851	33.14	2.651	0.013
Temp. zone	Sub-trop temp.	22.349	44.59	0.501	0.620
Open mouth	Perm. open	53.883	26.55	2.030	0.051
Open mouth	Temp. op/cl	25.994	32.17	0.808	0.425

The interpretations of the estimated parameters for the complete models significant variables are best demonstrated through an example. For this purpose, *WTPM* is compared between warm temperate and sub-tropical temperate estuaries. After fixing all other variables, the *WTPM* is predicted for both cases and compared. The form of the prediction equation was:

$$\begin{aligned}WT\hat{P}M &= \hat{\beta}_0 + \hat{\beta}_1(\Delta Fishing) + \hat{\beta}_2(\Delta Boating) + \hat{\beta}_3(\Delta Viewing) + \hat{\beta}_4(Cons.\,importance)\\ &+ \hat{\beta}_5(Warm\ temp.\ zone) + \hat{\beta}_6(Sub-trop.\ temp.\ zone)\\ &+ \hat{\beta}_7(Perm.\ open) + \hat{\beta}_8(Temp.\ open/closed).\end{aligned} \tag{8.3}$$

Substituting estimates for the coefficients Equation 8.3 becomes:

$$\begin{aligned}WT\hat{P}M &= 40.13 + 0.265(\Delta Fishing) - 0.160(\Delta Boating) - 0.219(\Delta Viewing) + 1.599(Cons.\,importance)\\ &+ 87.85(Warm\ temp.\ zone) + 22.35(Sub-trop.\ temp.\ zone)\\ &+ 53.88(Perm.\ open) + 25.99(Temp.\ open/closed).\end{aligned} \tag{8.4}$$

Fixing all other variables except warm temperate estuaries, the forecast *WTPM* is:

$$WT\hat{P}M_{WT} = \text{constant} + 87.85(Warm\ temp.\ zone) = c + 87.85\,. \tag{8.5}$$

Similarly, fixing all other variables except sub-tropical temperate estuaries, the forecast *WTPM* is:

$$WT\hat{P}M_{ST} = \text{constant} + 22.35(Sub-trop.\ temp.\ zone) = c + 22.35\,. \tag{8.6}$$

It was deduced that the mean willingness to pay of users of warm temperate estuaries exceeds that of users of subtropical temperate estuaries by:
R87.85 – R22.35 = R65.50.
A similar calculation showed warm temperate estuary users also have a mean willingness to pay of R87.85 more than cold temperate users.

The signs of the parameters for the variables the change in fish population and conservation importance are both positive, but the parameters are not significant. The implication of the positive coefficient is that *WTPM* increases as both variables increase;

a finding that is consistent with the prior expectation that they were positive predictors of mean user willingness to pay.

The results of estimating a reduced model including both 'significant' variables, temperate zone and mouth open, are shown in Table 8.12. As a result of excluding the quantitative variables, both qualitative variables are significant at the 5% level, lending support to the argument that these two variables are reliable predictors of user *WTPM* for freshwater inflows into South African estuaries.

Table 8.12: Reduced estuary characteristic model

	sum of squares	Degrees of freedom	Mean Squared	F-stat	p-value
Intercept	308517	1	308516.8	29.433	0.000004
Temp. zone	79705	2	39852.7	3.802	0.0320
Open mouth	68524	2	34262.0	3.269	0.0499
Error	366868	35	10481.9		

A reduced model of *WTPM* as a function of two significant estuary characteristic variables and the two significant user characteristic variables was also estimated. The results of the reduced model are shown in Table 8.13. The functional form of the relevant reduced model is:

$$WTPM = \beta_0 + \beta_1 (Race) + \beta_2 (Gender) + \beta_3 (Warm\ temp.\ zone) + \beta_4 (Sub-trop.\ temp.\ zone)$$

$$+ \beta_5 (Perm.\ open) + \beta_6 (Temp.\ open / closed) + error. \qquad (8.7)$$

The results of this estimation show that only one variable was significant at the 5% level, namely race (White). The influence of this user characteristic (race) diminishes the influence of the estuary characteristics.

Table 8.13: Reduced model of both user and estuary characteristics

	sum of squares	Degrees of freedom	Mean Squared	F-stat	p-value
Intercept	6893	1	6893	0.6985	0.409
White	41058	1	41058	4.160	0.050
Male	26415	1	26415	2.676	0.112
Temp. zone	8670	2	4335	0.4392	0.648
Open	32647	2	16324	1.654	0.207
Error	315821	32	9869		

There was an *a priori* expectation that estuary users would be *WTP* for maintaining or improving the fish population. In order to test this hypothesis, several models were estimated where improving the fish population was an explanatory variable. The best fitting of these models is shown in Table 8.14. The *p*-value of 0.168 is insignificant at the 10% significance level – insufficient statistical evidence on which to base support for this hypothesis. The estimated coefficient for the change in fish population variable was $\hat{\beta}_1 = 0.636$; the positive sign indicating that estuary user mean willingness to pay increased as the fish population increased, i.e. a finding that is consistent with prior expectation.

Table 8.14: Reduced model of estuary characteristics including fishing variables

	sum of squares	Degrees of freedom	Mean Squared	F-stat	p-value
Intercept	512237	1	512237	44.68	0.000
Fish	22675	1	22675	1.978	0.168
Temp. zone	108783	2	54391	4.744	0.015
Error	412717	36	11464		

4 Conclusion

An analysis of selected variables by means of linear model estimation show that user characteristics such as gender and race are highly significant in determining a user's *WTPM* for estuary services. These results support many of the individual findings of the surveys conducted at the estuaries. In addition, the analysis shows that important estuary factors for determining user *WTPM*s are the climatic zone in which the estuary falls and the time the estuary mouth remains open.

When user and estuary characteristics are considered simultaneously the users characteristics dominate in influence. The results of this analysis provide partial inferential support for the *a priori* expectation that the maintenance of the fish population is important.

The fact that WTP for inflows into estuaries of White males are higher than that of the other sections of the user population is not a reason for trivialising the interests of these other sections. Non-whites and females are major users of South African estuaries, and most stated that they highly valued the conservation of these estuaries. The qualifications recorded in Chapter 2 are also relevant in this connection – differences in income make WTP a weak proxy for interest.

Chapter 9

Conclusions and Recommendations

Estuaries yield many benefits, an important one of which is recreational value. Five primary hypotheses relating to this value were tested in WRC project K5/1413, namely that:

- a theoretically and practically appealing approach to the efficient managing of the allocation of South Africa's river water between estuaries and other uses is to do so with reference to marginal values – by comparing the value of water abstracted with that of the water flowing into the estuary
- the contingent valuation method is a credible method by which to value the flows of river water into estuaries
- the primary value of South African estuaries lies in the recreational services they yield
- the main recreational demand for estuary recreational services is that of white male fishermen
- the more highly developed the region in which the estuary is located, the greater the opportunity cost will be of water flowing into it.

The following conclusions are drawn:

(1) It is feasible to determine efficient allocations of South Africa's river water by reference the value of the water at different points along the rivers. Forty estimates of the value of river inflows into South African estuaries (the end points) were derived on the basis of stated bids elicitated from 7768 interviews conducted during a nine year period from 2000 to 2008. Of the responses elicited, 6397 were deemed valid (82%). The average value per cubic metre of river inflow of the forty estuary predicted mean estimates was found to be 36 cents and the standard deviation about this average was found to be 107 cents. The average and standard deviation values of the relevant predicted median estimates were found to be 11 and 44 cents, respectively. When three outlier (unreliable) estimates are excluded, there is a dramatic reduction in the average and standard deviation of the predicted means and medians. The average and standard deviation of the means drops to 7 cents, and the average and standard deviation respectively, of the medians drop to 3 and 4 cents.

(2) The contingent valuation method is indeed a credible method by which to determine these values, albeit not without problems. The validity of the contingent valuation method has been and continues to be challenged from many angles and quarters, but estimates are acceptable guidelines when they are properly generated. The estimates generated in this report were subjected to validity assessment, and evidence was found that raised concerns over fourteen of the forty estimates, including three suspected as unreliable. Better analytical methods may resolve some of the credibility challenges encountered in this attempt to use economic values to guide policy on the environment.

(3) There are many people with an interest in using estuaries, but the primary demand is for their recreation services they yield. The survey teams reported finding two different user populations at the estuaries – people engaging in recreation activity and people engaging in subsistence activity. The former tended to be wealthy and the latter poor. The latter derived much of their value indirectly; by supplying services to those engaged in recreation activity.

(4) The recreational demand for estuary services is mainly from White males, but not necessarily fishermen. There are many factors that explain the economic value of river inflows into estuaries. Two stand out. The first is the enhancement this inflow gives to the recreational appeal of the estuary. For some estuaries a little water has a big impact, leading the water to be highly valued. WRC Project Report Number 1304/1/04 showed that WTP was sensitive to the magnitude of the forecast impact on the services of the estuary of the change in river inflow. Substantially higher WTP was found for higher benefit scenarios. The second factor is the income of the people that use the services supplied by the estuary. High income earners correlate with high demand.

Given the importance of these two factors, this project focussed attention on two sets of characteristics to explain willingness to pay for river inflows into South African estuaries: one set relating to the users of their services and another set to the recreation characteristics of the estuaries. The project found demand for river inflows into estuaries to be best predicted by the number of Whites and male users, the climatic zone in which the estuary falls and the length of time the mouth is open. The impact of river inflows on the fish population was also found to influence demand positively, but not as convincingly as one would expect, *a priori*.

(5) The evidence is consistent with the opportunity cost of water flowing into the estuary increasing the more highly developed the region in which the estuary is located. These

comparisons are very limited, and it would be ill-advised to draw sweeping conclusions or generalisations from them. It was pointed out (Chapter 2) that there were important ommissions in the calculation of these marginal values, such as scarcity value and external cost. In addition to these ommissions there may be inconsistencies between what is efficient and welfare improving, especially when there are significant differences present in the incomes of the two groups of users and in the nature of their respective uses of water (as a luxury or a necessity). These ommissions and inconsistencies are important in the South African context because the National Water Act of 2008 has, as one of its primary aims, equitable access of water use. The concept of equity employed is providing more access than before to the previously disadvantaged, the poor and the marginalised (as pointed out in Chapter 1). There may be welfare reasons for reallocating water even when the estimated prices of water between different users are brought into equivalence, or alternatively, not reallocating water even when differences in the estimated prices of water suggest that it would be efficient to do so.

There are many challenges encountered in determining credible opportunity costs of river water inflows into estuary habitats from the information available. This information consists of (difficult to obtain) records of transactions in the current imperfect publicly administered markets that relate to water use rights or entitlement in South Africa. These factors undermine as opportunity cost references, actual (administrative) water service charges levied, so making it necessary to estimate this cost in indirect ways. Production costs (of potable water or irrigation water) must be deducted to make the values of the goods comparable (with water *in situ*).

The main argument against employing efficiency arguments to guide water allocations is the lack of normative economic appeal for them where there are significant distributional consequences of alternative allocations (estuary recreational use versus freshwater abstraction use) and many unresolved related economic rights issues. These perspectives should also be taken into account along with efficiency criteria. It is not simply values and efficiency that are important to South Africans and other people interested in our river systems. The field research of this project focussed its attention on this aspect, but the members of the research team were constantly being made aware that South Africans have many other interests and views on our estuaries and rivers than those we captured in the values reported.

Recommendations

(1) Many (not all) South African estuaries have been subjected to reduced functionality because of interference with their links to marine and freshwater inflows. As a consequence their recreational appeal has being undermined. There is a public good (economic) case for government intervention to prevent this loss of functionality by restricting uses of water that cause this problem.

(2) Efficiency should be used as one of the criteria that planners and CMAs use to guide this intervention. It entails comparing estimates of the marginal values of river water flowing into the estuary with those of river water abstracted or removed upstream of the estuary.

(3) There are several credible techniques available by which to estimate the marginal values of river flows; one of which is the contingent valuation method. When administered with the necessary validity checks contingent values may be used to guide water use planning.

(4) The results of applying the contingent valuation method revealed the following:
(a) Higher per cubic meter (unit) values for inflows into estuaries where relatively small reductions of inflow cause big reductions in estuarine service. For this reason it is recommended that prevention of these reductions be prioritised.
(b) Contingent values were positively correlated with the conservation importance of an estuary but not significantly; indicating (at best) a weak efficiency case for prioritising more river inflows into estuaries that are rated highly in terms of conservation importance. For this reason prioritising inflows into estuaries based on the scientific conservation is not supported.

(5) The results of applying the contingent valuation method provided very limited scope on their own for guiding allocations of river water toward efficiency. In order to guide efficiency, these values needed to be compared with the opportunity cost of the inflows into estuaries. Only two limited opportunity cost estimation pilot studies were undertaken as part of this project. One of the challenges in estimating the opportunity costs of river water inflows into estuary habitats is that the market information available to do so (on water use rights) consists of (difficult to obtain) records of transactions in imperfect publicly administered markets in South Africa. Under these conditions there is little merit in using actual (administrative) water service charges levied as references for opportunity

costs. For this reason it is recommended that stated choice techniques also be employed to estimate these opportunity costs.

(6) A policy framework for managing river water allocations based on prioritisation of certain users or uses reduces the merit of adopting the efficiency criterion. If a policy prioritises one allocation of water above another, efficiency is already excluded as a reference to guide the merit of these allocations. Its use is reduced to guiding allocations between uses that enjoy the same prioritisation rating.

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Appendix A

An example of the contingent valuation questionnaire administered

*WRC CVM QUESTIONNAIRE – ADMINISTERED BY UPE – PUBLIC ISSUE OF FRESH WATER INFLOW INTO THE ******* ESTUARY*

INSTRUCTIONS TO PERSON ADMINISTERING THE QUESTIONNAIRE.

(A) NAME OF PERSON ADMINISTERING QUESTIONNAIRE (NOT RESPONDENT):______________________

(B) DATE INTERVIEW CONDUCTED:):______________________

(C) NO RESPONDENTS NAME IS TO BE RECORED AND THE INFORMATION GIVEN BY THEM IS TO BE TREATED AS CONFIDENTIAL.

(D) THERE ARE 19 QUESTIONS. PLEASE TICK THE APPROPRIATE BLOCKS OR FILL IN THE ANSWERS.

*1. **RATE THE RELATIVE IMPORTANCE YOU ATTACH TO THE FOLLOWING ACTIVITIES/ATTRIBUTES OF THE ESTUARY:***

EXTREMELY IMPORTANT = 5

UNIMPORTANT=1

ACTIVITIES/ ATTRIBUTES	EX IMP				UNIMP
10.1 BOAT SPORTS (EXCLUDING FISHING)	5	4	3	2	1
10.2 SWIMMING	5	4	3	2	1
10.3 FISHING	5	4	3	2	1
10.4 VIEWING ESTUARY(ACTIVELY)	5	4	3	2	1
10.5 PROXIMITY – BANKS FOR PICNICS, WALKING, CYCLING ETC	5	4	3	2	1
10.6 BIRD WATCHING	5	4	3	2	1
10.7 COMMERCIAL – ALL BUSINESS ACTIVITIES- USING ESTUARY PROXIMITY	5	4	3	2	1
10.8 SUBSISTANCE- SOURCE OF FOOD	5	4	3	2	1
10.9 PRESERVATION OF UNIQUE FEATURES	5	4	3	2	1
10.10 PASSIVE USE- VIEWING ESTUARY CO-INCIDENTLY OR ENJOYMENT NOT RELATED TO ACTIVE USE.	5	4	3	2	1

2. RACE OF RESPONDENT

RACE	
BLACKS	1
WHITES	2
COLOUREDS	3
INDIANS	4
OTHER	5

3. GENDER OF RESPONDENT

MALE	1
FEMALE	2

4. VISITOR OR RESIDENT?

4.1 VISITOR	1
4.2 RESIDENT	2

5. LOCATION INTERVIEW CONDUCTED (CONSULT MAP)

---

6. HOW OFTEN PER YEAR DO YOU USE THE ESTUARY ON AVERAGE?

DAYS	
1	1
2 -7	2
8 -14	3
15 -28	4
29 -59	5
60 +	6

7. OF THE MEMBERS OF YOUR HOUSEHOLD, HOW MANY USE THE ESTUARY IN SOME WAY OR OTHER DURING THE YEAR?

NUMBER OF MEMBERS OF HOUSEHOLD	
1	1
2	2
3	3
4	4
5	5
6	6
7+	7

8. GROSS ANNUAL PRE-TAX INCOME OF RESPONDENT.

PRE TAX INCOME (RAND)	
0-10 000	1
10 001-30 000	2
30 001-50 000	3
50 001-100 000	4
100 001-150 000	5
150 001-200 000	6
200 001-250 000	7
250 001-350 000	8
350 001-500 000	9
500 001+	10

9. WHAT PERCENTAGE OF YOUR GROSS ANNUAL PRE-TAX INCOME WOULD YOU BE PREPARED TO SPEND, IN TOTAL, ON THE CONSERVATION OF ENVIRONMENTAL RESOURCES?

______________________%

10. WHAT DO YOU THINK WILL HAPPEN IF THERE IS A SIGNIFICANT REDUCTION OF FRESHWATER INFLOW INTO THE ESTUARY?

PERSON IS WELL INFORMED – KNOWS MORE THAN 3 OF THE IMPACTS LISTED BELOW	1
PERSON HAS PARTIAL KNOWLEDGE – KNOWS 1-3 OF THE IMPACTS LISTED BELOW	2
PERSON IS POORLY INFORMED – KNOWS 0 OF THE IMPACTS LISTED BELOW	3

<u>FILL IN THE GAPS IN THE PERSON'S KNOWLEDGE – IMPACTS TO BE READ TO THE RESPONDENT</u>

THE **** OF ** % OF CURRENT FRESH WATER INFLOW INTO THE ESTUARY CAN BE EXPECTED TO HAVE CONSEQUENCES OF THE FOLLOWING MAGNITUDES:

<u>FOR BOATERS</u>

*****

<u>FOR SWIMMERS</u>

*****

<u>FOR FISHERS/BAIT COLLECTORS</u>

1. A ****** OF ANGLING FISH (DUE TO SHRINKAGE OF NURSERY AREA.
2. A ****** IN MUDPRAWN BAIT AVAILABILTY

<u>FOR BIRDERS</u>

A ***** IN WADING BIRDS WHICH FEED IN THE INTERTIDAL ZONE.

<u>FROM THE PERSPECTIVE OF VIEW AND PEOPLE STAYING NEAR THE ESTUARY</u>

******

<u>FROM THE PERSPECTIVE OF LOSS OF UNIQUE HABITATS</u>

******

11. WHAT EXTRA AMOUNT IN USER FEES PER YEAR ARE YOU WILLING TO PAY SPECIFICALLY FOR A PROJECT TO CHANGE THE AMOUNT OF RIVER WATER FLOWING INTO THE ****** ESTUARY IN ORDER TO BRING ABOUT / PREVENT THE FOLLOWING CHANGES FROM OCCURRING (SEE SHADED BLOCK BELOW FOR CHANGES AND PAYMENT CARD FOR INDICATION OF AMOUNT WILLING TO PAY)?

THE USER FEES WOULD BE COLLECTED IN TWO WAYS:
- BY THE LOCAL AUTHORITY IN USER FEES FROM ALL USERS WHO WISH ACCESS TO THE **** ESTUARY
- BY THE LOCAL AUTHORITY IN A SPECIAL EXTRA PER ANNUM ESTUARY CONSERVATION LEVY COLLECTED FROM PEOPLE OWNING PROPERTY WITH A VIEW OF THE ESTUARY.

THE LOCAL AUTHORITY WOULD USE THE FEES SO COLLECTED TO 'PURCHASE' OF ****M^3 OF WATER, I.E., ENOUGH FRESH WATER INFLOW TO PREVENT OR BRING ABOUT THE CHANGES IN ESTUARY SERVICES INDICATED BELOW. THIS PURCHASE WOULD CONSTITUTE **% OF WHAT CURRENTLY FLOWS INTO THE ESTUARY AND *** % OF THE MAR.

DESCRIPTION OF CHANGES:
<u>FOR BOATERS</u>
****
<u>FOR SWIMMERS</u>
*****
<u>FOR FISHERS/BAIT COLLECTORS</u>
1. A **% OF ANGLING FISH (DUE TO SHRINKAGE OF NURSERY AREA.
2. A **% IN MUDPRAWN BAIT AVAILABILTY
<u>FOR BIRDERS</u>
1. A **% IN WADING BIRDS WHICH FEED IN THE INTERTIDAL ZONE.
<u>FROM THE PERSPECTIVE OF VIEW AND PEOPLE STAYING NEAR THE ESTUARY</u>
*****
<u>FROM THE PERSPECTIVE OF THE WORLD GENERALLY</u>
*****

PAYMENT CARD

AMOUNT I AM WILLING TO PAY (RAND) PER YEAR IN USER FEES		
0	0	
1-10	1	
11-20	2	
21-30	3	
31-50	4	
51-100	5	
101-200	6	
201-500	7	
501-1000	8	
1001-2000	9	
2001-3000	10	
3001-4000	11	
4001 + (SPECIFY)	12	SPECIFY

12. IF YOUR ANSWER TO THE ABOVE (QUESTION 12) IS ZERO, WHAT ARE YOUR REASONS (YOU MAY HAVE MORE THAN ONE)?

REASON	
12.1 CANNOT AFFORD THE FEES	1
12.2 GET NO OR NEGLIGIBLE VALUE OUT OF ESTUARY SERVICES	2
12.3 ABUNDANCE OF SERVICE OPTIONS – NO SCARCITY, THEREFORE WHY PAY	3
12.4 LACK OF CONFIDENCE IN LOCAL GOVERNMENT TO COLLECT AND USE FEES COLLECTED FOR THE WATER PURCHASE ONLY	4
12.5 PAYING ENOUGH USER FEES TO LOCAL GOVERNMENT ALREADY	5
12.6 SHOULD BE PAID TO CENTRAL GOVERNMENT IN TAXES AND NOT LOCAL AUTHORITY IN USER FEES	6
12.7 OTHER REASONS (SPECIFY)	7

13. HOW MUCH DOES YOUR HOUSEHOLD PAY PER YEAR IN LEVIES FOR USE/ACCESS TO THE ESTUARY IN FISHING, BOATING, BAIT COLLECTION AND OTHER FEES?
R______________________

WORKING BOX
BACKGROUND INFORMATION (PER ANNUM OR PER VISIT) – E.G., KEURBOOMS
BOATING FEE (R250 P.A. AND R115 FOR A 30 DAY LICENCE MOTORISED)
ANGLING FEE (R35 P.A.)
BAIT COLLECTION FEE (R50 P.A.)
LAUNCHING FEE (FREE)
ACCESS TO BANKS FEE (FREE)
LOCAL AUTHORITY CHARGES TO CONSERVE ESTAURY (NONE?)

14. HOW FAR DO YOU HAVE TO TRAVEL FROM HOME BY CAR/TRUCK TO REACH THE ESTUARY? (RETURN TRIP DISTANCE):
PERMANENT RESIDENCE TO ESTUARY: ______________________KM
ACCOMODATION NEAR ESTUARY TO ESTUARY ITSELF: ______________________KM
WHAT MAKE OF VEHICLE DO YOU USE TO TRAVEL TO THE ESTUARY?
MAKE______________________ AND YEAR (MODEL) ______________________
DO NOT GO BY VEHICLE, BUT BY OTHER MEANS?
IF SO WHAT MEANS______________________ (E.G., FLY AND HIRE CAR OR CATCH BUS)
APPROXIMATE COST OF RETURN TRIP TO ESTUARY BY THIS MEANS R ______________________

15. WHAT IS THE APPROXIMATE TOTAL COST OF THE ACCOMODATION YOU MAKE USE OF WHEN VISITING THE ESTUARY? (WHOLE PERIOD - RESIDENTS PAY ZERO)
R______________________

16. WHAT DO YOU SPEND ON EQUIPMENT PER ANNUM TO ACCESS THE SERVICES OF THE ESTUARY-IN BOATS, FISHING EQUIPMENT, VIEWING EQUIPMENT ETC?
R______________________

17.IF THE AREA AVAILABLE FOR BOATING AND THE NUMBERS OF FISH, BAIT, BIRDS ARE REDUCED SUBSTANTIALLY

17.1 I WOULD STILL VISIT THE ESTUARY	1
17.2 I WOULD VISIT OTHER ESTUARIES INSTEAD	2

18. USING THE ESTUARY IS APPROXIMATELY ____________________**%** OF THE REASON I VISIT THE ESTUARY OR LIVE IN THE AREA.

19. DO YOU HAVE ANY OTHER COMMENTS YOU WOULD LIKE TO CONTRIBUTE ON THIS PUBLIC ISSUE?

____

____

____

____

Questionnaire compiled by members of the Departments of Economics and Zoology, UPE. Questions about this project may be directed at Prof SG Hosking,, tel 041-5042205

Appendix B

The determination of sample size

The population in which this study was interested were the per annum users in the year when the survey was administered (one of those from 2000 to 2008). It was impossible to define this population or properly identify a sampling frame. For this reason, the goal of finding a representative subset of the population was pursued by the surveyors explicitly targeting users of different types (strata). Under these circumstances, the goal of simple random sampling cannot be achieved.

The most appropriate sampling method was the cluster one – selection in the vicinity of the estuary and during the peak holiday season. This method does not require that one draw up a sample frame listing all members of the population of users. Clusters increase the variability of sample estimates above simple random sampling. For this reason there is a need to assess the estimates generated on this basis for reliability.

The determination of sample size is influenced by many factors; of which particularly important ones are effort allocated for gathering the data (time, human resources and budgets), requirements of regression analysis and discretionary allowance for margin of error.

For this project (K5/1413) the effort allocation per estuary was set *ex ante* by the project proposal. In order to avoid making the results too specific to the sample (and thereby undermining the scope for generalising on this basis) the ratio of observations to explanatory variables (including dummy ones) should equal or exceed five (Hair, Anderson, Tatham and Black, 1998:105). In virtually all cases this requirement was more than met for the selected predictive equations. They had less than five explanatory variables; requiring minimum sample sizes of no greater than 25 observations.

The sample sizes afforded and adopted were benchmarked against Cochrane's (1977) formula. Cochrane (1977) distinguishes sample size requirements by the nature of the random variables for which data is being collected, the expected response rate, the t value for the selected alpha level in each tail of the relevant probability distribution, the estimated variance and the acceptable margin of error for the proportion of the variable being estimated.

Cochrane (1977) derives his formulae for sample size from that for the t statistic value for a single sample:

t = (sample mean – population mean)/[(standard deviation)/$\sqrt{n}$] (B.1)

When this equation (B1) is reformulated as a function on the sample size (n) and d is substituted for the difference (sample mean – population mean), it becomes one of equations B2 or B3:

$n_0 = n/(1 + n/\text{population})$ where $n > .05(\text{population})$ (B.2)

$n_0 = n = (1/d^2)(t^2 \,.\, s^2)$ where $n_0 < .05(\text{population})$ (B.3)

and

$n_1 = a(n_0)$ (B.4)

where

n_1 = required sample size adjusted for non-responses

n_0= n_1 = required valid <u>returned</u> sample size

d = acceptable (to researcher) margin of error for the proportion being estimated, normally .05 (Barlett, Kotelik and Higgins, 2001:47)

s^2 = variance about the mean

a = response rate.

For each estuary the measures used to populate these formulae were specified and sample size benchmarks were calculated against which the sample sizes affordable were compared, and deductions drawn about whether the size was sufficient or too small.

All of the studies estimated the variance (d) from that found for the willingness to pay variable in a pilot study at the Keurbooms Estuary (Du Preez, 2002). The population was estimated by the student responsible for managing the administering the particular survey. The valid response rate expected and targeted was between 80 and 90 percent. Various acceptable response rates were employed, but .05 was a common acceptable margin of error.

Appendix C

The travel cost methods (TCM) applied

C.1 Premises /assumptions

The TCM equates individual demand price to the costs incurred by the visitor to visit or access the site being valued. Although the site is typically a public good, market demand is not determined by vertical summation – the sum of all WTP for the recreational or scenic services of the site, as it is with the CVM. Market demand is determined by horizontal summation – the total number of visits made to the site per year.

The research problem is to identify the average visitor's WTP for different numbers of visits per annum. The price they pay may be called an entry fee, but it is most often not paid to a person at the 'gate'. In the market for most public attractions, if there is an official entry fee, it is trivial compared to the payment made by the 'buyers' to access (travel to) the public good. Access purchases take the form of buying extra accommodation or incurring travel costs.

The connection between real WTP and revealed 'WTP-as-Travel Cost' is imperfect. For instance, being local, does not necessarily mean that the person has a low WTP.

C.2 Rationale for using TCM

The travel cost method is a relatively inexpensive method by which to value changes in access cost to a site and changes in environmental quality of a recreational site. When other elements of revealed preference, such as investment in accommodation near the site to improve access to it, are not suitable, then it is preferred to the main alternative revealed preference method, viz. the Hedonic Price Method. The TCM also offers a convergence validation test option against which to compare more expensive stated preference estimate, like the CVM. The latter can yield more precise results of intended protection benefit, but being stated it is more controversial, and requires validation assessment. In order to estimate the demand function there needs to be enough difference in the travel costs of different visitors to influence the number of trips made.

C.3 Three variations of the TCM

There are three variations of the TCM:

– a zonal approach (ZTCM), based mainly on secondary data (limited survey data). This technique is also sometimes called the Clawson-Knetsch method after the authors who first formalised it in the literature.

– an individual TC approach (ITCM). This method requires a detailed survey of visitors.

– a random utility approach (RUTCM). This method uses survey data and provides a superior format for taking substitute effects into account.

C.4 Three basics stages in applying zonal and individual TCMs

Only the ZTCM and ITCM were applied in this analysis. There are three basic stages entailed in applying these methods.

STAGE 1: Generating the trip generating function (TGF)

(a) Zonal.

The ZTCM generates the TGF as an expected value function:

Pr(visit/annum from a member of user population per zone) = visitors/population per zone = f(TC per zone)

(b) Individual:

The ITCM generates the TGF as a predicted value function:

Predicted per person Visits/annum = V/a = f(TC; quality perception; other things).

Being a predictive (rather than expected value) function, the ITCM TGF can serve directly as the demand curve, unlike the ZTCM TGF (but see Cook, 2000). There are debates, *inter alia*, over what should be included as a travel cost, over whether travel time is a cost of a separate explanatory variable (Loomis, *et al*., 2000:184), how to incorporate complementary goods and prices (Parson and Wilson, 1997; Loomis, et al., 2000) and how to incorporate the prices of substitutes.

STAGE 2: Derivation and specification of the market demand function

(a) ZTCM

The ZTCM derives the market demand as an expected function.

Expected Market D = sum for all P (admission fee) of:

Population per TC zone x **Pr**(visit/annum from a member of user population per TC zone)

(b) ITCM:

The ITCM derives the market demand function directly from the TGF by inverting the function and substituting into the TGF selected values for all the variables other than price and quantity.

Predicted Market D = Population (<u>or visitors</u>) x **Predicted** Visits/annum

Given a travel cost price, a quality perception and other defined factors, e.g., income, mean investment in complementary goods/equipment, mean cost of alternative trip to an equivalent substitute, etc.

<u>Specification of the functional form of the demand curve</u>

Typically, the demand functions derived are specified in linear or exponential form. Using a distribution that is restricted to non-negative integers (count data models) is efficient from an estimation perspective because visits are limited in this way (Hellerstein and Mendelsohn, 1993). For this reason, Poisson and negative binomial distributions, are preferred options (Martinez-Espineira and Amoako-Tuffour, 2005). These models employ an exponential form of the quantity of trips:

Mean of Visits (V) fn = f(exp[TC; Z; b]) (C.1)

TC = travel cost variable

Z = other variables

b = vector of parameters

and

the Negative Binomial form of the Poisson count distribution.[14]

STAGE 3: Calculation of relevant consumer surplus from market D function

There are two types of consumer surplus that may be calculated and two ways by which to calculate the consumer surplus $(CS)_{V1}$ for V_1 visits per annum (see figure C.1 below).

---

[14] In this form the Poisson parameter is distributed as a gamma random variable (Γ = Gamma), and the Poisson requirement of identical mean-variance relation is relaxed (Hellerstein, 1991).

Γ(Mean of V fn; μ; v)

$E(V) = \mu$

$Var (V) = \mu + [\mu^2/v]$

v = chi-squared distribution

$Pr (V = n; n = 0,1,2..) = [\Gamma(n+v)/ \Gamma (n+1)\Gamma(v)].[v/(v+\mu)]^v[\mu/(v+\mu)]^n$

The two types of consumers surplus may be differentiated as gross and net. The former includes consumers surplus due to the complementary goods to the site being visited, while the latter excludes that proportion. There are many ways by which to differentiate the two. Where provision is not made for multi-purpose and multi-destination trips in the TGF, a downward adjustment has to be made to the gross value – based on the relative weighting the site had in motivating the trip made to it.

The two ways by which the gross consumer surplus may be calculated are the half-base time height method for linear demand functions and with integrals for the general case.

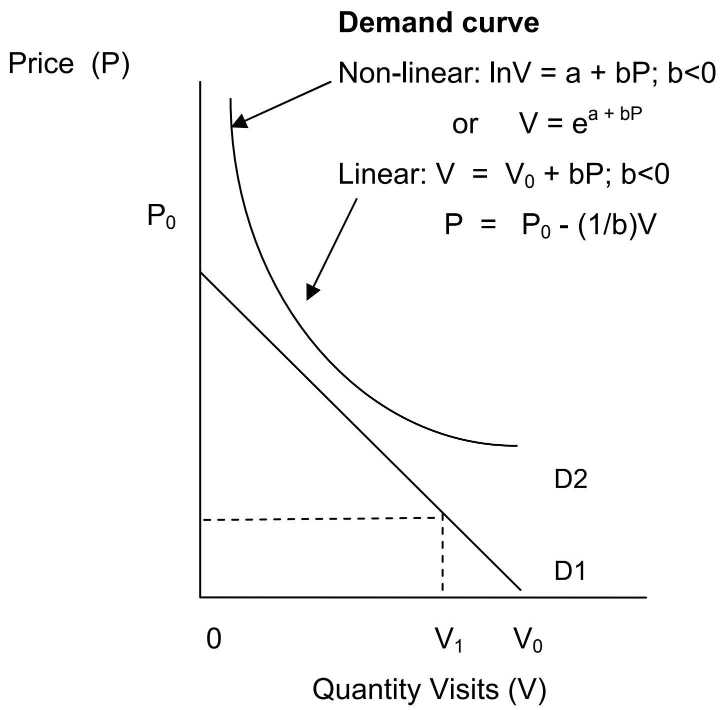

Figure C.1: Calculating the gross consumer surplus from linear and non-linear demand curves

Method for linear models (D1): the half base times height method

$CS_{V1} = ½(V_1).(P_0\text{-}P_1)$. for V_1 visits (C.2)

$= ½\, V_1[P_0\text{-} (P_0\text{-} (1/b)V_1)]$

$= ½\, (1/b)V_1^2$

The average CS for 1 visit is:

$CS = CS_{V1}/V_1$

$= ½\, V_1(1/b)$ (C.3)

The same result can be found by using integrals. This method was the one employed to calculate the consumer surpluses for the 23 estuaries for which travel cost valuations were calculated.

<u>Method for the general case</u>: the integral method.

The conventional model used is a non-linear model (D2). It has become conventional because it yields the convenient result that the consumer surplus may be calculated directly from the inverse of the estimated travel cost coefficient.

$CS_{V1} = \int dCS = \int_{P1}^{P} Vd$ P ; because dCS = V.dP by definition (a rectangle of CS)

$$= \int_{P1}^{P} e^{a + bP} dP$$

$$= \frac{1}{b} e^{a + bP} \Big|_{P1}^{P}$$

$$= \frac{1}{b} [e^{a + bP} - e^{a + bP1}]$$

$= \frac{1}{b}[-e^{a + bP1}]$; because $e^{a + bP} \rightarrow 0$ as $P \rightarrow \infty$, where $b<0$

$= - \frac{1}{b} V_1$; because $V_1 = e^{a + bP1}$

And average CS per visit equals

$$CS_{V1}/V_1 = - \frac{1}{b}$$

The final step in this stage entails multiplying the total number of visits per annum for the whole population of users by the average consumer surplus per visit:

$[CS_{V1}/V_1].V_1.N = - \frac{1}{b}.V_1.N$; where N = the population of users. (C.4)

The credibility of the total consumer surplus calculation rests on the correctness of N as much as the consumer surplus per visit estimate (Cook, 2000). N does not include non-users for the year the estimate relates to.

Appendix D

Models used to generate TGFs for applications of the ITCM

D.1 Example of Breede

Trip Generating Function for the Breede

VISITS = 228.24 + 0.30*QUALITY – 118.90*RES – 0.0001*INCOME + 36.92* KNOW – 83.25*USE_CAT – 0.0058*TRAVEL COST/VISIT (D.1)

The following median values were also calculated for the respondents sampled at the Breede Estuary:

RES: 1 (visitor); **INCOME:** R225000; **KNOW:** 1 (Well-informed); **USE_CAT:** 1 (Recreational/passive user); **TRAVEL COST/VISIT:** R250.

From this information the demand for day visits to the estuary in its current state may be estimated:

$\mathbf{VISITS_{CURRENT}}$ **=** 228.24 + 0.30*1 – 118.90*1 – 0.0001*R225000 + 36.92*1 – 83.25*1 – 0.0058*TC

= 40.81 – 0.0058TC

= 40.81 – 0.0058(250) = **39.36** visits per capita per annum

Calculation of individual gross consumer surplus

The trip generating function used for estimation was:

TC = 7036.21 – 172.41V (D.2)

and the consumer surplus calculated to be:

$$CS = \int_0^{Q_0} D(Q) \quad P_0 Q_0 \qquad (D.3)$$

$$= \int_0^{39.36} (7036.21 - 172.41V)\,dv - TC*VISITS_{CURRENT}$$

$$= [7036.21V - 86.21V^2]_0^{39.36} - 250*39.36 = \mathbf{R133\ 547.87} \text{ per household per annum.}$$

The total consumer surplus (for 5310 households) was calculated to be:

$\mathbf{TCS_{CURRENT}}$ = R133 547 *5310 = **R709 139 168** per annum.

By a similar method the decreased visitation rate was calculated for the case where there was deterioration in the quality of the estuary:

$\text{VISITS}_{\text{DECREASED}}$ = 228.24 + 0.30*0 – 118.90*1 – 0.0001*R225000 + 36.92*1 – 83.25*1 – 0.0058*TC

= 40.51 – 0.0058TC

= 40.51 – 0.0058(250) = **39.06** visits per capita per annum

and TC = 6984.48 – 172.41V

The consumer surplus for the reduced quality estuary was calculated to be:

$\int_0^{39.06}(6984.48 - 172.41V)\,dv$ - TC*$\text{VISITS}_{\text{DECREASED}}$

= $[6984.48V - 86.21V^2]_0^{39.06}$ - 250*39.06 = **R131 519.61** per capita per annum.

and the Total consumer surplus to be:

$\text{TCS}_{\text{DECREASED}}$ = R131 519.61 *5310 = **R698 369 106** per annum.

The loss in gross consumer surplus as a result of decreased freshwater inflow was estimated to be:

R709 139 168 – R698 369 106= **R10 770 062.**

Conversely, this is the gain in gross consumer surplus from securing the freshwater inflows (a freshwater requirement of **21 100 000**m^3 per annum) was estimated to be **R 0.51**per m^3. The information above is summarised in Table D.1 below:

Table D.1: Summarised Gross Consumer Surplus Computation for Breede Estuary

Estuary: Breede			
Median Values:		**Consumer Surplus:**	
RES	1 (Visitor)	Estimated user population	5310
INCOME	R225000	$\text{CS}_{\text{DECREASED (per capita/annum)}}$	R131 519.61
KNOW	1 (Well-informed)	$\text{CS}_{\text{CURRENT (per capita/annum)}}$	R133 547.87
USE_CAT	1(Passive\Recreational)	**Total Consumer surplus**	
TRAVEL COST/VISIT	R250	$\text{TCS}_{\text{DECREASED}}$	R698 369 106
Visits		$\text{TCS}_{\text{CURRENT}}$	R709 139 168
$\text{VISIT}_{\text{DECREASED}}$	39.06	**$\text{TCS}_{\text{(CURRENT - DECREASED)}}$**	R10 770 062
$\text{VISIT}_{\text{CURRENT}}$	39.36	Fresh water inflow	21 100 000 m^3
		Gross estimate (Rand/m^3)	0.51

Similarly the gross consumer surpluses were calculated for 15 other estuaries using the ITCM (see Tables D.2 to D.31 below).

Table D2: Travel Cost Regression Results for the Duiwenhoks Estuary

Dependent Variable: Visits				
Model: Reduced				
Observations: 28				
Method:	**Least Squares**			
Variable	Coefficient	Std. Error	t-statistic	Probability
C	80.6397	10.3328	12.3667	0.0000
QUALITY	12.0853	2.1494	2.1447	0.0021
RES	-3.5321	22.8744	-4.1339	0.0025
KNOW	4.7294	6.6304	2.6828	0.0002
TRAVEL COST	-1.0775	12.8407	-7.3832	0.0000
	R-Squared		0.2922	
	Adjusted R-Squared		0.2517	
	F-statistic		15.4911	
	Probability (F-Statistic)		0.0000	
	Sum Squared Residual		125033	

Table D3: Consumer Surplus Computation for the Duiwenhoks Estuary

Estuary: Duiwenhoks			
Median Values:		**Consumer Surplus:**	
RES	0 (local)	Estimated user population	400
TRAVEL COST	R35	$CS_{DECREASED}$ (per capita/annum)	R 1043
KNOW	1	$CS_{CURRENT}$ (per capita/annum)	R 1641
Demand for Visits:		**Total Consumer surplus:**	
$VISIT_{DECREASED}$(per capita/annum)	48	$TCS_{DECREASED}$	R 417 200
$VISIT_{CURRENT}$(per capita/annum)	60	$TCS_{CURRENT}$	R 656 400
		$TCS_{(\text{ CURRNET - DECREASED})}$	R 239 200
		Fresh water inflow	500,000 m^3
		ITCM estimate (Rand per m^3)	0.49

Table D4: Travel Cost Regression Results for the Great Berg Estuary

Dependent Variable: Visits				
Model: Reduced				
Observations: 248				
Method:	**Least Squares**			
Variable	Coefficient	Std. Error	t-statistic	Probability
C	181.1022	18.6620	9.7043	0.0000
RES	-126.9409	27.4162	-4.6301	0.0000
EDUC	33.9438	18.1894	1.8661	0.0632
QUALITY	30.9686	16.6702	1.8577	0.0644
TRAVEL COST	-2.5168	0.8930	-2.8182	0.0052
	R-Squared		0.2311	
	Adjusted R-Squared		0.2132	
	F-statistic		14.8184	
	Probability (F-Statistic)		0.0000	
	Sum Squared Residual		4096589	

Table D5: Consumer Surplus Computation for the Great Berg Estuary

Estuary: Great Berg			
Median Values:		**Consumer Surplus:**	
RES	0 (local)	Estimated user pop	8000
TRAVEL COST	R15	$CS_{DECREASED}$ (per capita/annum)	R 4085
EDUC	0 (low level)	$CS_{CURRENT}$ (per capita/annum)	R 6041
Demand for Visits:		**Total Consumer surplus:**	
$VISIT_{DECREASED}$(per capita/annum)	143	$TCS_{DECREASED}$	R 32 680 000
$VISIT_{CURRENT}$ (per capita/annum)	174	$TCS_{CURRENT}$	R 48 328 000
		$TCS_{(CURRNET - DECREASED)}$	R 15 648 000
		Fresh water inflow	75,000,000 m^3
		ITCM estimate (Rand per m^3)	0.21

Table D6: Travel Cost Regression Results for the Kleinemonde West Estuary

Dependent Variable: Visits				
Model: Reduced				
Observations: 132				
Method:	**Least Squares**			
Variable	Coefficient	Std. Error	t-statistic	Probability
C	45.6921	24.9464	3.9261	0.0331
RES	-26.3694	13.6921	-1.9282	0.0241
USE_CAT	20.5924	17.7571	0.8959	0.0834
KNOW	4.6253	7.9275	5.3452	0.0052
QUALITY	5.9452	16.5459	1.8195	0.0423
TRAVEL COST	-1.1043	0.0005	-1.5634	0.0032
	R-Squared		0.3621	
	Adjusted R-Squared		0.3472	
	F-statistic		4.5663	
	Probability (F-Statistic)		0.0000	
	Sum Squared Residual		1016690	

Table D7: Consumer Surplus Computation for the Kleinemonde West Estuary

Estuary: Kleinemonde West			
Median Values:		**Consumer Surplus:**	
RES	0 (local)	Estimated user pop	5000
TRAVEL COST	R33.50	$CS_{DECREASED}$ (per capita/annum)	R 82
KNOW	1(High level)	$CS_{CURRENT}$ (per capita/annum)	R 171
USE_CAT	0 (COM/SUB)		
Demand for Visits		**Total Consumer surplus**	
$VISIT_{DECREASED}$(per capita/annum)	13	$TCS_{DECREASED}$	R 410 000
$VISIT_{CURRENT}$ (per capita/annum)	19	$TCS_{CURRENT}$	R 855 000
		$TCS_{(CURRNET\ -DECREASED)}$	R 445 000
		Fresh water inflow	100,000 m^3
		ITCM estimate (Rand per m^3)	4.45

Table D8: Travel Cost Regression Results for the Mhlathuze Estuary

Dependent Variable: Visits				
Model: Reduced				
Observations: 286				
Method:	**Least Squares**			
Variable	Coefficient	Std. Error	t-statistic	Probability
C	22.6082	18.8510	1.1993	0.0314
RES	-18.0546	12.5373	-1.4400	0.1510
TRAVEL COST	-1.0524	0.4904	-2.1457	0.0328
QUALITY	38.8559	9.8790	3.9331	0.0001
	R-Squared		0.2381	
	Adjusted R-Squared		0.2053	
	F-statistic		10.5321	
	Probability (F-Statistic)		0.0000	
	Sum Squared Residual		149243	

Table D9: Consumer Surplus Computation for the Mhlathuze Estuary

Estuary: Mhlathuze			
Median Values:		**Total Consumer surplus**	
RES	0 (local)	$TCS_{DECREASED}$	R63 800
TRAVEL COST	R15	$TCS_{CURRENT}$	R2 894 200
Demand for Visits		$TCS_{(CURRNET - DECREASED)}$	R 2 830 400
$VISIT_{DECREASED}$(per capita/annum)	7	Fresh water inflow	9,900,000 m^3
$VISIT_{CURRENT}$ (per capita/annum)	46	**Consumer Surplus:**	
		Estimated user population	2900
		$CS_{DECREASED}$(per capita/annum)	R22
		$CS_{CURRENT}$(per capita/annum)	R998
		ITCM estimate (Rand per m^3)	0.29

Table D10: Travel Cost Regression Results for the Mlalazi Estuary

Dependent Variable: Visits				
Model: Reduced				
Observations: 161				
Method:	**Least Squares**			
Variable	Coefficient	Std. Error	t-statistic	Probability
C	119.3596	26.2638	4.8873	0.0000
AMOUNT	0.0282	0.0133	2.1216	0.0346
TRAVEL COST	-0.8554	0.4338	-1.9717	0.0495
RACE	75.8510	12.2245	6.2048	0.0000
RES	-49.6743	16.0878	-3.0876	0.0022
QUALITY	9.5979	10.6300	-0.9029	0.3672
USE_CAT	-80.9615	24.9934	-3.2393	0.0013
	R-Squared		0.3284	
	Adjusted R-Squared		0.2957	
	F-statistic		13.5453	
	Probability (F-Statistic)		0.0000	
	Sum Squared Residual		219376	

Table D11: Consumer Surplus Computation for the Mlalazi Estuary

Estuary: Mlalazi			
Median Values:		**Consumer Surplus:**	
RES	0 (local)	Estimated user population	6000
TRAVEL COST	R70	$CS_{DECREASED}$ (per capita/annum)	R2139
AMOUNT	R50	$CS_{CURRENT}$ (per capita/annum)	R2869
RACE	0 (Black)	**Total Consumer surplus**	
USE_CAT	1(passive)	$TCS_{DECREASED}$	R12 834 000
Demand for Visits		$TCS_{CURRENT}$	R17 214 000
$VISIT_{DECREASED}$(per capita/annum)	61	$TCS_{(CURRNET - DECREASED)}$	R 4 380 000
$VISIT_{CURRENT}$ (per capita/annum)	70	Fresh water inflow	8,700,000 m^3
		ITCM estimate (Rand per m^3)	
		0.50	

Table D12: Travel Cost Regression Results for the Olifants Estuary

Dependent Variable: Visits				
Model: Reduced				
Observations: 80				
Method:	**Least Squares**			
Variable	Coefficient	Std. Error	t-statistic	Probability
C	321.0291	25.65298	12.51430	0.0000
QUALITY	38.00708	25.86857	1.469238	0.1460
TRAVEL COST	-4.224758	1.154030	-3.660875	0.0005
RES	-191.4852	39.76575	-4.815329	0.0000
USE_CAT	-57.65215	25.26089	-2.282269	0.0253
	R-Squared		0.4526	
	Adjusted R-Squared		0.4233	
	F-statistic		15.5016	
	Probability (F-Statistic)		0.0000	
	Sum Squared Residual		751106	

Table D13: Consumer Surplus Computation for the Olifants Estuary

Estuary: Olifants			
Median Values:		**Consumer Surplus:**	
RES	1 (Visitor)	Estimated user population	2000
TRAVEL COST	R15	$CS_{DECREASED}$ (per capita/annum)	R9
USE_CAT	1(passive)	$CS_{CURRENT}$ (per capita/annum)	R254
Demand for Visits		**Total Consumer surplus**	
$VISIT_{DECREASED}$(per capita/annum)	9	$TCS_{DECREASED}$	R17 340
$VISIT_{CURRENT}$ (per capita/annum)	47	$TCS_{CURRENT}$	R508 680
		$TCS_{(CURRNET - CURRENT)}$	R 491 340
		Fresh water inflow	500,000 m^3
		ITCM estimate (Rand per m^3)	0.98

Table D14: Travel Cost Regression Results for the Swartvlei Estuary

Dependent Variable: Visits				
Model: Reduced				
Observations: 337				
Method:	**Least Squares**			
Variable	Coefficient	Std. Error	t-statistic	Probability
C	222.6408	16.4567	13.5288	0.0000
HOUSE	-14.5745	4.4309	-3.2892	0.0011
QUALITY	3.9253	26.8520	0.1461	0.0150
TRAVEL COST	-2.5900	0.6655	-3.8918	0.0004
RES	-106.3086	22.0349	-4.8245	0.0000
EDUC	-18.0283	14.1264	-1.2762	0.2028
	R-Squared		0.2634	
	Adjusted R-Squared		0.2436	
	F-statistic		12.5615	
	Probability (F-Statistic)		0.0000	
	Sum Squared Residual		4993442	

Table D15: Consumer Surplus Computation for the Swartvlei Estuary

Estuary: Swartvlei			
Median Values:		**Consumer Surplus:**	
RES	0 (local)	Estimated user population	16000
TRAVEL COST	R10	$CS_{DECREASED}$ (per capita/annum)	R718
HOUSE	2	$CS_{CURRENT}$ (per capita/annum)	R813
EDUC	1		
Demand for Visits:		**Total Consumer surplus:**	
$VISIT_{DECREASED}$(per capita/annum)	61	$TCS_{DECREASED}$	R11 488 000
$VISIT_{CURRENT}$ (per capita/annum)	65	$TCS_{CURRENT}$	R13 008 000
		$TCS_{(CURRNET - DECREASED)}$	R 1 520 000
		Fresh water inflow	5 400 000 m^3
		ITCM estimate (Rand per m^3)	
		0.28	

Table D16: Travel Cost Regression Results for the Gamtoos Estuary

Dependent Variable: Visits				
Model: Reduced				
Observations: 186				
Method:	**Tobit**			
Variable	Coefficient	Std. Error	z-statistic	Probability
C	25.8149	15.4024	4.5617	0.5743
QUALITY	0.01577	0.0044	3.5483	0.0004
RES	-0.0153	0.0067	-2.2911	0.0220
KNOW	3.5307	1.1145	3.1680	0.0015
INCOME	-0.000134	0.0040	-3.6154	0.0003
TRAVEL COST	-0.01436	0.0038	-0.9939	0.0462
	R-Squared		0.5053	
	Adjusted R-Squared		0.4211	
	F-statistic		7.2185	
	Probability (F-Statistic)		0.0000	
	Sum Squared Residual		611.5026	

Table D17: Consumer Surplus Computation for the Gamtoos Estuary

Estuary: Gamtoos			
Median Values:		**Consumer Surplus:**	
RES	1 (Visitor)	Estimated user population	5000
TRAVEL COST	R250	$CS_{DECREASED}$ (per capita/annum)	R 24.37
KNOW	1	$CS_{CURRENT}$ (per capita/annum)	R 24.49
INCOME	R250 000		
Demand for Visits:		**Total Consumer surplus:**	
$VISIT_{DECREASED}$(per capita/annum)	0.826	$TCS_{DECREASED}$	R 121 850
$VISIT_{CURRENT}$(per capita/annum)	0.828	$TCS_{CURRENT}$	R 122 440
		$TCS_{(CURRNET - DECREASED)}$	R 590
		Fresh water inflow	360,000 m^3
		ITCM estimate (Rand per m^3)	0.002

Table D18: Travel Cost Regression Results for the Mdloti Estuary

Dependent Variable: Visits				
Model: Reduced				
Observations: 144				
Method:	**Tobit**			
Variable	Coefficient	Std. Error	z-statistic	Probability
C	34.0983	42.4590	0.80308	0.4229
EDUC	35.0267	18.5790	1.88528	0.0608
QUALITY	0.21991	0.22075	0.99621	0.3203
RACE	39.7300	20.9210	1.89904	0.0590
RES	-38.4071	17.8880	-2.14708	0.0330
TRAVEL COST	-1.47837	1.19144	-1.24082	0.2161
USE_CAT	-44.6467	30.1802	-1.47933	0.1406
	R-Squared		0.3462	
	Adjusted R-Squared		0.3345	
	F-statistic		2.4116	
	Probability (F-Statistic)		0.0000	
	Sum Squared Residual		1852783	

Table D19: Consumer Surplus Computation for the Mdloti Estuary

Estuary: Mdloti			
Median Values:		**Consumer Surplus:**	
RES	0 (local)	Estimated user population	2730
TRAVEL COST	R10	$CS_{DECREASED}$ (per capita/annum)	R 31
USE_CAT	1	$CS_{CURRENT}$ (per capita/annum)	R 33
RACE	0		
EDUC	1 (high)		
Demand for Visits:		**Total Consumer surplus:**	
$VISIT_{DECREASED}$(per capita/annum)	9.7	$TCS_{DECREASED}$	R 84 630
$VISIT_{CURRENT}$(per capita/annum)	9.9	$TCS_{CURRENT}$	R 90 090
		$TCS_{(CURRNET - DECREASED)}$	R 5 460
		Fresh water inflow	2 060 000 m^3
		ITCM estimate (Rand per m^3)	
		0.003	

Table D20: Travel Cost Regression Results for the Mgeni Estuary

Dependent Variable: Visits				
Model: Reduced				
Observations: 144				
Method:	**Tobit**			
Variable	Coefficient	Std. Error	z-statistic	Probability
C	190.2931	41.22454	4.616015	0.0000
QUALITY	0.666684	0.227142	2.935101	0.0038
RACE	49.13323	20.19102	2.433420	0.0161
RES	-57.17024	22.18665	-2.576786	0.0109
TRAVEL COST	-0.176028	0.759831	-0.231667	0.8171
USE_CAT	-164.5152	33.34157	-4.934237	0.0000
INCOME	0.000145	5.28E-05	2.746591	0.0067
	R-Squared		0.3380	
	Adjusted R-Squared		0.3081	
	F-statistic		11.3095	
	Probability (F-Statistic)		0.0000	
	Sum Squared Residual		1536851	

Table D21: Consumer Surplus Computation for the Mgeni Estuary

Estuary: Mgeni			
Median Values:		**Consumer Surplus:**	
RES	0 (local)	Estimated user population	4414
TRAVEL COST	R28	$CS_{DECREASED}$ (per capita/annum)	R 16 503
USE_CAT	1	$CS_{CURRENT}$ (per capita/annum)	R 16 218
RACE	0		
INCOME	R40 000		
Demand for Visits:		**Total Consumer surplus:**	
$VISIT_{DECREASED}$(per capita/annum)	76	$TCS_{DECREASED}$	R 71 586 252
$VISIT_{CURRENT}$(per capita/annum)	77	$TCS_{CURRENT}$	R 72 844 242
		$TCS_{(CURRNET - DECREASED)}$	R 1 257 990
		Fresh water inflow	26 900 000 m^3
		ITCM estimate (Rand per m^3)	0.047

Table D22: Travel Cost Regression Results for the Mvoti Estuary

Dependent Variable: Visits				
Model: Reduced				
Observations: 144				
Method:	**Tobit**			
Variable	Coefficient	Std. Error	z-statistic	Probability
C	124.9503	21.84792	5.719091	0.0000
GENDER	18.63235	16.80672	1.108625	0.2685
QUALITY	0.382232	0.222283	1.719571	0.0866
RACE	34.13436	23.59980	1.446383	0.1491
RES	-108.6612	27.31436	-3.978172	0.0001
TRAVEL COST	-0.060083	0.129841	-0.462741	0.6439
	R-Squared		0.6423	
	Adjusted R-Squared		0.6378	
	F-statistic		4.0864	
	Probability (F-Statistic)		0.0000	
	Sum Squared Residual		4827433	

Table D23: Consumer Surplus Computation for the Mvoti Estuary

Estuary: Mvoti			
Median Values:		**Consumer Surplus:**	
RACE	0	Estimated user population	300
TRAVEL COST	R10	$CS_{DECREASED}$ (per capita/annum)	R 9855
GENDER	1	$CS_{CURRENT}$ (per capita/annum)	R 10 074
RES	1		
Demand for Visits:		**Total Consumer surplus:**	
$VISIT_{DECREASED}$(per capita/annum)	34.32	$TCS_{DECREASED}$	R 2 956 500
$VISIT_{CURRENT}$(per capita/annum)	34.70	$TCS_{CURRENT}$	R 3 022 200
		$TCS_{(\text{ CURRNET - DECREASED})}$	R 65 700
		Fresh water inflow	8 970 000 m^3
		ITCM estimate (Rand per m^3)	0.007

Table D24: Travel Cost Regression Results for the Sundays Estuary

Dependent Variable: Visits				
Model: Reduced				
Observations: 144				
Method:	**Tobit**			
Variable	Coefficient	Std. Error	z-statistic	Probability
C	72.31039	27.39922	2.639141	0.0090
QUALITY	0.186014	0.247142	0.752658	0.4525
RACE	-39.89196	19.44746	-2.051269	0.0415
RES	-134.4184	19.53820	-6.879773	0.0000
TRAVEL COST	-1.013071	0.603025	-0.021675	0.9827
	R-Squared		0.2190	
	Adjusted R-Squared		0.2004	
	F-statistic		11.5046	
	Probability (F-Statistic)		0.0000	
	Sum Squared Residual		2881065	

Table D25: Consumer Surplus Computation for the Sundays Estuary

Estuary: Sundays			
Median Values:		**Consumer Surplus:**	
RACE	0	Estimated user population	8300
TRAVEL COST	R20	$CS_{DECREASED}$ (per capita/annum)	R 73.94
RES	1	$CS_{CURRENT}$ (per capita/annum)	R 76.28
Demand for Visits:		**Total Consumer surplus:**	
$VISIT_{DECREASED}$(per capita/annum)	12.22	$TCS_{DECREASED}$	R 613 702
$VISIT_{CURRENT}$(per capita/annum)	12.41	$TCS_{CURRENT}$	R 633 124
		$TCS_{(\text{ CURRNET - DECREASED})}$	R 19 422
		Fresh water inflow	2 160 000 m^3
		ITCM estimate (Rand per m^3)	0.009

Table D26: Travel Cost Regression Results for the Gqunubie Estuary

Dependent Variable: Visits				
Model: Complete Tobit				
Observations:212				
Method:	**Tobit**			
Variable	Coefficient	Std. Error	z-Statistic	Probability
C	6.518679	0.441820	14.75416	0.0000
GENDER	0.193038	0.243781	0.791849	0.4284
INCOME	-5.20E-07	6.70E-07	-0.775927	0.4378
QUALITY	-0.868052	0.247384	-3.508930	0.0004
RACE	0.079321	0.315598	0.251336	0.8016
TOTAL_TRAVEL_COST	-0.000950	0.000137	-6.918745	0.0000
	R-Squared		0.262615	
	Adjusted R-Squared		0.241033	
	Log likelihood		-419.9233	

Table D27: Consumer Surplus Computation for the Gqunubie Estuary.

Estuary: Gunubie			
Median Values:		**Consumer Surplus:**	
GENDER	1	Estimated user population	2100
INCOME	R75000	$CS_{DECREASED}$ (per capita/annum)	R 18221.73
RACE	1		
TOTAL_TRAVEL_COST	6	$CS_{CURRENT}$ (per capita/annum)	R 23994.75
Demand for Visits:		**Total Consumer surplus:**	
$VISIT_{DECREASED}$(per capita/annum)	5.91	$TCS_{DECREASED}$	R38265637.7
$VISIT_{CURRENT}$(per capita/annum)	6.78	$TCS_{CURRENT}$	R50388966.33
		$TCS_{(\text{ CURRNET - DECREASED})}$	R12123328.63
		Fresh water inflow	5 230 000 m^3
		ITCM estimate (Rand per m^3)	R2.32

Table D28: Travel Cost Regression Results for the St. Lucia Estuary

Dependent Variable: Visits				
Model: Complete Tobit				
Observations (included):254				
Method:	**Tobit**			
Variable	Coefficient	Std. Error	z-Statistic	Probability
C	7.279869	0.346180	21.02911	0.0000
GENDER	-0.578410	0.294955	-1.961009	0.0499
INCOME	-1.50E-06	8.86E-07	-1.690334	0.0910
QUALITY	-0.795164	0.263700	-3.015407	0.0026
TOTAL_TRAVEL_COST	-0.001045	0.000143	-7.329130	0.0000
	R-Squared		0.396869	
	Adjusted R-Squared		0.384709	
	Log likelihood		-509.5729	

Table D29: Consumer Surplus Computation for the St. Lucia Estuary

Estuary: St. Lucia			
Median Values:		**Consumer Surplus:**	
GENDER	1	Estimated user population	700
RACE	1	$CS_{DECREASED}$ (per capita/annum)	R27111.18
TOTAL_TRAVEL_COST	243.06	$CS_{CURRENT}$ (per capita/annum)	R 39358.54
Demand for Visits:		**Total Consumer surplus:**	
$VISIT_{DECREASED}$(per capita/annum)	4.42	$TCS_{DECREASED}$	R18977824.26
$VISIT_{CURRENT}$(per capita/annum)	5.37	$TCS_{CURRENT}$	R27550976.38
		$TCS_{(CURRNET - DECREASED)}$	R8573152.116
		Fresh water inflow	2170 000 m^3
		ITCM estimate (Rand per m^3)	0.0105

Table D30: Travel Cost Regression Results for the Uilkraalsmond Estuary

Dependent Variable: Visits				
Model: Complete Tobit				
Observations:103				
Method:	**Tobit**			
Variable	Coefficient	Std. Error	z-Statistic	Probability
C	4.401731	0.901708	4.881547	0.0000
GENDER	-0.202734	0.405148	-0.500395	0.6168
QUALITY	-0.945788	0.398039	-2.376117	0.0175
RACE	1.363430	0.698097	1.953067	0.0508
TOTAL_TRAVEL_COST	-0.000393	0.000109	-3.610616	0.0003
	R-Squared		0.169615	
	Adjusted R-Squared		0.126812	
	Log likelihood		-216.0289	

Table D31: Consumer Surplus Computation for the Uilkraalsmond Estuary

Estuary: Uilkraalsmond			
Median Values:		**Consumer Surplus:**	
GENDER	0	Estimated user population	1800
INCOME	R40000	$CS_{DECREASED}$ (per capita/annum)	R19749.68
TOTAL_TRAVEL_COST	10	$CS_{CURRENT}$ (per capita/annum)	R 24940.91
Demand for Visits:		**Total Consumer surplus:**	
$VISIT_{DECREASED}$(per capita/annum)	4.42	$TCS_{DECREASED}$	R35549426.7
$VISIT_{CURRENT}$(per capita/annum)	5.37	$TCS_{CURRENT}$	R44893643.62
		$TCS_{(\text{ CURRNET - DECREASED})}$	R9344216.92
		Fresh water inflow	891000 000 m^3
		ITCM estimate (Rand per m^3)	3.95

Appendix E

CVM questionnaire on the opportunity cost of fresh water inflow into the Mngazi Estuary

INSTRUCTIONS TO PERSON ADMINISTERING THE QUESTIONNAIRE.

(A) NAME OF PERSON ADMINISTERING QUESTIONNAIRE (NOT RESPONDENT):______________________

(B) NO RESPONDENTS NAME IS TO BE RECORED AND THE INFORMATION GIVEN BY THEM IS TO BE TREATED AS CONFIDENTIAL.

(C) THERE ARE 16 QUESTIONS. PLEASE TICK THE APPROPRIATE BLOCKS.

CATEGORY OF RESPONDENT

CATEGORY OF USER/RESPONDENT	
HOUSEHOLD CONSUMPTION	1
COMMERCIAL/SUBSISTENCE – NON FARMING	2
FARMING	3

2. RACE OF RESPONDENT

RACE	
BLACKS	1
WHITES	2
COLOUREDS	3
INDIANS	4
OTHER	5

3. GENDER OF RESPONDENT

MALE	1
FEMALE	2

4. HOW MANY PEOPLE MAKE UP YOUR HOUSEHOLD?

NUMBER OF MEMBERS OF HOUSEHOLD	
1	1
2	2
3	3
4	4
5	5
6	6
7+	7

5. RATE THE RELATIVE IMPORTANCE YOU ATTACH TO WATER IN THE MNGAZI RIVER:

EX IMP = EXTREMELY IMPORTANT
V IMP = VERY IMPORTANT
M IMP = MODERATE IMPORTANCE
UNIMP= UNIMPORTANT

ACTIVITIES/ ATTRIBUTES	**EX IMP**	**V IMP**	**M IMP**	**UNIMP**	
5.1 FEEDER OF WATER FOR THE ESTUARY	4	3	2	1	
5.2 PROVIDER OF FRESHWATER FOR CONSUMPTION	4	3	2	1	
5.3 PROVIDER OF WATER FOR IRRIGATION OF FARM CROPS	4	3	2	1	
5.4 OTHER (SPECIFY)	4	3	2	1	SPECIFY

6. HOW MUCH DOES YOUR HOUSEHOLD PAY PER YEAR IN TARIFFS FOR HEALTHY DRINKING WATER (ASSUMING A HOUSEHOLD CONSUMES 30 kl A MONTH/360 kl PER ANNUM)?

RAND PAYMENTS	
0	1
1-20	2
21-50	3
51-80	4
81-110	5
111-150	6
151-200	7
201+	8

<u>WORKING BOX</u>
PAYMENT
- COST OF RETICULATION, IMPOUNDMENT, TREATMENT AND COLLECTION OF USER FEES
NET WTP =

7. HOW MUCH DOES YOUR HOUSEHOLD PAY PER YEAR IN TARIFFS FOR WATER FROM THE RIVER FOR IRRIGATION OF CROPS AND FEEDING OF ANIMALS (in kl)?

RAND PAYMENTS	
0	1
1-10	2
11-20	3
21-30	4
31-50	5
51-100	6
101-50	7
151+	8

<u>WORKING BOX</u>

PAYMENT

- COST OF TRANSPORT AND PUMPING AND EQUIPMENT AND OLLECTION OF USER FEES

NET WTP =

8. WHAT EXTRA TARIFF PER YEAR ARE YOU WILLING TO PAY (OVER AND ABOVE WHAT YOU ALREADY DO PAY) FOR A PROJECT TO INCREASE WATER SUPPLIED TO YOU

THE LEVY WOULD BE COLLECTED BY THE LOCAL AUTHORITY FROM ALL WATER USERS AS A USER CHARGE

R ______________ PER 10LITRES

9. IF YOUR ANSWER TO EITHER OF THE ABOVE (QUESTIONS 7 AND 8) IS ZERO, WHAT ARE YOUR REASONS (YOU MAY HAVE MORE THAN ONE)?

REASON	
9.1 CANNOT AFFORD THE FEES	1
9.2 GET NO OR NEGLIGIBLE VALUE OUT OF EXTRA WATER	2
9.3 ABUNDANCE OF ALTERNATIVE OPTIONS FOR FRESH WATER – NO SCARCITY, THEREFORE WHY PAY	3
9.4 DO NOT USE IRRIGATION TO GROW CROPS – SO WHY PAY EXTRA	4
9.5 OTHER (SPECIFY)	5

10. WHAT WOULD YOUR HOUSHOLD SACRIFICE IN ORDER TO MAKE THIS PAYMENT? (THE MONEY HAS TO COME FROM SOMEWHERE – THE BUDGET CONSTRAINT)

SERVICE INCOME WOULD BE REALLOCATED FROM	

11. WHAT SOURCES OF FRESHWATER ARE AVAILABLE TO YOU?

____

12. DISTANCE IN KILOMETRES OF RESPONDENT'S CURRENT ACCOMMODATION FROM THE MNGAZI RIVER

DISTANCE FROM ESTUARY (KM)	
0-1	1
1-3	2
3-10	3
10 +	4

12. DISTANCE IN KILOMETRES OF RESPONDENT'S CURRENT ACCOMMODATION FROM THE NEAREST HEALTHY DRINKING WATER SUPPLY (TAP)

DISTANCE FROM WATER SUPPLY (KM)	
0-1	1
1-3	2
3-10	3
10 +	4

13. APPROXIMATE WORTH OF RESPONDENTS HOUSE/POSSESSIONS:

TOTAL VALUE (RAND)	
0	0
1- 2 000	1
2001- 10 000	2
10 001- 20 000	3
20 001- 50 000	4
50 001- 200 000	5
200 001-400 000	6
400 001 +	7

14. HIGHEST EDUCATIONAL LEVEL ATTAINMENT OF RESPONDENT.

EDUCATIONAL LEVEL	
NO SCHOOLING	1
COMPLETED 1- 6 YEARS OF SCHOOLING	2
COMPLETED 7-11 YEARS OF SCHOOLING	3
COMPLETED 12 YEARS OF SCHOOLING	4
COMPLETED SCHOOLING PLUS 3 OR MORE YEARS TERTIARY SCHOOLING	5

15. GROSS ANNUAL PRE-TAX INCOME OF RESPONDENT.

PRE TAX INCOME (RAND)	
0	1
100-5 000	2
5 001-10 000	3
10 001-20 000	4
20 001-50 000	5
50 001-100 000	6
100 001-200 000	7
200 001+	8

16. DO YOU HAVE ANY OTHER COMMENTS YOU WOULD LIKE TO CONTRIBUTE ON THIS PUBLIC ISSUE? ARE YOU HAPPY WITH WHAT YOU PAY FOR WITH RESPECT TO WATER SUPPLY FROM THE MNGAZI RIVER

____

____

____

____

Questionnaire compiled by members of the Departments of Economics and Zoology, NMMU. Questions about this project may be directed at Prof SG Hosking, tel 041-5042205

Appendix F

Survey of preference for the development of the Mngazi/Mngazana estuaries

South Africa's coastal resources, estuaries to be specific, have come under increasing pressure and some are already severely degraded. For this reason, more research in the conservation and restoration of these resources is being undertaken. Further it explains why in the past five years environmental policy and legislation have been redirected to ensure more effective and efficient management of costal and marine resources plus other environmental resources in the country. The inalienable truth is that exploitation of these resources cannot be completely halted to preserve these resources; a middle ground where both exploitation and sustainability of the resource co-exist has to be sought. This questionnaire is specifically designed with this intent. Your opinion on how best develop the Mngazi/Mngazana catchment areas is required. Please answer as truthfully as possible. Your responses will be treated with the strictest of confidence. The results of this survey will be presented in a way that precludes your identity from being connected with the survey.

Instructions to interviewer:

Name of the interviewer: ____________________________
Estuary where the survey is conducted: _________________
No respondents name is to be recorded

Gender of the Respondent
Male ☐ Female ☐

Race of the respondent
Black ☐ White ☐ Coloured ☐ Indian ☐ Other ☐

Category of the respondent
Visitor ☐ Subsistence resident ☐
(Proceed to questions 4-6 if respondent is a subsistence resident)
What is your view on the visitors?
____
____

What do you believe should happen to this estuarine area to improve you welfare?
____
____
____

What kind of intervention in the estuary's management would make you happy?
____
____

(Questions 7-9 to be answered by visitors only)
What would you say inclined your visit to the estuary? ___________________
____
____

Why would you recommend this estuary to other visitors? _________________
____
____

What is your view on the presence of the subsistence community?

9.1	Should be moved closer and allowed to integrate with the visiting community as it all adds to the wild cost adventure	☐
9.2	Should be moved away and their access controlled as they reduce my recreational experience	☐

Land Use on Banks

If there was a decision to establish a park area with stricter controls of land use and development within 1 km of the estuary shore would you vote in its favour?

Yes ☐ No ☐

Furnish a reason for your answer in 10 above. ______________________________

____

Resource Exploitation in Estuary:

The estuarine resources identified are those believed to pose the highest risk to the estuary if not properly managed. For each of the resources, tick against your recommended management policy.

12.1. Mangroves

12.1.1	Stricter controls should be put in place to better manage their harvesting	☐
12.1.2	The harvest arrangements ought to be left as they are	☐

Fish

12.2.1	More marine and coastal management enforcement of rules and policies and regulation of marketing of Catches	☐
12.2.2	Less marine and coastal management enforcement of rules and policies and regulation of marketing of Catches	☐

Prawns

12.3.1	More marine and coastal management enforcement of rules and policies	☐
12.3.2	Less marine and coastal management enforcement of rules and policies	☐

crabs

12.4.1	More marine and coastal management enforcement of rules and policies	☐
12.4.2	More marine and coastal management enforcement of rules and policies	☐

other resources

12.5.1	More marine and coastal management enforcement of use of the estuary for boating	☐
12.5.2	Less marine and coastal management enforcement of the use of the estuary for boating	☐

Do the discharges into the river or directly into the estuary reduce its appeal to you for either subsistence or recreational use?

Yes ☐ No ☐

Do you have any contribution you would like to make as regards the development issues surrounding the Mngazi and Mganzana estuaries?

____

____

This questionnaire is compiled by Wasswa Francis Department of Economics NMMU contact wasachief@inbox.com . Further questions about this project may be directed at Prof SG Hosking Tel 041-5042205.

Appendix G

Local opinion on development options for the Mngazi and Mngazana estuaries

In November 2006 a small survey was carried out in area of the Mngazi and Mngazana river estuaries to investigate local opinion on development issues related to the estuary. Opinions of three issues were elicited:

The exploitation of natural resources in the estuaries by different users, extractive and non extractive. The extractive users are the subsistence users who extract resources such as mangrove wood, fish, prawns and crabs, for their own consumption. Their extraction activities diminish the availability of the resources in the estuary. The non-extractive users on the other hand use the resources in ways that do not diminish the availability of the resource for the next user like bird watching.

The relationship between the ways these resources are exploited by the different users (rivalry in demand). The extractive users can undermine the availability of future extractive as well as non-extractive users.

The curtailment of access to some current users of the estuary. Who should manage the resource and in whose interest? Should it be the public sector or private owners? Are their social benefits to be gained in excluding access to some parts of the estuary to some current users?

G.1 Results of the survey

There were 202 questionnaires successfully administered. The majority of the respondents were female (Figure G.1)

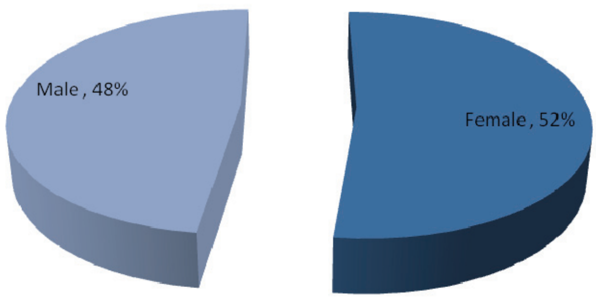

Figure G.1 Gender of respondent

The majority of the respondents (83 percent) were subsistence users of the estuary and the remainder (17 percent) were visitors.

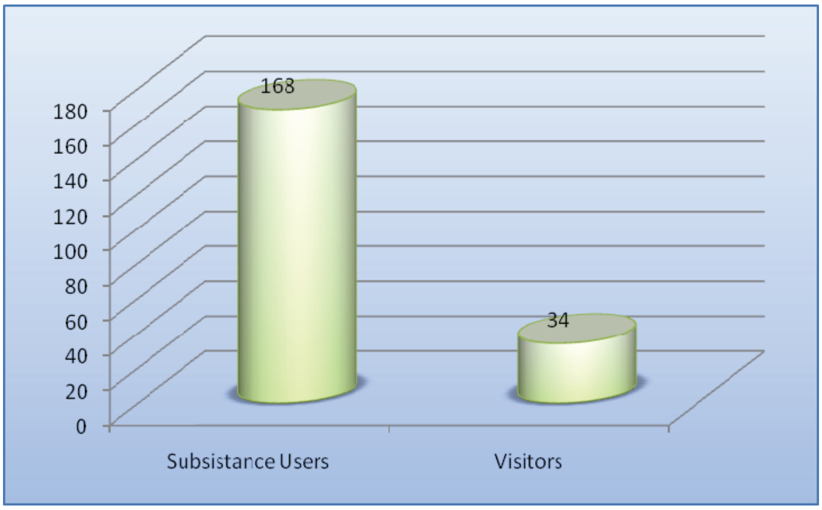

Figure G.2: Visitor and Subsistence user analysis

The race profile of the respondents is shown in Figure 6.3 below. Of the total 88 percent were black, 10 percent were white and 2 percent were coloured.

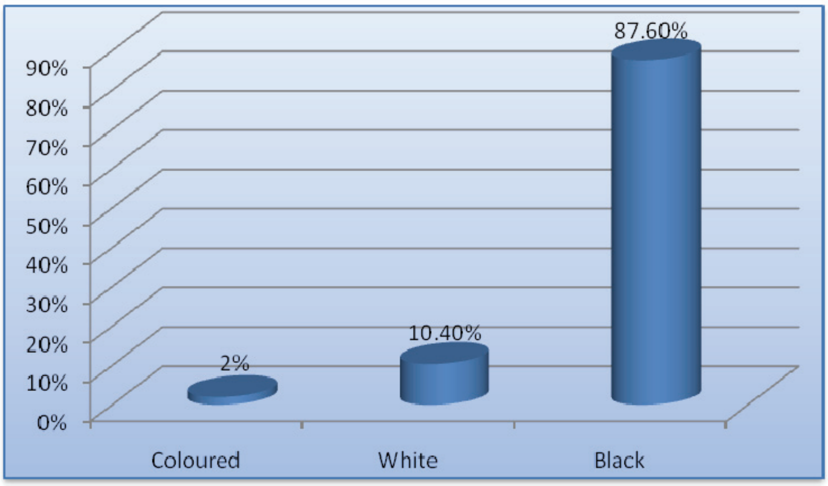

Figure G.3 Analysis of the race of the respondent

Local residents were asked if they welcomed the presence of visitors in their area. The question was applicable to 168 respondents. An analysis of their responses is provided in Table G1. An overwhelming 94 percent contended that the visitors were important to the region. The two main reasons they cited for this importance were: income injections

(28 percent) and non-economic reasons, especially the experience of meeting new people (66 percent).

Table G.1: Reasons why local residents welcome visitors to the Mngazi and Mngazana estuaries

	Frequency	Percentage of Total
Yes-income injection	47	28
Yes-Other reasons	111	66.1
No-Don't Support Local Economy	3	1.8
No-No reason	7	4.2
Total	**168**	**100**

Local residents and visitors were also asked to state the reasons that influenced their visit to the estuary. The question was applicable to 34 respondents (see Table G2). The main reasons were scenic beauty and naturalness (unspoilt by development).

Table G.2: Main Reasons why visitors come to the Mngazi and Mngazana estuaries

	Frequency	Percentage of Total
Friendly Atmosphere	3	9.1
Naturalness	14	42.4
Recommended By Others	2	6.1
Scenic Beauty	14	42.4
Total	**33**	**100**

The visitors were asked about their feelings regarding the integration with the locals. The question was applicable to 34 respondents, only 31 responded. Of these 97 percent felt their interaction with the local residents was a wonderful experience.

Table G.3: Visitors' feelings regarding integration with locals at the Mngazi and Mngazana estuaries

	Frequency	Percentage of total
Move Closer and Allow for Integration	30	96.8
Away and Their Access Controlled	1	3.2
Total	**31**	**100**

The local residents were asked which development and management plan for the resources of the estuary would best serve their interests. The identified resources were mangrove forests, the flood plain, fish and bait. Their responses classified them as environmentally sensitive and not environmentally sensitive (Table G4). Over 60 percent revealed themselves to be environmentally sensitive.

Table G.4: Preferences for a management plan for the mangrove forests (Mngazana)

Proposed Plan	Frequency	Percent of total
Control By use of Either Permits Guards Quotas Licenses	85	50.6
Monitor Use	2	1.2
Restrict Harvest	4	2.4
Plant More Mangroves	3	1.8
Avail Alternatives to the mangroves	2	1.2
Remove other trees such as Alien	6	3.6
Environmentally sensitive respondents	***102***	***60.8***
Indifferent	5	3
Leave as is	8	4.8
Find a market for us	3	1.8
No Control	50	29.8
Non-environmentally sensitive	***166***	***39.2***
Total	**168**	**100**

Table G.5: Preferences for a plan to manage the floodplain of the Mngazana Estuary

Proposed Plan	Frequency	Percentage of total
Clean the Banks	35	21
Control Usage	44	26.3
Fence Off	25	15
Restrict Access	6	3.6
Environmentally sensitive respondents	***110***	***65.9***
Crop Husbandry Supported The River Water	6	3.6
Guard For Our Animals' sake	8	4.8
Use for Any income generating activity for the Locals	12	7.2
Exploit for local benefit	***26***	***15.6***
No Control	31	18.6
Total	**167**	**100**

Table G.6: Preferences for a plan to manage the extraction of fish and bait at the Mngazi and Mngazana estuaries

Proposed Plan	Frequency	Percentage of total
Control [Licences, Permits and Quotas]	115	71
Monitoring exploitation	4	2.5
Environmentally Cautious respondents	***119***	***73.5***
Find Market	2	1.2
More Equipment	6	3.7
Exploit for local benefit	***8***	***4.9***
No control	35	21.6
Total	**162**	**100**

Table G.7: Preferences for a plan to establish a fenced and access controlled conservation area around parts of the estuaries

	Frequency	Percentage
Yes Responses		
To Conserve The Resources Here in	24	14.5
It would Create Jobs	55	33.3
It would Boost the Local Economy	21	12.7
It Would Improve Our Security	10	6.1
Both Security and Employment Would Improve	7	4.2
For Educational Purposes	4	2.4
it Would Boost the Local Tourism Industry	6	3.6
On Condition it Improves Our Welfare	2	1.2
It Would Improve the Local Infrastructure	1	0.6
It Would Confine Animals To One Secluded Area	1	0.6
Total In support	**131**	**79.4**
No Responses		
We Are in A better Position To manage Our Own Resources	3	1.8
It would Cause Unemployment	5	3.0
Would cause rivalry between animals and Humans	1	0.6
It is Not Necessary	13	7.9
There would be Rivalry between Households and Animals	6	3.6
It Would Raise Land Issues Among The Community	2	1.2
It is not likely to benefit the Local Community Much	4	2.4
Not in support	**34**	**20.6**
TOTAL	**165**	**100**

The majority of favoured a plan to created a controlled access park in the area (79%) even though it would restrict access to some degree and extraction of resources in the area (Table 6.7). The respondent preferences for having stricter or less strict management controls over the resources are reported in Figures G.4 to G.9.

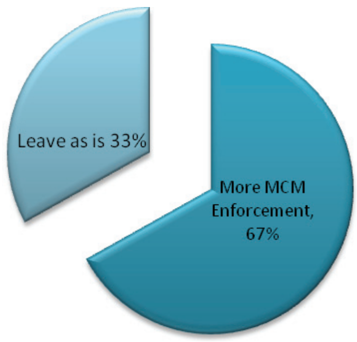

Figure G.4 Management of Mangroves

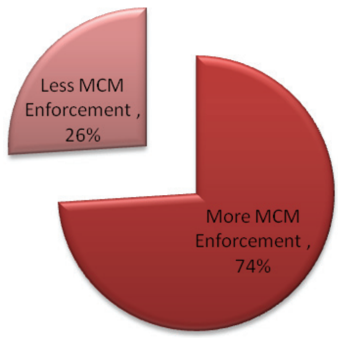

Figure G.5 Management of Fishing activities

Figure G.6 Management of harvesting prawns

Figure G.7 Management of harvesting crabs

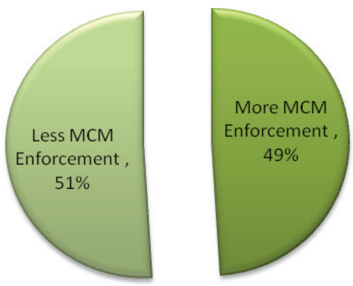

Figure G.8 Management of boating activities

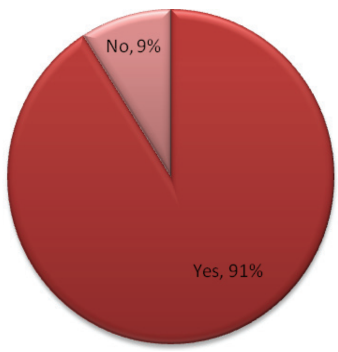

Figure G.9 Discharge on the river reduces my appeal for the River

G.2 Conclusions

It was deduced that the local population and visitors favour the extraction of resources in a sustainable manner. The visitors and locals see their uses as being complementary than rival. The survey findings support development that is led and managed by the state with more rather than less regulation.

Appendix H

The Relevance of Economic Valuation of Freshwater Inflows to Estuary Planning and Management in South Africa

H.1 Introduction and Context

This appendix uses perspectives from selected interested parties to deduce management information needs with respect to annual river inflows. It was drawn up in September 2004 by Duncan Hay and Margaret McKenzie and presented in the form of a mini-report. For further perspectives and information on the material contained in this chapter the former author may be contacted.[15] This report was conducted for and on behalf of the project team engaged in determining the economic valuation of freshwater inflows for select South African estuaries. It is complemented by an estuaries handbook (McKenzie and Hay, 2009).

Estuaries (and their catchments) are regularly located entirely within local and district municipalities. They are important economic, social and environmental assets to these municipalities which have de facto (and often de jure) administrative and management authority over these systems and their surrounds. Yet, a scan of municipality IDPs indicates that they are not adequately accounted for.

It is also recognized that one of the major impacts on estuaries in South Africa is human-generated alterations in the freshwater inflow regimes into estuaries. Various developmental activities in catchments including dam construction, agricultural irrigation, timber plantation establishment and residential, commercial and industrial development have served to reduce the flow of freshwater into estuaries. Other activities such as inter-basin transfers (including large water-borne sanitation systems) have reduced inflow into some estuaries and increased it in others. (Allanson and Baird, 1999)

The economic valuation of alterations of freshwater inflow regimes into estuaries is the focus of a Water Research Commission Project. The purpose of this report is to assist the economic valuation researchers to bridge the divide between their research and the management of estuaries by authorities. The report will attempt to determine the

15 Duncan Hay tel: 033-3863696, cell: 083 630 1749, email: hay@ukzn.ac.za

management relevance of economic valuation of estuaries as it relates specifically to freshwater inflows. Some of the questions that this report will attempt to answer are:

What are the key impacts management agencies are interested in?

Which relate to changes induced by changes in freshwater inflow?

For which estuaries is the research project particularly relevant? Why?

Is economic valuation relevant?

The report will provide some final conclusions which include some appropriate recommendations for the researchers to assist in linking their research strongly to management needs.

H.2 Methodology

The authors of the report have been involved in a number of estuary management projects. In particular they have shared leadership roles in the Eastern Cape Estuaries Management Programme and, in this context, have been involved in a number of long term management initiatives at the Mtentu, Mzintlava, Mngazana, Tyolomnqa, Bushmans and Kowie estuaries. The authors recently led the Coastcare Induction Programme in the Eastern Cape and KwaZulu-Natal through which they were able to interact with a number of stakeholders and especially municipal officials on estuaries and coastal management issues. The content of this report is partly based on the expert understanding of the authors of management issues that have been developed through these processes.

In addition the authors have conducted interviews with relevant municipal officials regarding estuaries that are not included in these long term management processes in order to expand their understanding of management concerns and usefulness of economic valuation of freshwater alterations to local authorities. Interviews were conducted in a semi-structured form based on the following prepared questions:

What are the key impacts on estuaries that are of concern to your municipality?

Which of your concerns link back to changes in freshwater inflow? (What particular changes in inflow?)

Which estuaries in particular are you concerned about and why?

Would an economic valuation of impacts related to freshwater inflow assist you in management decision-making?

What type of economic information would be of most use to you?

Are estuary management issues reflected in your IDP (how)?

Would economic valuation be useful for the IDP process?

People who participated in interviews/discussions were:

Andrew Mather: Project Executive: Coastal Policy, eThekwini Municipality

Richard Boon: Contract Consultant with Environmental Management Department, eThekwini Municipality

Thea van der Wateran, Deputy-director: Integrated Development Planning (Environmental Planning), uMhlathuze Municipality

Pravina Govender, Manager Planning, Ilembe District Municipality

Members of the Zandvlei Trust which included municipal officials.

This provided a good cross-section as it involved two metropolitan councils (where it is acknowledged there is greater capacity to engage the issues), a district municipality and a local municipality. All these were outside the Eastern Cape which served to provide a wide spread of experience.

H.3 Estuaries, Municipalities and integrated Development Plans

Two observations are worth noting. While attending a national Landcare workshop I engaged an agricultural extension officer from the Northern Province in a discussion on the Eastern Cape Estuaries Management Programme. Having described the programme to her for about ten minutes her response was ask what an estuary was! Secondly, I attended a WRC Open Day at Rhodes University in Grahamstown and interacted with about five Grade 12 School Groups (about 100 learners all of PDI status). Not a single learner knew what an estuary was.

Generally, this lack of understanding can also be observed in municipalities. They are not strongly involved or engaging proactively with estuaries. In many instances municipalities are new or have incorporated larger areas of responsibility and are grappling with fundamental issues of service delivery. This simply does not allow officials the space or time to think about or concern themselves with estuaries and their management. For many municipal officials this is also currently beyond their technical capacity. However, some municipalities have concerns about certain issues and would like to address some of these concerns but do not have the capacity to do so. Finally there is a small category of municipalities that are concerned about estuaries and are taking active steps to improve their management.

Despite the statement above that most municipalities are not thinking about or concerned with estuaries it should be recognised that all municipalities that contain estuaries in their areas of authority have a large impact on these estuaries through their actions (or, in some cases, inaction). The general challenge for those who wish to promote the sustainable management and wise use of estuaries is to influence municipal plans and actions. The key vehicle through which to influence municipalities is through their Integrated Development Plans.

Each municipality in the country is required to adopt and implement an Integrated Development Plan (IDP) in terms of the Municipal Systems Act (No 32 of 2000). An IDP is a unifying plan through which all aspects of municipal activity should be managed. In addition the activities of other government departments and statutory bodies should be incorporated within the IDP of the area in which these activities are taking place. An IDP should include the following components (Kahn, von Riesen and Jewell, 2001):

Vision Statement
Status Quo Development Report
Development Priorities and Objectives
Development Strategies aligned with sectoral plans (e.g. Coastal Management Plan)
Spatial Development Frameworks (leading to Land Use Management Systems)
Operational Strategies
Disaster Management Plans
Financial Plan
Key Performance Indicators and Performance Targets

When considering the issue of estuary management and Integrated Development Planning it is important to recognise that there are two fundamental ways in which Integrated Development Planning will interact with estuary management. Firstly there is the active management planning that could be reflected in an Integrated Development Plan through a Estuary Management Plan that would be a sectoral management plan within the Integrated Development Plan. Secondly there is the indirect manner in which Integrated Development Plans impact on estuary management through decisions outlined in other aspects of the plan that can have an impact on the estuary concerned. This is best illustrated through considering that Land Use Management Systems will outline the spatial future of development in a given area. If this area includes an estuary the Land Use Management System will have an important impact on the future of the estuary. Another example is Water Services Development Plans that are sector plans within Integrated Development Plans. These Water Services Development Plans would outline plans for abstraction and use of water that could have major impacts on the functioning of estuaries.

In future, as catchment management agencies are established and catchment management plans are developed municipalities will need to link up with these new institutions and the two planning processes will need to "talk to each other". As estuary management plans will be important components of catchment management plans there will need to be close links between these planning processes and the IDP process.

H.4 Key Impacts of Concern to Management Agencies

Some of the key impacts on estuaries that are of concern to management agencies are outlined in the sections below. The impacts that relate most strongly to freshwater inflow alterations are placed first, followed by other issues of concern:

Reduction in Freshwater Inflow

There are concerns about the reduction in freshwater inflow caused by dams, abstraction and forest plantation development. Some of the issues associated with this are:

- Reduction of the base flow into the estuary.
- Changes to the salinity gradient of the estuary.
- Reduction in small scale flood events that results in an accumulation of sediments in estuaries and allows pollutants to settle. This can also cause prolonged closure of estuaries.
- Possible retention of coarser sediments by dams and resultant impacts on the coastal sediment balance and scouring potential of inflows.

These issues in turn impact on the biodiversity of the estuary concerned and can interfere with recreational use because of low water levels. Threats to property can also be experienced through prolonged estuary closure and through a greater than normal build up of sediments that are a threat in large scale flood events.

Increases in freshwater inflow into estuaries

There are concerns about abnormal increases in freshwater inflow into estuaries caused by catchment transfer schemes and the resultant outflow from sewerage treatment works. Some of the issues associated with this are:

Quality of water flowing into estuaries

The increase in breach events or continual state of openness of an estuary that is intermittently closed

These issues are in turn linked to concerns regarding the visual attractiveness and recreational value of the estuary. In addition these issues can impact on biodiversity.

While increases in freshwater inflows into estuaries were discussed the issue of natural episodic flooding was not. This should be considered. Municipalities are obviously concerned with the economic costs of flooding (destruction of infrastructure, disruption of services, loss of life and livelihoods) but this needs to be balanced against the economic benefit of the resultant scouring and offshore nutrient deposition. Taking the Thukela as an example, while episodic flood events have destroyed infrastructure near the estuary, in the past these floods have been followed by the improved prawn catches in the Thukela bank fishery.

Deterioration in Water Quality

There are concerns about the deterioration of water quality as a result of agricultural, industrial and residential development. Some of the issues relating to this are:
Increases in the turbidity of the water
Increased presence of nutrients
Increased presence of toxins
These issues are in turn linked to concerns regarding impacts on biodiversity. Human health is also a concern because of recreational use of the estuaries and consumption of fish from impacted estuaries. The deterioration in water quality links directly back to changes in freshwater inflow. Normal flows have the effect of ameliorating impacts of reduced quality through dilution while lower than normal flows reduce the dilution effect.

Changes in Sediment Supply

There are concerns about the changes in sediment load. A major cause of concern, particularly in the estuaries of the Eastern and Western Cape is the accumulation of marine sediment in estuaries. The perception is that this is caused by reduced freshwater inflow into these estuaries and especially the reduction in small flood events caused by dam construction. In some cases, particularly in KZN, the sediment supply is increased through activities in the catchment that cause erosion. In other cases sediment supply is decreased through activities such as sandwinning. Changes in sediment supply are a cause for concern as too much sediment can interfere with recreational activities and economic activities where ports are concerned (e.g. Durban Harbour). Reduction in sediment supply is an issue because of concerns about the aggregate impact of reduced supply at a number of sites on the sediment balance of the coast. (For additional information see Schumann, 2003)

Development adjacent to estuaries

Estuaries are common sites of physical development due to the attractive nature of the estuary and its surrounds. Management concerns associated with this are:
Physical intrusion on the estuary – an impact on the sense of place of the area
The visual impact of development
Impact on the biodiversity
Development adjacent to estuaries also causes changes to freshwater flows. Particularly where an estuary is located in an urban setting it is surrounded by hard surfaces (roads, roofs etc) which prevent rainwater penetrating into the soil and increase the rate of run-off. During rainfall events inflow directly from the surrounds (through stormwater drainage systems and streams) increases beyond that which is normal, and during dry periods the discharge of water into the estuary from the surrounding streams and groundwater is less than normal.

Development within estuaries

There are many forms of development that take place in estuaries such as port developments; weirs and causeways; bridges and embankments; bulkheads and channelisation; and jetties (Van Driel and Breen, 2001). These developments can have many types of impacts (Van Driel and Breen, 2001):
Restrictions in water exchange and flow
Interference in patterns of flow, sedimentation and scouring
Interference in mouth position and status
Reduction in size of habitats, as well as types of habitats.
These issues in turn have impacts on biodiversity, subsistence, recreational and commercial resource use, and the use of estuaries for transport services.

Resource Harvesting

Both animals and plants are harvested in estuaries. Some of the impacts associated with resource harvesting are:
Damage to habitats
Reduction in numbers of specific species

Disruption of normal functioning of ecosystems
As has been stated, there is a concern that changes in freshwater inflows reduce the biodiversity in an estuary. This, in turn, impacts directly on those who are reliant on resource harvesting as a livelihood option.

H.5 Estuaries for which the project is most relevant

The estuaries for which the project is most relevant and the reasons why are outlined below:

St Lucia Estuary

St Lucia is South Africa's largest estuary and a focal feature of the Greater St Lucia Wetland Park, a World Heritage Site. Over the past fifty years the estuary and lake system has experience significant reduction in the inflow of freshwater – the large Mfolozi River which once fed into the estuary now discharges directly into the sea and there is significant abstraction of freshwater from other rivers feeding the system. The result has been changes in salinity regimes, reduced water levels and extended mouth closures. This, in turn, has impacted on its ecological functioning and its economic importance as a prime ecotourism and recreation destination.

Establishing the economic value of freshwater flowing into St Lucia would result in improved decision making on water allocations to users in the catchment and to the estuary.

Mhlathuze Estuary

The Mhlathuze River Estuary is a large estuary that was formed during the construction of the Port of Richards Bay. During harbour development the estuary was split into northern and southern sections with the north becoming the harbour and the south was retained as an estuarine sanctuary.

The municipality is particularly concerned about increased sedimentation in the estuary (Van der Wateran, 2004). In the uMhlathuze there are probably four forces at work which are contributing to observed accelerated increase in sedimentation of the system:
Soil conservation in the catchment: Increased agricultural and grazing pressure in the catchment increases sediment yield which is deposited in the estuary. It appears that

sugar cane farmers in the catchment do not adhere to the prescribed buffer zones and there are also a number of informal settlements in the catchment (Van der Wateran, 2004).
Reduced freshwater stream-flow: Abstraction of water in the catchment reduces its stream-flow and so the flushing of the estuary is reduced. This also results in increased inflow of marine sediment into the system.
Estuary configuration: The estuary is, in effect, a lake off to the side of both the river entrance and mouth which are both located in the north. Currents in the “lake” are likely to be fairly weak which encourages deposition.
Flooding (lack there-of): Over the past seventeen years there has been no major flooding in the system so no significant scouring has taken place.

Thukela Estuary

The Thukela Estuary is a large open estuary located within the Ilembe District Municipality. It plays an important role in supplying nutrients into the marine environment at the Thukela bank. The Thukela Bank supports a substantial prawn fishery that operates off the KwaZulu-Natal coastline.

While the Thukela catchment is largely undeveloped plans have been mooted for large scale abstraction as part of a water development scheme. As the Thukela Estuary is an important provincial resource the possible impact of changes in freshwater flow need to be well understood to prevent damage to the resource.

Mhlanga Estuary

The Mhlanga Estuary is situated in the north portion of the eThekwini Municipality. It is located in an area of increasing levels of development and high escalations of property prices. A recent sale of land near the estuary indicates a high value being placed on the visual attractiveness of the estuary (Mather and Boon, 2004). The estuary is usually closed providing a scenic environment for recreational use.

Increasing inflows of freshwater from sewerage treatment works into the catchment of Mhlanga have caused more frequent and longer lasting breach events (Mather and Boon, 2004). The municipality became concerned about the possible impact on biodiversity, visual attractiveness and recreational use. As a result the Municipality spent R25 million to divert sewerage inflows to other catchments (Mather and Boon, 2004). The

Municipality would like to know whether there was economic justification for this expenditure.

Mgeni Estuary

The Mgeni Estuary is a large estuary situated close to the urban centre of the eThekwini Municipality. It is a permanently open estuary.

The Mgeni River is subject to large scale abstraction of water which is redistributed into rivers through the sewerage system. Some of the issues of concern to municipal officials relating to this are (Mather and Boon, 2004):
Lower base flows resulting in less water to dilute pollutants.
Reduction in small scale flood events resulting in an accumulation of sediment that is a possible danger to infrastructure in the event of large scale flood events.
Reduction in the recreation value of the system because of low base flows. This is particular relevance to the Duzi Canoe Marathon, a large sporting event in the province.

Mtentu Estuary

The Mtentu Estuary is a medium size estuary situated in the northern portion of the OR Tambo Municipality and forms the northern boundary of the Mkambati Nature Reserve. It is part of a formerly protected marine sanctuary and is generally regarded as an estuary of national conservation significance. The estuary has a wilderness character with only two limited tourism developments in its immediate vicinity. The tourism developments in the area are owned by a community based tourism business that provides horse, hiking and canoe trails and, together with a private sector partner, operates a catch and release fly-fishing operation.

The catchment of the Mtentu Estuary has in the past been identified for possible abstraction. The community tourism business is based on the high scenic value of the estuary, it biodiversity and the seasonal presence of Giant Kingfish (the foundation of the fly-fishing operation). The impact of changes of freshwater inflow into this estuary is unclear however they could result in changes to all three factors mentioned. Understanding the impact of this would assist decision making regarding future changes in fresh water inflow.

Mngazi Estuary

Mngazi is a fairly small intermittently open estuary located about 15 km south of Port St Johns. The nationally renowned tourism resort, Mngazi River Bungalows, is located at its mouth. The river is currently experiencing increased abstraction as part of the water supply development scheme for the greater Port St Johns area. The concern, expressed particularly by Mngazi River Bungalows management is the impact this will have on mouth condition, and with this the recruitment of fish into the estuary. The fish are an important component for recreational fishing by guests at the resort.

Mngazana Estuary

Mngazana is located about 18 km south of Port St Johns. It is permanently open and contains the third largest stand of mangrove forest (+/- 130 ha) in South Africa. It is generally regarded as an estuary of national conservation importance. Mngazana is the subject of a detailed scientific study as well as efforts to reduce mangrove harvesting by local communities. While abstraction in the catchment is not yet a cause of concern, agricultural development is taking place and abstraction is likely in the future. Understanding the economic value of freshwater inflows would assist in the future management of upstream agricultural abstraction.

Nahoon Estuary

The Nahoon Estuary is located at East London. It is surrounded by residential development and has high recreational and conservation value. There is significant abstraction of water in the catchment and the concern is what impact this is having on recreational and conservation activities.

Kowie Estuary

The Kowie Estuary is a permanently open estuary situated within the town of Port Alfred. Port Alfred is a substantial town and there is considerable development in the lower reaches of the estuary including a marina development close to the mouth and canalisation of the mouth. The estuary is subject to extensive recreational use and is also a harbour for marine fishing boats.

In recent times sedimentation in the main channel near the mouth has accumulated to the extent that it interferes with boat movement and access to the sea.

Kariega Estuary

The Kariega Estuary is a permanently open estuary situated alongside the town of Kenton-on-Sea within the Eastern Cape. There is much residential development at the lower reaches of the estuary, the rest of the estuary is bordered by farmland.

The Kariega Estuary is marine dominated and on occasion has been known to become hypersaline (Cowley and Daniel, 2001). River inflow into the estuary is negligible due to low rainfall in the area and a 'very poor rainfall to runoff ratio' (Cowley and Daniel, 2001). In addition the catchment of the Kariega has three dams and numerous farm weirs (Cowley and Daniel, 2001). The lack of freshwater has altered the natural state of the estuary to one that is 'nutrient poor, has low fish stocks and is marine dominated' in addition this could also lead to long-term sedimentation problems (Cowley and Daniel, 2001).

Bushmans Estuary

The Bushmans Estuary is a permanently open estuary situated between the coastal towns of Kenton-on-sea and Bushmans River Mouth. There is much residential development at the lower reaches of the estuary, the rest of the estuary is bordered by farmland. The estuary is subject to heavy recreational use (Cowley and Daniel, 2001).

The estuary is marine dominated and freshwater inputs have been reduced because of the presence of several dams and weirs (Cowley and Daniel, 2001). In recent times sediment accumulation in the estuary has begun to interfere with recreational boating activities. Sediment accumulation is probably linked to the location of the bridge running over the estuary, reduction in freshwater inflows and the natural sedimentation cycle in estuaries.

Zandvlei Estuary

The Zandvlei Estuary is located immediately north of Muizenberg within the Cape Town metropolitan area. Its entire catchment also falls within this metropolitan area. Management is active and is aimed at balancing two needs: firstly to maintain a fairly constant water level for recreational use (sailing and boating) and to ensure that residences and infrastructure around the estuary (Marina de Gama) are not flooded; and secondly to maintain salinity levels/gradients within the system. Water level is maintained with a weir near the mouth which allows marine inflows during spring high tides. This is supplemented through the management of the sand barrier at the mouth, which is artificially breached at spring tides to allow marine water inflows. The net result of this management is that salinity levels are regularly depressed, especially during the rainy season (winter), and the estuary is fresh water dominated.

Despite being an urban catchment freshwater inflows are considered to be of acceptable quality and siltation is apparent but limited.

Zandvlei is considered to be of significant recreational importance. As the only functional estuary feeding into False Bay its ecological importance takes on an increased significance.

There is considerable management capacity and this management is well organised into the Zandvlei Action Committee, a sub-committee of the broader Sand (Zand) River Catchment Management Forum. There is a management plan for Zandvlei and for the entire catchment. The management plan for the catchment is implicitly linked to the IDP. The system has been well researched and its functioning is well understood.

H.6 Relevance of economic Valuation

There appears to be a strong role for the economic valuation of alterations in freshwater inflow regimes. The Cape Town and eThekwini Municipalities have in the past used economic valuation studies to assist in decision making regarding the funding of their open space management (Mather and Boon, 2004; Zandvlei Trust, 2004), so there is a precedent for municipalities making use of this type of information. The official at Mhlathuze expressed the need to be able to quantify environmental issues in economic terms in order to communicate better with councillors (Van der Wateran, 2004). The official at Ilembe district municipality felt that economic information of this sort would assist building estuary management the understanding of municipally officials and councillors (Govender, 2004). The Zandvlei Trust expressed the need to be able to establish an economic basis for management decision making as it relates to water levels and salinity levels. It also wishes to understand the economic impact of freshwater abstraction in the catchment. In particular it was emphasised that municipalities tend to have a very narrow focus on single issues and that this information would assist municipalities in looking at the bigger picture when making decisions (Govender, 2004).

In addition, as can be seen from the discussion on the Mhlanga estuary decisions are already being taken by municipalities relating to freshwater inflow into estuaries that have economic costs and benefits. However the municipalities are not clear on the actual value of these costs and benefits and improved information on the economic valuation of these estuaries would help municipalities to make better decisions.

Some municipalities in the country have already embarked on coastal and catchment management planning (City of Cape Town, Amatole and uThungulu) and others are planning to undertake similar exercises (eThekwini and Ilembe). These coastal/catchment management plans are incorporated into IDPs as sector plans. Officials have indicated that economic valuation issues could be incorporated directly into these sector plans. Some municipalities intend to have estuary management plans for each estuary included in the auspices of their coastal management plans. Where these management plans are established economic valuation issues will be particularly relevant.

H.7 Conclusions and Recommendations to the Project

Some municipality are already grappling with the economic costs and benefits of freshwater inflow changes into estuaries and are making decisions based on their perceptions of these costs and benefits. It is **concluded** that these municipalities would benefit greatly from detailed economic valuation studies on the estuaries of concern and that in turn these municipalities could provide improved insight into economic valuation research if they are actively engaged in the project. It is therefore **recommended** that to improve learning between managers and researchers detailed case studies of estuaries should take place within municipalities that are engaging with these issues. The economic data generated will be used by the municipality concerned and the researchers will gain increased insight in the management issues through engaging with officials that are already considering these issues. Mhlanga and Zandvlei are recommended as the first choices for detailed case studies. (It is recognised that in the short to medium term municipalities with limited capacity will find it difficult to incorporate resource economic information into decision making processes. That is why the estuaries recommended as first choices are both located in urban environments and within municipalities that are already including resource economics information in their decision making).

Some senior municipal officials are keen to engage in more depth with issues relating to estuary management and have insights into estuary management and municipal processes that would assist the project. It is **concluded** that it would be beneficial to the project in terms of improved direction and increased insight to involve municipal officials more closely in the management of the research project. It is therefore **recommended** that the Water Research Commission invite municipal officials to participate in the project steering committee, particularly those officials linked to detailed case studies described in (1) above.

From interaction with municipal officials it appears that there is a general recognition among municipalities that estuary management issues should be reflected in Integrated Development Plans through sectoral plans. However it is **concluded** that there is limited recognition of the need to consider estuary management concerns when making decisions that can have a large impact on the future of an estuary. It is therefore **recommended** that the research project consider ways in which economic valuation can be used to influence important components of Integrated Development Plans such as the Land Use Management Systems and Water Services Delivery Plans. It is further **recommended** that the project results in a set of overarching principles that should be considered when making decisions that will result in changes to freshwater inflow into estuaries.

Based on the outcome of the interviews it is **concluded** that environmental economics has a strong role to play in educating municipal officials and councillors regarding the consequences of various actions and decisions at local level regarding environmental resources. It is therefore **recommended** that the outcomes of the project are packaged in a simple, brief user friendly document that outlines what types of activities results in changes in freshwater inflow into estuaries, illustrates the economic costs and benefits of these activities and that outlines the principles that should underpin municipal decision making in this regard.

This report **concludes** that there is a general lack of capacity on the part of municipalities to engage in estuary management and planning. It is therefore **recommended** that, as part of the fieldwork component of the estuary valuation study, a capacity building component is built in so that when researchers engage municipal officials it is as much an information and knowledge sharing session as it is a data collection exercise. This is an ideal opportunity to build local municipal awareness on estuary management issues, and while it might not provide detailed information it will increase awareness amongst municipal officials of the need to take estuaries into account in local planning and management.

Capacity building for Appendix H

During this sub-project two capacity building elements were included:
During meetings with municipal officials information on estuary functioning and management was imparted by the consultants to improve the officials' understanding of estuary management issues.
Following the meeting at Zandvlei a presentation was provided to the public (about 50 participants) on estuary management and conservation issues in South Africa. This formed part of the Zandvlei Festival, a bi-annual event organised by the Zandvlei Action Committee.

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Appendix I

Capacity Building through the Project

The following students had graduated with masters degrees through this project at the time of writing or were in the process of doing so.

Student name	**Degree (year awarded)**	**Title of treatise/dissertation**
Moses Mlangeni	MCom (2006)	A contingent valuation of river inflows into the Swartkops, Kariega, Mngazi and Mngazana estuaries in the Eastern Cape
Marzanne Potgieter	Honours in Statistics (2005)	Valuing preferences for freshwater inflows into the Mngazi and Mngazana estuaries
Henri van der Westhuizen	MCom (2007)	Valuing preference for freshwater inflows into the Bira, Bushmans, Kasouga, Keiskamma, Kleinemonde East, Nahoon and Tyolomnqa estuaries
Johane Dikgang	MCom (2007)	A comparison of the values of water inflows into selected South African estuaries: the Heuningnes, Kleinmond, Klein, Palmiet, Cefane, Kwelera and Haga-Haga
William Akoto	MCom (2008)	Valuing preferences for freshwater inflows into selected western and southern Cape estuaries
Jedidah Chege	MA (2009)	Valuing preferences for freshwater inflows into five Eastern Cape and KwaZulu-Natal estuaries
Denis Nyaboga	MCom (not yet complete)	Valuing preferences for freshwater inflows into the Gqunube, St Lucia and Uilkraalsmond estuaries
Chatelle Oliver	MSc (not yet complete)	Eliciting willingness to pay preferences for various public policy options with respect to estuary management: a choice modeling pilot study