THE VALUATION OF CHANGES TO ESTUARY SERVICES IN SOUTH AFRICA AS A RESULT OF CHANGES TO FRESHWATER INFLOW

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DISCLAIMER

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EXECUTIVE SUMMARY

There are just over 250 functioning estuaries in South Africa and of these an increasing number are subject to river inflow deprivation. River water is abstracted upstream of the estuaries for urban and agricultural use, and runoff into rivers is undermined by forestry and the spread of high water consuming alien vegetation. As a result of the reductions in river water inflow, the services rendered by these estuaries are eroded.

The main purpose of this study was to develop a method of valuing changes in freshwater inflow that would better inform estuary managers on economic issues relating to the problem of freshwater deprivation. This aim is pursued by examination of the problem of freshwater deprivation (Chapter One), explaining how economics can better inform estuary managers on the allocation problem (Chapter Two), identifying an appropriate method of valuation (Chapter Three) and applying this method (Chapters Four to Seven). Two secondary objectives of this study were to develop capacity to apply the method of contingent valuation (CV) and inform the public on the nature of the problem of estuary freshwater deprivation. These objectives were pursued by training four students in applying the contingent valuation method (CVM) to value changes in freshwater inflow into selected South African estuaries and holding meetings with identified target populations to share information on the deprivation problem.

The nature of estuaries and the impact on them of freshwater deprivation is discussed in Chapter One. It is shown that some types of estuary are more vulnerable to freshwater deprivation than others. Particularly vulnerable are the type described as temporary open/closed estuaries. It is argued that there is recognition in South Africa that something should be done to counter the problem of freshwater deprivation into estuaries.

Chapter Two explains what Economics deems to be efficient with respect to freshwater inflow into South African estuaries. Efficiency is achieved when the marginal social cost of the freshwater inflow is brought into equivalence with the marginal social value of the inflow. The marginal social costs of freshwater inflow into estuaries are what people are willing to pay to abstract freshwater from (or projects to reduce runoff to) rivers upstream of the estuaries.

The marginal social values of freshwater inflow into estuaries are somewhat more complicated to estimate than the marginal social costs, because people do not directly use this water, but do so indirectly, by consuming the services dependent upon this inflow. These services take many forms, for instance, the area of the estuary available for boating and the quantities of fish, prawn and birds present in and around the estuary. This study focuses most of its attention on the estimation of the marginal social values.

The CVM is selected for the purpose of estimating the marginal social values because it is highly suited to quantifying the benefits to the public of environmental goods and attributes. It serves as an alternative to indirect techniques (the travel cost and hedonic pricing methods) for quantifying these

benefits. These values may be used in decision-making with respect to the management of the environment and, if desired, incorporated into cost benefit analyses.

The circumstances to which the CVM is particularly suited are those where market values are difficult to observe, either directly or indirectly. Markets cannot be relied upon to fully incorporate benefit where there are public good characteristics (non-excludability and non-rivalry) present and where passive use is significant. The benefit relating to the latter type of use is not reflected in market behaviour in ways that can be observed because the markets do not provide opportunities for people to show their preference.

The CVM is a highly appropriate technique for estimating value of changes of estuary services induced by changes in freshwater inflow because the environmental services yielded by estuaries are closely connected with quantity of freshwater flowing into the estuary, they are largely public in nature and it is plausible they may give rise to significant passive use benefits (unobservable ones). The public good features of South African estuaries are the tradition of open access to estuaries and the fact that consumption by one person only reduces the services available to others in a minimal way. The probability of there being a passive use benefit is high given that there are a number of 'uses' of estuaries that markets provide little scope for revealing, such as the pleasure of seeing it while passing through the area.

The CVM is a controversial valuation technique. It 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. The fact that it has proved very difficult to establish this correspondence has led to CVM being subject to criticism. On account of this difficulty debate continues over whether CVM makes a 'category' mistake by attempting to value judgements as if they were preferences.

Many aspects of the criticism of the CVM have been addressed - in the form of using methods to reduce biases, the adoption of conservative elicitation formats and the reporting of tests for consistency. Chapter Three describes some of the ways the criticism has been addressed and some of the recommended guidelines for applying the method that have emerged during the past 25 years.

One of the guidelines for applying the CVM is that pilot studies be conducted prior to the main study. Chapter Four reports the results of the pilot study that preceded the main study. It was undertaken in the year 2 000 at the Keurbooms Estuary; an estuary located on the southern coast of the Western Cape province of South Africa. Estimates were generated of both the marginal social benefit and marginal social cost and two validation tests were administered. Details of the estimates are discussed later in this summary. The expectations-based validity test showed the values generated in the pilot study to be plausible and consistent, but the convergence-type test generated some unexpected results. The unexpected results relate to the impact in an estimated hedonic price equation of view of estuary and distance of property from estuary on selected recorded prices paid for properties in the area.

Other very important guidelines to follow in applying the CVM relate to sample design. These aspects are covered in Chapter Five. The two sample design issues encountered in this study relate to the selection of estuaries to be valued and the selection of users at these estuaries. On the basis of expert opinion a sample of fifty estuaries were selected, and at seven of these the CVM was applied: the Knysna, Groot Brak and Klein Brak Estuaries in the Western Cape and the Kromme, Swartkops, Kariega and Kowie Estuaries in the Eastern Cape. Funding was available to survey about 5% of the estimated user populations at these seven estuaries. In the light of statistical theory, larger sample sizes than these are preferable – ones in the region of 8 to 15% of the target user populations.

For most of the estuaries both high and low forecasts are generated of the impacts of changes in freshwater inflow into estuaries. For proposed increases in freshwater inflow the former relate to optimistic scenarios and the latter to pessimistic scenarios, but for proposed decreases in freshwater inflow, the former relates to pessimistic scenarios and the latter to optimistic scenarios. The forecasts of impacts on estuary services of changes in freshwater inflows were generated on the basis of expert opinion.

Yet another important guideline that should be followed in applying the CVM is that both the person administering the questionnaire and the respondent should be clear about the scenario being valued. In order to achieve this clarity it is necessary that both understand the following: the forecasts of the impacts of the specified changes, the way the payments will be affected and the need for authenticity in response. Chapter Six provides the background information and discussion on selected issues relating to the administration of the CVM surveys.

Chapter Seven summarises what the respondents stated they were willing to pay and relates this to other information elicited from them. A payment card question format was used to elicit the respondent's willingness to pay for freshwater inflows into an estuary because this question format was expected to yield conservative values. Chapter Eight draws conclusions on the basis of what is reported in Chapter Seven and makes recommendations.

The main findings of this report, with respect to values, are shown in Tables 1 and 2 (overleaf). Value is measured in the form of the total willingness to pay (TWTP) in Rand for freshwater inflow into the estuary – the product of the median willingness to pay (WTP) bid per annum per household and the total number of user households per estuary. The respective TWTP amounts of the seven selected estuaries are shown in descending order by value in Table 1.

The highest TWTP found was for the Swartkops Estuary inflow, high estimate scenario. This estuary was also the one with the highest estimated number of users. The lowest TWTP was found for the Klein Brak Estuary, low estimate scenario.

Table 1: Estimated TWTP per annum per estuary

Estuary	Predicted median of WTP* p.a.	Estimates of number of households	TWTP p.a.
Swartkops: High benefit scenario (-)	R244	5 000	R1 220 170
Kromme: High benefit scenario (+)	R287	3 200	R 918 400
Kowie: High benefit scenario (+)	R290	3 234	R 937 860
Swartkops: Low benefit scenario (-)	R132	5 000	R 660 000
Knysna: High benefit scenario (-)	R149	3 891	R 579 759
Groot Brak: High benefit scenario (-)	R192	2 730	R 524 160
Knysna: Low benefit scenario (-)	R132	3 891	R 513 612
Groot Brak: Low benefit scenario (-)	R172	2 730	R 469 560
Kariega: High benefit scenario (+)	R211	2 000	R 421 308
Klein Brak: High benefit scenario (-)	R120	1 178	R 141 360
Klein Brak: Low benefit scenario (-)	R101	1 178	R 118 941

Notes: The values relate to the end of 2002 and start of 2003 and were derived using the CVM.

* Values are estimated on the basis of Table 7.70

Signs after estuary names indicate specified increase (+) or decrease (-) in water inflow.

The Rand value of water per cubic metre per annum is calculated by dividing the TWTP by the proposed change in freshwater inflow. These values are shown in descending order in Table 2.

Table 2: Value of water per m^3 – selected estuaries in South Africa

Estuary	TWTP p.a.	Specified change in inflow p.a. (million of m^3)	Value/m^3
Groot Brak: High benefit scenario (-)	R 524 160	5,0	R0,105
Groot Brak: Low benefit scenario (-)	R 469 560	5,0	R0,094
Swartkops: High benefit scenario (-)	R1 220 170	13,5	R0,090
Kowie: High benefit scenario (+)	R 937 860	13,0	R0,072
Kariega: High benefit scenario (+)	R 421 308	7,4	R0,057
Swartkops: Low benefit scenario (-)	R 660 000	13,5	R0,049
Klein Brak: High benefit scenario (-)	R 141 360	11,2	R0,013
Knysna: High benefit scenario (-)	R 579 759	46,0	R0,013
Kromme: High benefit scenario (+)	R 918 400	75,5	R0,012
Knysna: Low benefit scenario (-)	R 513 612	46,0	R0,011
Klein Brak: Low benefit scenario (-)	R 118 941	11,2	R0,011

Notes: Values relate to the end of 2002 and beginning of 2003 and were derived using CVM.

Signs after estuary names indicate specified increase (+) or decrease (-) in water inflow.

The CVs shown in Table 2 reflect a wide range of values – from 1,1 cents per cubic metre in the case of the Klein Brak low estimate scenario, to 10,5 cents per cubic metre in the case of the Groot Brak high estimate scenario. The median estimate of the 11 valuations reported in Table 2 is 4,9 cents per cubic metre of water and the mean estimate is 4,78 cents per cubic metre of water.

It was expected that the estuaries most prone to high change in services from changes in freshwater inflow would yield the highest values per cubic metre, for example, temporary open/closed estuaries (see Chapters One and Five). The results corresponded with this expectation (see Table 2). The Groot Brak Estuary heads the value list and it is particularly affected by freshwater inflow reductions. The Knysna estuarine bay, on the other hand, is only marginally affected by freshwater inflow reductions from the Knysna River and is near the foot of the value list.

On theoretical grounds, specified increases in water inflow were expected to yield higher than true estimates of the value of water and specified decreases were expected to yield lower than true estimates (see Chapter Two). No such patterns were found in the results, suggesting that other factors were of greater influence on values.

By definition estuary user population is an important determinant of TWTP value and the results shown in Table 1 confirm this to be the case. The Swartkops, Kromme and Kowie Estuaries, which have large numbers of users, top the TWTP valuations, while the estuaries with smaller numbers of users are at the bottom of the list, like the Klein Brak and Kariega.

CVs are subject to many biases and, for this reason, should ideally be subjected to tests for validity and reliability. Only expectation-based validation tests were administered. These tests are described in Chapters Three, Four and Seven. In terms of expectations-based tests, the different scenarios valued scored very differently (Chapter Seven). Strong support was found for valuations of the Groot Brak low estimate scenario, Knysna high and low estimate scenarios and Kowie high estimate scenario. Moderate support was found for valuations of the Groot Brak high estimate scenario, Kariega high estimate scenario, Kromme high estimate scenario and Swartkops low estimate scenario. Little support was found for valuations of the Klein Brak low and high estimate scenarios and Swartkops high estimate scenario.

In the light of the results and experiences of those administering the questionnaires there are also several recommendations made – some relate to the application of CVM to value changes in freshwater inflow into estuaries and some relate to river flow management.

Relating to method it is recommended that future CVs of this nature devote more attention to generating accurate information on the impact of changes in freshwater inflow and increase in sample sizes. Relating to river flow management the main argument of this study is that efficient management of freshwater allocations to South African estuaries can only be accomplished if it is informed by current estimates of marginal social costs and marginal social values of this inflow. As both of these estimates may be readily determined the challenge that lies ahead for research is to generate as many of these estimates as possible. In this connection it is recommended that priority be given to estimating marginal social costs of freshwater inflow for those estuaries whose marginal social valuations are found to exceed 5 cents per cubic metre. These marginal social costs should then be compared with the marginal social valuations of freshwater inflow into estuaries with a view to guiding management on the allocation of this inflow. With the development of water markets in South Africa (for regulating agricultural demand) it is envisaged that more information should become readily available on the marginal private cost of water flowing into the estuaries.

Only in the pilot study conducted at the Keurbooms Estuary was an attempt made to quantify both the marginal social cost and marginal social value of freshwater inflow into an estuary. It was found that the marginal social value of river water flowing into the Keurbooms Estuary was significantly less than the marginal social cost, and it is deduced that in the year 2 000 the economic case for increasing the allocation of freshwater inflow into the Keurbooms was weak. However, to this conclusion an important qualification should be taken into account – the two estimates were generated as part of a pilot study.

Based on findings with respect to the estimated bid functions and observations made by the field workers who collected the data for this study, it is also recommended that resources continue to be committed to educating the public affected by estuary services on the link between these services and the quantity of freshwater flowing into the estuaries. Many of the respondents held the view that, because the water flowing into estuaries had always been free, there was no case for introducing charges for this water. For this reason they were resistant to the idea that they should pay a price for this water. The researchers felt that the effect of providing education to the target population about the negative impact on the services yielded by estuaries due to freshwater deprivation was to soften this resistance and increase WTP to secure this inflow.

TABLE OF CONTENTS

Page

CHAPTER TWO: AN ECONOMIC MODEL FOR ALLOCATING FRESHWATER TO ESTUARIES

CHAPTER THREE: A METHOD FOR ESTIMATING THE VALUE OF CHANGES IN FRESHWATER INFLOW INTO ESTUARIES

CHAPTER FOUR: A PILOT STUDY OF THE KEURBOOMS/BITOU ESTUARY

CHAPTER FIVE: SAMPLE DESIGN ISSUES

CHAPTER SIX: ADMINISTRATION OF THE SURVEYS (BACKGROUND INFORMATION, QUESTIONNAIRES AND QUALITATIVE ASPECTS OF SURVEY REPORT)

CHAPTER SEVEN: RESULTS

CHAPTER EIGHT: CONCLUSIONS AND RECOMMENDATIONS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

CV	Contingent valuation
CVM	Contingent valuation method
DC	Dichotomous choice
DEAT	Department of Environmental Affairs and Tourism
DWAF	Department of Water Affairs and Forestry
EMF	Environmental management framework
GIS	Geographic information system
Ha	hectare
HPM	Hedonic pricing method
HSRC	Human Sciences Research Council
kg	kilogram
OLS	Ordinary least square
MAR	Mean annual runoff
MC	Marginal cost
MLE	Maximum likelihood estimation
MV	Marginal value
NOAA	National Oceanic and Atmospheric Administration
P1	Value per cubic meter of a specified quantity of freshwater in the best alternative use to the estuary
P2	Value per cubic meter of a specified quantity of freshwater inflow into the estuary to users and non-users of the estuary
REI	Riverine estuarine interface
RSA	Republic of South Africa
SP	Stated preference
TOC	Total opportunity cost
TV	Total value
TWTP	Total willingness to pay
USA	United States of America
WTA	Willingness-to-accept
WTP	Willingness-to-pay

CHAPTER ONE: THE PROBLEM OF DEPRIVATION OF RIVER INFLOW INTO ESTUARIES

1.1 Introduction

1.1.1 Objectives of the study

The main purpose of this study was to develop a method of valuing freshwater inflow into estuaries that better informs estuary managers on economic issues relating the problem of freshwater deprivation. Two secondary objectives were to develop capacity in the Eastern Cape to apply the contingent valuation method (CVM) and inform the most affected public about the nature of the problem of estuary freshwater deprivation.

The main objective is addressed in this report. Chapter One discusses factors that influence the health and value of estuaries, considers the particular role played by water deprivation in estuaries and outlines the main reasons why the problem of water deprivation should be attended to. It explains these adverse consequences and identifies obligations South Africa has to prevent them from occurring. In the subsequent chapters it is shown how economics can better inform estuary managers, an appropriate method of valuation is discussed and it is demonstrated how this method may be applied.

The secondary objectives were addressed by training four students at the University of Port Elizabeth in applying the method of contingent valuation (CV) to value changes in freshwater inflow into estuaries and by holding meetings with identified target populations to share information on the freshwater deprivation problem being experienced in many South African estuaries.

1.1.2 Estuaries as generators of environmental goods and services

Estuaries are productive systems that provide valuable supplies of goods and services, ranging from fisheries to recreational activities (Lamberth and Turpie, 2003:1). South African estuaries have been estimated to be worth R153 000 per hectare (ha) per year (at 2000 price levels) – R3 500 per ha in food production, R2 550 per ha in recreation and R141 000 per ha in nutrient cycling (Lamberth and Turpie, 2003:1).

1.1.3 The freshwater connection

Estuaries are reliant on uninhibited access to marine and freshwater links in order to function properly, but due to various forms of abstraction there is a growing deficiency of freshwater inflow to estuaries in South Africa (Adams, 2001; Lamberth and Turpie, 2003:2). This deficiency has adverse consequences for estuarine habitats and these should be addressed (Whitfield and Wood, 2003). These adverse consequences take the form of reduced wetland services; the loss of which has prompted widespread concern, both within South Africa and beyond its borders. The core of the problem is that there are many competing users demanding water. It has been estimated that by the year 2025 South Africa will have a population of 70 million and all its exploitable freshwater resources is expected to be used up (Schalacher and Wooldridge, 1996).

1.2 South African estuaries

1.2.1 Number of estuaries

South Africa has a coastline of about 3 000 kilometres (Baird, 2002:37). Along this coastline there are a large number of estuaries – 289 by some counts (Hattingh, Whitfield, van driel, Archibald, Hay, Bate and Schumann, 2002:5), 465 by others (Baird, 2002:37). There are about 255 estuaries that can be classified as "functioning" and that fit into standard types (see Lamberth and Turpie, 2003:1 and Section 1.2.3).

1.2.2 Determinants of estuary character

The morphology of estuaries (size, shape, and nature) in South Africa is determined by climate, hinterland topography, wave energy, sediment supply and different coastal characteristics (Baird, 2002:37). The different estuarine types in South Africa are dependent on where they are along the South African coast and on the climate of the region (see Figure 1.1). The eastern coastline has steeply tilted coastal plains that receive heavy rainfall during summer months. The west coast, on the other hand, is more arid than the east coast and less tilted, and estuaries become functional only during times of heavy rainfall. South African estuaries are relatively small if compared on a global scale, and cover only 600km^2 of coastline (Baird, 2002:37). Rainfall is a crucial element in determining the nature of estuaries. The South African region has an erratic and unevenly distributed rainfall, which divides the country into a wet, humid, subtropical eastern region and a dry, semi-desert western region with almost complete aridity in places (Baird, 2002:38).

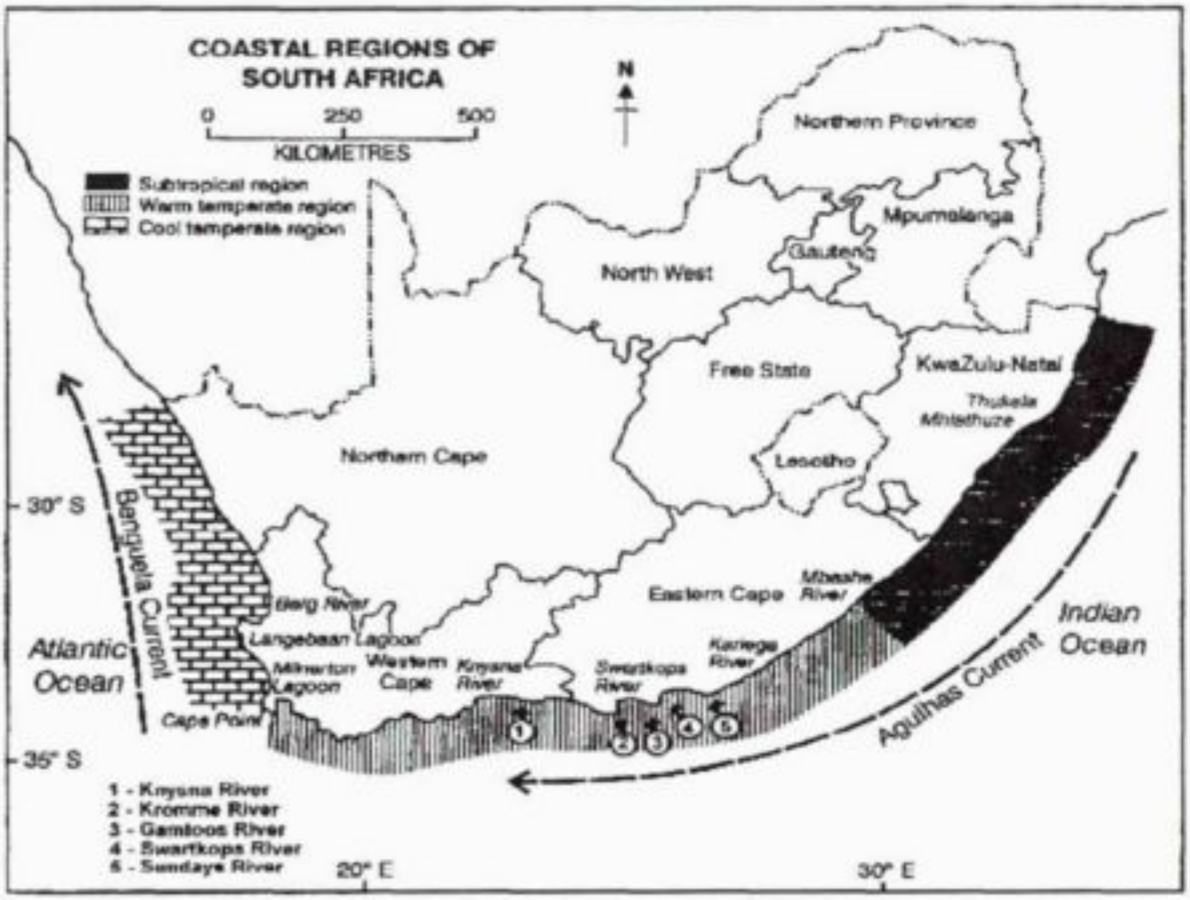

Figure 1.1: Climatological/Biographical regions and ocean currents along the South African coast

Source: Baird (2002:37)

The average rainfall of 500mm for the country is below the global average of 800mm and from time to time there are extended periods of drought, followed by severe floods (Baird, 2002:38). Rainfall is also highly seasonal, with more than 80% occurring during summer months (October-March) in the northern regions. The southern regions have most of their rain in winter. The rainfall is also influenced by the topography, with mountain ranges on the east coast capturing much of the rain.

Sixty-five percent of South Africa receives less than the average of 500mm for the country and 21% receives less than 200mm (Whitfield and Wooldridge, 1994:42). In most of the African subcontinent the average annual evaporation of 1 100mm to 3 000mm per annum is higher than the annual rainfall (Whitfield and Wooldridge, 1994:42). This high evaporation rate reduces the water available for storage and limits the quantity of water available to estuaries.

More than half of river runoff in southern Africa is already captured and stored in impoundments and only 8% of mean annual runoff (MAR) reaches the sea (Whitfield and Wooldridge, 1994:42). The main users of freshwater in South Africa are farmers. They use more than double what the others do (Whitfield and Wooldridge, 1994). Demand for freshwater is continually increasing due to population growth and economic development. At the current rate of growth in demand for freshwater it is estimated that all surface groundwater resources will be fully utilised by the year 2020 (Whitfield and Wooldridge, 1994).

The South African coastline can be divided into three broad climatic regions (see Figure 1.1). These three are a subtropical region from the northern border of KwaZulu-Natal to the Mbashe River, a warm temperate region from the Mbashe River to Cape Point in the south and a cool temperate region along the west coast. The warm Agulhas Current influences the first two regions and the cold Benguela current influences the third. The boundaries between these areas are approximate (Baird, 2002:38).

1.2.3 Types of estuaries

In terms of the National Water Act of 1998 an estuary is defined as a partially enclosed coastal body of water that is either permanently or periodically open to the sea and within which there is a measurable variation of salinity due to the mixture of seawater and freshwater derived from land drainage (see also Day, 1980). Estuaries are special types of wetland (see Appendix 1 for more discussion). The latter describes areas where water is present, whether static or flowing, fresh, brackish or salt, including marine water which has a depth at low tide not exceeding six metres (Barbier, Acreman and Knowler, 1997:69).

There are a number of different types of estuary. They range from those that maintain a permanent connection with the sea to estuaries that periodically close for varying periods. Incorporated in the latter category are estuaries that are sometimes referred to as "blind estuaries" or "lagoons." Whitfield (1992) has identified five types of estuaries based mainly on physiographic, hydrographic and salinity characteristics. As an estuary of one type can behave at times like a completely different type (depending on river inflow and inlet condition) this classification is typically made according to their dominant phase. The five types of estuaries identified by Whitfield (1992) are:

- Permanently open estuaries
- Temporarily open/closed estuaries
- River mouths
- Estuarine lakes
- Estuarine lagoons/bays

These five estuary types arise with diverse frequencies in the three biogeographical regions making up South Africa. Approximately 70% of South African estuaries are temporarily closed for some period of time (Breen and McKenzie, 2001:10). The reasons for closure are many. Due to climate they are subject to the extremes of drought and floods. Due to a fast growing population there are high levels of water abstraction from rivers and great interference with the hydraulic structure of estuaries. Due to the jagged coastline, the few protected bays, the high-energy waves and strong winds throughout the year estuaries are points of access to the sea and this has led to extensive development around them. This pressure has mostly been in the form of residential and recreational developments, for example, Knysna in the Western Cape (Baird, 2002:38). South African estuaries have also been rated according to ecological condition. About 30% of estuaries are thought to be in an "excellent" condition, 31% in a "good" condition, 24% in a "fair" condition and 15% in a "poor" condition (Baird, 2002:39).

1.2.3.1 Permanently open estuaries

Permanently open systems are continuously influenced by tidal action and exhibit typical estuarine characteristics, for example, a moderate tidal prism and horizontal salinity gradient. The water column may be well mixed or stratified (vertical salinity or temperature differences), with individual systems often shifting between conditions on a temporal scale. Stratification is dependent on factors such as bathymetry, tidal streaming and river flow. Many of these estuaries have catchment areas greater than $500km^2$ and sometimes greater than $10\ 000km^2$.

Rivers flowing into permanently open estuaries are usually perennial in their natural condition. Wetlands are often present and vegetated with salt marshes in more temperate regions and mangroves in tropical areas. The eelgrass *Zostera capensis* (see Figure 1.6) may be present sub-tidally, especially in middle to lower reaches. Salinity values usually fluctuate between 5 and 35, although hypersaline (>35) conditions sometimes develop during times of high evaporation and low or no river inflow.

Permanently open estuaries are usually large systems where there is a strong tidal exchange with the sea (Breen and McKenzie, 2001:10). When river flow conditions are low, the tidal exchange keeps the mouth open. An example of a permanently open estuary, namely the Kariega estuary, is shown in Figure 1.2 below.

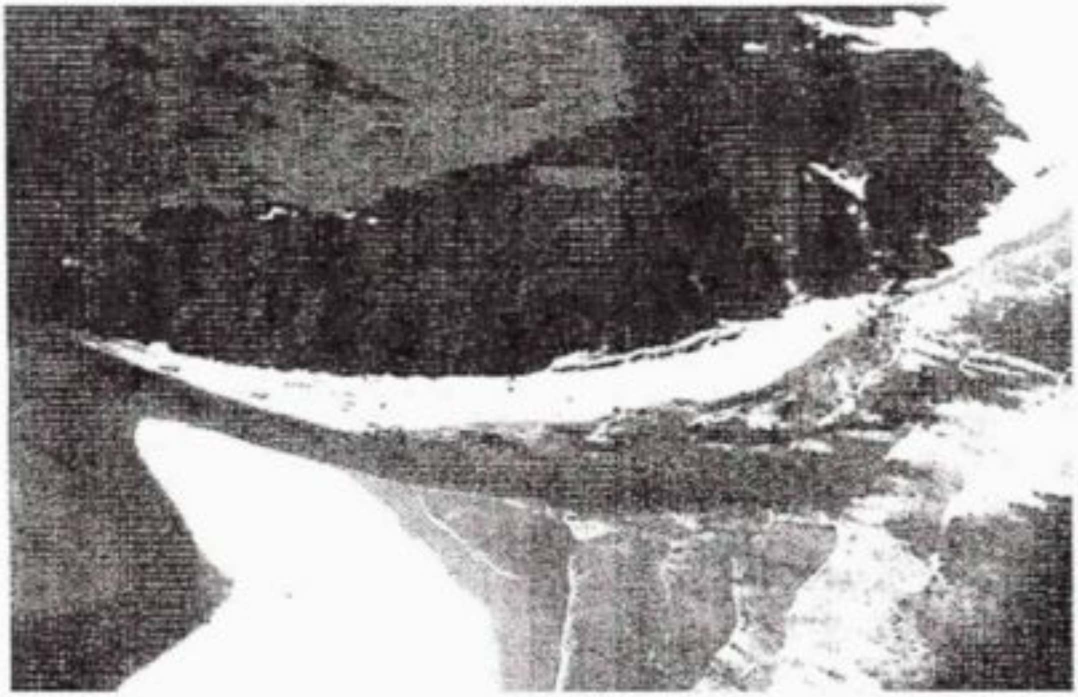

Figure 1.2: The permanently open Kariega Estuary
Source: Breen and McKenzie (2001:10)

1.2.3.2 Temporarily open/closed estuaries

Temporarily open/closed estuaries close off from the sea for varying lengths of time owing to sandbar formation at the mouth. This closure occurs during times of low or no freshwater inflow combined with longshore sand movement in the marine nearshore. Catchment areas are usually smaller than 500km^2. Hydrographic conditions are highly variable and large amounts of sediment are removed at times of flooding. During times of mouth closure, water levels in the estuary may gradually rise until overtopping the sandbar at the mouth. Water levels drop rapidly, often exposing previously inundated areas that sustained a high biomass of plant and animal life.

These estuaries are often closed for many months each year and can be closed for a year or longer (Breen and McKenzie, 2001:10). Temporarily closed estuaries have small catchments and limited penetration by tidal waters at any time that they are open. The mouth usually opens after periods of high rainfall. An example of a temporarily open/closed estuary is shown in Figure 1.3 below.

Figure 1.3: Marine sediment deposits temporarily closing an estuary mouth

Source: Breen and McKenzie (2001:10)

1.2.3.3 River mouths

River processes usually dominate physical processes in river mouth estuaries, with salinity values approaching oligohaline conditions (salinity < 5 parts per 1000) in the middle reaches (Breen and McKenzie, 2001:10). Tidal inlets often remain permanently open, although seawater penetrates only a short distance up the estuary on a flood tide. Catchment areas are usually large and their rivers generally carry a high silt load. However, on the Tsitsikamma coast where rivers are usually short and rise in Table Mountain sandstone, silt loads are typically low. The example of the Mzimvubu river mouth is shown in Figure 1.4 below.

Figure 1.4: The Mzimvubu "river mouth" type of estuary

Source: Breen and McKenzie (2001:10)

1.2.3.4 Estuarine lakes

Estuarine lakes mostly evolved from drowned river valleys that have separated from the sea by vegetated sand dune systems. In some cases the barrier dune has completely isolated the water body. These systems are usually referred to as coastal lakes. Some estuarine lakes retain their marine connection, although the link may be temporary. The marine connections vary in length and width (Breen and McKenzie, 2001:11). Salinity values in the lake may vary considerably, ranging from oligohaline (salinity < 5 parts per 1000) to hypersaline (> 35 parts per 1000) depending on freshwater inflow. Consequently, a biotic composition varies between extremes and may remain at extreme levels for long periods (years).

An estuarine lake can have a mouth that is either open, such as the Wilderness Lake, or closed, such as the Swartvlei Lake.

1.2.3.5 Estuarine lagoons/bays

Estuarine bays have a large tidal prism and salinity values in the lower reaches usually in excess of 25, i.e., high salinity levels. Near-marine conditions can extend into the upper reaches during periods of low freshwater inflow. Estuarine lagoons/bays have continuously open mouths due to strong tidal exchange (Breen and McKenzie, 2001:11). A regular replacement of marine water occurs in the lower and middle reaches of the estuary, for example, Richards Bay and Knysna. The dominant mixing process is tidal. Freshwater river characteristics are a feature only in the upper areas of the estuary (Whitfield and Wooldridge, 1994). In some cases estuaries are enlarged as a result of dredging activities in the mouth and/or elsewhere.

1.2.4 Estuarine plant communities

The plant life in South African estuaries is dependant on the availability of unpolluted freshwater inflow for its survival. South African estuaries have six different plant communities (Breen and McKenzie, 2001:14). These are:

- Small algae
- Large algae
- Submerged large plants
- Salt marshes
- Reeds and sedges
- Mangroves

Small algae (microalgae) are found on mud, sand and bigger plants. These organisms give surfaces a green or brown tinge and are a good indicator of nutrient status and pollution (see Figure 1.5). When these organisms start to die, their decay can consume so much oxygen that fish and other organisms are killed.

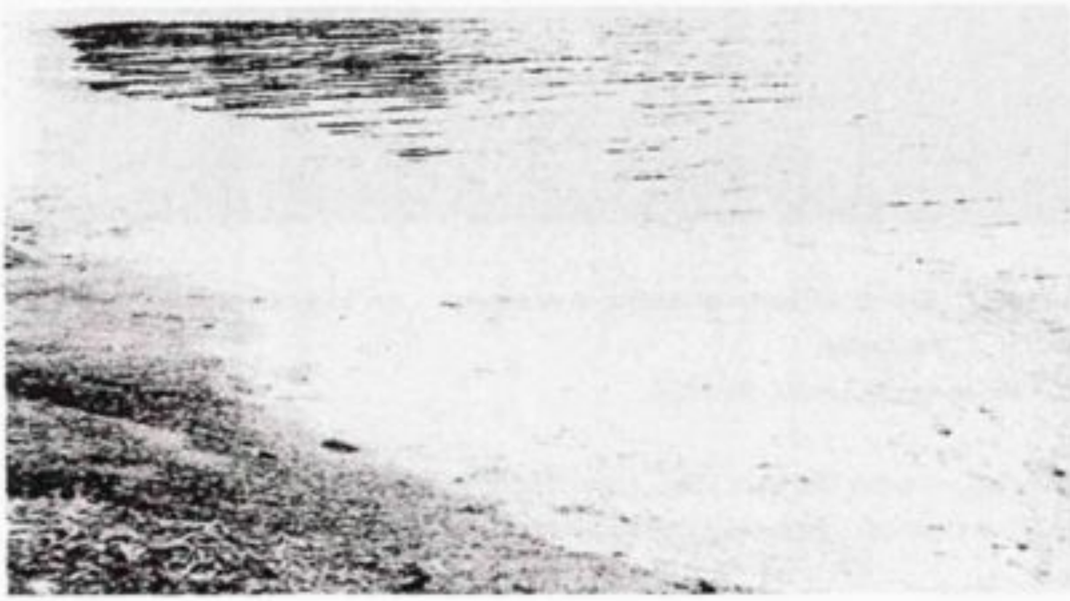

Figure 1.5: Algae along the shore decomposes to provide an important food source in estuaries

Source: Breen and McKenzie (2001:14)

Large algae (macroalgae) are found in most estuaries and are made up of two main groups – those with thread-like (filamentous) form and those that are firmly attached and have a leafy (thalloid) form.

Submerged large plants (macrophytes) are rooted plants that have stems and leaves that may reach the water surface (see Figure 1.6). Even though these species are able to survive strong tidal currents, whole beds are often washed out during floods. Some species boast beautiful flowers making the estuary more attractive to the eye. Submerged macrophyte beds are important habitats for other organisms living in estuaries, for example, fish.

Figure 1.6: Extensive beds of eelgrass (Zostera) - an important plant in many estuaries

Source: Breen and McKenzie (2001:18)

Salt marshes are areas that have a high concentration of sea salt and are important habitats for certain invertebrates, for example, crabs, and a source of organic litter that sustains many species.

Reeds and sedges in estuaries normally indicate a fresh or brak (slightly saline) water environment. During droughts and times of high salinity they often die back, but recover after floods have flushed away the saline water. Reeds and sedge beds provide a source of energy and nutrients during the freshwater phase of some estuaries, because they substitute those plant species that flourish during saline conditions. They are also well known as subsistence products, providing materials for craftwork and construction, for example, for roofs.

Mangroves are trees and shrubs that grow in tidal and saline coastal areas. High tide causes their aerial roots and lower stems to be submerged, but they can be exposed for several hours at low tide. They are not tolerant of continuous flooding with either fresh or saline water that cover their roots because this restricts the exchange of gases, especially oxygen. Small organisms are known to colonise the stems and roots of mangroves. These small organisms, together with leaf litter, supply energy and nutrients for other species. The wood extracted from mangroves (see Figure 1.7) is durable and used in building huts.

Figure 1.7: Mangrove poles ready for use in construction

Source: Breen and McKenzie (2001:15)

1.2.5 Estuarine animals

South African estuaries boast a variety of animals, namely (Breen and McKenzie, 2001):

- Invertebrates
- Fishes
- Birds

Invertebrates are animals that do not have a backbone, for example, crabs and worms. Some of these invertebrates, for example, crown crab and sand shrimp, known as benethic species, live on the sediment while others, for example, bloodworm and sand prawn (see Figure 1.8), live in the sediment. There are also some invertebrates (the nektonic species) that can swim actively in the water column, for example, the swimming prawn. Benethic species release nutrients by burrowing and water pumping. These invertebrates are important processors of living and dead plant material, making energy and nutrients available to other species.

Figure 1.8: The mud prawn - a popular bait organism and food item for carnivorous fish

Source: Breen and McKenzie (2001:16)

Fish can be divided into five main categories depending on their origin, biological adaptation to estuarine conditions and their degree of dependence on estuaries for their survival. The main category is the marine species that breed at sea and whose juveniles show various degrees of dependence on estuaries as nursery areas. Some of these fish feed on plant material, such as the stumpnose (see Figure 1.9). Others, such as mullet, feed off fine living and dead material. Grunter and cob are carnivorous, feeding on other animal species.

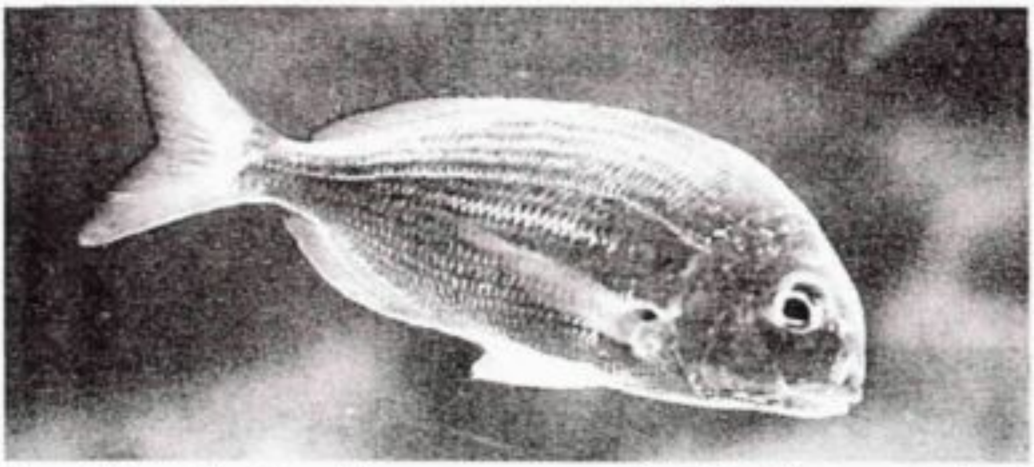

Figure 1.9: The Cape Stump nose - a species that relies on estuaries for the juvenile life stages

Source: Breen and McKenzie (2001:16)

A second category of fish comprises estuarine species that breed within estuaries and spend most of their lives within these systems. A third category of fish is the freshwater species. The extent to which they penetrate the estuary is determined by their salinity tolerance. The fourth species is comprised of marine species that stray into estuaries, but are not dependent on estuaries for their survival. The fifth group is comprised of anguillid eels that use estuaries as a conduit between the sea and river. These eels swim upstream during migration and return along the same path on their way to the marine environment, where spawning occurs.

Birds are attracted by the many different food resources and habitats provided in estuaries. Waders, waterfowl, kingfishers, cormorants, gulls, terns, egrets and herons inhabit many estuaries. Some birds feed on estuary vegetation, for example, the red knobbed coot. Others feed mainly on invertebrates; for example, the green shank, and still others feed mainly on fish, for example, the fish eagle and cormorant. The white-breasted cormorant and white pelican are shown in Figure 1.10 below.

Figure 1.10: White pelicans and white-breasted cormorants – fish eating birds that frequent many estuaries

Source: Breen and McKenzie (2001:16)

1.2.6 Other factors that affect the shaping of estuaries

1.2.6.1 Mouth closure and artificial breaching

When there is no or little fluvial action many South African estuaries close as a result of the formation of sand bars between rivers and the sea. When the freshwater input resumes, water dams up behind these sand bars. This damming of water often leads to the flooding of property along riverbanks. Artificial breaching of estuary mouths is sometimes used to remedy the situation of mouth closure, but this also can have serious negative long-term impacts upon the sediment dynamics and biota of an estuary (Allanson and Baird, 1999:297).

The sudden drop of water levels caused by artificial breaching leads to large losses in invertebrate biomass found in weed beds and large losses in avifauna, for example, redknobbed coots (*Fulicia cristata)* were lost during the artificial breaching of the Bot River mouth. During mouth closure many fish species are cut off and lost to estuaries as their reproductive cycles are destroyed due to the fish being either trapped out or in the estuary.

1.2.6.2 Sedimentation

Mouth closure may also result from sedimentation (see Figure 1.11). The results of large amounts of sediment collecting in estuaries are (Allanson and Baird, 1999):

- A shallower estuary basin and possibly reduced water surface area;
- A higher water temperature affecting the survival of certain plant and fish species; and
- A collection of sand and silt, making the estuary less appealing to recreational and commercial users.

Figure 1.11: The Thukela Estuary showing sediment deposition
Source: Breen and McKenzie (2001:22)

1.2.6.3 Pollution and encroachment

Some of South Africa's estuaries have had their estuarine functions severely undermined due to inflows of industrial, domestic and agricultural pollutants and encroachment on the banks by housing development (Allanson and Baird, 1999:300). This development is frequently undertaken with little sensitivity to its impact on the terrestrial biota (Allanson and Baird, 1999). In addition to the housing encroachment, the building of roads, railways, bridges (see Figure 1.12) and dams all too often cut off estuarine systems from the coastal zone and their feeder river systems.

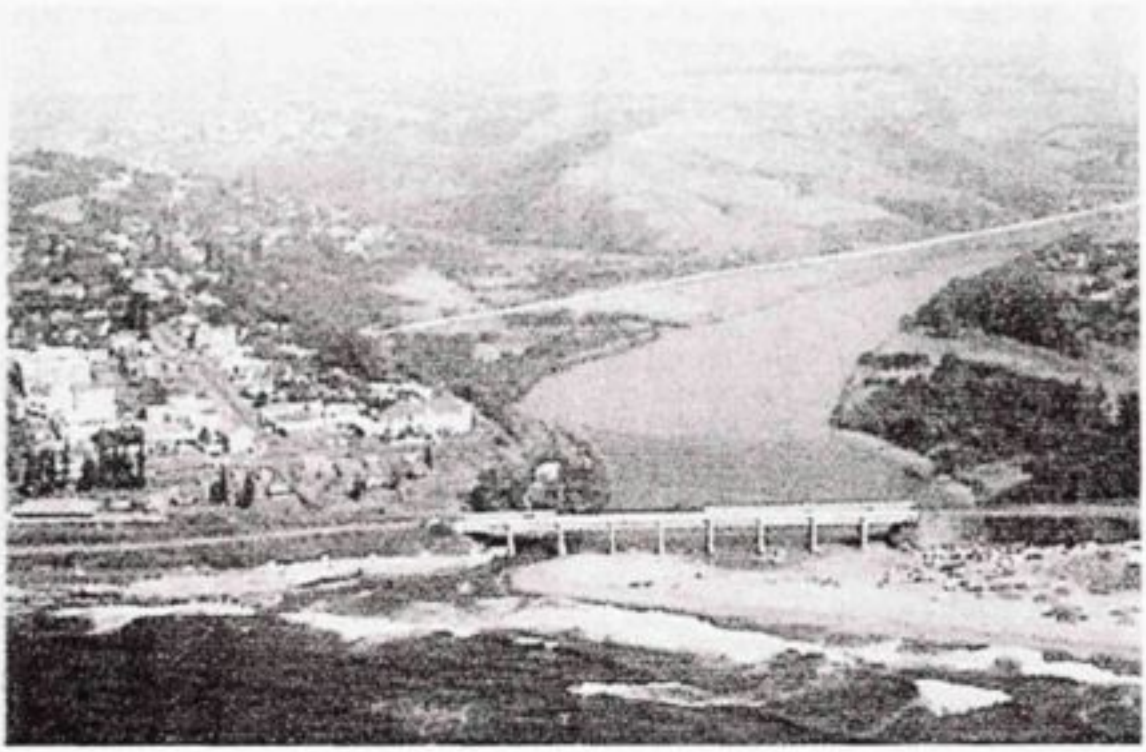

Figure 1.12: **A train bridge built across the mouth of the Mkomazi**
Source: Breen and McKenzie (2001:24)

1.3 The wetland conservation issue

1.3.1 Wetland loss/degradation becomes a problem

Estuaries are a type of wetland and the economic value of estuaries closely mirrors that of wetlands (Table 1.1). For this reason much of what has been written about wetlands also applies to estuaries. Wetlands[1] are permanently wet environments in close proximity to dry ones. Their key characteristic is the presence of water for a significant period of time. This presence shapes the soils, microorganisms, plant and animal communities in unique ways (Barbier *et al*, 1997:69).

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[1] The Ramsar Convention on Wetlands of International Importance is discussed further in Appendix A1.

Table 1.1: Total economic value of wetlands

Use values			Non-use values
Direct use value	**Indirect use value**	**Option and quasi-option value**	**Existence value**
• fish and bait • soil for agriculture • wood for fuel • recreation • transport • wildlife harvesting • peat/energy • water supply • views • environmental study areas • grazing • building sand • sediment (for beaches and sand banks)	• nutrient retention • regulatory tank storing floodwater • storm protection • groundwater recharge • external ecosystem support • micro-climatic stabilisation • shoreline stabilisation • improves water quality • break up harmful sediment/toxic substances • regulates air temperature • absorbs carbon dioxide • recycles nitrogen • development opportunities (transport services, marinas)	• potential future uses (as per direct and indirect uses) • future value of information	• biodiversity • culture, heritage • bequest values • spiritual value

Source: Barbier et al (1997)

Wetlands are dynamic systems, continually undergoing natural change (Bacon, 1999). Some wetlands are not permanent features of the landscape and are expected to change. Thousands of years ago wetlands played a crucial role in the creation of fossil fuels (Barbier *et al*, 1997:71). In more recent times, wetlands have become better known as sources of food, drinking water and mediums over which goods may be transported.

Wetlands are the planet's most productive ecosystems (Barbier *et al*, 1997:71). The components of the system are the biotic and non-biotic features, which include soil, water, plants and animals. The interactions between the components take the form of functions. These functions include nutrient cycling and the movement of water between the surface and the ground and the movement of water between the surface and the atmosphere. These functions give rise to specific attributes, like the provision of habitats for selected species.

Wetland uses yield both use values and non-use values (see Table 1.1). Use values may be direct, indirect or of the option type.

Direct uses of wetlands involve both commercial (fishing/baiting) and non-commercial activities (subsistence/recreation). Typically market prices serve as a reference for the value of commercial uses. Non-commercial uses are also important. They include satisfying subsistence needs of local populations in developing countries and use for sport and recreation (Barbier et al, 1997:82). The value of non-commercial direct uses is often difficult to determine because market price reference values are difficult to find. As a result these values are often ignored in the making of development decisions affecting wetlands.

Indirect use values of wetlands are derived from the services and goods generated that are not directly consumed, for example, recharging ground water supplies (Barbier et al, 1997:83). As is the case with non-commercial values, indirect values are often ignored in wetland management decisions.

Another type of use value is that of option value. It is the value a person potentially derives by the future availability of the good (Barbier et al, 1997:84). A quasi-option value is the expected value of the information derived from delaying exploitation and conversion of the wetland (Barbier et al, 1997:85). Individuals who currently do not use the wetland, but want to keep the right to use it at a specific future date, hold an "intrinsic value" or existence value for the wetland (Barbier et al, 1997:85). This intrinsic value is a form of non-use value. A similar type of value to existence value is bequest value. The latter is that value placed by people on the conservation of wetlands for future generations to use.

Of the values shown in Table 1.1 fishing has attracted the most attention (see Appendix 2). The value of estuarine fisheries is often used to estimate the economic value of estuaries (Lamberth and Turpie, 2003:5).

Due in part to a lack of understanding of the full value of the wetland type called estuaries; the management of South African estuaries has been inadequate (Lamberth and Turpie, 2003:1). In particular there has been a failure to recognise them as having a legitimate demand for freshwater inflow. As already mentioned estuaries have been subject to increasing pressures, especially as a result of reductions in river water inflow and increasing development along estuary banks. As a result many South African estuaries have become isolated from the sea through the formation of sand banks across the mouth.

1.3.2 Wetland deprivation and the hydrological cycle

Earth's renewable supply of water is governed by the hydrological cycle, a system of continuous water circulation (see Figure 1.13). Estuaries are part of the hydrological cycle. Various points in the water cycle have been under severe demand pressure for many years leading to water scarcities and degradation of the environment. The problem of water scarcity is a worldwide one but is particularly acute in Africa, especially North and South (Reid, 1998:

71). The water scarcity problem is a worldwide phenomenon, but Africa, North America, the Middle East, Latin America and South Asia are especially susceptible to water scarcity.

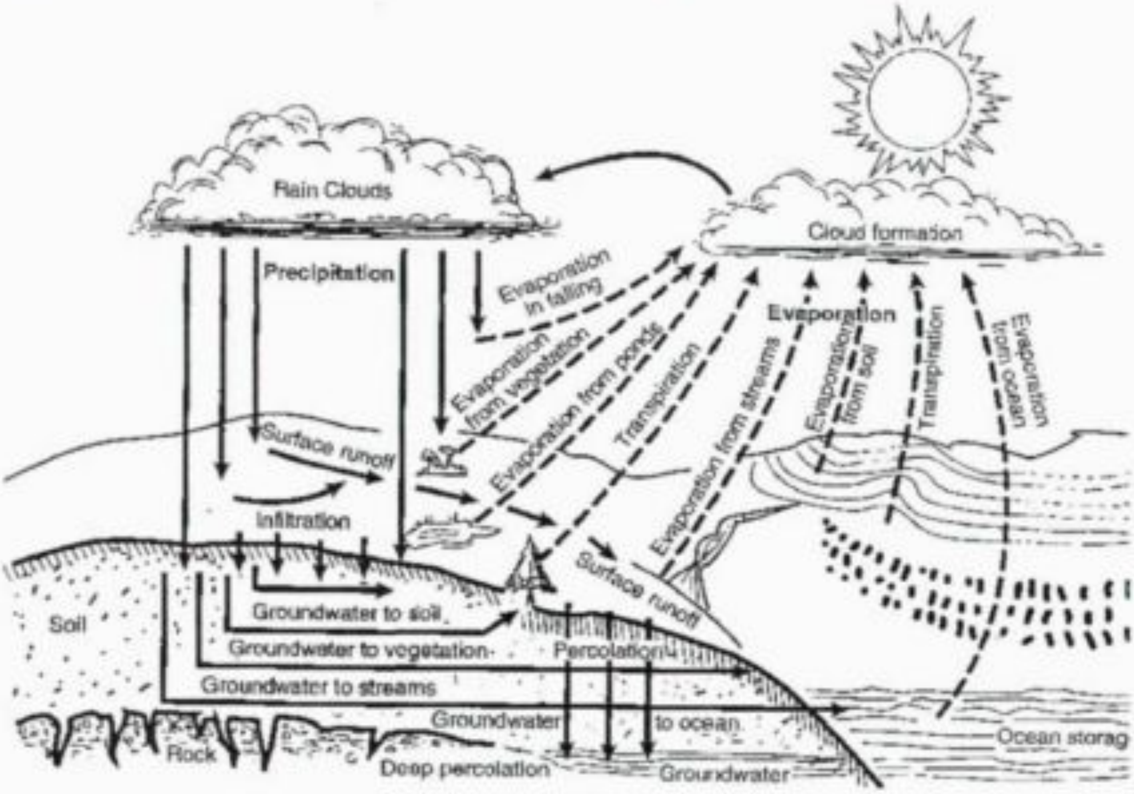

Figure 1.13: The hydrological cycle
Source: Tietenberg (2000:209)

In the different parts of the world freshwater deprivation differs according to estuary type and locality. Estuaries located in regions of low rainfall and high evaporation rates are more adversely affected by excessive freshwater abstraction from rivers than similar systems in higher rainfall areas. Estuarine processes rely on the functional link with the marine environment and are only preserved if there exists a strong enough freshwater inflow into the estuary (Wooldridge, 2002). Limiting the flow reduces tidal action, thereby affecting estuarine characteristics. This change to tidal ebb and flow can lead to the following:

- Decreasing salinity values that become lethal to trapped biota.
- Salinity values may decline to below threshold levels necessary for reproduction and larval survival of estuarine organisms.
- Changes in the vertical structure of the water column.
- Changes in water temperature, especially in shallow marginal areas. Limited flushing of these areas during summer could lead to elevated water temperatures that would be lethal for some species of fish.
- Changes in water quality and turbidity.

- Changes in estuarine sediment characteristics.
- Changes in inter-tidal zonation patterns (salt water reaches higher up the river), particularly in salt marsh areas.
- A disruption of the lifecycle of marine species that depend on estuaries as nursery areas. Conversely, the same species become trapped in estuaries where they are unable to breed.
- A disruption in the lifecycle of estuarine species that have a marine phase of development. In extreme cases this may lead to the disappearance of selected estuarine populations.
- A disruption in the lifecycle of catadromous species.
- A disruption in the immigration and emigration of species moving between estuarine and marine environments.
- A restriction in inter-tidal area available to foraging birds (Wooldridge, 2002).

The effect of freshwater abstraction has different effects on different types of estuaries (Schalacher and Wooldridge, 1996; Whitfield and Wooldridge, 1994). These effects are summarised below.

- Permanently open estuaries will experience:
  (a) A decline in riverine nutrient inputs, for example, phytoplankton, needed by estuarine primary producers.
  (b) Elevated salinity levels leading to salt accumulation in inter-tidal marshes, ultimately causing the extinction of some local species.
  (c) A decline in fish recruitment to estuaries due to many larvae needing high riverine inputs.
  (d) An increase in the size of sand shoals, situated in the lower reaches.
  (e) A greater degree of mud compaction in the middle and upper reaches and a collection of sediment leading to flood threats.
  (f) A bigger flood requirement to remove built-up sediments.

- Temporarily open estuaries will suffer the same consequences as permanently open estuaries, but less freshwater inflow may also lead to:
  (a) Prolonged mouth closure and a shorter open phase, thereby inhibiting invertebrate and fish migrations between the estuary and the sea, for example, of the mud prawn.
  (b) Hyper saline conditions developing, which in turn result in the loss of major components of the food chain.

- Estuarine lakes have salinities that are extremely variable and depend on various factors. The most important of these factors is the balance between freshwater input, evaporation and water exchange across the mouth. Limited freshwater supply can lead to hypersaline conditions that adversely affect fauna and flora. Possible mouth closures in these systems lead to a decline in marine-dependent invertebrate and fish populations due to natural mortality and a breakdown in recruitment processes. Reduced nutrient inputs can lead to declines in primary production.

- A decreased inflow of freshwater into estuarine bays will result in an increase in salinities in the upper and middle reaches, but little change in the lower reaches due to strong tidal exchange patterns. The water temperature in the lower and middle reaches of the estuaries is mostly influenced by marine conditions and these extend further up the system if the freshwater inflow is reduced. Reduced inflows have a negative impact on oligohaline and migratory species that use the riverine portions of these systems, for example, freshwater prawns and freshwater mullet.

- Less freshwater inflow into river mouth systems leads to marine conditions extending higher up the estuary, provided the mouth remains open. In the event the river mouth closes, oligohaline conditions are likely to prevail behind the sand bar during the lagoonal phase. Freshwater biota normally dominates river mouths. Marine organisms are usually confined to the lower reaches of the estuary system, but they may extend upstream during periods of reduced freshwater input.

1.4 The conservation of estuaries in South Africa

1.4.1 South African and world concern over wetland loss

This chapter has already shown how the issue of wetland conservation is closely linked to the protection of freshwater resources and *vice-versa*. Wetland loss is the conversion of a wetland area to a non-wetland area as a result of human activity (Bacon, 1999). On the other hand, wetland degradation is the impairment of wetland functions as a result of human activity (Bacon, 1999). Wetland degradation often occurs without the loss of wetland area, but due to changes in the characteristics of the wetlands. It is difficult to reverse wetland loss. This reversal is done by wetland restoration (the reinstatement of some, or all, pre-existing functions to "lost" wetlands) or wetland creation (the introduction of some wetland functions to formerly non-wetland areas). South African estuaries investigated for this study (Chapter Six) predominantly suffer the consequences of wetland degradation, and if effective water management schemes are not introduced the services of estuaries, such as the Great Brak, could be lost to society.

The loss of wetland services is not only a South African problem (Moser, Prentice and Frazier, 1999). Appendix 3 discusses this problem in the context of Europe and the United

States of America (USA). Current European Union policy is that there should be no further wetland loss or degradation (Bacon, 1999).

In South Africa, the building of dams, reservoirs and canals has created new non-natural wetlands, but intensive agricultural, industrial or residential uses have led to the demise of more wetlands than have been gained. The productivity of wetlands is also being undermined by pollution, waste disposal, and mining and groundwater abstraction.

1.4.2 International and other obligations

The loss of wetlands in South Africa is contrary to commitments made by various governments of the country during the past 30 years, starting with those entered into in 1971 at the Ramsar Convention[2]. These commitments were reinforced at the 1992 United Nations Conference on Environment and Development ("the Rio Earth Summit"). At this conference it was resolved that participants should encourage their governments to conserve all biological resources and use these in a sustainable manner. The signing of this and the Ramsar Convention by various southern African governments demonstrated their commitment to the principle of sustainable utilisation of natural resources.

During the 8th meeting of the Conference of Contracting Parties to the Convention on Wetlands held in Spain between 18 and 26 November 2002, a strategic plan was adopted for application by the Convention during the period 2003-2008. It built upon the first Ramsar strategic plan, which covered the period 1997-2002 and is relevant to the current period.[3]

The second strategic plan of the Ramsar Convention adopted a broad approach to wetland conservation and their sustainable use. This second strategic plan adopted five general objectives to be implemented by all member countries. These were:

- The wise use of all wetlands. All contracting parties were to develop, adopt and use the necessary and appropriate instruments and measures to ensure the wise use of all wetlands. Members were called upon to apply national wetland policies and wetland

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[2] The Ramsar Convention was initiated in Iran in 1971 and was the first global intergovernmental treatise on the conservation and wise use of natural resources (Barbier *et al*, 1997:75). The Ramsar Convention has 136 contracting parties as per the list of "Contracting Parties to the Ramsar Convention on Wetlands" of 19 May 2003. South Africa itself was one of the founding members at the inception of the Ramsar Convention. The mission of the Ramsar Convention is the conservation and wise use of wetlands by national action and international co-operation as a means to achieving sustainable development throughout the world. The Ramsar Convention provides the structure needed for international co-operation and was started after worry in the 1960s about the severe decline in populations of waterfowl. In 1997, the Ramsar Convention created and implemented its Stategic Plan for the period 1997-2002, with broad objectives as to how the mission should be achieved. These objectives included avoiding harmful changes to wetland areas in countries party to the Convention.

[3] One of the main recommendations of the first strategic plan of the Ramsar Convention was that physical and social values for wetlands be generated. The task of the signatories to the Ramsar Convention is a challenging one. Wetlands have attracted development because they have many uses (Table 1.1). The "strategic plan" for 1997-2002 provided more details on this valuation – specific guidance was given on economic valuation techniques, and on the use of valuation studies in national wetland policies, regional plans, environmental impact assessments and river basin management (Barbier *et al*, 1997:89).

conservation considerations within national land-use planning, to develop integrated catchment management plans and, in particular, to adopt and apply guidelines for implementation of the wise use concept.[4]

- To select wetlands for inclusion in the "List of Wetlands of International Importance" and to maintain their ecological character. The goal was to develop and maintain an international network of wetlands, and by so doing conserve global biographical diversity, *inter alia*.
- To ensure the Convention has the required implementation mechanisms, resources and capacity to achieve its mission.
- To promote international cooperation between contracting parties about transfrontier wetlands, shared water systems, shared species, shared technical assistance and development aid for wetland projects.
- To progress towards the accession of all countries to the Convention.

1.4.3 South Africa's response to "Ramsar" – proposed guidelines

In line with commitments provided internationally South Africa has adopted new legislation and policy with respect to managing and regulating the freshwater requirements of estuaries in South Africa. In recent times, the most general policy statement relating to the coast was the Coastal Policy Green Paper of 1998 (see Section 1.4.4.1) and the most notable Act, the National Water Act of 1998 (see Section 1.4.4.2).

The commitment of the government of South Africa to the principles of the Ramsar Convention was underscored in February 1998 when it hosted the Southern African sub-regional Ramsar Meeting in Pretoria. The Department of Environmental Affairs and Tourism (DEAT) were entrusted with applying the Ramsar guidelines for managing wetlands.

One of the objectives agreed to at this meeting in Pretoria was to identify priority actions for strengthening the application of the Convention in Southern Africa, and in particular to ensure the conservation of South Africa's wetlands in such a way that the ecological and socio-economic functions, products and attributes of wetlands are maintained for present and future use (Cowan, Dini, van der Walt and Kyle, 1995:2). The goals, guiding principles and implementing themes derived at this meeting covered the following areas, inter alia:

- National policy on the conservation and sustainable use of South Africa's biological diversity;
- National water policy; and

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[4] The Wise Use Concept concerns the sustainable utilisation of wetlands for the benefit of mankind in a way compatible with the maintenance of the natural properties of the ecosystem. The Ramsar wise use concept applies to all wetlands and water resources in a contracting party's territory, not only to those sites designated as wetlands of international importance.

- Coastal zone management policy.

1.4.4 South African policies for wetland management

1.4.4.1 Coastal management policies

The DEAT released the Coastal Policy Green Paper in September 1998. It laid the foundations for the implementation of an integrated coastal management policy. Wetland management was not mentioned directly in the paper, but was covered by it. Specific mention was made to "maintain the diversity, health and productivity of coastal processes and ecosystems" and to "ensure the renewable resource user practices are in accord with the regenerative capacity of coastal ecosystems." Both of these objectives relate to the sustainable use of estuaries.

1.4.4.2 National Water Act of 1998

Also of great influence on the management of wetlands in South Africa has been the drafting of the National Water Act, published in South Africa's Government Gazette on 26 August 1998. The main object of the National Water Act (1998) was to provide for the management of the nation's water resources so as to enable the achievement of sustainable use of water for the benefit of all water users. One of its fundamental principles is:

The quantity, quality and reliability of water required to maintain the ecological functions on which humans depend shall be reserved so that the human use of water does not individually or cumulatively compromise the long-term sustainability of aquatic and associated ecosystems (Cowan *et al*, 1995:9).

Noteworthy aims of the National Water Act include the need to:

- Meet the basic human needs of present and future generations.
- Promote equitable access to water.
- Promote the efficient, sustainable and beneficial use of water in the public interest.
- Provide for growing demands for water use.
- Protect aquatic associated ecosystems and their biological diversity.
- Reduce and prevent pollution and degradation of water resources.
- Meet international obligations.
- Promote dam safety.
- Manage floods and droughts.

The National Water Act of 1998 provides for the progressive development of integrated catchment management strategies for specified catchments. One of the strategies provided for is the use of incentives or penalties to reduce pollution and prevent environmental degradation. In order to set these incentives and penalties, there is a need for knowledge of the monetary costs and benefits of alternate wetland scenarios.

1.5 Concluding comments on the need for valuation

Estuaries may be considered part of a nation's natural capital. They yield flows of current and future services that have value. The exploitation of this capital should be optimised and to do this their functioning must be understood. Of particular importance is that the contribution be understood of freshwater inflows into estuaries.

There are many dimensions that need to be considered in this connection; one of which is the economics underlying freshwater allocations. The relevance of economics is that any extra freshwater allocated to estuaries will have to come from somewhere else, and for this reason that there will be an opportunity cost. Efficient water reallocations require the extra benefits to exceed the extra opportunity costs. Chapter Two develops this theme and proposes a model by which these extra costs and benefits may be used to guide decisions on the inflow of freshwater into estuaries.

CHAPTER TWO: AN ECONOMIC MODEL FOR ALLOCATING FRESHWATER TO ESTUARIES

2.1 Introduction

The renewable natural resource, river water, has been subject to high demand, and to satisfy this demand, there have been high levels of abstraction in South Africa (see Chapter One). The users are many – households, industry, agriculture, forestry and others. Unfortunately, there have been some adverse consequences of this abstraction. Chapter One described some of these consequences; the most notable of which was estuary degradation.

Many of South Africa's estuaries are currently believed to be generating lower levels of services than they used to in the past due to substantially reduced inflow of river water, among other reasons. The service reductions take many forms, including losses in areas of estuary available for recreational boating and losses of habitat for species of fish, birds and vegetation.

As the degradation of estuaries worsens, pressure has mounted from both national and international sources, on South Africa's Department of Water Affairs and Forestry (DWAF) to re-examine the basis by which river water is allocated in South Africa, particularly with a view to incorporating conservation demand. As a consequence the National Water Act of 1998 requires catchment management authorities to be established; one of whose functions are to ensure that estuary demand for freshwater is explicitly taken into account in the management of catchments.

Similarly, there has been pressure on South Africa's Directorate of Marine and Coastal Management in the DEAT and local authorities to counter the consequences of the degradation of estuaries. One of the consequences has been the institution of requirements on local authorities to integrate into their development planning sensitivity to the ways estuaries work and the services and goods they deliver; the relevant legislation being the Municipal Systems Act No. 32 of 2000. However, for the most part these authorities lack the tools to guide them in formulating development plans that have impacts on the estuaries falling under their control. The issues relating to estuaries that they face are many, for example, what emissions they should allow into the estuary, what land uses they should permit on the banks, what resources (like fish, bait and mangrove trees) they should allow to be extracted from the estuary and what freshwater they should permit to be removed from the inflow into the estuary. This study offers advice on merely one of these issues, that relating to the freshwater inflow.

It is generally accepted that sound water resource management requires that the benefits and costs of different water allocations be compared and an optimum determined (Loomis, 1998). The same principle applies to the allocation of river water (or alternatively, freshwater) inflow into estuaries. This chapter defines the optimum inflow and describes the value information needed to identify it.

2.2 Defining optimum freshwater inflow

2.2.1 Optimising conditions

The optimum freshwater (river) inflow (Q^*) into a given estuary at any given time is defined at that level where the positive difference between the total value and the total 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.[5] Total value is what the public would be willing to pay to consume the services, and 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 marginal value, $\sum$ MVi.

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.

2.2.2 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 = Value per m^3 of a specified quantity of freshwater in the best alternative use to the estuary

P2 = Value per m^3 of a specified quantity of freshwater inflow into the estuary to users and non-users 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

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

= dTC/dQ

= P1.∆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. ∆Q

where i = 1........n people deriving utility from the freshwater inflow into the estuary.

MC = P1 if ∆Q = 1 and MV = P2 if ∆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 ....(2.1)

and

P1 = P2 ....(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) and dP1/dQ > 0 ....(2.3)

P2...= f(Q) and dP2/dQ < 0 ....(2.4)

The P1 and P2 functions would be expected to change over time and, for this reason, the optimising conditions (Equations 2.1 and 2.2) would be expected to yield different values at different moments in, or periods of, time. The researchers did not set out in this research to explore or speculate on the time path of optimums. Given the nature of P1 and P2 functions (Equations 2.3 and 2.4) it would be expected that at Q*:

TC < TV

The same condition for optimality (P1 =P2) may be derived within a welfare framework, but the derivation yields fresh insights – notably in connection with the welfare assumptions. If the same welfare weight is accorded to users of the estuary services as is accorded to the users of the services from upstream water abstracted, and if social welfare (W) is defined 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):

$$W = W(U_1(-Q)) + W(U_2(Q)) \qquad (2.5)$$

where utility is an increasing function in Q and welfare an increasing function in the respective utilities.

Welfare is maximised where the relevant partial welfare derivatives with respect to the respective utilities equate to zero.

From this welfare maximising condition, it may be deduced that for a given change in Q the change in welfare is zero where $U_1 = U_2$ (by the assumption of equal welfare weights). Assuming further that prices (revealed and stated) are linearly related to the utilities gained from the changes in Q:

$P1 = aU_1$ and

$P2 = aU_2$

where *a* is a constant,

it may also be deduced that the change in welfare would be reduced to zero if P1 = P2, that is that the equivalence of prices is a condition for a welfare optimising freshwater allocation into an estuary.

On the other hand, if estuary service users were accorded a higher welfare weight than upstream abstractions, then welfare optimisation would occur where P1 > P2. By similar reasoning, if estuary service users were accorded a lower welfare weight than upstream abstractors (say, to satisfy basic human rights), then welfare optimisation would occur where P1 < P2.

Given that neither freshwater abstractors nor estuary service users can be conclusively linked to specific income earning groups, there does not appear to be a basis for making general deductions on whether welfare is optimised where P1 < P2 or P1 > P2. However, in specific cases, it may well be that at the optimum P1 < P2, because the estuary services are predominantly used for recreation (as a luxury good), and that on average, these users fall into higher income groups than the groups abstracting freshwater do. The latter argument takes no account of the welfare of the recipients of the expenditures on recreational services or future generations, nor the fact that some freshwater use also fits into the luxury good category, for example, when it is used in swimming pools.

2.2.3 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 below.

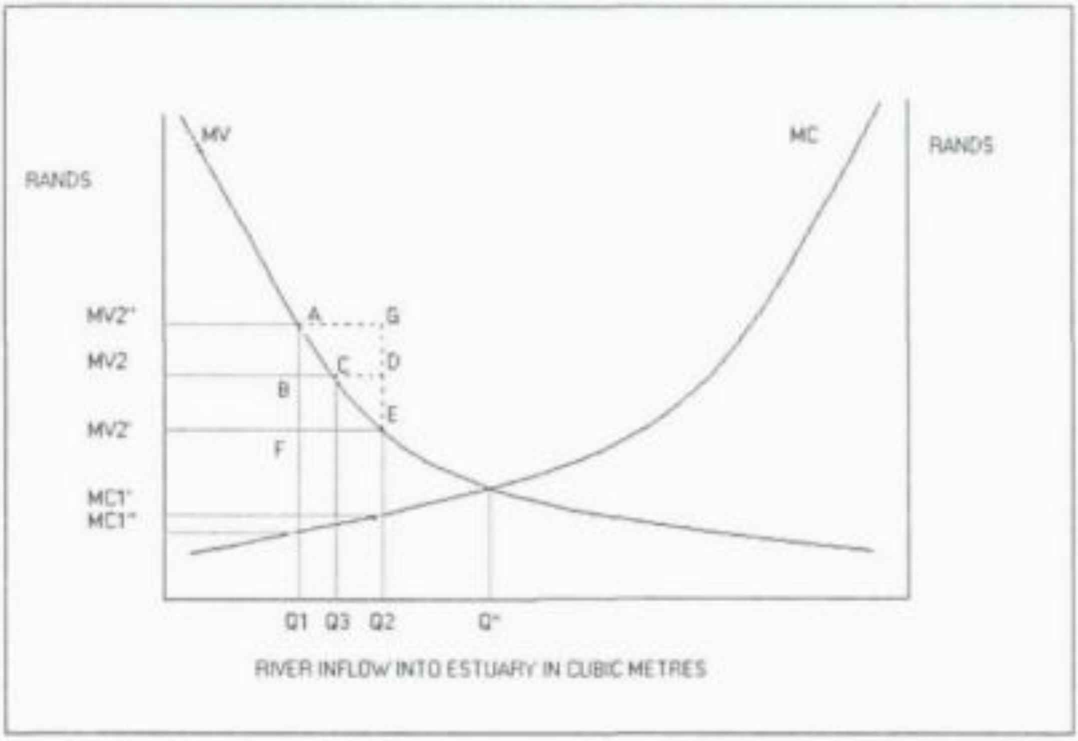

Figure 2.1: Expected Marginal Social Value and Marginal Social Cost functions

In Figure 2.1 the river inflow into the estuary is shown in m^3 on the X-axis and the marginal value and marginal cost of it in Rand is shown on the Y-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 defined. 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*, when P1 equals P2.

2.3 A theory on how to measure P2

Efficient allocation of river water in South Africa requires management to be informed on both P1 and P2. There have been numerous attempts to estimate P1 in South Africa – using marginal cost and willingness-to-pay (WTP) for agricultural land in South Africa (Hosking, du Preez, Campbell, Wooldridge and du Plessis, 2002). There has been less work done on estimating P2.

For this reason, at this point in time, the generation of estimators of P2 is a potentially useful exercise. In generating these estimates, the first question one is faced with is which MV2 should be targeted for the estimation of P2? The question is whether MV2" or MV2' or MV2 should be targeted (see Figure 2.1)? 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).

Unfortunately, however, 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 2.4) and the greater the change in Q being considered.

In principle there are several methods by which MV2 may be identified, for instance, hedonic price method, travel cost method and CVM. Of these the one most amenable to the required fine-tuning, and for this reason preferred in this study, is the latter. This method may be used to generate average WTP per annum for a specified ΔQ at a given estuary. The measure P2 is 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:

$$P2 = TWTP/\Delta Q \qquad (2.6)$$

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 2.1, depending on the direction of the specified change)

and

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

2.4 Additional insights to be gained in the valuation of estuary characteristics through the estimation of statistical TWTP functions

In addition to generating information useful to guiding the allocation of freshwater to estuaries, the CVs can also be used to shed further light on the special role played by estuary characteristics in explaining public WTP for estuary services – by examination of the coefficients in a total estuary WTP function (see Equation 2.7 below). In this function the specific contributions of estuary characteristics are captured in the coefficients of the variables E1, E2 and E3 in a statistical TWTP function, as described in Equation 2.7 below.

TWTP = f(D1; D2; D3; D4; D5; A1; A2; A3; A4; E1; E2; E3) ....(2.7)

Demographic explanatory variables

D1 = Population within a 10km radius of the mouth of the estuary (purchased data – Human Sciences Research Council (HSRC) GIS service)

D2 = Average education of population within a 10km radius of the mouth of the estuary (purchased data – HSRC GIS service)

D3 = Average income per capita of population within a 10km radius of the mouth of the estuary (or sample average stated income as an alternate) (purchased data – HSRC GIS service)

D4 = Estimated recreational visitor population per annum (survey team)

D5 = Other selected demographic statistics (survey team)

Access and other attractions of the area related to the estuary

A1 = Road access index based on distance of mouth in km from nearest national road, distance in km on gravel to mouth and quality of road (survey team)

A2 = Estuary access rating, based on number of points of entry and rating thereof (survey team)

A3 = Proximity by road of another estuary with similar attractions – the substitute good effect (survey team)

A4 = Subjective rating of estuary attraction appeal relative to total attraction appeal of area for recreation – the complementary good effect (survey team)

Estuary characteristics related to river inflow

E1 = Presence/absence of unique biotic and abiotic features or conservation status rating (Turpie *et al*, 2001)

E2 = Relative change in Q inflow, $\Delta Q/Q$ (DWAF and other sources for MAR)

E3 = Total area covered by estuary (survey team)

The advantage of this approach (the statistical estimation of Equation 2.7) over one typically followed in estimating the values of the estuary characteristics is that it takes better account of demographic factors and the effect of other resort attractions, and it values at the margin rather than the total. The approach that has been favoured by some in South Africa for valuing estuary characteristics is one where the services of estuaries are valued individually and then summed (Mander, 2000; Mander, Cox, Turpie and Breen, 2002).[6] One problem with it is that the individual valuations frequently appear to capture the influence of factors other than the estuary characteristics, for instance, other resort attractions are captured in the value of recreational fishing. Another problem with it is double counting values because estuary recreational services are composite goods. Double counting occurs when each component is valued at the composite value rather than at its component value (which may be extremely difficult to isolate).

2.5 Concluding remarks

That there are adverse consequences for estuaries of freshwater deprivation has been widely accepted in South Africa (Lamberth and Turpie, 2003:2; Whitfield and Wood, 2003). As could be expected the government has acted to address the problem in new legislation that creates catchment management authorities 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

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[6] The approach recognises that an estuary yields a flow of services and that this flow is seasonal. It further recognises that only some of the services are useable to humans. In order to determine the capital value of the estuary per annum estimates of the values of these services are projected into the future, discounted and then summed. In addition to services like flood damage minimisation, these services are seen as comprising roughly the following:

- habitat for fish harvested at the estuary – both recreational and survival
- habitat for invertebrates harvested at the estuary, for example, crabs and prawns
- habitat for plants harvested at the estuary, for example, reeds
- habitat for birds viewed at the estuary
- habitat for resources utilised elsewhere (conservation service)
- recreation area for boat sports – sailing, skiing, cannoeing and travel
- recreation area for sun bathing, swimming, snorkeling and beach games
- aesthetic attraction
  - visual
  - presence - sounds, smell and proximity (feeling of closeness)
- assimilator of waste, for example, nitrogen, nutrient filtering/retention and other solids

As trade in many of these services is limited, for example, to trades in fish, invertebrates and in aesthetic attractiveness (indirectly through property values), there is also great reliance in this approach on the use of non-market based valuation techniques, for example, travel cost valuations of estuary recreational fish yield per kilogram.

catchment management authorities 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 study 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 the freshwater reserve.

Chapter Two has explained how optimal allocations of freshwater inflow into South African estuaries may be identified, namely when the marginal social values of the inflow are brought into equivalence with the marginal social costs. It advocates that catchment management be guided towards optimal allocation of freshwater inflow into estuaries, by reference to current estimates of the relevant marginal social costs and marginal social values. It argues that the CVM may be usefully employed for this purpose, and that the estimates thus generated may make it possible to obtain additional insight into the value of the estuary characteristics.

The remainder of this study is devoted to the discussion and application of of how this method to generate the marginal values of freshwater inflow into South African estuaries.

CHAPTER THREE: A METHOD FOR ESTIMATING THE VALUE OF CHANGES IN FRESHWATER INFLOW INTO ESTUARIES

3.1 Introduction

This chapter outlines how the contingent valuation method (CVM) can be applied, common biases related to its results and tests that it should be subjected to. The CVM evolved as a method to value public goods and especially those yielding services to passive users (Carson, Flores and Mitchell, 1999: 100). Public goods are ones that may be used by one person without affecting the amount available for others or their cost of use. Environmental resources often have the characteristics of public goods. Markets for these goods rarely exist and as a result there their value is not revealed through them (Perman and McGilvray, 1996:251). A further complicating factor is that the demand for them incorporates passive user willingness to pay, that is a demand by people whose benefit cannot be observed.

It is on account of its capacity to cope with these complications that the CVM is an appropriate method by which to value the demand for freshwater input into estuaries. Estuaries are renewable resources. The flow of services they yield depends, *inter alia*, on the amount of freshwater flowing into them. The services rendered by them decline when this inflow drops below a threshold, in some cases precipitously. However, the value thereby lost is revealed in markets in very limited ways because consumption of these services is by open access. One way it is revealed is in the travel expenditures and user fees incurred by people to access the estuary services. The method that aims to measure value in terms of this impact is called the travel cost method. Another way is in the values of property with superior access to the estuary services. The method that aims to measure value in terms of this impact is called the hedonic pricing method (HPM). Neither method lends itself to the subject of this study, the valuation of changes to freshwater inflow into estuaries. It was against this background that it was decided to use the stated preference (SP) technique in this study, namely the CVM.

There are two alternative approaches to applying the CVM. One approach is to determine how much a person would be willing to pay for the public good (WTP) and the other is to determine how much a person would be willing to accept for the loss of the public good (willingness-to-accept compensation). The WTP approach is applicable where respondents do not have rights to the good in question and must buy it. The willingness-to-accept (WTA) approach is applicable where respondents hold property rights to the good in question and the right to change current conditions must be bought from them. In many cases either approach can be applied. In most cases researchers have found differences between WTP and WTA amounts for the same public good, with the WTA amount being higher (Breedlove, 1999:6).

WTA is likely to be especially high for those goods that do not have close substitutes, and/or where people have strong personal attachments to the goods (Breedlove, 1999:6). Other reasons for the difference between WTP and WTA are uncertainty and aversion to risk. Where possible, the WTP approach is favoured because it yields more conservative results, and given all the factors that can distort the responses elicited, being conservative is recommended (Breedlove, 1999:6).

When applying CVM respondents are asked: "what are you willing to pay?" or "are you willing to pay Rand X?" Scenarios are supposed to be sketched to these respondents that simulate markets (Wattage, 2001:5). These simulated markets take one of two forms: private goods markets or political goods markets. In the private market scenario, people are asked to choose price-quantity combinations. In the political market scenario, people are asked to vote (as if in a referendum) about payments of increased taxes. There are problems with both forms. In the private goods market form, a small number of individuals with high valuations can distort the outcome. In the political market form, intensity of preference is not reflected and a simple majority typically is used to determine the outcome. One advantage of the political market model is that it more closely resembles the way people do in fact make decisions about the environment.

The CVM has been contentious for many years (Hausman, 1981). The validity of the technique depends on there being a close correspondence between expressed answers given to hypothetical questions (willingness to pay) and voluntary exchanges in competitive markets that would be entered into if money did actually change hands. The fact that it has proved very difficult to establish this correspondence has led to CVM being subject to criticism (Azevedo, Herriges and Kling, 2003). It has also been argued that in many of the situations where the CVM is applied, a 'category' mistake is made of quantifying judgements as if they were preferences (Keat, 2002).

However, many aspects of the criticism of CVM have been addressed - in the form methods to reduce biases and the incorporation of tests for consistency, and as a result, acceptance of the technique has grown steadily during the last 25 years (Boyle and Bergstrom, 1999). There have been many significant methodological contributions (see Appendix 4) to the CV approach, and its history and development date back many decades. By the 1970's the CV method was being used extensively by economists to measure the benefits of a wide variety of goods, including recreation, hunting, water quality, risk of nuclear power plant accidents and toxic waste dumps (Wattage, 2001:8). In 1979, the Water Resources Council in the USA published a revised "Principles and Standards for Water and Related Land Resources Planning" in the Federal Register. This document created the rules for federal participation in project valuation. In that document the CVM was advocated for valuing public projects.

Following controversy in the application of CVM to value environmental damage, in 1990 the National Oceanic and Atmospheric Administration (NOAA) commissioned a panel of economic experts, co-chaired by Nobel laureate economists Kenneth Arrow and Robert Solow, to evaluate the use of CV in determining values for natural resource damage. The NOAA is a branch of the Department of Commerce in the USA. The findings and recommendations of this panel have been very influential. The main finding was that the CVM was a credible technique by which to quantify benefits if applied 'acceptably', that is, if the people applying the technique adhere to specified procedures and guidelines (Breedlove, 1999:4). Further discussion of the development of the CVM is provided in Appendix 4.

3.2 Applying CVM

3.2.1 Step 1: Establishing a credible/realistic market

3.2.1.1 Questionnaire design – purpose and attitude

The first step to applying the CVM is to design a questionnaire. The CVM questionnaire must be drawn up with reference to certain principles. The respondents must understand the context in which the CV question is put. The implications of their response must be described in detail. The people being interviewed must be motivated to cooperate and be able to participate in an informed manner by well-trained interviewers. The context should be as realistic as possible in order to encourage realistic and truthful responses. The interviewers should explain who they are, for example, conducting a survey on behalf of an organisation, and should assure respondents that their answers will be confidential. The respondents' attitudes to general issues concerning the good in question should be determined and the interviewer should be as concise as possible in order to prevent "yea-saying" by respondents wishing to bring the interview to a quick conclusion. The questions should relate to scenarios that the respondents are able appreciate and in which they have an interest.

3.2.1.2 The valuation scenario

The valuation scenario defines the good in question and the nature of the change in the provision of that good (Arrow, Solow, Portney, Learner, Radner and Schuman, 1993:2). This scenario is what the respondents will value. It should correspond with a potential future event and not one that has already occurred (Breedlove, 1994:4). Care must be taken not to overload respondents with information (information effect) so that they become confused about what they are being asked to value. Poorly defined scenarios will elicit confused answers. The respondent must also have belief that what they say will influence the decision. Ideally the institution conducting the survey should have the capacity to influence decision-making about the particular good. This capacity contributes to the credibility of the questionnaire. Care needs to be taken in designing questions that reduce errors in response induced by the hypothetical nature of the exercise. For instance, the WTP question should be phrased in such a way that the respondent takes proper cognisance of his or her budget constraint. Pilot studies should be undertaken to fine-tune the questionnaire.

3.2.1.3 The payment vehicle

The payment vehicle describes the way in which the respondent is (hypothetically) expected to pay for the good (Arrow *et al*, 1999:3). An appropriate payment vehicle is credible, realistic, relevant and acceptable. Payments could be of a coercive nature, such as a national tax, local tax or compulsory user fee, or in the form of a price increase or a voluntary donation. Respondents are often hostile towards taxes, but this method of payment is also often the most realistic. A payment vehicle modelled around voluntary contributions may induce free-riding behaviour and lower bids than would otherwise be made. In order to minimise non-responses it is advisable to test the target population's attitude towards payment vehicles with a focus group before administering the questionnaire.

3.2.1.4 Respondent characteristics and questionnaire design

Determining respondent characteristics is an important part of CV questionnaire design. One expects that there be relationships between stated values and the characteristics of the respondent (Bateman, 2002:85). The following are likely to be important:

- Use made of the good. The relationship between the use of the good and stated values is expected to be positive.
- Attitudes towards the good. There are strong associations between stated values and reported attitudes.
- Attitudes towards the whole scenario. Attitudes regarding the equity, fairness, justice and trust dimensions of the valuation scenario will impact upon stated values.
- Distance. Proximity would be expected to influence stated WTP. A respondents' WTP would be expected to decrease with increased distance from an environmental good and increase with increased distance from an environmental "bad."
- Budgets. People with higher incomes would be expected to be willing to pay more (because they are able to).

Where these expectations are confirmed they lend credibility to the results of the survey.

3.2.2 Step 2: Administering the survey – methods and interviewer effects

There are many different ways of administering surveys, for example, by mail (suffers from high non-response), telephone (difficult to communicate effectively) or face-to-face. The approach selected can influence the quality of information acquired and have a major influence on the WTP/WTA results. Face-to-face surveys are the most expensive to conduct but they provide the most effective method of data collection.

The structure of the sample population also influences the survey method. When respondents live far away from each other, budget and time constraints may create the need for using telephonic interviews. Interviewers should be well informed and neutral and have their techniques critically analysed before administering the questionnaire.

3.2.2.1 Eliciting valuations

The CV method is one of simulating a market for a non-market good. The WTP question aims to elicit the maximum amount the good is worth to the respondent (Wattage, 2001:5). From this response it is possible to deduce the respondent's consumer surplus for the good being valued and a sample average respondent WTP for the good. Additional questions are asked of the respondents in order to statistically explain the WTP offered by respondents. Examples of elicitation questions and the pros and cons of the main formats are discussed in Appendix 5.

Whichever format is used, the respondents must be reminded to keep their budget constraints in mind. Respondents must be made aware of the need to make compensating adjustments in other types of expenditure in order to accommodate the additional outlay implied in their declared WTP answers. Respondents must also be made aware of possible substitutes existing for the good they are valuing. In order to understand the motives behind answers to WTP and WTA questions, it is also important to administer "follow-up" questions to the respondents on these motives.

3.2.2.2 Types of questions applied in CVM

There are many types of questions that can be used to elicit responses from respondents. Examples of these types are discussed below (and their merits are discussed in Appendix 5). The types of questions most frequently used are:

- Open-ended elicitation
- Closed-ended (single-bounded) dichotomous choice (DC)
- Double-bounded DC

- Modified DC
- Bidding game elicitation
- Payment card elicitation

When an open-ended format is used the respondent is not given a price to accept or reject (see Appendix 5 for further discussion). Asking respondents to give a monetary valuation in response to an open-ended question presents them with an extremely difficult task (Arrow *et al*, 1993:49). A more manageable task is presenting respondents with a specific money value to accept or reject (a closed-ended format). However, the latter approach also has difficulties associated with it, for instance, the creation of anchoring bias (Wattage, 2001:6). This bias is discussed further in Section 3.2.5.

The closed-ended format is currently preferred in authoritative literature to the open-ended one because it simplifies the decision that the respondent needs to make and makes it correspond more closely in nature to the purchase decisions people actually have to make (Arrow *et al*, 1993:49). The type of question linked to the closed-ended format is called a dichotomous-choice question (Appendix 5). The respondent is presented with a value and given a "yes"/"no" answer to choose from as to whether or not they would pay the amount in question. The single question method is also known as a single-bounded DC (Arrow *et al*, 1993:50). A more sophisticated type of question is the double-bounded DC one, where the respondent, after saying yes or no to a stated sum, is then asked to say yes or no to higher or lower bids.

A further extension of the DC method is to continue with this iterative bidding process could be continued until a final price is reached – also called the bidding game method (Wattage, 2001:6). The bidding game process is identical to normal auctions and, therefore, familiar to respondents. This method is modelled on a real-life situation in which individuals reach agreement on prices for goods. This format is best adapted to personal interview surveys, but may be used in telephone surveys (Wattage, 2001:6). The interviewer will continually change the amount of money to be paid or received until the highest amount the respondent is WTP, or the lowest amount the respondent is WTA, is identified. Examples and arguments for and against single-bounded DC, and double-bounded DC are taken from Arrow *et al* (1993) and described in Appendix 5. One of the disadvantages of the closed-ended question format is that it creates a heavy demand for statistical technique (Hanemann and Kanninen, 1999:302)

Another popular way of presenting the willingness to pay question is by the payment card method (Mitchell and Carson, 1981 and 1984; Wattage, 2001:6). It retains the properties of a direct question approach while increasing the response rate to the WTP question by providing respondents with a visual aid. It specifies the increment or decrement in value for the non-market good to be provided in quantitative terms. The format of question presented is in one sense open-ended but in another it is closed-ended. It is more like the open-ended format in that the WTP response is elicited from a wide range of values (not a WTP a specific lower limit). The feature that it shares in common with the closed-ended format is that the WTP selected has a lower bound and an upper bound. Arguably the most important advantage of the payment card method (Appendix 5) is that it avoids the bias caused by starting point bidding at a specific point (Wattage, 2001:6). In terms of WTP outcomes the payment card method would seem most likely to generate similar results to the open-ended and bidding game question formats – probably significantly lower WTP outcomes (Bateman, Langford and Rasbash, 1999).

3.2.3 Step 3: Calculating the average bid – valid and invalid responses

Bids offered by respondents are collected using one of various question types (see Appendix 5). These bids must be aggregated and an average WTP/WTA bid per respondent determined. However, firstly valid responses must be distinguished from invalid ones, for example, so-called protest zeros. This distinction is made with the help of follow-up questions.

Some discrepancies (see Section 3.3.5 on biases) in the answers given by the respondents can sometimes be identified using follow-up questions. These questions are especially useful where there is some form of protest about WTP (or WTA compensation) for the good in question (Arrow *et al*, 1993). Protest bids are refusals to answer a valuation question, or zero bids when the WTP is actually greater than zero (protest zeros). A similar problem may occur with unrealistically high bids. Ways to minimise the number of protest bids include:

- Avoiding open-ended question formats, which tend to be associated with high levels of protest zeros.
- Asking why a zero WTP was offered. Zero responses may be genuine, but could reflect strategic behaviour of low WTP respondents. Scenarios may be poorly understood and this can be checked in the follow up questions.
- Comparing very high bids with the respondent's uncommitted income (WTP cannot exceed ability to pay).
- Sensitising interviewers to identify protest bids.
- Inferring the WTP of any respondent who does not answer the valuation question but answers other questions. Inferred values can be taken from the WTP statements of respondents who have similar characteristics (income, etc.) to those who protest.
- Deleting non-respondents and adjusting the sample to reflect any change in representativeness (Bateman *et al*, 2002:82).

The various types of follow-up questions that can be used to determine reasons behind protest bids are shown in Appendix 6. In addition to helping to clarify motives for answers, follow-up questions can also be used to test the credibility of the scenario. Such questions may ask about the respondents' interest in the good in question, about the need for public consultation, and about the perceived credibility of the institution hypothetically charged with providing the good.

3.2.4 Step 4: Estimating a bid function

Information collected using questionnaires will allow for the estimation of bid functions. These bid functions are estimated by relating WTP to various characteristics of respondents. The main purpose of estimating bid functions is to check if responses statistically correspond with what would be expected.

3.2.5 Step 5: Aggregating data and identifying biases

There are many factors that may induce biases.

3.2.5.1 Incentives to misrepresent responses

Compliant and strategic behaviour may lead respondents to inaccurately represent their preferences (Breedlove, 1999:9). The problem is called compliance bias – the respondents give answers that they feel the interviewer wants. Using neutral parties for surveys helps to reduce such bias, but respondents may still seek to provide "right" answers (those that they think the interviewer would consider appropriate for them or morally correct).

Strategic bias arises when respondents intentionally misrepresent their preferences. They do this because they believe it will influence the amount of the good provided, the amount or system for collecting money to provide it, or in damage appraisals, the compensation (Breedlove, 1999:11). Table 3.1 describes types of strategic behaviour.

Table 3.1: Strategic behaviour in valuing public goods

	Obligation to pay perceived as the amount offered	**Obligation to pay perceived as being uncertain**	**Obligation to pay perceived as being fixed**
Provision of good perceived as contingent on revealed preference	**True preference**	**Variable (true value might be overstated or understated)**	**Over pledge (overstates true value)**
Provision of good perceived as likely, regardless of revealed preference	**Free ride (understates true value)**	**Free ride (understates true value)**	**Non-strategic minimum effort (answers that minimise time/effort)**

Source: Breedlove (1999:11)

In Table 3.1 predictions are made about how individuals would act under different payment and provision situations. CVs are meant to reveal true values (Breedlove, 1999:11) and these values are most likely to be revealed when both the fees charged and the amount provided would be based on the response that is on the stated WTP. On the other hand, where respondents feel they will have to pay a fixed amount and the good will be provided regardless of what they say, free-riding thinking is likely to occur. In this case overbidding is probable because respondents believe that the good is more likely to be provided with higher bids, but the bidders still anticipate paying a fixed amount, regardless of their bids.

Most CVs fall into the variable category because the payment amount is normally uncertain and provision is usually believed to depend in some way on stated amounts. In this situation, free riding thinking and overpledging are both possible results.

Factors that may lessen strategic behaviour include altruistic motives, personal honesty and integrity, considering financial implications when offering a bid, and the possibility that the good may not be provided at all. Strategic behaviour can bias the valuation and steps should be taken by the interviewers to minimise it.

3.2.5.2 Implied value cues

Implied value cues occur when respondents decide on a valuation based on a "clue" as to what they believe the right answer should be (Breedlove, 1999:10). For instance, a starting point bias can result when the respondents feel that the starting bid is intended to approximate the correct value. A problem related to this is "yea-saying", which can occur when respondents simply accept a bid, even if it does not match their true valuation. The payment card approach was developed to correct the starting point bias of bidding games. Where respondents wish to choose a valuation of higher or lower than the amounts listed, there is range bias. Payment cards try to eliminate such problems, by having a wide range of options.

Where respondents focus on benchmarks (relate the goods to other similar goods) and value in terms of these, a relation bias may occur. If several items are being listed, items listed first are sometimes believed to be "more valuable" than items listed later. This belief causes position bias. The later a good appears in a sequence, the lower WTP tends to be for that good. Altering the order in different interviews can overcome this bias, but it increases the number of interviews needed.

3.2.5.3 Scenario misspecification

A third bias type is scenario misspecification or information bias (Wattage, 2001:16). This form of bias arises when the scenario is incorrectly specified according to theoretical or policy information (theoretical bias) or when the respondent incorrectly interprets the scenario (methodological bias). Theoretical misspecification can be minimised with sufficient research and interviewer training before the survey takes place. It is important for the interviewer to provide as much information about the good as possible in order to prevent misunderstandings by the respondents. On the other hand, too much information can also be negative, with information overload taking place. As a result respondents may ignore important information. A correct balance must be struck.

Some important ways that methodological biases can occur are:

- Respondents value the symbolic nature of the good, rather than the amount (resulting in the same WTP for different levels of the good).
- Respondents may include items in their thinking other than the quantity of the good in question.
- Respondents may use a different measurement scale to the researcher.
- A respondent may be sceptical that the good will be provided and that the study will achieve any of the desired goals.
- A respondent may become tired or bored and a bias occurs due to the respondent complying with expected answers to complete the interview as soon as possible.
- Respondents value the good differently according to who is funding it or who provides it.
- Respondents do not keep their budget constraint in mind.
- Respondents use other questions or information in the interview to come to their decisions.
- Respondents do not treat other unrelated valuations as independent.

In order to limit theoretical and methodological biases there is a need to devise as realistic a scenario as possible.

3.2.5.4 Payment vehicle biases

Differences in WTP based on methods of payment are known as vehicle biases (Wattage, 2001:15). Typical payment vehicles used are utility bills, entrance fees, taxes, user fees and higher prices. Pilot surveys can be used to determine vehicle bias potential and public payment preference before the final study is undertaken.

3.2.5.5 Sample design and inference biases

When sample design and benefit aggregation are not performed properly this also causes biases. The sample used for the CV survey must represent the target population, but to determine this is difficult when the people who pay for the good differ from those who receive the most benefit from the use of the good. It is always important to have as large a sample as possible. If different groups making up the population are improperly represented sample selection bias will result.

Including non-responses can also lead to biased results. Non-responses to questions include: don't know, refusal to respond, protest zeros, obviously wrong answers and responses that are inconsistent with others in the questionnaire. Follow-up questions (described earlier in this chapter) can be used to differentiate between protest zeros (where respondents do not agree with the survey procedure) and actual zeros (where respondents would actually pay nothing for the good). This distinction will determine whether a bid is valid or invalid. Bids that are way out of line with the rest (outliers) need to be reviewed and reasons for this identified. Invalid responses should be excluded.

Inference biases occur when one particular CV study is used to estimate the value of different goods (Breedlove, 1999:12). Each study is unique to a specific good or service.

Temporal selection bias occurs when information from one study is used for a different time period (Breedlove, 1999:13). Public "tastes" for goods/services change over time. The information acquired using CV studies is most applicable as close to the time of administering the questionnaires as possible. However, the problem of time lag is often not a serious one because evidence from public opinion polls and CV studies has shown that valuation results tend to stay fairly stable over time (Breedlove, 1999:12).

Sequence aggregation bias takes place when data from independent studies are aggregated over additional locations or goods (Breedlove, 1999:14). If several estuaries are to be valued for their usage purposes, each should be valued independently (Breedlove, 1999:14).

All the biases described above affect both the reliability and validity of a CV, but they can be reduced if mitigating actions are taken when administering the survey. However, it is inevitable that biases will still remain and for this reason it is important to subject WTP estimation procedure to as much reliability and validity testing as possible.

3.2.6 Step 6: Assessments for reliability and validity

The objective of a stated preference (SP) survey is to determine a respondent's WTP or WTA for the change in provision of a good (Bateman *et al*, 2002:78). The criteria upon which the success of a survey is assessed are reliability and validity. Reliability refers to the degree of replicability of a measurement or low variation between results of different samples of the same population (Bateman *et al*, 2002:78). Tests of reliability aim to show if the survey can be relied upon to provide the same values if the survey were administered repeatedly under similar conditions.

One test for reliability is the variation of responses. Valuations with a relatively low variation among responses are considered more reliable estimates of value than those with a high variation (Breedlove, 1999:8). Variability of response may be caused by various biases, but also may be perfectly normal – individuals behave differently in different settings and have unique characteristics that affect their responses. Respondents may interpret the questionnaire differently, may be motivated by different aspects of the scenario when making decisions and use different cost-minimising procedures or rules-of-thumb to make decisions when they know little about the good in question (Acks, 1995:7).

Validity, on the other hand, measures the degree to which a study succeeds in measuring the intended values (Bateman *et al*, 2002:79). Given the hypothetical way the WTP amounts are derived, validity tests are highly recommended. The main difficulty in testing for the validity of WTP/WTA values is to find yardsticks against which to compare the survey results. There are three types of validity tests; content validity, construct validity and expectations-based validity tests (Bateman *et al*, 2002:79).

3.2.6.1 Content validity

If a survey has a high content validity, the questionnaires' descriptions and questions are clear, reasonable and unbiased (Bateman *et al*, 2002:80). In this case respondents would be encouraged to answer seriously, thoughtfully and truthfully. The determination of content validity is a subjective expert appraisal task. Content validity judgments are applicable to the whole study process, from the aims of the research to the clarity, interpretation and plausibility of the questions and how the interviewer carried out the survey. Specific questions must be asked in assessing whether a CV survey has content validity (see Appendix 7).

Designers of CV questionnaires should be aware that the following factors characterise SP studies with a low content validity:

- Inadequate sample size or poor coverage of the relevant population.

- Non-stratified or biased sampling methods (where the representativeness of the sample is an issue).
- High survey or individual question (or item) non-response rates.
- Large numbers of "protest" bids.
- Prevalence of free-riding behaviour.
- High numbers of improbably large bids.
- Inadequate responsiveness to the scope of the good in question, that is, WTP does not vary with quantity of the good.
- The valuation scenario and corresponding valuation task are poorly understood and/or have low credibility.
- The description of the change in the provision of the good is poorly understood and/or has low credibility.
- The relevant authorities are not trusted or considered to be of low competence or efficiency.
- Low explanatory power of responses in terms of theoretical or other expectations.
- Survey or post-survey respondents provide answers that indicate that strategic behaviour may have affected responses, causing respondents to under or overstate their WTP.

3.2.6.2 Convergent/construct validity

Convergent validity, also called construct validity, compares different valuation techniques for consistency (Breedlove, 1999:10). Convergent validity typically compares results obtained from the CV study with:

- Results from revealed preference valuation methods, for example, travel cost,[7] hedonic pricing.[8]
- Results from other SP studies, like choice modelling.[9]
- Results from the analysis of actual or surrogate (proxy) markets.

There are a number of difficulties encountered in determining convergent validity. Neither the value derived from the CV study nor the value against which it is being compared can

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7 The travel cost method is used to estimate economic use values associated with ecosystems or sites that are used for recreation (Feather *et al*, 1997:44). The basic premise of the travel cost method is that time and travel cost expenses that people incur to visit a site represent the "price" of access to the site. In this way peoples' WTP demand to visit the site can be estimated based on the number of trips they make at different travel costs (Feather *et al*, 1997:44).

8 Hedonic pricing, on the other hand, is a method that relates the price of a composite good to its components, or services it provides. For example, the price of a car reflects the characteristics of that car – comfort, style, luxury, fuel economy, etc. The individual characteristics of a car may be valued by the coefficients of these characteristics in a multiple regression model related to the price of the car or partial derivatives of the hedonic pricing function.

9 A statistical approach starts by developing a theoretical model, with given assumptions about expectations and hence a statistical model that can be estimated. Modern simulation technology is used to evaluate specific choice probability expressions and form the appropriate likelihood of behavioural expectations.

automatically claim superiority in terms of being a naturally closer approximation of the "true" value (Bateman *et al*, 2002:82).

3.2.6.3 Expectations-based validity

WTP/WTA values produced by a SP study may also be tested for expectations-based validity. One would expect WTP to be statistically related to other variables reported by the respondents in a theoretically plausible way. If it is not related in this way this casts doubt on the plausibility of the WTP measure (Bateman *et al*, 2002:82).

Expectations-based validity testing is the comparison of what would be expected with what is found with respect to a statistical fit relating WTP or WTA responses to various covariates collected in the survey (the bid function). The Ordinary Least Square (OLS), Tobit, Logit and Probit statistical models[10] can be used to determine variations of WTP for different studies, and between expected and actual values. To show expectations-based validity, coefficients should have the right signs and be significant. If the parameters are found either to be insignificant or to affect stated values in unpredicted ways, the validity of the results is thrown into question and explanations for these findings should be sought. Another test for validity is comparing for consistency WTP estimates generated from different question formats. This type of test, for instance, could compare WTP responses acquired using close-ended questions with those responses acquired using open-ended questions or respondents' WTP for a small amount of the good with respondents' WTP for a large amount of the good.

Expectation-based testing is the major form of validity testing conducted in CV studies. It is therefore very important to use data analysis techniques that are of high quality and appropriate to the study conducted. Expectations that should be considered include (Bateman *et al*, 2002:83):

- Price of the good. Following a central theme of economic theory, it would be expected that as the price of the good increases, other things being equal, consumption of that good would fall.
- Respondent income. An expectation is that WTP increases as income does.
- Quantity of the good. It would be expected that respondents' WTP is related to the quantity of the good available – that WTP for extra units of the good would decrease as the quantity supplied increases. CV surveys often include tests to see if this expectation holds and the results of these tests may show:

[10] OLS statistical models can be used to estimate the relationship between dependent and independent variables (Mendenhall and Sincich, 1996:102). Tobit models are used to determine similar relationships between variables. Logit and Probit models test the statistical relationship between two or more categorical values as is determined by the application of dichotomous type questions in CVM valuations.

- Scope insensitivity,[11] which occurs when WTP does not vary with the quantity of the good offered.
- Embedding (also known as nesting), which occurs when the WTP elicited is not for a specific good but includes other goods.

3.3 Concluding comments

The CVM has become widely accepted in economics. More and more experience in applying the method is helping to reduce biases. However, even when great care is taken to apply it appropriately, controversy over its results will remain, because it is a complicated and imperfect method, and the difficulties difficult to overcome.

Each survey has its own unique problems that must be overcome if the CV is to enjoy credibility. In order to address such problems various authorities have drawn up guidelines they recommend be followed in applying the CVM. One such set of guidelines are those drawn up by the Blue-Ribbon panel (see Appendix 8). These guidelines are not a substitute for analysis based on fundamental principles, but they do draw attention to the many issues that need to be taken into account in applying the CVM. They are very demanding guidelines to meet and most CVM studies undertaken have not fully complied (Bateman and Wallis, 1999:4). One of the main constraints is the funding available for conducting the valuation. Often less than sufficient funding is provided and shortcuts are necessary. In these cases it is inevitable that biases will occur (Whitehead, Haab and Huang, 1998).

Notwithstanding the complexities of applying CVM there has been considerable progress made in developing the technique, so much so that its use has been recommended by Congress in the USA and by governments in many other countries as well (Breedlove, 1999:16).

The question method utilized in this study was the payment card one. This choice was made in order to reduce the starting point bias problem and because it was felt that a conservative approach was recommended and would be more readily accepted by policy makers (Bateman, Langford and Rasbash, 1999; Amigues, Boulatoff, Desaigues, Gauthier and Kieth, 2002). The payment vehicle selected was user fee payments to a regulating local authority. This method of collecting payments most closely approximated that already employed at estuaries. The responses were elicited through personal interviews – there being no other alternative feasible given the substantial information exchange required in the elicitation

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[11] This scope insensitivity/embedding may be the result of:

- Satiation. This occurs when the WTP for a good stays the same for increasing amounts of a good, that is the incremental WTP is zero when the respondent is satiated in a particular good on offer. The insensitivity is therefore quite rational.
- Warm glow. It also could occur that respondents get a moral satisfaction from the act of paying for the good and this may not vary with the amount of the good on offer.

process. The primary test for validity provided for in the questionnaire was a comparison of bid function coefficients against what would be normally expected. Adherence to the 'blue-ribbon' guidelines was not financially feasible for this project with respect to sample size (see for more discussion Chapter Five).

Chapter Four describes the application of the method as a pilot study.

CHAPTER FOUR: A PILOT STUDY OF THE KEURBOOMS/BITOU ESTUARY

4.1 Introduction

Chapter Four reviews the valuation of freshwater inflow into the Keurbooms/Bitou Estuary by means of the CVM. The CVM estimates generated are compared to estimates generated using a hedonic pricing model (HPM) valuation in order to test for convergence between the CVM estimates and HPM estimates.

The CV study of du Preez (2002) on the Keurbooms Estuary serves as the basis for the review. Du Preez's (2002) OLS models are considered as well as other preferable models – the Tobit, Logit and Probit models. In all of these models the aim is to explain the individual's WTP[12] for freshwater inflow into the estuary and improvements of estuary ecology.

A total of 150 respondents were interviewed in the year 2000, representing about 5,6% of the target population. The sample frame was an estimated 13 250 people, or 2 650 five-person households. A stratified sampling technique was adopted, with five strata, specified according to groups of users, that is, anglers, boaters, swimmers/bathers, water frontage owners and others.

Nine variables were identified as likely to influence the WTP amounts. These were annual levies, gender of the respondent, distance from the estuary, freshwater worth, worth of owned fixed property, worth of owned vehicles and boats, education level of respondent, knowledge on estuary ecology and gross annual income of respondent. Descriptions of the selected variables are shown in Tables 4.1 and 4.2. All the explanatory variables were recorded and processed in quantitative, ordinal and nominal scales for multiple regression analysis.

Table 4.1: Description of dependent variables in the multiple regression analysis

Dependent variables	Description
WTP_Q	Amount household would pay for increased freshwater inflow: the amount was the mid-point value of each interval from WTP question (for OLS and Tobit models)
WTP_C	"Yes" or "no" responses taken from the WTP question: 1 = respondent is willing to pay 0 = respondent is not willing to pay (for Logit and Probit models)

Source: du Preez (2002:149-154)

12 The values generated by du Preez (2002) relate to 2000 price level.

Table 4.2 Description of independent variables in the multiple regression analysis

Independent variables	Description	Expected sign in regression model
Annual levies	1 = if the respondent has paid levies, I, per annum, I ≤ R50 2 = if the respondent has paid levies, I, per annum, R50 ≤ I ≤ R200 3 = if the respondent has paid levies, I, per annum, I > R200	+
Gender	1 = if gender of respondent is male 2 = if gender of respondent is female	+
Distance	1 = if residence distance, d, away from the estuary d ≤ 1km 2 = if residence distance, d, away from the estuary 1km < d ≤ 5km 3 = if residence distance, d, away from the estuary 5km < d ≤ 15km 4 = if residence distance, d, away from the estuary d > 15km	-
Water worth	1 = if freshwater currently flowing worth more for consumption or worth the same after water reallocation 2 = if worth more for flowing into estuary after water reallocation	+
Education	1 = if the respondent attained matric qualification or less 2 = if the respondent attained diploma, degree qualification or greater	+
Knowledge	1 = if the respondent is well informed on ecology 2 = if the respondent is not well informed on ecology	-
Worth_prop	1 = if respondent has fixed property, f, owned, f ≤ R200 000 2 = if respondent has fixed property, f, owned, R200 000 < f ≤ R500 000 3 = if respondent has fixed property, f, owned, f >R500 000	+
Worth_v_b	1 = if respondent has vehicles/boats, v, owned, v ≤ R50 000 2 = if respondent has vehicles/boats, v, owned, R50 000 < v ≤ R100 000 3 = if respondent has vehicles/boats, v, owned, R100 000 < v ≤ R200 000 4 = if respondent has vehicles/boats, v, owned, v > R200 000	+
Income	1 = if gross annual pre-tax income, i, earned by respondent, i ≤ R120 000 2 = if gross annual pre-tax income, i, earned by respondent, R120 000 < i ≤ R250 000 3 = if gross annual pre-tax income, i, earned by respondent, i > R250 000	+

Source: du Preez (2002:149-154)

Table 4.3 summarises the OLS estimates of the du Preez (2002) study.

Table 4.3: Results of OLS reduced model of WTP function for Keurbooms Estuary

Model	Reduced model			
Method	Least squares			
	OLS			
Variable	Coefficient	Std. Error	z-Statistic	p-Value
Levies	82,204	20,967	2,970	0,000
Worth_V_B	107,02	20,710	25,170	0,000
R^2	0,321			
Adjusted R^2	0,304			
F-Statistic	23,043			

Notes: Rand values are at 2000 price levels

Source: du Preez (2002:155)

The significance of each variable can be tested through the null hypothesis that its coefficient is equal to zero. For simplicity's sake, the p-value is used to determine whether to reject or fail to reject the null hypothesis. The p-value shows the lowest significance level at which a null hypothesis can be rejected (Gujarati, 2003:136). For the purpose of this study a significance level of α=10% or less (0,10) of each variable indicates that the variable is weakly significant. A significance level of α=5% or less (0,05) indicates that the variable is significant. A significance level of α=1% or less (0,01) indicates that the variable is highly significant (Mendenhall and Sincich, 1996).

In terms of the p-values shown in Table 4.3, the null hypothesis is rejected at the 1% significance level (α=0,01) and it is deduced that the respondent's levy payment and worth of vehicles/boats owned are highly significant in explaining an individual's WTP amount.

The overall significance of the regression model with independent variables, levies and worth of vehicles/boats, was assessed using an *F* test. It was found that the F-statistic value was 23, which is greater than the critical value (at 5% significance level) of $F_{0{,}05;3;146}$=2,60. For this reason, the null hypothesis was rejected and it was concluded that the reduced OLS model was a reliable predictor of the individual's WTP amount.

The reduced OLS model's coefficients suggest that, for each category increase in the levy paid by the respondent, the mean WTP increases by R82,20. Similarly, for each category increase in the worth of vehicles/boats owned, the mean WTP increases by R107,02.

Despite the criticism of the OLS model, when applied to situations like this (Mendenhall and Sincich, 1996), it remains popular with researchers on account of its simplicity to fit and interpret. 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 positive. In addition, OLS models become awkward with respect to the zero WTP responses at the specification stage. Should these zero WTP responses be treated like other positive observations, or should they be left out altogether (Hill, Griffiths and Judge, 2001)? The OLS model has also been criticised for generating biased and inconsistent parameter estimates in WTP functions (Pindyck and Rubinfeld, 1998:325). This was evident in the du Preez (2002) study.

The predicted individual's minimum WTP amount was negative using the reduced OLS model (Table 4.4).

Table 4.4: Predicted individual WTP statistic using OLS

Variable	Mean value	Minimum value	Maximum value
WTP in Rand	275,00	-53,07	553,63

Notes: Rand values are at 2000 price levels

In cases like the one du Preez (2002) analysed, a censored dependent variable model is advocated in preference to the OLS model (Green, 2003). One such censored model, the

Tobit model, is often advocated in this case, because of its use of a restricted dependent variable.

4.2 Alternative models

4.2.1 A continuous dependent variable model

The Tobit model is more appropriate than the OLS model where the data include a substantial number of zero value responses (see, for example, Berndt, 1991, on the discussion of "whether and how much women work for pay" and Gujarati, 2003, on the discussion of "housing expenditures"). In this model the range of the dependent variable is censored (cut-off), that is, restricted at a selected particular value (Verbeek, 2000).

The restriction is to ensure non-negative values for WTP estimation. In applying the Tobit model, responses are divided into two groups – one consisting of all respondents who are willing to pay greater than R0, and another consisting of those who are unwilling to pay anything. The Tobit model will only predict values greater than or equal to zero – a necessary requirement for the WTP estimation.

In du Preez's (2002) Keurbooms sample, 23 people responded that they were unwilling to pay anything. The rest were willing to pay positive amounts, that is approximately 85% of the respondents were willing to pay positive amounts for the improvement of estuary service delivery.

Table 4.5 summarises the statistical analysis of du Preez's (2002) Keurbooms data in terms of complete and reduced Tobit models. The complete model includes all defined variables that would be expected to influence the WTP. The reduced model is a more parsimonious model that includes only explanatory variables that were found to be significant, or very close to it, in the complete model.

Table 4.5: Tobit models of WTP function for Keurbooms Estuary

Dependent Variable: WTP_Q								
Model	**Complete model**				**Reduced model**			
Method	**ML – Censored Normal Tobit**				**ML – Censored Normal Tobit**			
Variable	Coefficient	Std. Err.	z-Statistic	p-Value	Coefficient	Std. Err.	z-Statistic	p-Value
Constant	-372,944	204,497	-1,824	0,068	-302,059	166,802	-1,811	0,070
Distance	-8,920	25,454	-0,350	0,726				
Education	-10,117	43,863	-0,231	0,818				
Water_worth	208,746	56,701	3,682	0,000	212,681	54,731	3,886	0,000
Gender	27,168	51,542	0,527	0,598				
Income	73,745	46,572	1,583	0,113	84,173	41,522	2,027	0,043
Knowledge	-80,014	48,189	-1,660	0,097	-98,076	45,529	-2,154	0,031
Levies	33,245	28,755	1,156	0,248				
Worth_prop	1,194	42,307	0,028	0,978				
Worth_V_B	76,928	30,266	2,542	0,011	77,247	29,835	2,589	0,010
R^2	0,351				0,332			
Adjusted R^2	0,304				0,309			
Log likelihood	-889,852				-890,816			

The variables freshwater worth, knowledge, worth of vehicles/boats and income were significant, or very close to it, in the complete model.

Freshwater worth is highly significant in both the complete and reduced models (Table 4.5). This significance shows that freshwater worth is highly correlated with individual WTP. The signs of the partial coefficients in the reduced model are consistent with expectations (see Table 4.2).

A maximum likelihood estimation (MLE) procedure was used to estimate the coefficients in the Tobit model. The estimators ($\hat{\beta}_i$) generated in this way have a number of desirable distributional asymptotic properties (Green, 2003; Rencher, 2000). The estimators are normally distributed with an unbiased mean, have a constant variance and yield estimator matrices and variances that are independent of each other. They are asymptotically efficient and there are no other asymptotically unbiased estimators that have smaller variances than MLE estimators do. In addition, the estimation results have been shown to be more consistent than those generated using the least square method (Pindyck and Rubinfeld, 1998).

The log-likelihood ratio statistic is usually used to compare two Tobit models, where one is nested within the other. 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 test statistic takes the following form:

Log likelihood ratio = -2(log likelihood value of restricted model - log likelihood value of unrestricted model)..(4.1)

Using the information reported in Table 4.5, it was calculated that the test statistic was -2[-890,816-(-889,852)] =1,928. With a chi-squared (χ^2) distribution, the calculated upper 5% point of the χ^2 distribution with five degrees of freedom yields a critical value of 11,07. Consequently, the null hypothesis (that the parameters excluded from the reduced Tobit model are equal to zero) was not rejected, and it was concluded that the reduced Tobit model was appropriately specified.

People who were well informed on estuary ecology were likely to increase their mean WTP by approximately R98 for the specified change per annum more than people who were uninformed on estuary ecology (see the reduced Tobit model). People who believed that freshwater inflow into the Keurbooms Estuary was worth more flowing into the estuary than being abstracted for consumption, were likely to pay R212,68 for the specified change per annum more than people who view the worth as equivalent. Respondent's income has a positive effect on their mean WTP. The model predicts that if a respondent's income category increases by one category, he or she is willing to pay R84,17 more per annum for the specified change than those respondents in their previous income category. Approximate worth of vehicles and boats owned by the respondent also has a positive effect on their WTP. The model predicts that if a respondent's approximate worth of vehicles and boats owned category increases by one category, he or she is willing to pay R77,25 more per annum for the specified change per annum more than those respondents in their previous approximate worth of vehicles and boats owned category.

In both of the reduced OLS and reduced Tobit models, the variable, worth of vehicles/boats, was significant in explaining WTP (see Tables 4.3 and 4.5). It was found that the variables of levies, income and worth of vehicles and boats were significantly correlated (see Appendix 9), which explains why levies were significant in the OLS models and not Tobit models. The magnitude of the collinearity impact was more significant in the Tobit models than in the OLS models.

As the adjusted R^2 values in the reduced OLS and Tobit models are 0,304 and 0,309 respectively, there is little to choose between the two models in terms of overall explanatory power.

The predicted individual's minimum WTP amount is positive using the reduced Tobit model (Table 4.6). By comparing these predicted values with those predictions using the reduced OLS model (see Table 4.4) it was deduced that the Tobit models are preferable.

Table 4.6: Predicted individual WTP statistic using reduced Tobit model

Variable	Mean value	Minimum value	Maximum value
WTP in Rand	284,08	41,83	605,37

Notes: Rand values are at 2000 price level

4.2.2 Binary response dependent variable models

Two non-linear models were also estimated for the Keurbooms Estuary, the Logit and Probit models. In these models the dependent variable, WTP, was transformed into a binary response variable, coded as either yes (the respondent was willing to pay a positive amount for healthier estuary ecology) or no (the respondent was unwilling to pay a positive amount for healthier estuary ecology). Table 4.1 provides the coding used for the dependent variable (see Section 4.1). The usefulness of these non-linear models lies in their prediction capabilities of whether an individual is willing to pay or not. It is the probabilities of WTP that are estimated rather than the WTP values.

Tables 4.7 and 4.8 show summaries of the results after fitting the Logit and Probit models to du Preez's (2002) data. In both of the complete Logit and Probit models (Table 4.7) the coefficients have the same signs. The significant variables (p-value < 0,10) in both the complete Logit and Probit models are the same. Comparing these results to the fitted reduced Tobit model results shows that the variable of worth of vehicles and boats owned is not significant in the reduced Logit and Probit models and levies is not significant in the reduced Tobit model. These inconsistencies are possibly caused by multicollinearity between some of the explanatory variables.

Table 4.7: Complete Logit and Probit models of WTP function for Keurbooms Estuary

Dependent Variable: WTP_C								
Model: Complete model								
Method	ML-Binary Logit				ML – Binary Probit			
	LOGIT				PROBIT			
Variable	Coefficient	Std. Err.	z-Statistic	p-Value	Coefficient	Std. Err.	z-Statistic	p-Value
Constant	-0,141	2,557	-0,055	0,956	-0,193	1,386	-0,139	0,889
Distance	0,356	0,373	0,954	0,340	0,216	0,207	1,044	0,296
Education	-0,294	0,572	-0,514	0,607	-0,186	0,316	-0,590	0,555
Water_worth	1,727	0,621	2,782	0,005	1,022	0,348	2,940	0,003
Gender	0,321	0,685	0,468	0,640	0,220	0,373	0,590	0,555
Income	1,538	0,645	2,383	0,017	0,884	0,344	2,567	0,010
Knowledge	-1,214	0,642	-1,892	0,059	-0,684	0,351	-1,948	0,051
Levies	-0,658	0,366	-1,800	0,072	-0,356	0,197	-1,804	0,071
Worth_prop	-0,433	0,541	-0,802	0,423	-0,237	0,302	-0,782	0,434
Worth_V_B	0,070	0,392	0,179	0,858	0,012	0,213	0,059	0,953
Log likelihood	-50,399				-49,947			
LR statistic	23,627				24,533			
Probability(LRstat)	0,005				0,004			
McFadden R^2	0,190				0,197			

For both the Logit and Probit models MLE procedures were also used. A log-likelihood statistic was used to compare the complete model with the reduced model, as recommended by Gujarati (2003). The respective log-likelihood statistics were 1,864 and 2,178 for the Logit and Probit models. With 5% upper limits and five degrees of freedom, the reject region of χ^2 value is 11,07. It followed that the null hypothesis could not be rejected and it was concluded that both the reduced Logit and Probit models (see Table 4.8) were preferable to the complete models.

Table 4.8: Reduced Logit and Probit models of WTP function for Keurbooms Estuary

Dependent Variable: WTP_C								
Model: Reduced model								
Method	ML-Binary Logit				ML – Binary Probit			
	LOGIT				PROBIT			
Variable	Coefficient	Std. Err.	z-Statistic	p-Value	Coefficient	Std. Err.	z-Statistic	p-Value
Constant	0,306	1,983	0,154	0,877	0,089	1,090	0,081	0,935
Water_worth	1,802	0,578	3,116	0,002	1,069	0,327	3,264	0,001
Income	1,151	0,491	2,343	0,019	0,637	0,259	2,457	0,014
Knowledge	-1,063	0,622	-1,707	0,088	-0,585	0,334	-1,754	0,079
Levies	-0,841	0,329	-2,555	0,011	-0,462	0,177	-2,605	0,009
Log likelihood	-51,331				-51,036			
LR statistic	21,763				22,353			
Probability(LR stat)	0,000				0,000			
McFadden R^2	0,175				0,180			

The partial coefficients of the Logit and Probit models have no direct interpretations (Verbeek, 2000). The Logit and Probit models are derived from the continuous random variable *Z*, with a logistic distribution in the former case and a standard normal distribution in the latter. 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), $d\hat{P}/dX$ (Mirer, 1995:321).

The determination is obtained when $d\hat{P}/dX$ is equal to zero. For both Logit and Probit models this occurs when $\hat{P}$ = 0,5 and $\hat{Z}$ = 0. If $g(Z)$ and $f(Z)$ respectively are the density functions of the logistic and the standard normal distribution, the $\hat{\beta}_i$s are the coefficients of the independent variables, it can be shown that in the Logit model

$$\frac{d\hat{P}_i}{dX_i} = g(\hat{Z}_i) \times \hat{\beta}_i \quad \text{(4.2)}$$

and in the Probit model that

$$\frac{d\hat{P}_i}{dX_i} = f(\hat{Z}_i) \times \hat{\beta}_i \quad \text{(4.3)}$$

Equations 4.2 and 4.3 are applicable for interpretation of individual independent variables if, and only if, all other independent variables are held constant at the point where $\hat{P}$ = 0,5. For this reason, $g(\hat{Z}_i)$ and $f(\hat{Z}_i)$ are calculated at the stationary points 0,25 and 0,399 respectively.

In the reduced Probit model (Table 4.8) the estimate for the income coefficient is 0,637 and $d\hat{P}/dX = (0{,}399)\,(0{,}637) = 0{,}2542$.

This implies that a one category increase in income increases the probability of WTP by no more than 25,4 percentage points, if all other explanatory variables are held constant at the point $\hat{Z} = 0$.

Similar observations may be made with respect to the coefficients in the Logit model. Table 4.9 shows the percentage changes relevant in the reduced Logit and Probit models. The values in Table 4.9 show the maximum percentage change in probability of WTP with respect to each explanatory variable.

Table 4.9: Calculated percentage changes by coefficients

Variables	Logit	Probit
Water_worth	45,05%	42,65%
Income	28,78%	25,42%
Knowledge	-26,58%	-23,34%
Levies	-21,03%	-18,43%

Notes: Calculated from Table 4.6 using formulas 4.2 and 4.3

The percentage changes in the Logit and Probit models are similar to each other. The respondents who believed freshwater inflow into the estuary to be worth at least as much as abstracted for consumption, had a maximum of 43% (Probit model) and 45% (Logit model) higher probability of WTP. For each category, the Probit and Logit models respectively, predicted that an increase of income earned by respondents increased the probability of WTP by 25% and 29%. The Probit and Logit models, respectively, also predicted that well-informed respondents on estuary ecology had a 23% and a 27% higher WTP probability than poorly informed respondents. Levies diminish the probability of WTP by 18% in the reduced Probit model and by 21% in the reduced Logit model, per extra category paid in levies.

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 and Hill *et al*, 2001) and on how well the data fits the model. A useful comparative measure of goodness of fit of the Logit and Probit models is the count R^2. The dependent variables of Logit and Probit models are coded into values of 1 or 0. If the actual value of the dependent variables were coded into 1 and the predicted probabilities were greater than 0,5, then the dependent variables are correctly predicted, and vice-versa for the actual value of the dependent variables that were coded into 0. The count R^2 is defined as follows (Gujarati, 2003):

$$\text{Count } R^2 = \frac{\text{number of correct predictions}}{\text{total number of obervations}} \quad \text{(4.4)}$$

Out of 150 observations, there were 20 in the reduced Logit model and 21 in the reduced Probit model that were incorrect predictions. As a result the count R^2 was 0,87 for the Logit model and 0,86 for the Probit model, that is, that the reduced Logit model had marginally more correctly predicted observations. Alternatively, the McFadden R^2 is used as a measurement of goodness of fit for these models. For the reduced Logit and Probit models the McFadden R^2 statistics were 0,175 and 0,180 respectively (Table 4.8), that is, the reduced Probit model was a marginally better fit than the reduced Logit model.

4.2.3 Deduction

With respect to fitting the Tobit model and the Probit and Logit models to the Keurbooms Estuary data reported in du Preez (2002), it is deduced that expectation-based validity tests do not provide grounds for rejecting the Keurbooms WTP findings. The coefficient signs mostly are as expected and the overall goodness of fits do not give cause for concern.

4.3 Findings of a hedonic pricing model (HPM) valuation

4.3.1 Motivation for applying HPM

Due to the hypothetical underlying basis for CVM valuation it is highly desirable to verify the results, if possible, by use of additional valuation methods, especially revealed preference based methods (Shechter, 2000). One such method is HPM.

The HPM identifies urban environmental amenities as part of the element characteristics, and expresses the benefits from those amenities in terms of a relationship with market prices. It assumes that in these markets, the attributes of the goods are clearly recognised and identified by purchasers, even though those attributes cannot be unbundled when purchasing the goods (Hanley and Spash, 1993; Lofgren, 1995).

The most common application of HPM with respect to valuing environmental aspects relates to residential housing prices. Multiple regression analysis is used to determine marginal valuations of changes with respect to environmental amenities. Often the housing prices are differentiated by the proximity of environmental amenities – the better the environmental quality, the higher the housing price (Field, 1994; King and Mazzotta, 2003). These type of environmental amenities are not pure public goods because distance serves as an excluding mechanism.

HPM has a big advantage over CVM in that the value of the "bundle of attributes" is determined in a real market. With CVM, on the other hand, value is deduced from respondent information in respect to the amount they are willing to pay to purchase non-market goods in a constructed hypothetical market (Hanley and Spash, 1993; Shechter, 2000).

However, HPM also has its complications. Firstly, because the independent variables are often highly correlated (multicollinearity) the parameters often become unstable. Secondly, the signs of the coefficients of some variables may be intuitively incorrect, although the overall explanatory power (R^2) is high. Thirdly, HPM cannot capture non-user values and pure public good values derived from the environment. Fourthly, HPM only values in terms of the magnitude of the environmental attribute to changes, for example, distance from the amenity. Other quality changes to the environmental amenity are not considered in the analysis, for example, impact of reduced quality of service yielded (Hanley and Spash, 1993).

4.3.2 The application of HPM to the Keurbooms case

In order to see if the CVM results of the Keurbooms study were consistent with HPM, information on sales was gathered on 110 properties situated around the Keurbooms Estuary. The main objective of the HPM exercise was to determine if the proximity to estuary services coefficient in the HPM equation showed this variable to be positively related to WTP for property. Unfortunately, it was not possible to compare this coefficient with the estimated proximity to estuary coefficient in the fitted WTP bid function because the latter was not estimated.

A HPM function was fitted comprising of three types of explanatory variables and specified in semi-log form:

$$LN(P_h) = f(S_i, V_j, D_k) \qquad [i = 1, j = 1 \ldots 2, k = 1 \ldots 5] \quad \ldots\ldots (4.5)$$

where $LN(P_h)$ = natural log of housing price

S_i = site characteristics in terms of erf and building sizes in m^2

V_j = visual characteristics, namely the qualitative view of the house/property

D_k = distance characteristics, namely distance from estuary mouth and distance from central business district (CBD).

Table 4.10 explains the relevant variables. All the qualitative rating variables were modelled as dummy variables. Building size and distance measurements were observed in quantitative terms.

Table 4.10: Description of selected variables in the multiple regression analysis

Variable name	Description	Expected sign in regression model
	Dependent variables	
LN (Sale price)	House/property value sold in Rand in the natural log	
	Independent variables	
Building size	Measurements of building sizes in m^2	+
Visual rating	1 = if visual rating of the house/property is rated good (4, 5, 6) 0 = if visual rating of the house/property is rated poor (0, 1, 2, 3)	+
General view	1 = if general view rating around the house/property is rated good (4, 5, 6) 0 = if general view rating around the house/property is rated poor (0, 1, 2, 3)	+
Distance (mouth)	distance of the house/property away from the mouth in km	-
Distance (closest point)	distance of the house/property away from the closest point in km	-
Estuary view	1 = if estuary view rating from the house/property is rated good (4, 5, 6) 0 = if estuary view rating from the house/property is poorly rated (0, 1, 2, 3)	+
Distance (main road)	distance of the house/property away from the main road in km	-
Distance (beach)	distance of the house/property away from the beach in km	-
Distance (CBD)	distance of the house/property away from the CBD in km	+

A logarithmic transformation on the dependent variable was done to normalise the observations. The prior expectations were of a positive correlation between the dependent and all the visual characteristic explanatory variables (visual rating, general view and view of estuary). The critical characteristic, distance from estuary, was expected to have a negative relationship – the further the distance between the houses and the locations of the estuary, the lower the property values.

The descriptive statistics of the dependent variable are shown in Table 4.11. There was enormous variation of sale price. The minimum price was R60 000, while the maximum was 83 times higher at R5 000 000. The average housing/property price was R500 618.

Table 4.11: Descriptive statistics of the dependent variables

Variables	Valid N	Mean (Rand)	Minimum (Rand)	Maximum (Rand)	Std. dev. (Rand)
Sale price (Rand)*	110	500 618,30	60 000,00	5 000 000,00	682 271,80

* Values are at 1999 to 2000 price levels

The descriptive statistics of the explanatory variables are shown in Tables 4.12 and 4.13.

Visual rating, general view and view of the estuary were categorically coded (Table 4.12) in the scale rating from 0 to 6, reflecting very bad to exceptional. Nearly half of the property profiles had a visual rating of 0, implying property with a bad view was traded more often than property with a good view. More than one third of the houses were located with unappealing views, and approximately 80% of the houses had no view of the estuary at all.

Table 4.12: Descriptive statistics of categorical explanatory variables

Explanatory variables	Rating scales	Counts	Percentages
Visual rating	0	54	49,1
	1	0	0,0
	2	7	6,4
	3	32	29,1
	4	12	10,9
	5	4	3,6
	6	1	0,9
General view	0	3	2,7
	1	37	33,6
	2	17	15,5
	3	24	21,8
	4	19	17,3
	5	9	8,2
	6	1	0,9
View of estuary	0	1	0,9
	1	81	73,6
	2	7	6,4
	3	8	7,3
	4	9	8,2
	5	4	3,6
	6	0	0,0

Table 4.13: Descriptive statistics of quantitative explanatory variables

Variables	Valid N	Mean	Minimum	Maximum	Std. dev.
Building size (m^2)	110	143,2	0,0	872	165,5
Distance (mouth) (km)	110	4,2	1,0	5,0	1,2
Distance (closest point of estuary) (km)	110	5,5	1,0	7,0	1,6
Distance (main road) (km)	110	3,9	2,0	5,0	1,0
Distance (beach) (km)	110	3,3	1,0	5,0	1,0
Distance (CBD) (km)	110	3,5	1,0	5,0	0,9

Where the erf had no building constructed on it, the building size was deemed to be $0m^2$. The average building size was $143m^2$. All the observed houses/properties were situated within a radius of a 5km distance from the river mouth, main road, beach and CBD, and within a radius of 7km from the closest point to the estuary (Table 4.13).

4.3.3 Results

An OLS model was used to fit an equation to the data. The results are shown in Tables 4.14 and 4.15.

Table 4.14: Regression summary of complete model for LN sale price function

Dependent Variable: LN (Sale price)
Models: Complete models
Method: Least squares

Variable	Coefficient	Std. Error	t-Statistic	p-Level
Constant	13,849	0,495	27,960	0,000
Building size	0,004	0,000	9,702	0,000
Visual rating	0,274	0,179	1,525	0,130
General view	0,453	0,135	3,344	0,001
Distance (mouth)	-0,151	0,095	-1,585	0,116
Distance (closest point)	0,039	0,082	0,478	0,633
Estuary view	-0,350	0,182	-1,918	0,058
Distance (main road)	-0,169	0,115	-1,463	0,147
Distance (beach)	-0,261	0,059	-4,447	0,000
Distance (CBD)	0,008	0,076	0,108	0,914
R^2	0,752			
Adjusted R^2	0,729			
SSE	26,6104			
F-Statistic	33,659			
Prob (F-statistic)	0,000			

Table 4.15: Regression summary of reduced model for LN sale price function

Regression Summary for dependent variable: LN sale price
Models: Reduced models
Method: Least squares

Variable	Coefficient	Std. err.	t-Statistic	p-Level
Constant	13,400	0,332	40,320	0,000
Building size	0,005	0,000	14,096	0,000
General view	0,470	0,130	3,606	0,000
Distance (mouth)	-0,186	0,052	-3,555	0,000
Estuary view	-0,305	0,168	-1,813	0,073
Distance (beach)	-0,219	0,054	-4,088	0,000
R^2	0,738			
Adjusted R^2	0,725			
SSE	28,1158			
F-Statistic	58,521			
Prob (F-statistic)	0,000			

Both the complete and reduced models had good fits of the data, with adjusted R^2 statistics of 0,729 and 0,725 respectively. Both models also had p-values that were smaller than α=1%, that is, were good fits. In order to compare the two models, one nested in the other, the null hypothesis was tested that all the variables excluded in the reduced models were equal to zero. The test statistic (F-statistic) used for this purpose was (Mendenhall and Sincich, 1996:235):

$$F = \frac{(SSE_R - SSE_C)/(k-g)}{SSE_C/[n-(k+1)]} \qquad (4.6)$$

where: SSE_R = sum of squared errors for the reduced model

SSE_C = sum of squared errors for the complete model k-g = number of parameters specified in null hypothesis

k+1 = number of parameters included in the complete model

n = sample size

The F-statistic value was 1,41. Its critical value was 2,43 and for this reason (the F-statistic being less than the critical value), the null hypothesis was not rejected and it was deduced the reduced model was acceptable for predictive purposes.

Due to the semi-logarithmic specification of the equation fitted to the data (Equation 4.5) the coefficients express percentage changes (Mirer, 1995). The coefficients are shown in Table 4.15. If the general view was rated as "good" (rating at 4, 5 and 6), the fit predicted it would lead to a 47% increase in sale price. For every one kilometre further from the river mouth and beach respectively, the property price was predicted to decline by 19% and 22%.

Due to the dependent variable being a logarithm, and the above percentage changes being "large," the approximation is imprecise (Mirer, 1995).

Many of the signs of the coefficients were as expected, for example, for building size, general view rating and distance from beach. However, inconsistent results were yielded with respect to the critical variable, distance of the property from the estuary (distance of closest point to the estuary). Distance of property from the mouth of the estuary was negatively correlated with the natural log of the sale price, as expected, but distance to the closest point on the estuary was positively correlated, the opposite of what was expected. To complicate matters there appeared to be multicollinearity between the distance explanatory variables (a problem discussed further in Appendix 10).

The fit of the reduced OLS model is shown in Table 4.15. With the elimination of all insignificant variables, the estuary view variable was only found to be significant at the 10% significance level. However, its coefficient had a negative sign, suggesting (improbably) that improved view of the estuary reduces property prices.

There were many possible reasons for this result. The survey team felt that both omitted variables and inconsistencies in the assessor's ratings may have played a part. Of all the observations 88% fell into the bad-rating category (0 to 3) (See Table 4.12).

4.4 Concluding comments

Chapter Four reports a pilot study estimation (both numerically and categorically) of the Keurbooms estuary user population's WTP for freshwater inflows into the estuary. Expectations-based testing by statistical fits of bid functions to the data collected are also made. The statistical models used are the OLS, Tobit, Logit and Probit models. The estimates show that individual WTP is positively related to the respondents' knowledge of estuary ecology, their belief in the benefit of conserving the estuary ecology, their income and their wealth in equipment for use in the estuary.

The respondents were willing to pay an average of R283,76 for freshwater inflow into the Keurbooms Estuary, and it was found that there was an 85% likelihood of them being willing to make payments for this water (see Table 4.16).

Table 4.16: Estimated WTP using reduced Tobit and Probit models

	Mean	Median	Minimum	Maximum	Std. dev.
Tobit (in Rand)	283,76	269,04	47,094	587,36	139,36
Probit (in percentage)	0,85	0,89	0,22	0,99	0,15

A HPM model was also estimated; the purpose being to reflect on the relation between property values and the Keurbooms estuary. It was not possible to make direct comparisons between the values generated from the CVM and HPM as they measured different things. However, the fact that neither proximity to the estuary nor view of the estuary were positively linked to property prices is not consistent with the positive WTP values generated using the CVM. It appeared that property values were more influenced by the presence and view of the beach than the presence and view of the estuary.

The overall impression gained from the pilot study was that applying the CVM to estuaries yielded valid results in terms of expectation-based testing but not in terms of tests for convergence with HPM estimates. The differences between the results of the CVM and HPM do not suggest a failure in either the CVM or HPM of estimation, but rather of the limitations inherent in each method (Azevedo, Herriges and Kling, 2003).

CHAPTER FIVE: SAMPLE DESIGN ISSUES

5.1 Introduction

Chapter Five identifies the estuaries and population from which the samples were selected for the CV and describes the sample decision issues that were encountered in the study . An overview of estuaries in South Africa is presented and a representative sample of 50 of them is identified (about 20%). Of these 50, seven estuaries were valued using the CVM, namely the Knysna, Groot Brak, Klein Brak, Kromme, Kowie, Swartkops and Kariega Estuaries. Chapter Six describes these estuaries and Chapter Seven reports the results of the CVs.

5.2 The sample frame of estuaries in South Africa

A sample frame of 249 estuaries was identified for this study (see Appendix 11). Most (72%) are classified as temporarily open/closed (Whitfield, 2000).

Whitfield (2000) recognises five estuary categories, of which three are shown in Table 5.1 below. The category "Other" includes river mouths (like the Orange and Tugela), estuarine bays (like Knysna and Richards Bay) and estuarine lakes (like Swartvlei, Nhlabane, St Lucia and the Kosi system). The sample frame was extracted from Whitfield (2000).

Table 5.1: Summary analysis of estuaries included in the sample frame

	Permanently open	Temp open/closed	Other	Total	%
N. Cape	-	-	1	1	**<1**
W. Cape	12	28	6	46	**18**
E. Cape	27	95	10	132	**53**
KZN	5	57	8	70	**28**
Total	**44 (18%)**	**180 (72%)**	**25 (10%)**	**249**	**100**

Source: Whitfield (2000)

Permanently open estuaries in South Africa have received most attention from scientists in the past and the knowledge base with respect to these estuaries is considered to be moderate to excellent. About 67% of South African estuaries in the permanently open group are classified as having a moderate to excellent knowledge base. By contrast, the knowledge base of temporarily open/closed systems (72% of South African estuaries by type) is extremely poor, with 80% of these 180 estuaries classified as having a poor knowledge base.

Least known of all of all the estuaries are those located in former Ciskei/Transkei. About 21% of South African estuaries in the 'other' group are classified as having an excellent knowledge base (mostly estuarine lakes).

From the complete list of South African estuaries (see Appendix 11) 50 were selected (see Table 5.2 below), taking into account the region (cool temperate, warm temperate or subtropical), mouth type (river mouth, permanently open, temporarily open/closed, estuarine bay or lake), scientific information available or knowledge base, the botanical importance of the estuary, the importance of the estuary for fish, the importance of the estuary for birds, the importance of the estuary for invertebrates, the conservation importance of the estuary, the condition of the estuary, the demand for development in the surrounding environment of the estuary and the degree of conservation protection afforded the estuary. Also considered in the selection of the sample were geographical location, the relative importance and available knowledge of the estuary. The list was then reduced further to seven estuaries in the initial round that would provide a testing ground for the methodology and help refine the questionnaire.

Table 5.2: The selected 50 representative estuaries listed by province

Western Cape	Eastern Cape	Wild Coast section of Eastern Cape	KwaZulu-Natal
Olifants	Storms	Great Kei	Mzimkulu
Groot Berg	Kromme*	Nqabara	Fafa
Sand (Zandvlei)	Gamtoos	Mbashe	Mkomazi
Klein	Swartkops*	Mtata	Umgababa
Palmiet	Kariega*	Mngazana	Durban Bay System
Bot/Kleinmond	Kasuka	Mngazi	Tongati
Heuningnes	Kowie*	Mzimvubu	Thukela (Tugela)
Breë (Breede)	Kleinemond (Wes)	Mbotyi	Mlalazi
Duiwenhoks	Kleinmond (Oos)	Mtentu	Mhlatuze
Klein Brak*	Great Fish	Mtamvuna	Mfolosi
Groot Brak*	Bira		Kosi System
Swartvlei	Keiskamma		
Knysna*	Nahoon		
Keurbooms+	Kwelera		
	Cefane		
	Haga-haga		

Of the 50 estuaries listed in Table 5.2 above, freshwater inflow was valued at the seven marked with an asterisk (*) and a pilot study valuation was undertaken at the one marked with a plus sign (+). The specified water inflow changes and forecast consequences of these changes are summarised below in Tables 5.3 and 5.4.

Table 5.3: Summary of specified change in water inflow

Estuary	Proposed* inflow scenario as % of MAR	% Reduction (-) or increase (+) over current flow
Klein Brak	60	-37
Groot Brak	60	-27
Knysna	40	-54
Kromme	80	+71
Swartkops	40	-30
Kariega	80	+85
Kowie	80	+56

Note: *Wooldridge (2002)

Table 5.4: **Forecast of changes resulting from changes in freshwater inflow**

Estuary	Mouth closure	Area change – for boaters	Bait and bird populations changes low (high)	Fish population change low (high)	Quality changes – for swimmers
Klein Brak	Yes	Increase	-40% (-100%)	-40% (-100%)	increase potential entrapment of pollutants + increase in reed growth
Groot Brak	Yes	Increase	-80% (-100%)	-80% (-100%)	increase potential entrapment of pollutants + increase in reed growth
Knysna	No	Shrinkage of nursery area (small in relation to total lagoon area)	-40% (-80%)	-40% (-80%) also less variety	
Kromme	No	No	+25% (0%)	+25% (0%) also more variety	
Swartkops	No	No	0% (-25%)	-10% (-25%)	increase in pollutant concentration – reducing safety of water for swimming and boating
Kariega	No	No	+25% (0%)	+25% (0%) also more variety	
Kowie	No	No	+25% (0%)	+25% (0%) also more variety	

Source: Wooldridge (2002)

5.3 Respondent selection

5.3.1 Target population

The target population in this CVM study was all those people with a demand for estuary services, directly or indirectly. Identifying them proved to be a complicated task. These people cannot be identified *ex ante* because they only reveal their propensity to consume estuary services when they use them and no records are kept of their identities. Most of them are visitors to the area and not permanent residents. For this reason, statistically preferred respondent selection procedures could not be applied.

As an alternative to these procedures it was assumed that demand was inversely related to distance of residence (vacation or permanent) from the estuary, and that at some distance, the demand for estuary services became trivial. With respect to non-users it was assumed that a demand from them would only exist if the estuary hosted something unique.

Initially, the researchers responsible for conducting the interviews were tasked to collect information about the user populations in the areas in which they thought these people were most likely to reside. From this information they were asked to determine the target populations. The researchers involved visited municipalities, tourism authorities, boating clubs, water sport clubs, National Parks Boards and any other authorities that could help in determining how many users utilise the estuary and for what purpose they do so. In addition they were provided with GIS census data on the size and characteristics of the population living within 10km of the estuary mouths.

Based on all this information they were only able to estimate the sizes of the target population of households for each estuary, broken down into the following predominant user categories: anglers, boaters, bait collectors, swimmers, commercial users, subsistence users and other users. It proved absolutely impossible to identify the individuals making up this target population because no records of them exist – most were visitors to the estuary.

5.3.2 Sample size

Sample determination is one of the most crucial aspects of any empirical research. Too small a sample size undermines the power of the statistical tests of significance (Hair, Anderson, Tatham and Black, 1998). In order to be acceptable a sample must be representative of the entire target population.

As a starting point for respondent selection it was assumed that those with a demand for the estuary services would locate themselves at some stage in a given year within a 10km radius from the mouth of each estuary; thereby revealing their propensity to consume estuary services.

A second decision made with respect to sample design was to set its size at 5% of the preliminary estimated target populations. This size was the maximum that could be surveyed with the budget available. These preliminary estimates were approximate and similar in scale. They are shown in Table 5.5 below.

Table 5.5: Sample size based on preliminary user population estimates

Estuary	Estimates of number of households	Sample size of households at 5% of sample population
Groot Brak	3 000	150
Kariega	2 000	100
Klein Brak	2 000	100
Knysna	4 000	200
Kowie	3 000	150
Kromme	3 000	150
Swartkops	4 000	200

Source: UPE Economics Department survey team

The preliminary estimates of the target population were revised on the basis of additional information gained during the administration of the surveys. The revised estimates are shown in Table 5.6.

Table 5.6: Sample size after revision of population size estimates

Estuary	Estimates of number of households	Sample size of respondents	Sample size as % of target population
Groot Brak	2 730	150	5,49%
Kariega	2 000	100	5,00%
Klein Brak	1 178	100	8,49%
Knysna (above rail bridge only)	3 891	200	5,14%
Kowie	3 234	150	4,64%
Kromme	3 200	150	4,69%
Swartkops	5 200	200	3,85%

Source: UPE Economics Department survey team

The sample sizes that could be afforded were smaller than was desirable. This conclusion was based on the approach taken by Cochrane (1977) with respect to random sampling with continuous data. The approach uses the following formulas (Equations 5.1 and 5.2 below):

$$n_o = \left(\frac{z_{\alpha/2} s}{r\overline{Y}}\right)^2 \quad \text{......} (5.1)$$

where: n_0 = first approximation of n

n = sample size

$z_{\alpha/2}$ = area under the normal distribution

r = relative error (error allowance about the mean)

s = standard error

$\overline{Y}$ = sample mean

The approach assumes that sample sizes are normally distributed. Normal distributions are symmetric with scores more concentrated in the middle than in the tails. Normal distributions are sometimes described as bell shaped (Gujarati, 2003:639). If the population sizes (*N*) are known, the sample size can be computed as follows:

$$n = \frac{n_o}{1 + \left(\frac{n_o}{N}\right)} \qquad (5.2)$$

In order to populate these formulas, the relevant mean and the standard deviation statistics were needed. Fortunately, some were available from a pilot study on the Keurbooms Estuary carried out in the year 2000 by members of the survey team. From this data, mean and standard deviation estimates were made. They were 273,67 and 262,26, respectively (du Preez, 2002). It was assumed that the sample mean of WTP for each of the seven selected estuaries would vary within 10% of the real mean and with a 95% confidence level.

The estimated sample sizes for the seven selected estuaries in terms of the Cochrane (1977) method are shown in Table 5.7. These sample size estimates are based on the preliminary target population estimates (which was the actual reference used for determining the sample size).

The preferred sample sizes (Table 5.7) are significantly higher than those that were selected (see Tables 5.5 and 5.6), especially for the cases where the target populations were small. The main impact of this error was to undermine the significance of the WTP function estimates (see later in Chapter Seven).

Table 5.7: Preferred sample sizes using a random sampling technique and revised user population estimates

Estuary	Estimates of number of households	Preferred sample size of respondents*	Preferred sample size as % of target population
Groot Brak	3 000	315	10,5%
Kariega	2 000	300	15,0%
Klein Brak	2 000	300	15,0%
Knysna	4 000	325	8,1%
Kowie	3 000	315	10,5%
Kromme	3 000	315	10,5%
Swartkops	4 000	325	8,1%

Note: *Using formulas 5.1, 5.2 and du Preez's (2002) Keurbooms data

5.3.3 Targeting the respondents

Based on the assumptions about distance being relevant in identifying users and uniqueness being a prerequisite for non-user demand, sample selection was made at the sites of the estuaries and the responsibility for making it representative was delegated to those who were charged with conducting the interviews. The guidelines provided to them to carry out this task were that:

- the whole estuary area was to be covered
- the proportions of user groups within the respondents were to match those estimated for the target population and
- the duration of the survey should include both school recess and non-school recess periods.

Most of the survey work was completed during December 2002 and from January to April 2003.

5.3.4 Questionnaire administration

A pre-coded questionnaire was designed to conduct the survey (see Appendix 12 for an example). Interviewers were trained and educated about the various sites to be researched in order to limit information bias. A scenario was formulated to make respondents aware of the consequences of a reduction of water inflow. The respondent needed to know how these changes would affect his/her life, in order to estimate his/her WTP for a water supply arrangement to prevent these consequences.

Respondents were reminded of the substitutes available before being asked to answer the WTP question. The WTP question was linked to a possible future event (the scenario) about a change in freshwater inflow.

Two scenarios were presented to the respondent – one representing an optimistic result and another, a pessimistic result. The reason for there being two scenarios was that expert opinion suggested that a range of impacts were possible. The alternative scenarios described the range.

The payment card question format was used to elicit WTP responses for both of these scenarios. This question format was tested against others in a pilot study conducted at the Keurbooms Estuary and found to be understood by the respondents and efficient from a time point of view. Using a levy as the payment vehicle was found to be credible with the respondents. They were told that the same levy would be charged to residents and tourists. Many of the respondents already paid similar such levies for estuary services.

The scenario was kept as concise as possible and the number of questions was kept to a minimum so as not to impose excessively on respondents. A balance had to be struck between providing enough information for respondents to understand the problem being researched and minimising the time imposition on them.

The questionnaires used to conduct the CV were made up of 19 questions (for details see Appendix 12). These questions are discussed below. The design of this questionnaire was undertaken with reference to the steps recommended in Chapter Three for the administration of questionnaires.

Question 1

Question 1 asked what the predominant use made of the estuary was. A respondent using an estuary to make money as well as for recreation was allotted into the commercial or recreation category (not both), depending on what his or her main use was. A non-user category was added to the options in order to capture those who were prepared to pay to conserve an estuary they did not use, be this for emotional (warm glow effect) or other reasons.

Question 2 and Question 3

Questions 2 and 3 asked the race and gender of respondents. Their inclusion was motivated by a desire to test if race and gender explained differences in WTP.

Question 4

Question 4 asked if the respondent was a visitor or a resident. It was expected that permanent residents would have a stronger desire than visitors to conserve an estuary. It was thought that visitors would not have as high a willingness to conserve a specific estuary because they had alternative places to spend the vacation time.

Question 5

Question 5 tested the respondent's knowledge about the estuary. It was an interactive question and the interviewer's responsibility was to fill in the gaps in the respondents' knowledge.

Question 6

Question six asked whether the respondent made a living out of the estuary. It proved to be unnecessary as the information revealed nothing additional to question 1.

Question 7, 8 and 9

Questions 7, 8 and 9 asked for information about the frequency of use of the estuary by the respondent. The higher the number of estuary uses a respondent answered to and the higher the frequency of use for these users, the higher the WTP was expected to be.

Question 10

Question 10 asked the respondent to rank the different attributes and activities for the estuary. The purpose of this question was to reinforce the knowledge of the different services yielded by the estuary and their relevance to the user. The higher the ratings assigned to the activities/attributes the higher the respondent's WTP were expected to be.

Question 11

Question 11 asked the respondents what their current cost in terms of user fees directly paid was of using the estuary.

Questions 12a and b

Questions 12a and b asked what the respondent was willing to pay to prevent a specified reduction of freshwater inflow into the estuary or secure a specified increase in freshwater inflow. The main aim of a CV is to determine the WTP of each respondent. The payment vehicle was in the form of an annual levy. The freshwater inflow would ensure that the attributes or activities that respondents associated with a particular estuary were maintained or improved. To provide the freshwater to conserve the services provided by the estuaries would lead to a cost in the form of funding a project, such as the Working for Water Programme, to do so. The annual levy to be paid was over and above what the respondents already paid and was specifically to fund the specified freshwater inflow. Respondents were informed that a specific percentage change in freshwater inflow to a specified estuary would result in one of two scenarios (Questions 12a and b). A pessimistic and an optimistic scenario were posed to the respondent as alternatives for what may happen to the estuary as a result of changed freshwater inflow. Both scenarios were valued. The interviewers were asked to be particularly careful of "compliance" by respondents when they answered the WTP question for each scenario, and to make sure that they were mindful of their budget constraints in answering the question. The payment card method was used to elicit the WTP. This method reduces starting point bias by providing a range of options from which to choose one alternative. The interviewers felt that the ranges were too wide for some user groups, for example, subsistence users.

Question 13

Question 13 was a follow-up question on the zero responses. The respondents who stated they would not pay anything were asked for their reasons for this response. A zero WTP may be a protest response against the payment collection system rather than a real bid.

Question 14

Question 14 asked what the respondent would sacrifice to make his/her payment. The purpose of reminding respondents of their budget constraints was to get the respondents to reflect one last time on their WTP response. The interviewers were asked to check if the respondent was still happy with their WTP answer after having answered this question.

Question 15

Questions 15 to 18 were asked to obtain information that would help explain the respondent's WTP. Question 15 asked how far the respondents stayed from the estuary. Respondents who lived closer to a specific estuary were expected to have a higher WTP.

Question 16

Question 16 asked what the value was of the equipment used to access the estuary services owned by the respondent.

Question 17

Question 17 asked what the respondent's highest level of education was.

Question 18

Question 18 asked what the respondent's level of income was. It was expected that level of income and WTP would be positively correlated.

Question 19

Question 19 was an open question in which respondents were invited to raise any other issues related to the research being undertaken. The purpose of this question was to highlight issues affecting WTP that were not covered in the questionnaire. The interviewers expressed some concern at the inclusion of this question as some were detained for long periods in discussions that added little extra relevant information.

5.4 Conclusion

Sample design is one of the most important aspects of the CVM. The objective, both with respect to estuary and population sample selection, was to achieve representative and unbiased samples. Of the 249 estuaries identified a sample of 50 was selected (about 20%) with the aim of being representative, and of these a sub-sample of seven were selected for immediate valuation.

At these seven estuaries it proved impossible to exactly identify the user populations. The sample user population size was estimated using secondary sources, and sample selection was delegated to those tasked with administering the questionnaires. In order to keep costs within the budget provided, the sample sizes were set at 5% of the target population. This sample size was smaller than indicated by statistical theory, given the study team's preferred significance levels.

The information elicited from the respondents related both to their willingness to pay for freshwater inflows into estuaries and factors that are related to this willingness. Chapter Six describes details of the respective estuaries at which the different research teams were tasked to administer the questionnaires.

CHAPTER SIX: ADMINISTRATION OF THE SURVEYS (BACKGROUND INFORMATION, QUESTIONNAIRES AND QUALITATIVE ASPECTS OF SURVEY REPORT)

6.1 Knysna

6.1.1 Physical description and uses

The Knysna Lagoon (see Figures 6.1, 6.2 and 6.3) is located on the southern coast of the Western Cape Province of South Africa (34,1°S, 23,0°E). The dominant source of freshwater to the estuary is the Knysna River, with salt water exchange occurring at the Knysna Heads (see Figure 6.1). (The Knysna Heads is the opening that links the estuary with the sea.) Knysna has a tidal estuary. The tide of the estuary ranges from 0,5 to 2,0m, and the tidal influence reaches 19km inland from the Knysna Heads and is prevented from further incursion by a weir (Switzer *et al*, 2001). Knysna is a large estuary, covering 3 540 ha. Of this area, 30% is useful for boating and other water sport activities Vermuelen, 2003). The area of the Knysna Estuary affected by freshwater inflow is from the red bridge to the train bridge (see Figures 6.2 and 6.4). The CV was focused on this area.

Figure 6.1: The Knysna Heads (mouth of the Knysna River)
Source: Wooldridge (2003)

The area surrounding the estuary supports various commercial activities, from subsistence agriculture to well-developed recreation business enterprises. In particular the area it has in recent years become a popular area for residential, restaurant and golf course development schemes. This development has led to increased abstraction of water from the Knysna River, thereby reducing freshwater inflow into the Knysna Estuary. Factors limiting development along the banks of the estuary have been steep sloping ground bordering the upper sections of the estuary and control of some of the area by the National Parks Board.

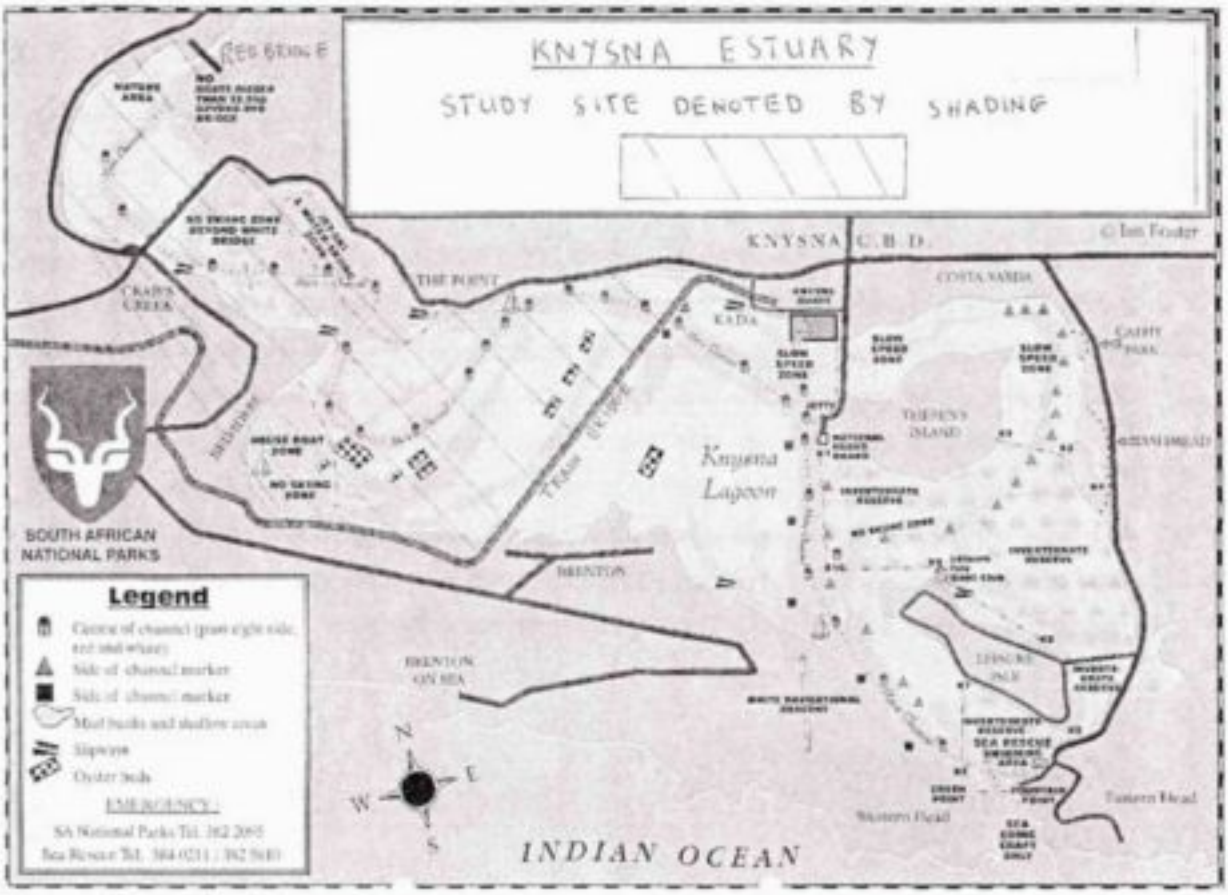

Figure 6.2: The Knysna Estuary

Source: Joubert (2002)

The negative effects these reductions in inflow into the estuary have caused include:

- build-up of mud banks in the lagoon
- less fish and birdlife
- bad smells and polluted, stagnant water
- less flood protection
- less appeal for swimming
- less recreational space
- a deterioration in visual beauty of the lagoon
- less area for boat sports and
- less appeal for walking, cycling, jogging.

Access points to the Knysna Estuary (see Figure 6.4) are in good condition and spread evenly around the estuary. Tar roads provide many points of access to the Knysna Estuary.

The excellent access facilities give the Knysna Estuary extra usage appeal for residents and tourists. Many residents live close to these access points and boats are often moored at jetties found close to these points.

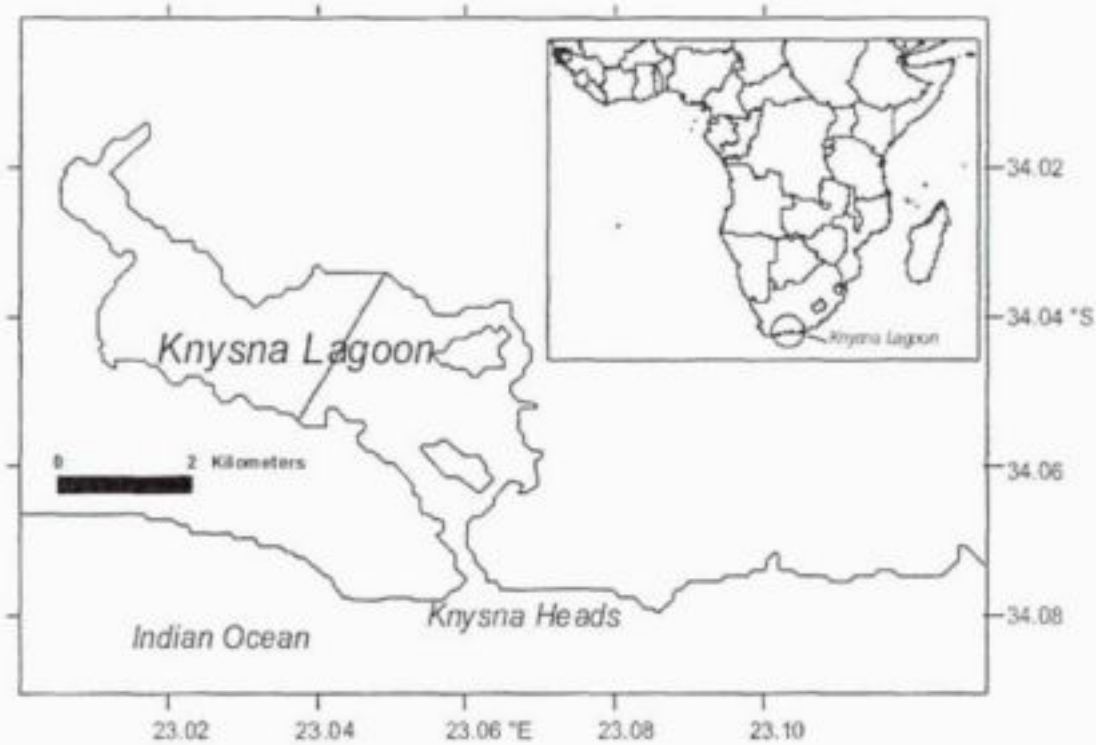

Figure 6.3: Location and map of Knysna Lagoon/Estuary

Source: Baird (2002:40)

Knysna is only 15km away from Sedgefield, a town that includes an estuary with similar environmental attractions, attributes and uses.

Figure 6.4: Access points to the Knysna Estuary

Source: Joubert (2002)

An estuary bank that has been highly developed is the Belvidere area. It includes private homes, a hotel, a restaurant and many private moorings for boats (see Figures 6.2 and 6.5). Examples of other accommodation premises built close to the estuary are Bridgewater B&B, Phantom View Lodge, Waterfront Lodge, Diaz Guest House and Brenton Hill Guest House. Prominent businesses also use proximity to the estuary as part of their appeal. Examples of these businesses are "Pembreys Pub", "Crabs Creek Restaurant", "Madiba Tide Hotel", and "Lightley's Boat Cruisers." Any deterioration in the level of services yielded by the Knysna Estuary is of great concern to many of these businesses.

6.1.2 The specified change and WTP question

The recreational services yielded by the Knysna estuary are partly dependent on the supply of freshwater flowing into it. The average per annum freshwater inflow for the Knysna estuary, without abstraction, is 97,51 million m^3 per annum (DWAF, 2002c). The current average annual loss of the MAR of water from the Knysna River is 33,11 million m^3 per annum. This loss constitutes 66% of the MAR (DWAF, 2002c). Most of the water is abstracted for agriculture (8,29 million m^3 per annum) and urban use (15,35 million m^3 per annum), but some is lost due to the spread of alien plant plants (9,47 million m^3 per annum).

During periods of "normal" rainfall, Knysna's water needs are adequately met by the supply of freshwater from the Knysna River, but ongoing development has made this situation unsustainable. These flows are being undermined in many ways: increased abstraction for urban use and agriculture, increased water use for development and servicing golf courses and the replacement of indigenous vegetation by higher water-consuming alien vegetation.

In order to maintain the level of environmental services provided by the upper section of the Knysna Estuary it has become essential to maintain its freshwater supplies. These supplies can be secured in different ways, namely, demand management, removal of alien vegetation growth, and supplementation schemes in which water is imported from other river basins. In all these cases supply measures have cost implications – benefits foregone (by urban and farm users) or costs incurred by water transfer or cutting back alien vegetation.

The primary question that this research addresses relates to the benefits – the value of a project to maintain the freshwater flow into the Knysna Estuary. Respondents were asked what they would be willing to pay to prevent a further 54% reduction in freshwater inflow (see Chapter 5, Table 5.3) to the Knysna Estuary. They were informed that failure to implement this project would result in one of two scenarios (Wooldridge, 2002). The pessimistic scenario was:

- A small shrinkage of the nursery area (small in relation to the total lagoon area).
- An 80% reduction in the bait and bird population.
- An 80% reduction in the fish population and also less variety.
- A build up of mud banks spoiling the view and leading to less flood protection, but no mouth closure.

The optimistic scenario stated was the same except:

- Only a 40% reduction in bird population.
- Only a 40% reduction in fish population and also less variety.

6.1.3 Determination of target population and the sample population

The permanent residents living within 10 kilometres of the Knysna Estuary make up 32 500 people (see Table 6.1). These people make up 4 233 households (Davids, 2002) with an average of 7,68 people per household. The literacy rate amongst this population is 90%. Many of Knysna's permanent residents use the estuary on a regular basis for commercial, subsistence and recreational activities.

Table 6.1: Knysna residents within 10km of Knysna Estuary

Population group (race)	Population size
Black	8 625
Coloured	13 475
White	10 400
Total	**32 500**

Source: Davids (2002)

Knysna is also a popular tourist destination and approximately 45 000 tourists visit Knysna annually (Knysna Tourism Board). This figure relates to visitors who stay in Knysna for at least one evening. Knysna also has many tourists who visit the town for just a few hours. Some of these visitors also use the Knysna Estuary. The national road passes through Knysna and borders the estuary to the west of Knysna. Travellers can enjoy the view of the Knysna Estuary, even if they have no intention of staying in the town. As a result there are a large number of passive users of the Knysna Estuary. The possibility also exists that there are also passive users who value the estuary as a habitat purely because the bay area adjoining the upper estuary provides a home for the threatened Knysna sea horse.

There were 202 questionnaires administered in the Knysna Estuary area; an area defined as the portion of the estuarine bay affected by freshwater inflow from the Knysna River (Joubert, 2002). Many tourists visit the bay area that is unaffected by freshwater inflow, rather than the estuary area that is. These people were not included in the target population.

Another complicating factor in determining the target population for the part of the estuary affected by freshwater inflow is that the national road runs along its banks, with the result that almost all people passing through Knysna derive a "forced/involuntary" benefit from the upper estuary in the form of a view. This study concerned itself only with people who derived a benefit from the estuary's existence by "choice" and not people who simply travelled through the area (and had no alternative but to pass through the estuary area).

The following information was gathered about the sample population of recreation users of the Knysna Estuary:

- McCarthy (2002) estimated that about 25% of the white population group of Knysna have close proximity to the estuary area, that is, about 2 600 people. He observed that Coloured and Black residents did not enjoy close proximity to the estuary.
- According to Joubert (2002) and Ogilvy (2002) it was expected that about 16 250 residents would use the Knysna estuarine bay at least once during 2002, and of these, about 4 063 would use the area of the estuary affected by changes in freshwater inflow. According to the Knysna Municipality the resident recreational user population in 2002 was about 5 800. The municipality's figure excluded residents with close proximity, but included 1 000 people who were both commercial and recreation users.
- Ogilvy (2002) estimated that 12 000 of the 45 000 visitors who were expected to visit Knysna in 2002 would derive benefit from the estuary; 9 000 of whom would locate themselves in accommodation close to the estuary.
- Recreational users of the Knysna estuary include tourists renting accommodation along the estuary's banks and those engaged in bird watching, fishing, swimming, skiing, boating, canoeing, jogging, sightseeing, sailing, windsurfing and visiting restaurants, pubs and coffee shops along the estuary's banks.
- Joubert (2002) estimated that in 2002 less than 1 000 people were making use of the estuary for subsistence purposes, less than 300 people were owners of businesses along the estuary's banks, less than 100 people were informal traders situated on the estuary's banks and less than 500 people were employees of businesses and farms on the estuary's banks.
- The Knysna estuarine bay area is well known for the Knysna loerie, Knysna seahorse, Knysna oysters, an excellent crab-fishing area and a boat-sporting environment. The more limited area of the bay affected by changes in freshwater inflows attracts less visitors than the remainder of the estuarine bay.

Based on the preliminary fieldwork undertaken of the target population for the Knysna Estuary, it was concluded that it consisted of:

- Commercial/subsistence users – 2 000 people
- Recreational users (including passive view users) – 19 400 people
- Existence users (non-users) – few in number due to the availability of close substitutes.

The division of this target population into user categories is shown in Table 6.2.

Table 6.2: Estimates per annum visitor population for the Knysna Estuary (users for train bridge to red bridge area)

User group description (mutually exclusive)	Number of visitors per annum		Number of visitor days per annum	
	Resident	Tourist	Resident	Tourist
(1) Recreation	7 400	12 000	100	7
(a) Boat sports – (30% and 20%)	2 220	2 400		
(b) Swimmers – (10% and 10%)	740	1 200		
(c) Anglers and baiters – (20% and 15%)	1 480	1 800		
(d) Birders (4% and 2,5%)	296	300		
(e) Proximity/view (36% and 52,5%)	2 664	6 300		
(2) Commercial/subsistence	1 800	200		
(a) Subsistence – people living off direct consumption	1 000	100	250	250
(b) Sale of outputs/services of estuary	800	100	350	200

Source: Ogilvy (2002); Joubert (2002); McCarthy (2002)

In 2002 it is estimated that about 9 200 residents used the estuary area for recreation and commercial reasons. If these residents reside in households with an average of 7,68 members each (Davids, 2002) they make up 1 197 households. By way of contrast it is estimated that about 12 200 tourists visited the estuary area for recreation and commercial reasons. If these tourists reside in households made up of an average of 4,5 members each (Joubert, 2002) they make up 2 711 households. The sum of resident and visitor households in 2002 was 3 898 and 5% of this sum is 195 – the approximate number of households targeted for interviewing (see Chapter Five for further discussion).

The proportions of the different the user types included in the sample did not exactly match those of the estimated target population (see Table 6.3). There were 202 questionnaires administered. More subsistence and commercial users were included because of their higher frequency of use (see Table 6.2). The numbers of questionnaires actually administered are as shown in Table 6.4.

Table 6.3: Guideline proportions for questionnaire administration: Knysna Estuary

Recreational users	%
Boat sports	16
Swimmers	9
Anglers and bait collectors	12
Birders	2
Proximity/view	32
Commercial users – 50 questionnaires, assigned as follows:	
Subsistence – living off direct consumption	12
Commercial – sale of outputs/services of estuary	12
Non-users	5

Notes: 1 The number of questionnaires administered to commercial and subsistence users was adjusted upwards to allow for higher frequency of use (see Table 6.2).

Table 6.4: Actual number of user types selected to answer questionnaires: Knysna Estuary

Recreational users – 142 questionnaires, assigned as follows:	Number
(a) Boat sports	37
(b) Swimmers	16
(c) Anglers and bait collectors	30
(d) Birders	7
(e) Proximity/view	52
Commercial users – 46 questionnaires, assigned as follows:	
(a) Subsistence – living off direct consumption	16
(b) Commercial – living off direct consumption	30
Non-users – 14 questionnaires	

6.1.4 Impressions gained and comments made during the administration of the questionnaires

For this kind of survey personal interviews were the only sensible option as the information requirements were considerable. The following were the observations of the interviewer who conducted the survey:

- The scenario set out in the questionnaire was well understood by respondents and taken seriously.
- The payment vehicle was realistic and relevant.
- The questions of race and gender seemed relevant, as there were differences in interests in the estuary area and differences in WTP results by race and gender. Whites seemed far more interested in boat sports than Coloureds and Blacks.
- Visitors to Knysna seemed to have a higher WTP than those visiting other estuaries like the Groot Brak and Klein Brak.
- Residents of Knysna seemed to have a higher WTP than those of Groot Brak and Klein Brak areas.
- Protest bids (zero WTP) could seemingly be justified by answering the open question no. 19 and the follow-up question no. 13.

- Most of the visitors and residents using the Knysna Estuary were well informed about its ecology.
- The Knysna Lake area seemed to have at least a very important rating for most features, except for picnics. The character of the upper estuary (lagoon area) does not lend itself to picnics.
- Many respondents rated walking and cycling as popular activities in the area.
- The rating respondents attached to different estuary uses, activities and attributes seemed to be closely related to their WTP.
- Activities/attributes seemed even more important than income earned with respect to WTP.
- Many users claimed that they were already paying levies for the use of the estuary.
- The higher the factors "income earned," "approximate worth of respondents' vehicles and boats," and "annual pre-tax income" was, the higher WTP seemed to be.
- WTP seemed to be higher the closer the respondents were to the estuary.
- Schooling level did not seem to make a difference to WTP.
- Some respondents were adamant that they already paid the highest rates and taxes in South Africa and would not want to assign any WTP value for fear of having to pay more.
- Some respondents in Knysna noted that they would pay to preserve or improve the water inflow, but only if the local Municipality cleaned up the river banks of prostitutes, drug-dealers and informal dwellers cleaning their clothes in the river. It is evident, that in a community that pays high taxes, there is much anger and frustration amongst the resident recreation users with the way the banks of the estuarine area are being administered.

6.2 Groot Brak

6.2.1 Physical description and uses

The Groot Brak Estuary (see Figure 6.5) is located approximately 98km west of Knysna. The Groot Brak and Klein Brak Estuaries are classified within one municipal area but distinct differences exist between the two ecosystems. For this reason the study sites are described separately.

Figure 6.5: Southern Cape
Source: (Liebenberg, 2002)

The dominant source of freshwater to the Groot Brak Estuary is the Groot Brak River. Salt-water exchange occurs at the river mouth when it is open. The Groot Brak River mouth (see Figure 6.6) is closed for most of the year. It opens for short time periods under certain conditions (described later). The Groot Brak Estuary has a potential average per annum freshwater inflow of 22,29 million m^3, excluding abstraction (DWAF, 2002c). It loses freshwater inflow due to abstraction for agricultural use (3,12 million m^3 per annum), urban use (0,8 million m^3 per annum) and alien vegetation (0,01 million m^3 per annum) (DWAF, 2002c). The area of the estuary at neap high tide is 122 ha, of which at least 30% is usable for boating and water sports. The Wolwedans Dam on the Groot Brak River was completed in 1989. One of the main reasons for the construction of this dam was to supply water to the Mossgas petrochemical plant and to supplement the growing demand for water in the Mossel Bay area (Allanson and Baird, 1999).

Figure 6.6: Groot Brak River Mouth

Source: Wooldridge (2003)

The Groot Brak Estuary is heavily utilised by people. There is good access to the estuary – both by tar and dust roads and the public use the estuary for many forms of recreation. Characteristics that make the Groot Brak and Klein Brak Estuaries popular with people (Liebenberg, 2002) include:

- Fishing (for kabeljou, knorhaan and leervis),
- Water sports – sailing, windsurfing, canoeing, pedal boats,
- Historical buildings,
- Fauna and flora (fynbos),
- Camping (there is a camp site on the estuary banks of Groot Brak and another near to the Klein Brak Estuary),
- Bird watching (great kingfisher, olive woodpecker, suikerbekkie and blackhead oriole),
- Relative peace and safety of the area,
- Jogging, cycling, walking along estuary banks,
- Beautiful, unspoilt view.

Much of the income of Groot Brak residents is made from people visiting the area to enjoy the services provided by the estuary. During the past ten years the Groot Brak has had an average of 35 000 tourists per year (Grimbeek, 2002).

The development of the Wolwedans Dam on the Groot Brak River has reduced the services provided by the estuary to the public. A direct effect of the erection of the Wolwedans Dam was the closure of the Groot Brak River mouth for long periods. This river mouth closure has led to:

- Build-up of mud banks and sedimentation
- More smells and polluted, stagnant water
- Less recreational space
- Less fish and birdlife
- Less area for boat sports
- Less appeal for swimming and walking
- Increased potential for flooding
- Deterioration of the visual beauty of the estuarine area.

Water has been allowed to flow out of the Wolwedans Dam periodically in an attempt to restore some of the ecosystem services of the Groot Brak Estuary, but these releases seem to have had little structural benefit. The rapid rate of economic development along the estuary banks has been a complicating factor (Huizinga and van Niekerk, 1999).

6.2.2 The specified change and WTP question

The services yielded by the Groot Brak Estuary depend on there being a healthy inflow of freshwater, but with the building of the Wolwedans Dam this inflow has been undermined. It was against this background that people in the area were asked what they are willing to pay for a project to prevent a further reduction of freshwater inflow into the estuary.

Respondents were asked what they were willing to pay, in the form of a levy, for a project to prevent a 27% reduction in freshwater inflow to the Groot Brak Estuary. Respondents were informed that failure to prevent this reduction in freshwater inflow would result in one of two scenarios. A pessimistic scenario was:

- A possible increase in size for boat use (due to the damming of the water at the mouth).
- Mouth closure.
- A 100% reduction in the bait and bird population.
- A 100% reduction in fish population.
- Increased potential for entrapment of pollutants.

- Increases in reed growth.
- A build up of mud banks spoiling the view and leading to less flood protection.

An optimistic scenario was similar except for:

- A 80% reduction in bait and bird population.
- A 80% reduction in fish population.

6.2.3 Determination of target population and sample population

The Groot Brak/Klein Brak municipal area has a population of 10 687 residents (Table 6.5) of which approximately 70% (approximately 7 500 residents) live in the Groot Brak area (Gouws, 2002).

Table 6.5: Groot Brak residents within 10km of the Groot Brak Estuary

Population group (race)	Population figure
Black	417
Coloured	3 583
White	3 500
Total	7 500

Source: Davids (2002); Proportions of different races provided by Gouws (2002)

The following information was generated in a preliminary study to estimate the target population.

- The commercial user target population group for the Groot Brak Estuary was made up of people using the estuary for subsistence purposes, developers building houses due to high economic returns attained for property in close proximity to the estuary, businesses on estuary banks (restaurants, coffee shops, accommodation), businesses using the estuary (rental boats, windsurfing, fishing, caravan park), employees of businesses that also derive an income from the estuary and tour guides and other non-resident business users.
- The commercial/subsistence users were made up of 300 subsistence users (using estuary for food) and 600 "pure" commercial users (owners, family and workers). (Gouws, 2002).
- There were 1 800 people deriving a benefit due to close proximity. About 40% of the white population of Groot Brak have built homes along the banks of the estuary and have close proximity and good access to the estuary and about 10% of other population groups have homes that provide close proximity to the estuary.
- Opinions varied as to how many residents who did not have close proximity use the Groot Brak Estuary purely for recreation. Estimates range from 20% (Grimbeek, 2002) to 10% (Gouws, 2002). The higher figure (20%) yields 1 500 users. Approximately 300

of these users are accounted for in the commercial category (Gouws, 2002). This figure therefore is reduced to 1 200 users. Approximately 40% of these 1 200 users have close proximity to the estuary (Gouws, 2002), so the final figure representing resident recreation users (excluding users with close proximity to, or commercial income from the estuary) for the Groot Brak Estuary, was thought to be 720 people.

- It is estimated that 7 000 tourists use the estuary for recreational purposes each year (Grimbeek, 2002).
- Groot Brak is not as popular a tourist destination as Knysna, Mossel Bay and Hartenbos nearby, but tourism in the area is growing due to good marketing of the Groot Brak area. Interest in visiting the estuary is expected to develop over time due to the growing knowledge of the services the Groot Brak can provide to people seeking an affordable holiday destination (Grimbeek, 2002).
- The non-user population was guessed to be trivial, due to the absence of unique features of the Groot Brak Estuary.

Research into the size of the target population of people with a demand for services of the Groot Brak Estuary led to the conclusions shown in Table 6.6.

Table 6.6: Estimates of the users per annum population: Groot Brak Estuary

User group description (mutually exclusive)	Number of visitors per annum		Number of visitor days per annum	
	Resident	Tourist	Resident	Tourist
(1) Recreation	2 520	7 000	80	5
Boat sports – (30% and 20%)	302	980		
Swimmers – (10% and 10%)	454	1 400		
Anglers and baiters – (20% and 15%)	580	980		
Birders (4% and 2,5%)	50	140		
Proximity/view (36% and 52,5%)	1 134	3 500		
(2) Commercial/subsistence	900	0		
(a) Subsistence-people living off direct consumption	300	0	200	
(b) Sale of outputs/services of estuary	600	0	280	

Source: Gouws (2002); Grimbeek (2002)

It was estimated that in 2002:

- 227 households of residents (900 people in households of 3,96 members (Davids, 2002)) would use the Groot Brak estuary for commercial/subsistence reasons
- 1 867 households of tourists (7 000 people in households of 3,75 members (Gouws, 2002)) would use the Groot Brak estuary for recreation

- 636 households of residents (2 000 people in households of 3,96 members (Davids, 2002)) would use the Groot Brak estuary for recreation.

The estimated total number of households making up the target population of Groot Brak estuary users in 2002 was 2 730 (227 + 1 867 + 636). Of this population about 5% was targeted for interviewing. In the end a bit more than 5% were interviewed (see Chapter 5 for details). There were 151 questionnaires administered during the survey. The recommended proportions per user group for administering the 151 questionnaires and actual numbers administered are shown in Tables 6.7 and 6.8.

Table 6.7: Guideline proportions for questionnaire administration: Groot Brak Estuary

Recreational users	%
(a) Boat sports	12
(b) Swimmers	17
(c) Anglers and bait collectors	14
(d) Birders	2
(e) Proximity/view	42
Commercial users	
(a) Subsistence – living off direct consumption	3
(b) Commercial – sale of outputs/services of estuary	6
Non-users	5

Notes: 1 The number of questionnaires administered to commercial and subsistence users was adjusted upwards to allow for higher frequency of use (see Table 6.6).

Table 6.8: Actual number of user types selected to answer questionnaires: Groot Brak Estuary

Recreational users – 124 questionnaires, assigned as follows:	Number
(a) Boat sports	16
(b) Swimmers	31
(c) Anglers and bait collectors	24
Birders	2
Proximity/view	51
Commercial users – 16 questionnaires, assigned as follows:	
(a) Subsistence – living off direct consumption	4
(b) Commercial – living off direct consumption	12
Non-users	11

6.2.4 Impressions gained and comments made during the administration of the questionnaires

- The aspects affecting scenario, payment vehicle, levies, follow-up questions, race and gender were expected to be similar to the Knysna study.
- Visitors to the Groot Brak/Klein Brak Estuary seemed to have a lower WTP than the Knysna Estuary.
- Protest bids were expected to show similar tendencies to the Knysna Estuary.

- The Klein Brak Estuary area seemed to have a higher usage rating for activities and attributes than did the Groot Brak Estuary, except for picnics. The Klein Brak area does not provide picnic facilities.
- Many respondents considered walking and cycling as important estuary "usages" in the Groot Brak and Klein Brak areas.
- The rating respondents attached to different estuary uses, activities and attributes seemed to be related to the WTP.
- The higher the approximate worth of respondents' vehicles and boats, and annual pre-tax incomes were, the higher WTP seemed to be.
- WTP seemed to increase the closer respondents resided to estuaries.
- Schooling level did not seem to influence WTP.
- The final open question was useful in identifying external factors affecting answers provided by respondents.
- It was not expected that non-user demand for either the Groot or Klein Brak Estuaries would be significant due to the availability of many substitutes in the area.
- Respondents felt that the Klein Brak Estuary was better preserved and managed than the Groot Brak Estuary.
- There were many advantages that the Klein Brak Estuary was thought to have over the Groot Brak Estuary, namely the cleanliness of the water, the availability of fish and bait and the constant inflow of freshwater.
- Respondents seem to blame the construction of the Wolwedans Dam for a reduced inflow of freshwater into the Groot Brak Estuary. The reduced freshwater inflow was blamed for the creation of stagnant water, closing the river mouth, killing off fish and bait, causing terrible pollution, smells and exposing mud banks – an "eyesore" for any user of the Groot Brak Estuary.
- Groot Brak seemed to be more highly rated with regard to boat sports. This may be as a direct result of it having better launching facilities than the Klein Brak.
- The availability of rental boats, canoes and windsurfers make Groot Brak a more "fun" estuary to visit as far as activities are concerned.
- Even though the number of respondents chosen to represent subsistence users was low, it was evident that subsistence users were using the Klein Brak for fishing as a substitute for Groot Brak due to the negative effects of the Wolwedans Dam on fish populations in the Groot Brak.
- Proximity values for Groot Brak seemed higher than Klein Brak due to there being more recreational facilities and more businesses, sports facilities, mountain trails, bird watching tours and restaurants.
- The Groot Brak Estuary has more points of access than does the Klein Brak Estuary and these access points are of higher quality.

It was expected that the WTP for a water inflow project into the Groot Brak would yield a higher WTP than one for the Klein Brak because the population of Groot Brak appeared to be feeling the effects of a degraded estuary and sought to conserve the estuary. The services provided by the Groot Brak and Klein Brak Estuaries show definite differences. It seems that before the Wolwedans Dam was built, both estuaries provided similar services to users, but since the building of the Wolwedans Dam and badly managed economic development, the Groot Brak area surrounding the estuary has lost much of its appeal and use value.

6.3 Klein Brak

6.3.1 Physical description and uses

The Klein Brak Estuary is located 8km west of Groot Brak (see Figure 6.7). There are fewer recreation facilities and access points to the Klein Brak estuary than there are to the Groot Brak estuary (Grimbeek, 2002). The access points that do exist are in poor condition and difficult to reach by road. The area adjacent to the estuary supports various agricultural activities, including cropping, grazing and various recreational activities. It is a popular area for residential development and people use the estuary for swimming, fishing, boating activities and quiet walks along the riverbanks. On the other hand, the Klein Brak Estuary has a great advantage over the Groot Brak Estuary in that it has not suffered the degradation of the Groot Brak Estuary caused by mouth closure and freshwater abstraction.

Except for periods of drought or exceptionally low tide, the Klein Brak River mouth (see Figure 6.9) remains open throughout the year. The Klein Brak Estuary is a tidal estuary with the tidal differences of 0,5 to 1,5m. The current area at neap high tide is about 96 ha. Of this area at least 40% is usable for boating and various water sport activities. This estuary has a potential average per annum freshwater inflow of 31,56 million m^3 (excluding abstraction). Only about 1,3 million m^3 of freshwater inflow is lost annually – all due to alien vegetation growth (DWAF, 2002c).

Figure 6.7: Klein Brak River mouth

Source: Wooldridge (2003)

Characteristics that make the Klein Brak Estuary popular for public use are similar to those of the Groot Brak Estuary. Unlike the Groot Brak Estuary, the inflow of freshwater into the Klein Brak Estuary has not been severely reduced. For this reason the services of the Klein Brak Estuary have not been negatively affected. The Klein Brak Estuary also has had less economic development than the Groot Brak Estuary along its banks.

6.3.2 The specified change and WTP question

The Klein Brak Estuary is dependent on the supply of freshwater to provide services to the public. Freshwater inflow figures (see Section 6.3.1) show that the Klein Brak Estuary is not currently losing much of its freshwater inflow (DWAF, 2002c), but increased demand for freshwater is starting to occur due to economic development in the area.

The Klein Brak Estuary users were asked what they were willing to pay (in the form of a levy) for a project to prevent a 37% reduction of freshwater inflow to the Klein Brak Estuary. It was explained to respondents that failure to prevent this reduction would result in one of two scenarios. The pessimistic scenario would yield results similar to those reported for the Groot Brak Estuary (see Section 6.2.2). The optimistic scenario would be similar except for the following:

- A 40% reduction in bait and bird population,

- A 40% reduction in fish population.

6.3.3 Determination of target population and the sample population

Of the Groot Brak/Klein Brak population of 10 687 residents (Davids, 2002) approximately 3 500 live in the Klein Brak area (Gouws, 2002). The average family size for the Groot and Klein Brak area is 3,96 and the various population groups are made up as shown in Table 6.9.

Table 6.9: Klein Brak residents within 10km of the Klein Brak Estuary

Population group (race)	Population figure
Black	250
Coloured	1 500
White	1 750
Total	3 500

Source: Davids (2002)

The population of the Klein Brak area has a relatively low average income. This fact, coupled with high unemployment in the area, make the Klein Brak a popular estuary for subsistence purposes. The Klein Brak accommodates approximately 15 000 tourists per annum (Grimbeek, 2002). Despite having fewer points of access, many tourists prefer the Klein Brak Estuary to the Groot Brak Estuary because recreation activities such as swimming, fishing, water sport and boating are more enjoyable in the relatively unspoilt Klein Brak Estuary.

Background research into the target population of users of the services of the Klein Brak Estuary yielded the following information:

- Approximately 20% of Klein Brak residents use the Klein Brak Estuary at some time during the year for recreation (Gouws, 2002; Grimbeek, 2002).
- The commercial user target population group for the Klein Brak Estuary is made up of similar users to Groot Brak. The population sums to about 350 people (Gouws, 2002). Of these people, 250 use the estuary for subsistence purposes, and 100 use the estuary for commercial purposes (Gouws, 2002).
- It is estimated that 30% (525) *white* residents of the Klein Brak area have built homes within close proximity to the estuary while 15% (263 people) of other population groups have close proximity to the estuary (Gouws, 2002). This makes up a total of 788 people who are proximity users.
- A disparity exists between figures provided by Gouws (2002) and Grimbeek (2002) as to how many people use the estuary purely for recreation (excluding users within close proximity). It was estimated that there were 360 recreation users excluding those in close proximity (another 340 people) and 100 people who were both commercial and recreation users.

- There were also about 3 000 tourists who use the estuary annually (Grimbeek, 2002).

This information was used to estimate the target population and numbers of the different user types in the area of the Klein Brak Estuary (see Table 6.10).

Table 6.10: Estimates of the per annum visitor population of the Klein Brak Estuary

User group description (mutually exclusive)	Number of visitors per annum		Number of visitor days per annum	
	Resident	Tourist	Resident	Tourist
(1) Recreation	1 148	3 000	100	5
(a) Boat sports – (14% and 10%)	160	300		
(b) Swimmers – (21% and 25%)	240	750		
(d) Anglers and baiters – (26% and 20%)	300	600		
(e) Birders (1% and 1%)	11	30		
(f) Proximity/view (38% and 44%)	437	1 320		
(2) Commercial/subsistence	350	0		
(a) Subsistence – people living off direct consumption	250	0	200	
(b) Sale of outputs/services of estuary	100	0	280	

Source: Gouws (2002); Grimbeek (2002)

It was estimated that in 2002:

- 88 households of residents (350 people in households of 3,96 members (Davids, 2002)) would use the Klein Brak estuary for commercial/subsistence reasons
- 800 households of tourists (3 000 people in households of 3,75 members (Gouws, 2002)) would use the Klein Brak estuary for recreation
- 290 households of residents (1 148 people in households of 3,96 members (Davids, 2002)) would use the Klein Brak estuary for recreation.

The estimated total number of households making up the target population of Klein Brak estuary users in 2002 was 1 178 (88 + 800 + 290). Of this population about 5% was targeted for interviewing. In the end more than 5% were interviewed (see Chapter 5 for details). There were 101 questionnaires administered during the survey. The recommended proportions per user group for administering the 151 questionnaires and actual numbers administered are shown in Tables 6.11 and 6.12.

Table 6.11: Guideline proportions for questionnaire administration: Klein Brak Estuary

Recreational users – 88 questionnaires, assigned as follows:	%
(a) Boat sports	10
(b) Swimmers	21
(c) Anglers and bait collectors	19
(d) Birders	1
(e) Proximity/view	47
Commercial users – 8 questionnaires, assigned as follows:	
(a) Subsistence – living off direct consumption	5
(b) Commercial – sale of outputs/services of estuary	3
Non-users	4

Notes: 1 The number of questionnaires administered to commercial and subsistence users was adjusted upwards to allow for higher frequency of use (see Table 6.10).

Table 6.12: Actual number of user types selected to answer questionnaires: Klein Brak Estuary

Recreational users – 79 questionnaires, assigned as follows:	Number
(a) Boat sports	8
(b) Swimmers	18
(c) Anglers and bait collectors	19
Birders	2
Proximity/view	32
Commercial users – 14 questionnaires, assigned as follows:	
(a) Subsistence – living off direct consumption	4
(b) Commercial – living off direct consumption	10
Non-users	8

The qualitative aspects affecting the survey at Klein Brak are included in Section 6.2.4 relating to the Groot Brak Estuary.

6.4 Kromme Estuary

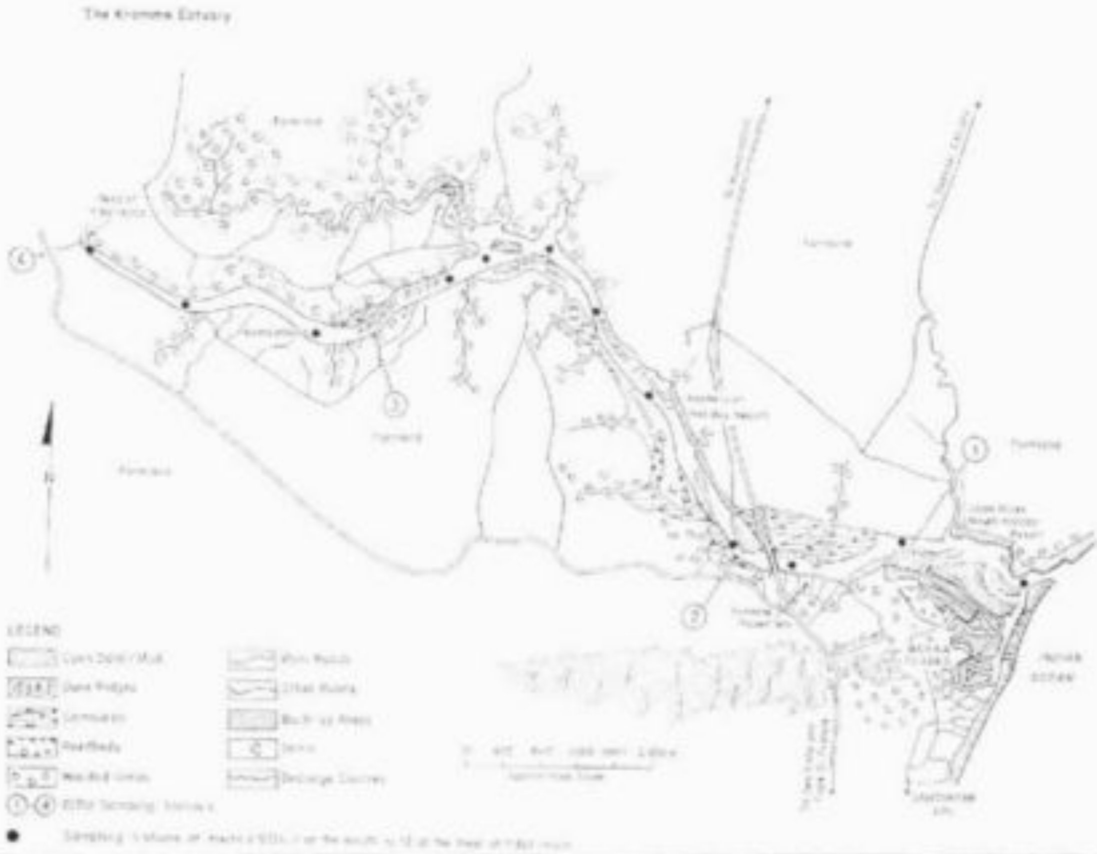

Figure 6.8 Map of the Kromme Estuary

Source: Heydorn and Grindley (1982)

6.4.1 Physical description and uses

The estuary of the Kromme River opens into St Francis Bay (Indian Ocean) at 34°08'S, 24°51'E (see Figure 6.8). The estuary is located approximately 55km west of Port Elizabeth, in the Eastern Cape and is classified as a permanently open estuary. It is one of the larger estuaries found in the Eastern Cape and has a relatively undisturbed catchment area (Heymans, 1992). Its abiotic features are described below.

<u>Climate</u>

Rainfall occurs throughout the year in the areas surrounding the Kromme River. Annual rainfall varies between 700mm and 1 200mm (Baird, 1992).

<u>Area of the river catchment</u>

The area of the river catchment is between 936km² (Baird, 1992) and 1 085km² (Day, 1981).

Geology

The sediment yield of the Kromme River is small and consists of mud weathered from Bokkeveld slates (Reddering and Esterhysen, 1983). The sediment input is reduced due to the ability of its quartzitic source to resist weathering and erosion. The middle reaches of the river meander through hilly foreland south of the Kouga Mountains near Humansdorp. This foreland consists mainly of soft overlying sandstone and shale of the Bokkeveld Group as well as friable sandstone and quartzite from the Table Mountain Group.

River length

The total length of the Kromme River is approximately 95km.

Land ownership and catchment users

Minimal industrial activity occurs in the catchment or in the estuary floodplain (Baird, 1992). The estuary is considered to be one of the few relatively pristine systems in the country. Small agricultural and urban settlements are found in the catchment area. The catchment area comprises of 11,73km² of natural forest, 79,6km² of fynbos and private farmland, on which the main activities are stock raising and grain cultivation (Heymans, 1992). A marina's canal system was constructed in a marshy area at the estuary mouth. It was excavated for the construction of these canals. The canal system has since undergone numerous expansions in order to accommodate the construction of more houses.

Obstructions

Two major dams have been constructed in the catchment area of the Kromme Estuary, namely the Churchill Dam, completed in 1943 and the CW Malan Dam, completed in 1982. The Churchill Dam supplies water to the Port Elizabeth area and has a holding capacity of 33 000 000m³ (Heymans, 1992). Numerous small dams are also situated on the tributaries of the Kromme River. These restrict the water flow. Other obstructions include several minor crossings in the catchment as well as the N2 national road.

Run-off and flow records

The annual flow in the Kromme River is erratic, with floods occasionally occurring between March and October (Bickerton and Pierce, 1988). Estimates of the MAR figures in million m³ vary, for example, 123 (Adams, 1991), 105,5 (Reddering and Esterhuysen, 1983) and 116,8

(Bickerton and Pierce, 1988). The high MAR is due too the geomorphological characteristics of the catchment, namely the high relief, rocky slopes and sparse vegetation. As previously stated, the two dams have severely reduced freshwater input into the estuary (Baird, 1992). The dams have the combined capacity of storing approximately 133% of the MAR of the Kromme River catchment (Baird, 1992). Freshwater inflow into the Kromme Estuary is irregular and relatively low with a mean annual inflow rate of about 11 000m³. The system is starved of freshwater (Baird, 1992).

Hydrological impact of alien plant infestations

In a preliminary assessment of alien invading plants and water resources in South Africa by Chapman, le Maitre and Versveld (1998), it was found that plant species invading Eastern Cape estuaries included *Hakea*, *Pinus spp*, *Acacia dealbata*, *Acacia melanoxylon* and *Eucalyptus spp*, with *Acacia mearnsii* being the worst invader. They found 6,50% of the catchment area of the Kromme River system to have been invaded. This invasion reduces annual water runoff by about 27,90 million m³ per annum (Chapman *et al*, 1998).

General description of the Kromme Estuary

The Kromme River rises in the forests of the Tsitsikamma Mountains. Its main tributary is the Dwars River. The water is clear and of good quality. The flow into the estuary is controlled by the sluice gates of the Churchill Dam. These gates are generally closed in summer (Day, 1981).

The Kromme River Estuary is approximately 14km long and has a surface area of 3km² and has an average depth of 3m (Baird, 2001). Damming of the river has decreased the scouring effect of floods (Heymans, 1992). As a result there has been sediment accumulation in the lower reaches of the estuary. Added to this, a large sand-spit of approximately half a kilometre long has been raised and vegetated in order to provide protection to the marina against strong south-easterly gales.

The seasonal temperature range varies between 14°-24° (Day, 1981). Due to the fact that the sluice gates of the Churchill Dam are closed in summer, salinity values often rise to above 35 parts per thousand in parts of the estuary. The normal salinity values vary from about 20 to 33 parts per thousand in the middle reaches to about 35 parts per thousand near the mouth (Day, 1981).

The Kromme River Estuary is a marine dominated one, with a rich fauna and flora. The Kromme River Estuary is the main recreational asset of the town of St Francis Bay. Services provided by the estuary are mainly of a recreational nature. The estuary has been extended to include a marina. Recreational activities on the estuary include fishing, birding, bait collection, waterskiing, canoeing, boat cruisers, hiking and swimming.

6.4.2 The specified change

Prof T Wooldridge of the University of Port Elizabeth set the changes to the estuary that were to be valued. The respondents were informed that an increase of 812% of current freshwater inflow into the Kromme Estuary would be expected to have consequences of the following magnitudes:

For boaters:	No change in estuary services would occur.
For swimmers:	No change in estuary services would occur.
For anglers/bait collectors:	A 25% increase of angling fish that use the estuary.
	A 25% increase in the availability of mud prawn.
For birders:	A 25% increase of foraging birds in the inter-tidal areas.
From the perspective of view:	No change in estuary services.
From the perspective of the world generally:	No change.

From the above, it is clear that anglers, bait collectors and birders would be expected to be most concerned with changes to the Kromme Estuary brought about by increased inflow. The respondents were asked what they would be willing to pay to bring fund a project to supply the specified increase of water to the estuary.

6.4.3 Determination of target population and sample

The local tourist authority estimated the per annum population of users to be about 18 000. It was postulated that there existed no non-users because the estuary lacked special marine features.

Users were broken down into three main categories: recreation, commercial/subsistence and non-users. Recreational users were asked for which type of use they mainly valued the estuary: boating, swimming, fishing/bait collecting, bird watching or aesthetic appeal. The majority were multi-users of the estuary. A total of 150 respondents were interviewed. Assuming six-person households, this amounted to 5% of the target population estimated through a preliminary study.

6.4.4 Comments on qualitative aspects of the responses

Mr Dods Blom, who was trained by Dr Mario du Preez of the University of Port Elizabeth, administered the survey. Mr Blom reported that the majority of respondents were interested in the study being carried out. He also found that complex scenarios had to be fully explained to the respondents, as many possessed little or no knowledge of impact of changes to the estuary induced by changes in freshwater inflow.

6.5 Kowie Estuary

Figure 6.9 Map of the Kowie Estuary

Source: Heydorn and Grindley (1982)

6.5.1 Physical description and uses

The estuary of the Kowie River opens to the Indian Ocean at 33°36'S, 26°54'E (see Figure 6.9), and is found midway between East London and Port Elizabeth. The lower reaches of the estuary are located within the town of Port Alfred. Distances to the nearest towns, namely

Port Elizabeth, East London and Grahamstown, are 160km, 140km and 58km, respectively (Zwamborn, 1980). The Kowie Estuary is located on the coastal section of the N2 national road. Access to the estuary by road is good from both sides. There are approximately 25 public points of access. Another estuary with similar characteristics is that of the Fish River. It is approximately 15km away, by road. The closest residential area is located on the estuary.

Abiotic features

The climate of the Kowie Estuary is temperate. Most of the rainfall occurs in spring and autumn. The mean annual precipitation of 650mm is distributed evenly over the catchment area (Heydorn and Grindley, 1982). Moderate droughts and floods are a relatively common occurrence (Day, 1981). The catchment area of the Kowie River is between 576km² (Day 1981) and 769km² in size (Noble and Hemens, 1978).

A large part of the Kowie River lies within a strip of the Bokkeveld Series. The Bokkeveld Series consists of shale and subsidiary sandstone bands. The quarries and cuttings of Port Alfred show pronounced dipping and folding. The Alexandria Formation can be found along the coast, overlying and resting on the shale. The Alexandria Formation is a succession of thin, marine sediments. Resting on top of this Alexandria Formation is dune rock. The characteristic layers one finds in this formation provide evidence that the origin of the dune rock is windblown (Heydorn and Grindley, 1982).

The length of the Kowie River from the mouth to the source is approximately 70km. The last 21km of the river, leading into the Indian Ocean, is tidal and is regarded as estuarine (Kowie Estuary Management Plan, 1999). The major part of the Kowie River catchment is made up of privately owned farms. The main agricultural activities of the region focus on the production of pineapples, chicory, citrus, fodder crops, beef cattle and goats.

Many activities are associated with the Kowie Estuary. The estuary is used as a harbour for commercial fishing boats, recreational boats and yachts. The recreational activities that take place in the estuary include fishing, sailing, skiing and jet skiing. Subsistence fishing also occurs in the estuary (Kowie Estuary Management Plan, 1999). The steep slopes along the river are covered with indigenous vegetation. The main crop cultivation takes place on the level parts of the floodplain, mostly where the river bends.

The estuary provides 21km of navigable water and is mainly used for recreation. The registering of boats is essential and a full-time river control officer enforces regulations. Due to the fact that recreational activities, such as skiing and fishing, are not fully compatible, the river is zoned for different uses. Well-situated, visible signs are utilised to ensure accidents are kept to a minimum. The lower reaches of the estuary have many salt marshes and mudflats. These have been semi-developed and used for recreational purposes. An excellent example of this semi-development is a fully tidal lagoon, formally known as Little Beach, now known as Kid's Beach, which is used by families with young children.

Obstructions

Many small bridges cross the Kowie River in the upper catchment area, but none of these structures obstruct the tidal flow of the river (Heydorn and Grindley, 1982). According to Day (1981), however, the stone beams that contain and concentrate the tidal and river flow of the Kowie Estuary form a major hindrance to the natural configuration of the estuary and this has led to a general impoverishment of the system (Heydorn and Grindley, 1982). Certain sections of the river banks are lined with stonewall and due to the constant collapse and erosion of these walls, continual repair is necessary (Heydorn and Grindley, 1982).

Many private waterfront homes are situated along the lower reaches of the estuary, particularly along the western bank. These homes often have jetties and slipways protruding into the main channel. These jetties, together with larger boats moored midstream, obstruct and limit the utilisation of the main channel (Heydorn and Grindley, 1982).

Over time, the mouth and lower reaches of the estuary have been significantly developed and altered. During the last century the mouth of the estuary was canalised and infrastructural and residential development has taken place in and around the lower reaches of the estuary. A marina has been established on the east side of the estuary, close to the mouth (Kowie Estuary Management Plan, 1999).

Runoff and flow records

The annual flow of most rivers in the Eastern Cape is irregular (Heydorn and Grindley, 1982). Although the Kowie River is considered to be perennial, the river flow can come to a halt for 2 to 3 months during drought conditions. The flow of the river is very unreliable and rain in the catchment does not necessarily result in river flow. The Kowie River has a very swift run down period resulting in a high flow for a very short duration (Heydorn and Grindley, 1982). A number of estimates have been made of the MAR, in million m^3. They range between 17 and 23,6 million m^3 (Noble and Hemens, 1978).

Hydrological impact of alien plant infestations

The water resources of South Africa are extremely vulnerable to alien invading plants (Chapman *et al*, 1998). Plant biomass of a specific invader must be known in order to generate a correct estimate of the stream flow reduction caused by the alien vegetation. Chapman *et al* (1998) found the catchment area of the Kowie and Riet River system to have an area of 23 263 ha (20,12% of 115 623 ha) invaded. This causes runoff losses amounting to 24 million m^3 per annum (Chapman *et al*, 1998).

Description of the Kowie Estuary

The Kowie estuary system can be divided into three categories, namely the upper reaches, the middle reaches and the final 3km to the mouth (Day, 1981). The upper reaches, which are 13km long, 50 to 90m wide and 2 to 6m deep, have steep, rocky banks 1 to 3m high. Due to the steep banks the inter-tidal zone is only 3 to 10m wide. The tidal range at spring tide is 1,1m and currents vary from 12 to $20m^3$ per sec. The middle reaches wind through a broad valley 3km long. The estuary here ranges from 100 to150m wide and is approximately 3m deep with rough troughs of up to 8m on bends. The floor is mainly sandy. The maximum tidal range is 1,5m with currents of up to $12m^3$ sec. The final 3km leads to the mouth. Prior to 1890 this was dredged, straightened and stabilised by stony embankments. A breakwater 75m apart guards the mouth. Here the sandy bottom is approximately 3m deep. The spring tide range is 1,7m and the currents are up to $25m^3$ per sec.

Sedimentation

The two piers, which extend out through the surf zone, have had a dramatic effect on the normal pattern of sediment drift at Port Alfred (Heydorn and Grindley, 1982).

According to the Kowie Estuary Management Plan (1999), one of the main problems experienced in the estuary is the deposition and accumulation of sediment. This has been found to negatively interfere with the boating activities that take place on the river (Kowie Estuary Management Plan, 1999).

Temperatures

According to Day (1981), the seasonal temperatures range at the mouth is 14 to 22°C, while in the upper reaches it is 11 to 27°C.

Salinity

Salinity is usually around 30 parts per thousand. However, in dry periods, some areas of the estuary may increase to above 40 parts per thousand and during times of heavy rains the surface of the estuary may even have zero salinity (Day, 1981).

6.5.1.1 Biotic characteristics

The Kowie Estuary supports a vast range of flora and fauna. The flora includes phytoplankton (microscopic plants drifting in plankton), algae, aquatic vegetation, semi-aquatic vegetation and terrestrial vegetation. The fauna includes zooplanktons (minute animals drifting in the water), aquatic invertebrates, fish, reptiles and amphibians, birds and mammals (Heydorn and Grindley, 1982). A brief description of each is provided below.

Flora

Phytoplankton can be found in the Kowie Estuary (Day, 1981). Two main semi-aquatic vegetation-mapping units have been identified around the Kowie Estuary, namely *Juncus cactus/scirpus maritimus*, Red Swamp and tidal salt marshes (Heydorn and Grindley, 1982). Terrestrial vegetation around the Kowie Estuary includes Hummock, dune vegetation, warm temperate coastal forest, sub-succulent woodland, Acacia Karoo Bushdump and vegetation complex between coastal woodland and forest scrub (Heydorn and Grindley, 1982).

Fauna

A total of 39 species of zooplankton have been recorded in the Kowie Estuary (Grindley, 1976). They provide a valuable food source for fish. The main fish species include mullet, juvenile stumpnose, and shoals of steenbras. Late in summer spotted grunter appear in the estuary. Resident species of the Kowie Estuary include gobies, silverside and cob (Heydorn and Grindley, 1982).

There also are a vast number of species of shrimps and prawns (Day, 1981). A total of 11 species of frog, 20 species of snail and four species of tortoise have been recorded in the area (Heydorn and Grindley, 1982). The Kowie Estuary also provides an ideal habitat for water birds, due to the mudflats and marsh areas (Heydorn and Grindley, 1982). It supports 93 species of bird, including 35 species of waders. The remaining 58 species are found along the upper reaches of the Kowie River (Heydorn and Grindley, 1982).

Services provided by the Kowie Estuary

The Kowie Estuary provides many important environmental, social and economic services. These can be grouped as follows: agriculture, industry, formal residential, informal residential, resource harvesting, recreation and tourism and nature conservation (See Table 6.13).

Table 6.13: Assessment of estuarine services: The estuarine services provided by the Kowie Estuary

Estuarine services	Score	Comment/details
Agriculture		
Dryland crops	0	
Irrigated crops	0	
Domestic livestock grazing	2	Cattle farming takes place on both banks in the upper reaches
Wild livestock grazing	2	Bushbuck are often observed along the banks (middle and upper reaches)
Industry		
Buildings and infrastructure	3	Shops, restaurants and other industries have infrastructure on the estuary (lower reaches)
Transport infrastructure	3	The R72 road bridge and the Putt Road bridge are heavily utilised by commercial and local traffic
Solid and/or liquid effluent	1	Effluent from various industries has been reduced
Mining (extractions)	0	
Formal residential		
Buildings	3	Houses surround the entire lower reaches and portions of the middle reaches
Other infrastructure	3	Jetties, slipways and landscaped gardens infringe on the banks of the lower and middle reaches
Solid and/or liquid effluent	3	Storm water drains and septic tank overflows enter the estuary at several points
Informal residential		
Buildings	0	
Other infrastructure	0	
Solid and/or liquid effluent	1	Effluent from Station Hill enters the estuary at the Bay of Biscay and the Kowie quarry
Resource harvesting		
Recreational fishing	3	Mostly over holidays and weekends from boats and from the shore
Recreational bait collecting	2	Sand prawns and mud prawns are heavily utilised by anglers throughout the year
Subsistence fishing	1	Mostly at night and on weekends
Subsistence bait collecting	3	Heavy utilisation of mud prawns, which are sold to recreational anglers
Commercial activities	3	Enterprises such as canoe and booze cruise craft hire
Recreation and tourism		
Water skiing	3	Mostly over the Christmas holiday season and occasionally on weekends
Canoe and hiking trails	3	Canoeists are often observed even out of season including the organised Kowie Canoe Trail
Boat cruises	3	Year round. Tour groups and overseas visitors on a regular basis, and holiday makers seasonally
Nature appreciation	2	Bird watching and appreciation of the overall aesthetics
Organised sports	2	Annual events such as power boat races and intervarsity rowing attract many people to the area
Leisure activities	3	Swimming, windsurfing, rowing, sailing as well as occasional biathlons, triathlons and fishing competitions
Nature conservation		
Reserve areas	2	The Kowie Nature Reserve (WDC), Waters Meeting Reserve (DEAT) and the Mansfield Farm (Private)

Notes: (Scores: 0 = none/absent, 1 = present, 2 = important and 3 = very important)
Source: Cowley and Daniel (2001)

Table 6.13 shows the importance of the Kowie Estuary to the town of Port Alfred. Much of the industry in Port Alfred is dependent on the tourists attracted to the Kowie Estuary and there are many shops and restaurants established on the banks of the lower reaches. Many of the recreational and tourism activities in Port Alfred are based on the environmental services provided by the estuary such as water skiing, fishing and boating.

6.5.2 The specified change and WTP question

Prof T Wooldridge of the University of Port Elizabeth set the change that was to be valued. Respondents were informed that an increase of 56% of current freshwater inflow into the Kowie estuary would be expected to have consequences of the following magnitudes:

For boaters: No change in estuary services would occur.
For swimmers: No change in estuary services would occur.
For anglers/bait collectors: A 25% increase of angling fish that use the estuary.
A 25% increase in the availability of mud prawn.
For birders: A 25% increase of foraging birds in the inter-tidal areas.
From the perspective of view: No change in estuary services.
From the perspective of the world generally: No change.

It was believed that anglers, bait collectors and birders would be most affected by changes to the Kowie Estuary brought about by increased freshwater inflow. Respondents were asked what they were willing to pay for a project to supply the increase in water to the estuary.

6.5.3 Determination of target population and sample population

A preliminary estimate of the per annum population of users was 18 000. This estimate was made on the basis of estimates by local tourism authorities (Paterson, 2002). Subsequent investigation suggested that that this estimate was slightly low. According to Beverley Young (2003), of the local Port Alfred tourism authority, the per annum user population of the Kowie Estuary in 2002 was 19 406 (see Table 6.14).

Table 6.14: User population of the Kowie Estuary

User groups	Number of visitors per annum	
Recreation	**Resident**	**Tourist**
Boat sports	100	1 000
Swimmers	100	200
Anglers/bait collectors	150	800
Birders	15	1 000
Proximity/view	10 000	6 000
Commercial	21	0
Subsistence	20	0

Source: Young (2003)

It was deduced that there existed no non-users because the estuary had no special unique features. Users were broken down into three main categories: recreation, commercial/subsistence and non-users. Recreational users were in asked which type of activity they mainly engaged – boating, swimming, fishing/bait collecting, bird watching or aesthetic appeal. The majority of people were multi-users of the estuary. A total of 150 respondents were interviewed. Based on census estimates in the area, six-person households were assumed.

6.5.4 Comments on qualitative aspects of the responses

The survey was carried out in January 2003. The majority of respondents were polite and friendly, although a small fraction of aggressive and rude respondents were also encountered. No difficulties were encountered in locating suitable respondents. It was found that many respondents experienced a degree of sensitivity when the question of income was raised. Many respondents did not feel comfortable revealing their pre-tax income, even when informed of the anonymous nature of the questionnaire.

The surveyor felt that certain respondents may have inflated their pre-tax incomes. It was also found that many respondents, especially locals, felt that other issues regarding the Kowie estuary were of greater importance than the river inflow issue, for example the excessive sedimentation caused by the marina development. Many of the respondents selected appeared to be interested, but often not well informed about the water issues. Some of the interviews lasted over an hour as a result.

6.6 Swartkops

6.6.1 Background

The Swartkops River flows into the sea within the Nelson Mandela Metropole. The estuary it forms is a popular destination for residents of this coastal city. Figure 6.10 below shows an aerial view of the Swartkops Estuary whereas Figure 6.11 shows a street map of Swartkops.

Figure 6.10: The Swartkops River Estuary in Port Elizabeth

Source: Bate (2003)

Figure 6.11: Street map of the Swartkops area

Source: Map Studio (2000)

6.6.2 Physical description and uses

6.6.2.1 Physical description

The Swartkops River originates about 100km south east of Port Elizabeth, where the Groot Winterhoek mountain range serves as its main water catchment area. This catchment lies within the 30 000 ha Groendal Wilderness area. The Kwazunga River, flowing from the catchment area, pours its water into the Groendal Dam, which has a capacity of 11 662 megalitres. From this dam, the water flows down towards the sea for several kilometres, where it is joined by the Elands River and continues down as the Swartkops River, which finally flows into the sea, about 15km away from the Port Elizabeth city centre.

The estuary is tidal for about 16km, has a total inter-tidal and sub-tidal area of about 580 ha, and reaches a depth of about 3 to 4m in the channels. The estuary has the third largest area of salt marsh along the whole South African coastline and exhibits a wide variety of estuarine flora. Salt marshes cover an area of approximately 240 ha (Reddering and Esterhuysen, 1988). The river meanders over a floodplain that contains the Redhouse saltpans as well as the Chatty River Salt Works, the New Brighton Power Station pans and the modern Fishwater Flats sewage works (Turpie and Martin, 1998:2). The river mouth is permanently open and shows no sign of closure in the near future. Scientists have classified the estuary as permanently open and remark that it is "ecologically viable despite urban developments and floodplain modification" (Whitfield, 2000). The estuary is located in a warm temperate region and is considered to be in a fair condition. Its location is 33°57'S, 25°38'E. To make it possible for different modes of transport to traverse across the estuary, three large bridges have been constructed; one being the bridge on the Grahamstown N2 freeway, another being a bridge for trains leaving Port Elizabeth for Uitenhage or Johannesburg and a third bridge for road transport going towards Motherwell township. This infrastructure makes the estuary highly accessible through public roads.

Biotic features worth noting in the estuary include salt marshes, fish and bird species. There is a historic monument, the Settlers Steps, on the northern side of the estuary in Amsterdamhoek. The estuary banks are highly developed with human settlements and commercial enterprises. The area most used by visitors and the public in general is the Strand Road access. The other highly used area is the Amsterdamhoek side, where several houses have their own private jetties.

6.6.2.2 Permanent residents

There are four main residential areas bordering the Swartkops Estuary, namely Swartkops Village, Amsterdamhoek, Bluewater Bay and Redhouse. According to 1996 data, the total population of residential areas within a 10km radius from the estuary mouth is about 367 000 people (Davids, 2002). Other residential areas within a 10km radius of the estuary mouth include Wells Estate, Despatch, New Brighton, Kwazakhele and Zwide. There are also pockets of squatter settlements on the periphery of Swartkops Village, giving temporary shelter to bait diggers around the estuary. The age profile of the people living within a 10km radius of the estuary mouth shows a bias towards youth (see Figure 6.12 below).

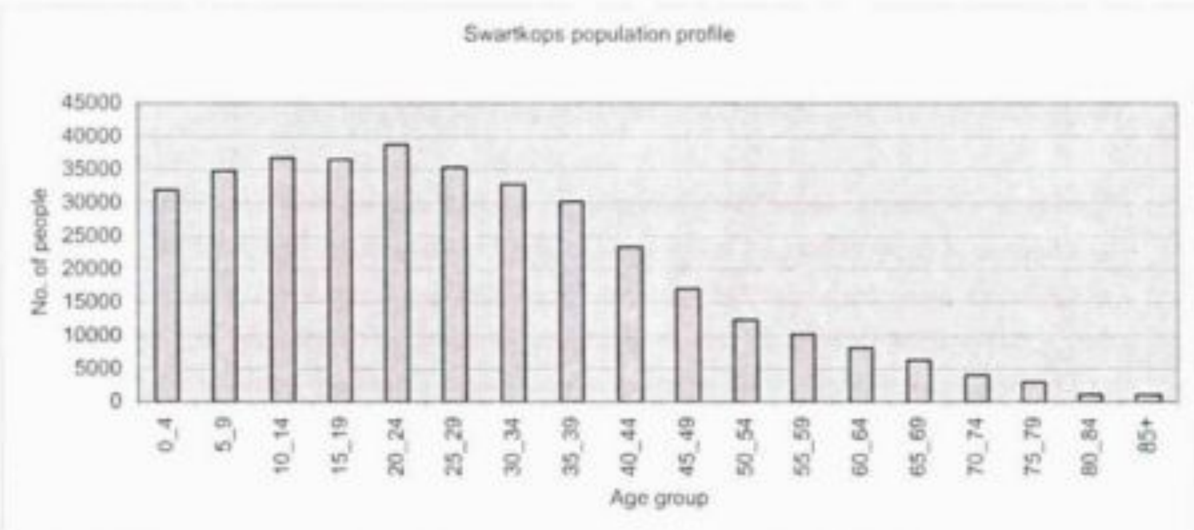

Figure 6.12: Population of residents living within 10km radius of the Swartkops River mouth

Source: Davids (2002)

6.6.2.3 Uses of the Swartkops Estuary

The estuary is used for recreational purposes throughout the year, including water sports competitions and team building activities. Other notable uses include subsistence bait collection, fishing and an array of commercial enterprises.

6.6.2.4 Recreational use

Fishing: Writing for a community publication called The Bay Window, a senior resident had this to say about the history of fishing in the estuary: "When I came to settle around this river in 1922, it was deep and strong and most fishing was done around Redhouse. What is now Amsterdamhoek and Bluewater Bay residential areas were just bush and the river water was right against the hill. There were two houses built on stilts, and these houses served as hunting lodges only. There was no road and one could only get to the houses by boat. There were no sand banks in the river and it was so deep that at one point it was surveyed with possibilities of turning it into a harbour. On the edges of the water were small inlets where we had to dig for our bait. There was no limit on the amount of bait one could dig and in half an hour one had all the bait one needed. The fishing was amazing and one caught as many fishes as one desired. And in those days there were no grunter fish in the estuary, but steenbras, cob, elf and leervis were the only fish species available. During beautiful days people would row to the mouth of the river and watch the shoals of fish coming into the river as the tide turned to come in. Many times it seemed the breakers had no water, as it was solid fish rolling into the river. These fish came into the river to feed and would spend months in the estuary before moving out to their next habitat" (The Bay Window, 2003:4). Today, fishing remains the most popular recreational activity at the Swartkops Estuary, and on a normal week day (not a weekend or holiday) one could expect to find about 25 people fishing on the estuary banks along Strand Road, and another 25 people fishing in the river from their boats. On frequent occasions cars continue to stop by the estuary for a short while, view the scenery and then drive off.

Of all the anglers interviewed none of them were doing it for a living, although most of those fishing for leisure were eating their catch. On arrival at Swartkops at peak times one sees anglers in every possible accessible place. There are two angling clubs at the estuary.

Boating: There are five slipways from which boats can be launched into the estuary. There also exists yachting, canoeing and angling clubs around the estuary. On a normal week day one is likely to see about 25 boats, of which over half will be angling. The boats can use about 25% of the estuary surface water. The leisure boat riders, unlike anglers, ride long distances around the estuary and often ride past the river mouth and straight into the sea. In addition, alleged poachers of abalone frequently prowl around the estuary, using it as a place of entry to the sea.

Viewing/proximity: There are numerous users who enjoy the spectacular views of the environment in and around the estuary. Unlike fishing, which is male dominated, there is a more even balance of gender among viewers. Families visit the estuary banks for outdoor meals, especially on weekends and holidays. During weekdays people working within a walking or driving distance frequent the estuary during lunch or tea breaks. Companies sometimes take their staff out there for functions, which include catching and braaiing fish. There are also a large number of strollers and joggers who use the estuary banks.

Bird watching: The Swartkops Estuary is also a popular bird watching site in the city. Some of the scenery viewers also enjoy the site of foraging and wading birds around the estuary. Elderly residents and pensioners appeared to be the ones with the biggest interest in birds around the estuary. In more inland parts of the estuary, for example Redhouse, there are more varieties of birds than closer to the river mouth.

Swimming: At the mouth of the Swartkops River, there is a sign prohibiting swimming around the river mouth. During hot days, however, parts of the river further away from the mouth are used for swimming, as the water levels are not too deep. Because swimming is viewed as dangerous in areas, due to boats and currents, it is discouraged in many areas around the estuary. Nevertheless, residents often swim in certain areas along the banks when it is hot. Compared with the numbers of anglers and viewers, the number of swimmers is lower.

Surfing: There is a popular surfing spot at the mouth of the Swartkops Estuary.

6.6.2.5 Subsistence use

Bait collectors: There are about 100 irregular bait collectors in the area, either coming from KwaZakhele, a nearby township, or from Wells Estate or informal settlements around the estuary. The bait diggers are mainly unskilled and uneducated African males who claim they earn a living out of digging bait to sell to anglers. Some of the bait collectors claim to have been doing the work for nearly 25 years. One digger, a Mr Raymond Johnson (2003), lives under the bridge with his wife and two children.

Residents around the estuary complain about the bait collectors, saying their numbers are growing rapidly, posing security problems. Residents said these collectors have sometimes pounced on unsuspecting environment users and robbed them of goods and money. An angler said regular people fishing at Swartkops usually used pilchards as bait, and not the mud or pencil prawns and the tapeworm sold by the bait collectors. It is generally felt that the bait collectors are fast degrading the environment as their digging methods damage prawn banks. When prawns are dug out from their natural habitat, the bait collectors are supposed to sell their whole stock as these die not long after removal from their natural environment. During a bad business day, and there are a number of those, bait collectors throw the prawns away into rubbish bins instead of throwing them back into the estuary water, which is a very environmentally unfriendly action. One female bait collector says if her stock is unsold she cooks it and eats it at home.

In an endeavour to control the bait diggers around the Swartkops Estuary, in December 2002 the Marine and Coastal Management organisation issued 64 subsistence diggers with temporary permits, stainless steel pumps and a set of rules by which to operate. The estuary management organisation said that each of the bait collectors would be issued with a vest displaying his or her number. This would help the control of not only the unlicensed collectors but also the compliance to the rules by the authorised subsistence bait collectors. Other future plans included proper bait distribution sites, the provision of refrigeration facilities and training courses.

Rules for the permitted bait collectors include the following: subsistence anglers need to keep their permit ready for inspection whenever in possession of bait and bait collected should be restricted to a maximum of 150 prawns (mud and sand combined), 60 pencil bait (limit is 20 if other bait has been collected), five tapeworm and five bloodworm. All bait is to be collected without the use of a spade or fork, except for Fridays when a fork will be allowed. All bait is to be collected between the hours of 06h00 and 15h00 Mondays to Saturdays, and no bait is to be collected on Sundays. The rules are not strictly enforced and are frequently ignored by the bait diggers. All fish caught by subsistence anglers are to conform to legal size and quantity and fish caught are for own consumption and not for resale.

Fishing: Subsistence anglers are often the same people digging and selling bait, and by so doing compete with numerous recreational anglers. The subsistence anglers usually do not have proper fishing equipment like rods and nets, and instead use a hand line – a length of twine that is tied with bait on one end and thrown into the water. By law, any fish caught by the subsistence anglers is for their own consumption and not to be sold. These rules are not strictly enforced and are largely ignored.

Security: Since fishing and bait collection is periodical the subsistence anglers use their extra time as security volunteers, patrolling the main estuary road and looking after cars and trailers parked by estuary users.

General assistance: When fishing and bait digging is slow, some subsistence users avail themselves as general assistants to visitors coming to the estuary. Assistance offered may include, off-loading equipment from vehicles, helping push boats from the slipway into the water, or helping pull the boats out of the water and connecting the boat to the trailers.

6.6.2.6 Commerce and industry use

As one approaches Swartkops Village from Deal Party, industrial activity within a five kilometre distance from the estuary include the following: Fishwater Flats, Port Elizabeth's biggest water reclamation works; Algorax, the producer of rubber fill used in the manufacture of tyres; Freight Dynamics truck depot, Spoornet's Swartkops Locomotive depot; Sasko, the bread and flour producer and a power station. There are several other industrial activities as one moves away from the estuary towards Deal Party, such as SAPPI, a big consumer of recycled water.

On arrival at the Swartkops Village town centre, one sees the normal grocery shops, bakery, hardware, garage, butchery, and an automated teller machine. An enterprise worth noting is the Corner Shop, which sells bait, rods, nets and other fishing or bait digging needs. On

Strand Road, on the edge of the estuary water, the following enterprises exist: The Rod Club; Hook & Reel Angling Club; boat registration offices; Bluewater Canoe Club; Fishing Net Repairs; Swartkops River Rides; squash courts and the Swartkops Yacht Club. The offices of the Directorate of Nature Conservation, Karoo sub-region, are also on Strand Road, facing the estuary. Another commercial enterprise largely dependent on the estuary is the Riverside Lodge, offering accommodation to visitors to the estuary coming from outside Port Elizabeth. Close to the estuary mouth on the Bluewater Bay side, there is a surfing club with a pub and a restaurant.

6.6.2.7 Non-users

No non-users (with an expected positive demand) were interviewed as it was unclear who would fit into such a category and where they would be found.

6.6.3 The specified change and WTP question

6.6.3.1 The specified change

The river inflow data used in this study was sourced from the Department of Water Affairs. The Swartkops River inflow is gauged at a gauging weir at Uitenhage Nivens Bridge. The river has a catchment area that is approximately 906km^2 in size.

The station records the day in a month that a peak inflow occurs for the first time. It also records the lowest flow in the month. The average annual freshwater inflow into the Swartkops Estuary without abstraction and runoff yield loss was estimated to be 78,63 millions of m^3, a figure calculated from the monthly inflow data in Table 6.15. Abstraction and runoff yield loss of the river inflow due to agriculture, urban use, forestry and alien plant invasion was calculated to be 33,08 million m^3. Subtracting this figure from the MAR (the 78,63 millions of m^3) the current annual inflow into the estuary was found to be 45,55 million m^3.

As the current annual inflow is 57% of the MAR, users of the estuary were asked their WTP for a project to prevent a 30% decrease of the water inflow into the estuary, that is, a willingness to prevent a reduction from 57% to 40% of the MAR flowing into the estuary - a reduction of 13,5 million m^3 of water.

Table 6.15 below gives monthly volumes of river inflow in millions of m^3 starting from 1994, as recorded at Uitenhage. The highest inflow was in November 1996, a total of 137 million m^3 of water, followed by August 2002 at 45,7 million m^3 of water.

Table 6.15: Monthly flow volumes of the Swartkops River (millions of m^3)

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
1994-95	0.000	0.003	4.04	15.4	0.855	1.28	1.73	0.000	0.000	0.000	0.000	0.000	23.08
1995-96	0.046	0.073	0.130	0.283	0.347	0.083	0.056	0.033	0.020	0.037	0.031	0.013	1.15
1996-97	29.3	137	27.6	10.7	0.668	0.219	28.1	2.02	0.733	3.28	1.42	2.21	243
1997-98	0.634	0.089	0.007	0.539	0.035	2.96	1.94	0.538	0.196	0.206	0.717	0.537	8.4
1998-99	0.164	0.065	0.698	0.100	0.017	0.037	0.085	0.083	0.075	0.278	0.348	0.248	2.20
1999-00	0.374	0.138	0.100	0.878	0.199	42.8	23.5	2.32	0.694	0.260	0.235	0.095	71.6
2000-01	0.044	2.76	0.400	2.97	0.413	0.074	0.353	0.191	0.000	0.040	0.183	0.654	89.88
2001-02	0.451	3.98	1.91	0.375	0.074	0.025	0.014	0.017	0.005	0.214	45.7	0.000	52.77

Source: DWAF (2002a)

If the inflow were to reduce by the estimated 30%, the following scenarios were predicted for the estuary: no mouth closure and no area change for boaters; optimistically no change for bait and bird populations and pessimistically a 25% reduction of bait and bird populations. For fish population, an optimistic 10% reduction and a pessimistic 25% reduction would result. Other changes could be increases in pollutants, which could reduce the safety of water for swimming and boating. All these adverse changes could be expected to reduce the appeal of the estuary to the hundreds of people who use it regularly.

6.6.3.2 Current revenues versus current costs

According to speed boat registration officials at the Swartkops Estuary, an average of 900 boats is registered annually, with boaters paying a minimum of R85 per boat for the first half of the year and R45 for the next half, all amounting to approximately R120 000 for boating revenues. In addition to this, there is an amount received for fishing and bait collection licenses, which could not be determined by the authorities. As there are as many anglers as boaters, one can estimate it to also be in the region of R100 000 (angling fee is R35 per annum and bait collection for recreational anglers is R50 per annum). If these figures are close to actual then almost a quarter of a million Rands is received from speed boaters and anglers of the Swartkops Estuary.

6.6.4 Determination of target population and the sample population

Two hundred interviews were conducted during a field survey of the Swartkops Estuary that commenced in the last week of January 2003 and ended ten days into February 2003. Prior to the field survey several meetings were held with research supervisors in November and December 2002 to discuss the administration of the questionnaire. The people interviewed in the survey were mainly residents and users captured in the act of using the estuary. The questionnaire appeared to be well understood by most of the respondents and many showed an interest in the results of the study.

6.6.4.1 Target population

From the outset it was decided that the population targeted for the Swartkops Estuary should comprise of people using it for recreation, residents, commercial enterprises and subsistence users. Popular recreation groups targeted were boaters, anglers, swimmers, bird watchers, and scenery viewers. All resident groups were targeted, including pensioners, high-income residents, low-income residents, and property owners who use their Bluewater Bay or Amsterdamhoek property as holiday homes. Commercial enterprises dependent on the estuary for their survival and subsistence local users were also targeted.

Initial efforts to obtain guiding figures of users from environmental affairs authorities and from the Swartkops Trust were fruitless. The selection of respondents was structured so as to attempt to represent all categories of users.

6.6.4.2 Sample size

To estimate the sample population of people who used the Swartkops Estuary annually, the figures in Table 6.16 were used. User estimates were arrived at through personal communication with environmental affairs authorities at Swartkops Estuary.

Table 6.16: Estimated total population of users of households using the Swartkops Estuary per annum by main user category

Estuary use	No. of household users annually and (%)	
Proximity/viewing	1 000	(19,2%)
Anglers	2 500	(48,1%)
Bait collectors	100	(1,9%)
Boaters	1 000	(19,2%)
Bird watching	100	(1,9%)
Picnicking	200	(3,8%)
Swimming	100	(1,9%)
Other (walking)	200	(3,8%)
Total	**5 200**	**(100%)**

Source: Tiger Bay Boat Registration Office (2003)

In Table 6.16 above it is estimated that at least 5 200 households (about 31 800 people, assuming six-person households) use the Swartkops Estuary on an annual basis, with anglers being the biggest users (2 500), followed by boaters (1 000) and scenery viewers (1 000) living in close proximity to the estuary. Bait collection is another regular use of the estuary (100 subsistence diggers). The estuary is also commonly used for picnics and bird watching. The 200 interviews conducted at the Swartkops Estuary represented 3,8% of the total estimated household target population of 5 200.

Table 6.17 below shows the people counted at the estuary during patrols by nature conservation officials at Swartkops Estuary.

Table 6.17: Once-a-month count of people and boats at the Swartkops Estuary in 2003

Date	Time	People counted	Power boats registered	Rowing boats registered	Sail boats registered
Sat 25 Jan	09h30	115	9	0	1
Sat 22 Feb	10h00	98	41	2	3
Sun 23 Mar	11h00	61	7	1	0
Sat 12 April	09h00	81	16	1	0
Sat 24 May	10h00	263	22	2	4
Sun 29 Jun	14h00	174	12	4	1
Sat 26 Jul	10h00	44	8	2	0
Sat 2 Aug	13h00	101	19	1	1
Wed 24 Sep	11h00	63	16	0	2
Sat 11 Oct	08h00	86	9	1	1
Sat 29 Nov	09h30	103	32	3	2
Tue 6 Jan 04	10h00	136	26	2	3
Total		**1 325**	**217**	**19**	**18**

Source: Tiger Bay Boat Registration Office, 2003

6.6.5 Comments on qualitative aspects of the responses

Most users of the Swartkops Estuary felt it is an environment that should be better conserved. However, there were respondents who were unwilling to pay should the proposed project be implemented. There was wide speculation about the bad smell that is said to sometimes emanate from the estuary water. Some said the stench is caused by sewerage mismanagement somewhere up in Motherwell Township. Others said it was caused by leaks from Wastetech, the waste management company in Perseverance. It is also possible that Fishwater Flats, the reclamation water works situated close to the estuary, caused the smell.

The majority of users of the Swartkops Estuary were found to be white, male and visiting for recreation. (In Appendix 13 some of the comments and recommendations made by respondents at the Swartkops Estuary are listed and in Appendix 14 an account is provided of the field experiences of the person conducting the survey).

6.7 Kariega

6.7.1 Background

The Kariega and Bushmans Rivers run parallel to each other, flowing towards the Indian Ocean. The beautiful town of Kenton-on-Sea lies between them and along the riverbanks and surrounding coastal land, approximately 30km from Port Alfred. The town does not consume water from these rivers for domestic or industrial purposes on account of its poor quality relative to ground reserves.

6.7.2 Physical description and uses

In the figures below are an aerial view of the Kariega River Estuary and a map of the town, Kenton-on-Sea.

Figure 6.13: The Kariega Estuary in Kenton-on-Sea

Source: Bate (2003)

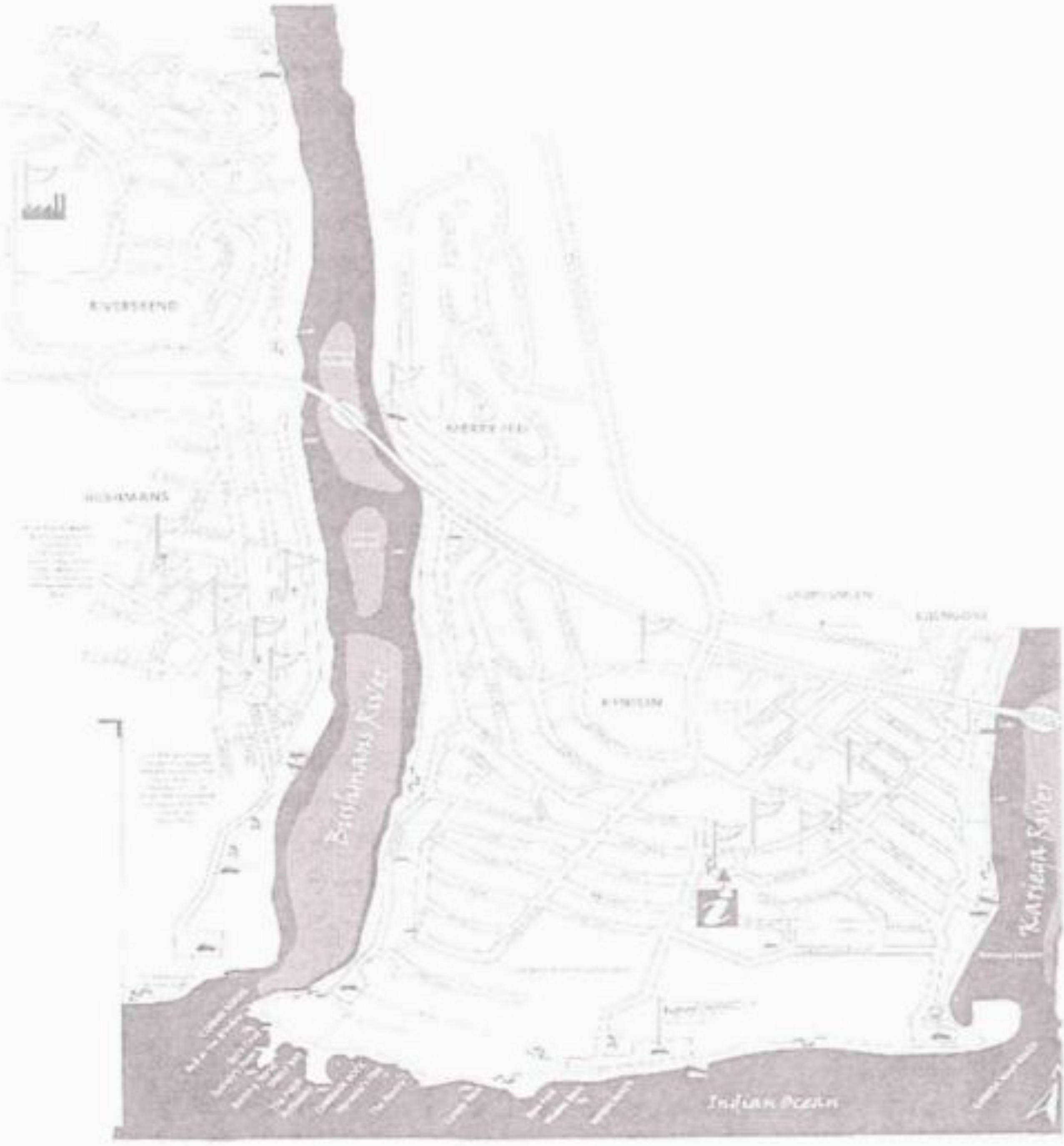

Figure 6.14: Street Map of Kenton-on-Sea

Source: Kenton Tourism Office (2003)

6.7.2.1 Physical description

The Kariega is a small river, originating about 30km west of Grahamstown. Its mouth is permanently open. There is one large dam on the river, the Settlers Dam, and numerous weirs. The people of Grahamstown use the water stored in the Settlers Dam and farmers use that stored behind the weirs. Despite these abstractions, scientists rank the condition of the estuary as fair (Whitfield, 2000). The surface area of the estuary is 1,6km^2 and it is 17km long. It is a marine dominated system with very little riverine influence.

With an average depth of 2,4m, the estuary's channels in the upper reaches are narrow, 40 to 60m, and usually flanked by steep slopes. In the lower reaches the estuary widens to about 100m, bordered by sand flats and salt marshes.

The system has been known to be hypersaline in the upper reaches and apart from periodic freshwater inputs, which require the overflow of the Settlers Dam, river inflow is negligible for extended periods. The estuary is situated in a warm temperate climate and its location is 33°41'S, 26°44'E. Siltation is one of the problems faced by the estuary and is caused by more sand being brought in by the incoming tide than is removed by the outgoing tide. It is a situation that can be rectified by tidal flooding.

6.7.2.2 Permanent residents

Table 6.18 below shows that the total population of Kenton-on-Sea and Bushmans River Mouth area is 10 487, made up of approximately 2 500 households (Mouton, 2003). Only a minority of this total are in the high-income bracket. The majority have low incomes and there are a high number of pensioners. Some property owners live elsewhere and use these properties as holiday homes.

Table 6.18: Kenton-on-Sea total population

Area	Population (1999)	Estimated population (2005)	Remarks
Kenton-on-Sea	650		Additional ~ 20 000 in peak holiday season
Merry Hill/Ellengone	200		
Ekuphumuleni	4 200		
Small holdings/farms	265		Farmers and workers
Subtotal	**5 150**	**6 091**	
Bushman's River mouth	300		Additional ~ 3 000 in peak holidays. 80% of population > 60 years
Rivers Bend	200		
Marselle	4 037		40% of population < 14 years. Ereyeni Ext to have 305 serviced erven
Klipfontein	800		Ext to have 225 serviced erven
Subtotal	**5 337**	**6 313**	
Total	**10 487**	**12 404**	Plus 23 000 holidaymakers

Source: Mouton (2003)

Ekuphumuleni, an informal settlement of Africans, has the largest number of people, followed by Marselle. The latter houses both Africans and coloureds. Together these two settlements house 80% of the local population. Klipfontein and Kenton-on-Sea follow next in terms of size of population. There are pockets of small farm holdings around the area, most of who enjoy the benefits of services provided by the estuaries.

6.7.2.3 Uses of the Kariega Estuary

Like most of South Africa's estuaries, the main uses of the Kariega Estuary are recreation, subsistence and commercial. During the survey conducted at the Kariega Estuary respondents gave the highest rating to estuary viewing and using the banks for picnics and accommodation around the estuary. A sign at the slipway of the estuary states the following rules to users: *1) Die gebruik van munisipale waters deur vaartuie benodig 'n permit. 2) Waterski binne die munisipale grense is verbode. 3) Die area tussen die brug en die riviermond is 'n eweesnelheids zone. Ry stadig. 4) Geen jetski nie.*

6.7.2.4 Recreational uses

Boating: The Kariega Estuary has a long distance of water available for river boating, thus making it attractive to many boat owners. Boating is done mostly over holiday periods and weekends. The Kariega Park, a commercial enterprise around the estuary, offers guided boat trips on the Kariega River. The Kenton Marina has boats and canoes for hire, and they offer upriver canoe trails, with overnight stays alongside the river. Of the respondents surveyed, 18% said boat sports were extremely important and just over half of the respondents rated the hobby as very important.

Fishing: Recreational fishing is a popular pastime in the Kariega Estuary, especially during public holidays and during the festive season. However, there are a few occasional anglers in the estuary during off-peak periods and weekdays. A few of the anglers interviewed during the survey said they were induced to fish in the Kariega estuary because of overcrowding of the fishing spots closer to Port Elizabeth. In addition to recreational anglers there are some residents of Ekuphumuleni (a high density settlement overlooking the estuary) who catch fish and extract prawns from the estuary for subsistence purposes.

Swimming: The estuary is known to have long sandy banks that provide a good base for swimming. Swimming is common in summer and during hot weekends out of season.

Scenery viewing: There are many angles from which one can obtain good views of the Kariega Estuary, for example from the Kariega Game Reserve.

Bird watching: There are more than 200 bird species in the contrasting riverine, bushveld and grassland ecosystems around the estuary. The Kenton Bird Club organises bird watching trips or trails for bird and nature lovers. Graham Arnott (2003), the artist who illustrated Roberts Bird Book lives in Kenton-on-sea and spends most of his time drawing birds. Bird enthusiasts visiting the area often visit him.

Hiking and game watching: Further up the estuary, animals including giraffe, zebra, eland, wildebeest, a wide variety of antelope and vervet monkeys, attract some visitors to the estuary for hikes and game watching. The Kariega Park Game Reserve borders the upper section of the estuary and offers visitors an opportunity to see game from marked walking trails or horseback.

6.7.2.5 Subsistence use

With Africans living in Kenton-on-Sea being a majority of the population, but with low monthly incomes due to limited business and industrial activity in the area, some locals resort to fishing and bait collection around the estuary for subsistence.

Bait digging: Unemployed youths, mainly from Ekuphumuleni and Marselle townships, frequent the estuary almost every day to dig mud prawns to sell to recreational anglers. The bait diggers do not have proper digging implements and they do not have permits.

Fishing: When households have low incomes, such as in Ekuphumuleni township, harvesting estuary fish is an activity done to put a meal on the table. More fish is eaten in this community than meat, as fish can be more cheaply obtained.

<u>**Security and other assistance**</u>: Like in most of South Africa's regularly used estuaries, local folk are often seen at Kariega Estuary providing security services to visitors, particular keeping an eye on vehicles while owners walk around the estuary or go on boat rides. Also unemployed local folk are often seen trying to earn some money by assisting estuary visitors with any help that may be required, from launching boats in the slipways to cleaning sand off vehicles after fishing activities.

6.7.2.6 Commerce and industrial use

<u>**Food and grocery shops**</u>: The small town centre of Kenton-on-Sea has the normal food and grocery shops, including a Spar and a pizza shop. Other popular restaurants around the Kariega Estuary are Stanley's Bar, Homewoods Restaurant, The Local, The Garden and Waves Coffee Corner.

<u>**Fish and bait shops**</u>: The only fishing and bait shop in Kenton-on-Sea is Ward's Bait Shop on the town's main road. The shop sells bait and fishing equipment and accessories for anglers.

<u>**Bedding and lodgings**</u>: There are a number of different overnight accommodation enterprises close to the estuary. These include Kariega River Bungalows, Mrs Galpin's, Intaka Lodge, Woodlands Country Cottages, Bandar-Log B&B, The Bell B&B, Berribridge B&B, Burke's Nest, B&B, Carriage House, Chateau Blanc B&B, Fishtale B&B, Hillcrest House, Kariega Cottage, Oribi Haven and Woodside B&B.

6.7.2.7 Agriculture use

Some farmers graze their cattle on the banks of the middle and upper reaches of the estuary.

6.7.2.8 Non-users

No non-users (with an expected positive demand) were interviewed as it was unclear who would fit into such a category and where they would be found.

6.7.3 The specified change and WTP question

6.7.3.1 The specified change

In this study, it was proposed that for the Kariega River Estuary, inflow of freshwater be increased by 85% over current inflow. The current inflow is 43% of MAR (the latter being 20,3 million m^3). After the increase, the inflow would be 80% of the MAR. The increase of inflow required was 7,4 million m^3. The estimated average per annum freshwater inflow into the estuary without abstraction and runoff yield loss was calculated to be 20,3 million m^3.

River inflow is abstracted and runoff yield is lost mainly through agriculture and urban use, forestry and alien plant invasion. For Kariega the abstraction is at 11,5 million m^3 annually, and to calculate the current annual inflow of freshwater into the Kariega Estuary, the amount of water abstracted or lost (11,5 million m^3) is subtracted from the MAR (20,3) to get 8,8 million m^3. If the estuary receives the proposed supplies of freshwater the following scenario could result: no mouth closure, no area change for boaters, a 25% increase in bait and bird population, more variety of fish and a 25% increase in fish population on an optimistic side and no change on a pessimistic side.

Table 6.19 below shows monthly volumes of flow of the Kariega River as recorded at Smithfield Gauging weir.

Table 6.19: Monthly flow volumes of the Kariega River (in millions m^3)

YEAR	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1981-82	0,486	0,112	0,085	0,065	0,002	0,001	0,006	0,006	0,009	0,009	0,038	0,007	**0,826**
1982-83	0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	3,240	0,852	0,061	**4,150**
1983-84	0,390	0,090	0,004	0,001	0,000	0,010	0,004	0,003	0,005	0,003	0,010	0,009	**0,529**
1984-85	0,003	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	**0,003**
1985-86	0,001	7,570	8,720	1,170	0,066	0,103	0,025	0,012	0,021	0,008	0,037	0,048	**17,80**
1986-87	0,317	0,327	0,198	0,004	0,003	0,002	0,001	0,001	0,000	0,002	0,003	0,002	**0,860**
1987-88	0,002	0,000	0,000	0,000	0,435	0,412	0,054	0,009	0,007	0,052	0,019	0,013	**1,000**
1988-89	0,009	0,015	0,005	0,001	0,000	0,007	0,004	0,004	0,002	0,002	0,002	0,001	**0,052**
1989-90	0,951	19,40	0,922	0,019	0,020	0,097	0,030	0,023	0,026	0,047	0,020	0,015	**21,60**
1990-91	0,017	0,009	0,004	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	**0,032**
1991-92	0,002	0,003	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	**0,007**
1992-93	0,000	0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,072	**0,073**
1993-94	0,005	0,003	0,035	0,122	0,128	0,054	0,004	0,003	0,003	0,003	0,006	0,008	**0,374**
1994-95	0,126	0,005	1,880	9,940	0,245	0,119	0,134	0,112	0,025	0,017	0,011	0,008	**12,60**
1995-96	0,006	0,005	0,005	0,003	0,003	0,001	0,002	0,000	0,000	0,002	0,002	0,003	**0,032**
1996-97	0,003	2,890	0,397	0,252	0,007	0,005	0,025	0,138	3,290	1,580	0,402	0,171	**9,160**
1997-98	0,029	0,012	0,007	0,007	0,004	0,047	0,044	0,036	0,014	0,012	0,016	0,028	**0,256**
1998-99	0,021	0,011	0,206	0,028	0,006	0,008	0,007	0,005	0,007	0,007	0,008	0,007	**0,321**
1999-00	0,009	0,007	0,005	0,003	0,003	0,007	0,011	0,009	0,010	0,008	0,009	0,009	**0,090**
2000-01	0,007	1,710	0,127	0,043	0,012	0,009	0,015	0,023	0,012	0,012	0,078	0,404	**2,450**
2001-02	0,370	0,812	0,475	0,060	0,015	0,010	0,010	0,08	0,009	0,015	6,840	26,00	**34,60**

Source: DWAF (2002b)

In the above table a recording of zero means there was no inflow of freshwater into the estuary.

6.7.3.2 The WTP question

The WTP question involved requesting users to disclose the amount they are willing to pay for injections of water into the estuary.

6.7.4 The target population and the sample population

A survey of the Kariega Estuary was done in March 2003 and 100 questionnaires were administered over a two-week period.

6.7.4.1 Target population and sample size

The user population targeted for the Kariega Estuary survey included recreationists, residents, commercial enterprises and subsistence users. The recreational users were boaters, anglers, swimmers, bird watchers, picnickers and scenery viewers. Table 6.20 below gives estimates of total user population for the Kariega Estuary on an annual basis. The table shows that a total of 2 000 households use the Kariega Estuary per year.

Table 6.20: Estimated total household user population for the Kariega Estuary per annum by main user category

Estuary use	No. of household users annually and (%)	
Proximity/viewing	500	(25%)
Anglers	500	(25%)
Bait collectors	50	(2,5%)
Boaters	500	(25%)
Bird watching	150	(7,5%)
Picnicking	100	(5%)
Swimming	100	(5%)
Other (walking)	100	(5%)
Total	**2 000**	**(100%)**

Source: van der Merwe (2003); Fouchie (2003); Lardner-Burke (2003)

Fishing, boating and estuary viewing each make up 25% of users (see Table 6.20). Bird watching was found to be another common hobby in the estuary, making up 7,5% of users. Members of the Diaz Cross Bird Club and the Grahamstown Bird Club were among the regular users of the Kariega Estuary (Lardner-Burke, 2003). Picnicking, swimming and other activities common during the festive season each accounted for 5% of users. The sample size for the survey, 100 questionnaires, was 5% of the total user population and considered representative.

A thesis by a UPE student, Forbes (1998), gave percentages of interest shown by different users at the Kariega Estuary. Table 6.21 below shows the percentages of users' interest in various services provided by the estuary.

Table 6.21: Kariega Estuary: users' interest in services

Activity	% of previous interest shown
Angling	25,6
Water skiing	12,5
Jet skiing	0,3
Wind surfing	4,5
Canoeing	6,7
Boating	17,3
Swimming	25,6
Other activities	7,5

Source: Forbes (1998)

When comparing figures in Table 6.20 with those in Table 6.21 it can be seen that the estimates on fishing activities are almost similar – 25% and 25,6% respectively – as well as boating activities – 25% and 24% (i.e. 17,3% + 6,7%) respectively. However, the two tables show different estimates on swimmers – 5% and 25,6%. The reason for such a discrepancy could be attributed to the different time periods during which the surveys were undertaken.

6.7.5 Comments on qualitative aspects of the responses

The Kariega River Estuary is relatively highly used despite shortages of freshwater inflow into the system. Residents living close to the estuary range from extremely poor to extremely rich, a phenomenon that sees recreational activities compete side by side with survivalists for services provided by the estuary. Residents are also often hit by water shortages during the course of the year and often raised this issue. Almost a third of respondents were not prepared to pay for any inflow of water into the estuary. (A list of comments made by users may be found in Appendix 15 and in Appendix 16 an account is provided of the field experiences of the person conducting the survey.)

CHAPTER SEVEN: RESULTS

7.1 Introduction

Chapter Seven reports the information collected in the survey and estimated WTP (bid) functions using various statistical models, namely, OLS, Tobit, Logit and Probit ones. In addition, validity and reliability tests relating to the WTP estimates are described. In the estimation of bid functions', WTP responses were used as the dependent variable and a range of other responses as explanatory variables. Chapter Four described the method – in the form of a pilot study application (relating to the Keurbooms Estuary). Population selection and sample design issues relevant to this report were discussed in Chapter Five. Seven estuaries were selected, namely the Groot Brak, Kariega, Klein Brak, Knysna, Kowie, Kromme and Swartkops Estuaries. These estuaries were selected in consultation with the Water Research Commission and selected members of the staff at UPE.

7.2 Descriptive statistics

This section describes the following: the sample information of the respondents, the socio-economic characteristic profiles, descriptions of respondents' knowledge regarding the ecological effects of changes in freshwater inflow, the importance to users of activities/attributes of the estuaries, frequency of annual usages of estuary services and the number of members from each household that utilise estuary services. This data was collected during the period December 2002 to June 2003.

7.2.1 Sample information

A total of 1 053 questionnaires were administered at the seven selected sites. Of this total there were 1 003 valid responses. The valid response rate was 100% at all sites, except at the Kowie, where it was only 67%. The reason for the low response rate at the Kowie was that respondents were particularly sensitive to giving the relevant interviewer critical information (especially annual pre-taxed income). It appears that this was in part due to the interview technique used. The revealed estimated sample sizes and valid responses are shown in Table 7.1.

Table 7.1: Number of questionnaires completed and valid responses

	Groot Brak	Kariega	Klein Brak	Knysna	Kowie	Kromme	Swartkops	Total
Questionnaires completed	151	100	101	201	150	150	200	1 053
Valid responses	151	100	101	201	100	150	200	1 003

Table 7.2 shows the categories of users/respondents. Most of the respondents selected were recreational users. In total, 42 respondents stated that they were non-users and 39 respondents identified themselves as multi-users.

Table 7.2: Category of user/respondent

	Groot Brak	Kariega	Klein Brak	Knysna	Kowie	Kromme	Swartkops	Total
Recreation	124	84	79	141	97	138	175	838
Commercial/subsistence	16	1	14	46	3	4	0	84
Non-users	11	2	8	14	0	7	0	42
Multi-users: Recreation and commercial/subsistence	0	13	0	0	0	1	25	39

7.2.2 Socio-economic characteristic profiles

Table 7.3 and Figures 7.1 and 7.2 summarise the socio-economic characteristics of the sample of respondents selected at each estuary.

Table 7.3: Socio-economic profile of sample respondents

Averages	Groot Brak	Kariega	Klein Brak	Knysna	Kowie	Kromme	Swartkops
Household size (no. of people)	4,2	4,7	3,8	3,9	4,0	2,8	4,1
Annual levies paid (in Rands)	100	242	32	112	335	391	194
Distance of respondents' current accommodation (in km)	3	2	3	3	2	3	4
Approximate worth of respondents' vehicles and boats owned (in Rands)	76 133	72 670	68 020	105 562	219 340	208 173	44 245
Education level of respondents (no. of years)	12	13	12	13	13	13	12
Annual pre-tax income (in Rands)	106 623	141 750	79 951	141 418	258 500	186 833	114 125

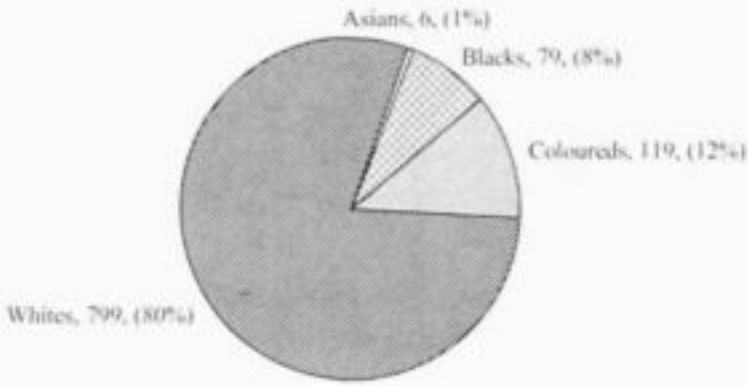

Figure 7.1: Race of respondents

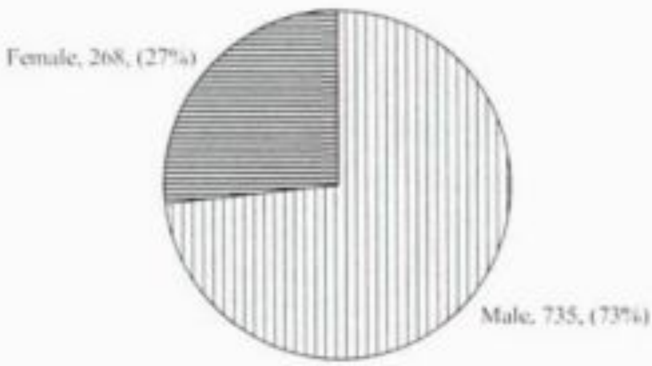

Figure 7.2: Gender of respondents

The average size of the majority of the households was four persons, except in the area of the Kromme Estuary, which had an average of three persons per household. Annual levies paid ranged between R32,43 and R390,80. This range was as the result of fee differences between the estuaries, as well as variations in accessing estuary services by the respondents interviewed. The majority of sample respondents travelled short distances to the estuary. The Swartkops Estuary had respondents who travelled the furthest distance. The Swartkops respondents were located an average of 4km away from the estuary.

The worth of boats and vehicles owned differed between sites. The average value of boats and vehicles owned by respondents from the Kowie area was R219 340, nearly five times higher than the average value owned by the respondents in the Swartkops area. The average value of boats and vehicles owned by the respondents in the Swartkops Estuary area was R44 245. The respondents (for all estuaries) had an average of least over 12 years of education, that is, had obtained a matric certificate. There was a relatively high education level in the Kariega, Kowie and Kromme areas, with tertiary qualifications having been obtained by many respondents. The average annual pre-taxed income was highest among the Kowie respondents. It was in excess of R200 000, almost three times as high as that earned by respondents from Klein Brak area, namely R79 950.

Most of the users of estuary services surveyed were white males. White respondents made up almost 80% of the total sample and male respondents interviewed constituted almost three quarters of the entire sample size (73%).

7.2.3 Knowledge of estuary ecology

The relationship between education levels and knowledge of estuary ecology is reported in Table 7.4. Most of the respondents had a partial knowledge of environmental issues relating to the estuary (45,8% of the entire sample).

Table 7.4: Relationship between education level and knowledge of estuary ecology

	Percentage of total respondents				
Level of knowledge	No schooling	Completed 7-11 years of schooling	Completed 12 years of schooling	Completed schooling plus 3 or more years tertiary schooling	Total
Person is well informed	0,1	1,7	16,9	16,5	35,2
Person has partial knowledge	1,1	6,9	20,7	17,0	45,8
Person is poorly informed	0,2	3,4	9,7	5,8	19,0
% of entire sample	1,4	12,0	47,4	39,3	100,0

It was expected that the respondents' education levels and knowledge of estuary ecology would be positively correlated, since people who are more educated would be expected to be more aware of the ecological benefits to an estuary resulting from an increase in freshwater inflow. The data shows that majority of the respondents had a partial knowledge of the estuary ecology and the respondents' education levels and knowledge of estuary ecology exhibit a positive correlation (Figure 7.3).

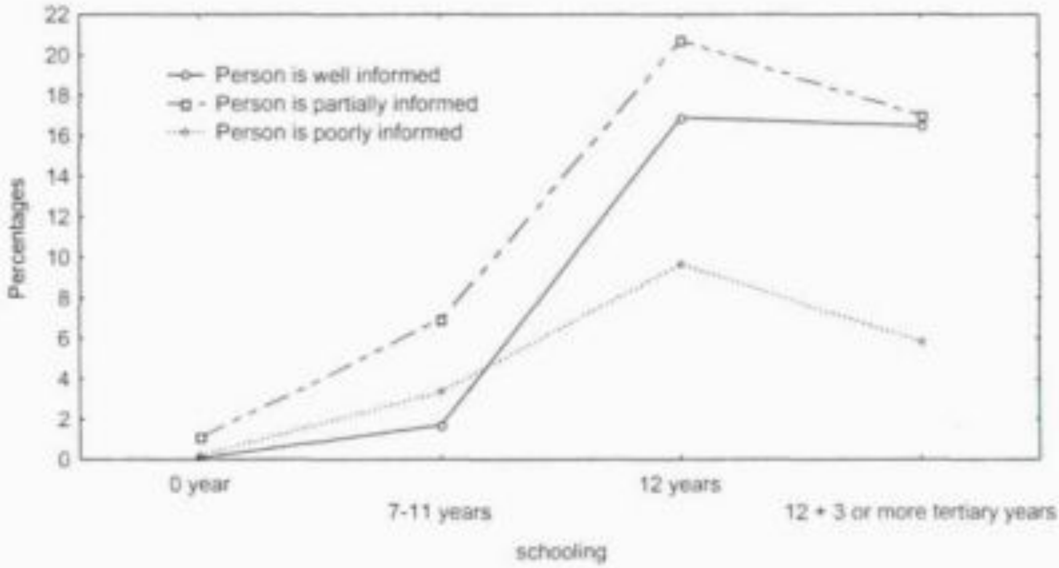

Figure 7.3: Line plot for correlation between education level and knowledge of estuary ecology

7.2.4 Importance attached to various activities

In order to reflect on the importance the respondents attached to the estuary services, respondents were asked what activities attracted them to the different estuaries. Tables 7.5 to 7.12 report a summary of their responses.

The majority of respondents perceived the listed activities/attributes as ranging from extremely important to very important. The overall results showed that the respondents were interested in the environmental services provided by estuaries, and that almost every sampled respondent was directly or indirectly using the particular estuary about which they were being questioned.

The proportion of residents who considered boat sports as being extremely important was similar to the proportion of residents who considered boat sports to be unimportant. On the other hand, the proportion of visitors who considered boat sports as being extremely important was more than twice as high as the proportion of visitors who considered boat sports as being unimportant. A higher proportion of Whites than members of other races valued boat sports as extremely important. These results indicated that White respondents were more likely to be involved in boat sports than the non-White respondents. These results are shown in Table 7.5.

Table 7.5: Relationship between importance of boat sports, nature of respondent and race group

		Boat sports (excluding fishing) activities/attributes							
		Extremely important		Very important		Moderately important		Unimportant	
Nature of respondents	Visitors	142	(14,16)	117	(11,67)	104	(10,37)	66	(6,58)
	Residents	134	(13,36)	174	(17,35)	154	(15,35)	112	(11,17)
Race groups	Blacks	6	(0,60)	32	(3,19)	25	(2,49)	16	(1,60)
	Whites	252	(25,12)	231	(23,03)	176	(17,55)	140	(13,96)
	Coloureds	17	(1,69)	27	(2,69)	55	(5,48)	20	(1,99)
	Asians	1	(0,10)	1	(0,10)	2	(0,20)	2	(0,20)
Entire sample		276	(27,52)	291	(29,01)	258	(25,720	178	(17,75)

Notes: All numbers refer to the number of respondents

The numbers in parentheses are percentages

Table 7.6 shows the ranking of importance of swimming activities by the respondents. Similar rating patterns were evident amongst the different groups. Of all those surveyed, 34,7% rated swimming to be very important, whilst 14,66% rated swimming as unimportant. Overall, swimming at estuaries was not extremely important to the respondents.

Table 7.6: Relationship between importance of swimming, nature of respondent and race group

		Swimming activities/attributes							
		Extremely important		Very important		Moderately important		Unimportant	
Nature of respondents	Visitors	102	(10,17)	150	(14,96)	128	(12,76)	49	(4,89)
	Residents	137	(13,66)	198	(19,74)	141	(14,06)	98	(9,77)
Race groups	Blacks	12	(1,20)	31	(3,09)	26	(2,59)	10	(1,00)
	Whites	184	(18,34)	273	(27,22)	218	(21,73)	124	(12,36)
	Coloureds	43	(4,29)	42	(4,19)	22	(2,19)	12	(1,20)
	Asians	0	(0,00)	2	(0,20)	3	(0,30)	1	(0,10)
Entire sample		239	(23,83)	348	(34,7)	269	(26,82)	147	(14,66)

Notes: All numbers refer to the number of respondents

The numbers in parentheses are percentages

Relatively more respondents, both visitors and residents, considered fishing extremely important. A higher proportion of the residents than the visitor's valued fishing as being extremely important. The proportion of residents who rated fishing as extremely important was more than 18 times higher than residents who rated fishing as unimportant (see Table 7.7).

Table 7.7: Relationship between importance of fishing, nature of respondent and race group

		Fishing activities/attributes							
		Extremely important		Very important		Moderately important		Unimportant	
Nature of respondents	Visitors	188	(18,74)	138	(13,76)	79	(7,88)	24	(2,39)
	Residents	273	(27,22)	200	(19,94)	86	(8,57)	15	(1,50)
Race groups	Blacks	36	(3,59)	35	(3,49)	6	(0,60)	2	(0,20)
	Whites	358	(35,69)	267	(26,62)	144	(14,36)	30	(2,99)
	Coloureds	65	(6,48)	33	(3,29)	15	(1,50)	6	(0,60)
	Asians	2	(0,20)	3	(0,30)	0	(0,00)	1	(0,10)
Entire sample		461	(45,96)	338	(33,7)	165	(16,45)	39	(3,89)

Notes: All numbers refer to the number of respondents

The numbers in parentheses are percentages

Table 7.8 summarises responses on the perception of the importance of viewing the estuary. High proportions of visitors and residents deemed view as being extremely important for the appeal of an estuary. Similar patterns were found for all race groups. Of the whole sample 66,8% rated the view of the estuaries as extremely important. Clearly, the attribute of viewing the beautiful natural qualities of the estuaries is an important aspect of the value of an estuary.

Table 7.8: Relationship between importance of viewing estuary, nature of respondent and race group

		Viewing estuary activities/attributes			
		Extremely important	**Very important**	**Moderately important**	**Unimportant**
Nature of respondents	**Visitors**	304 (30,31)	100 (9,97)	21 (2,09)	4 (0,40)
	Residents	366 (36,49)	177 (17,65)	27 (2,69)	4 (0,40)
Race groups	Blacks	40 (3,99)	36 (3,59)	3 (0,30)	0 (0,00)
	Whites	539 (53,74)	219 (21,83)	35 (3,49)	6 (0,60)
	Coloureds	86 (8,57)	21 (2,09)	10 (1,00)	2 (0,20)
	Asians	5 (0,50)	1 (0,10)	0 (0,00)	0 (0,00)
Entire sample		670 (66,8)	277 (27,62)	48 (4,79)	8 (0,80)

Notes: All numbers refer to the number of respondents

The numbers in parentheses are percentages

The majority of visitors and residents rated the proximity of their accommodation to the estuary as extremely important. The proportion of residents who considered proximity to be extremely important was marginally higher than the proportion of visitors (see Table 7.9). The majority of all race groups considered proximity of accommodation to the estuary to be extremely important.

Table 7.9: Relationship between importance of proximity, nature of respondent and race group

		Proximity activities/attributes			
		Extremely important	**Very important**	**Moderately important**	**Unimportant**
Type of respondent	**Visitors**	264 (26,32)	109 (10,87)	40 (3,99)	16 (1,60)
	Residents	284 (28,32)	157 (15,65)	101 (10,07)	32 (3,19)
Race groups	Blacks	43 (4,29)	28 (2,79)	5 (0,50)	3 (0,30)
	Whites	416 (41,48)	214 (21,34)	127 (12,66)	42 (4,19)
	Coloureds	84 (8,37)	23 (2,29)	9 (0,90)	3 (0,30)
	Asians	5 (0,50)	1 (0,10)	0 (0,00)	0 (0,00)
Entire sample		548 (54,64)	266 (26,52)	141 (14,06)	48 (4,79)

Notes: All numbers refer to the number of respondents

The numbers in parentheses are percentages

The majority of the visitors felt that bird watching was moderately important (see Table 7.10). On the other hand, the majority of residents considered bird watching to be very important. It was deduced that residents were more likely than visitors to be bird watchers, and that bird watching was a less attractive to the visitors.

Table 7.10: Relationship between importance of bird watching, nature of respondent and race group

		Bird watching activities/attributes							
		Extremely important		Very important		Moderately important		Unimportant	
Nature of respondents	Visitors	82	(8,18)	139	(13,86)	152	(15,15)	56	(5,58)
	Residents	144	(14,36)	214	(21,34)	155	(15,45)	61	(6,08)
Race groups	Blacks	10	(1,00)	25	(2,49)	27	(2,69)	17	(1,69)
	Whites	198	(19,74)	291	(29,01)	233	(23,23)	77	(7,68)
	Coloureds	18	(1,79)	35	(3,49)	44	(4,39)	22	(2,19)
	Asians	0	(0,00)	2	(0,20)	3	(0,30)	1	(0,10)
Entire sample		226	(22,53)	353	(35,19)	307	(30,61)	117	(11,67)

Notes: All numbers refer to the number of respondents

The numbers in parentheses are percentages

Commercial activities were least important in the minds of most visitors and residents (Table 7.11). A third of the total sampled respondents considered commercial activities to be unimportant. Due to some residents using estuaries to make a living, it was expected that a higher proportion of residents than visitors would consider business activities to be more important. A higher proportion of Black respondents rated the commercial activities to be very important than did any other race group respondents.

Table 7.11: Relationship between importance of commercial activities, nature of respondent and race group

		Commercial – All business activities/attributes							
		Extremely important		Very important		Moderately important		Unimportant	
Nature of respondents	Visitors	47	(4,69)	110	(10,97)	120	(11,96)	152	(15,15)
	Residents	96	(9,57)	153	(15,25)	167	(16,65)	158	(15,75)
Race groups	Blacks	5	(0,50)	42	(4,19)	23	(2,29)	9	(0,90)
	Whites	125	(12,46)	179	(17,85)	212	(21,14)	283	(28,22)
	Coloureds	13	(1,30)	40	(3,99)	51	(5,08)	15	(1,50)
	Asians	0	(0,00)	2	(0,20)	1	(0,10)	3	(0,30)
Entire sample		143	(14,26)	263	(26,22)	287	(28,61)	310	(30,91)

Notes: All numbers refer to the number of respondents

The numbers in parentheses are percentages

Table 7.12 summarises the importance ratings for the unique features that are attached to the estuaries – 74% of the respondents reported the conservation of unique features to be extremely important to them.

Table 7.12: Relationship between importance of unique features, nature of respondent and race group

		Preservation of unique features/attributes							
		Extremely important		Very important		Moderately important		Unimportant	
Nature of respondents	**Visitors**	332	(33,10)	50	(4,99)	27	(2,69)	20	(1,99)
	Residents	412	(41,08)	111	(11,07)	34	(3,39)	17	(1,69)
Race groups	Blacks	47	(4,69)	28	(2,79)	3	(0,30)	1	(0,10)
	Whites	632	(63,01)	106	(10,57)	37	(3,69)	24	(2,39)
	Coloureds	63	(6,28)	25	(2,49)	19	(1,89)	12	(1,20)
	Asians	2	(0,20)	2	(0,20)	2	(0,20)	0	(0,00)
Entire sample		744	(74,18)	161	(16,05)	61	(6,08)	37	(3,69)

Notes: All numbers refer to the number of respondents

The numbers in parentheses are percentages

In addition to the above ratings of importance, there were four respondents from Knysna who rated cycling around the estuary to be extremely important and walking around the estuary to be moderately important.

7.2.5 Frequency of use

The average usages of estuary services in days per annum by the respondents and number of members per household using the estuary are shown in Figures 7.4 and 7.5. Of course, non-users use the estuaries 0 days per year and 0 household members consume their services. The average usage of estuary services was 60 or more days per annum and by two members per household. It was deduced that most respondents made repeated use of the relevant estuary services.

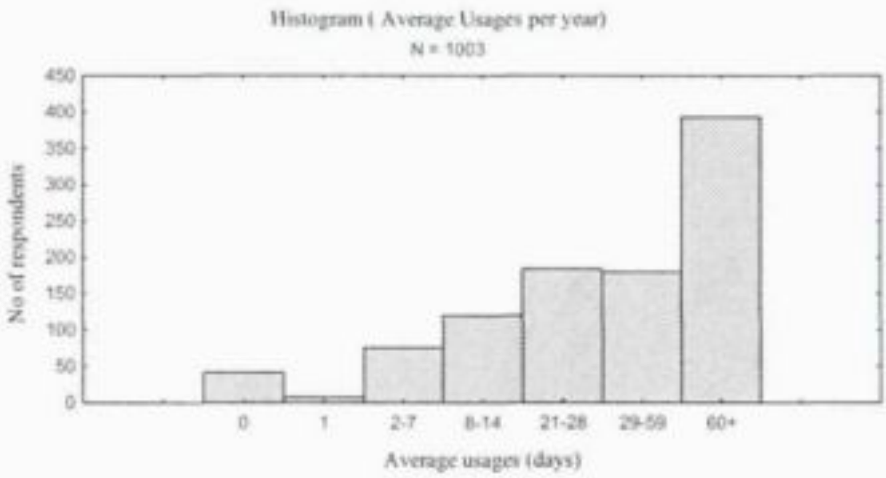

Figure 7.4: Histogram for average use of estuary services per year

Note: Class intervals for average usages (days) differ in range

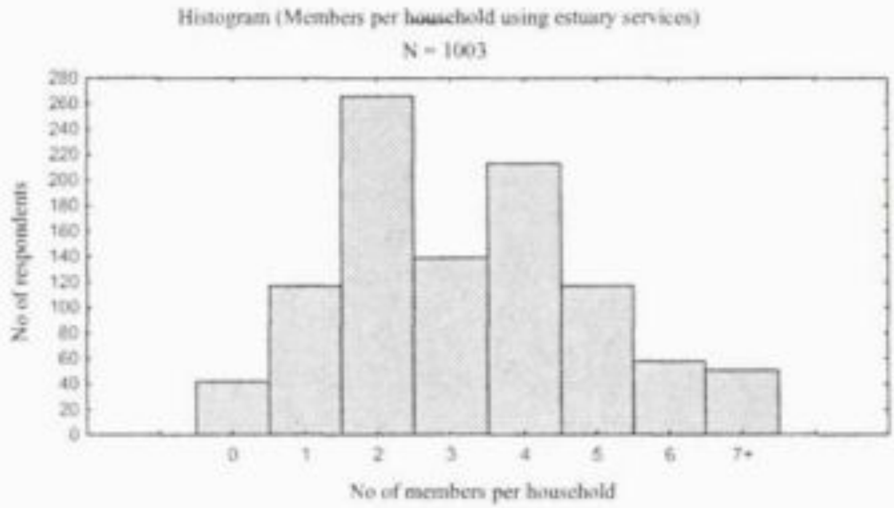

Figure 7.5: Histogram for number of members per household using estuary services

7.2.6 WTP for water inflow into estuaries

The WTP of respondents for the improvement of estuary services is shown in Table 7.13.

Table 7.13: Percentage of respondents who gave positive responses to WTP and zero WTP

WTP	Scenarios										
	Groot Brak		Kariega	Klein Brak		Knysna		Kowie	Kromme	Swartkops	
	High	Low	High	High	Low	High	Low	High	High	High	Low
Zero WTP											
0	19,9	19,9	29,0	25,7	43,6	23,9	23,9	22,7	28,7	9,5	21,0
Non-zero bids (Rands)											
5	0,0	0,0	2,0	1,0	3,0	0,0	0,5	1,0	0,0	1,5	4,5
15	1,3	1,3	3,0	0,0	4,0	1,5	2,0	3,0	0,0	2,5	5,0
25	1,3	3,3	5,0	2,0	5,0	2,0	1,5	2,0	0,0	8,0	7,5
40	11,3	9,9	6,0	13,9	10,9	7,5	8,0	10,0	0,7	11,0	14,5
75	21,2	23,8	9,0	31,7	19,8	12,4	15,9	18,0	7,3	15,0	18,0
150	21,9	20,5	4,0	15,8	5,0	22,9	23,4	15,0	8,7	14,0	7,5
350	13,9	11,9	9,0	6,9	6,9	22,4	18,4	22,0	33,3	17,5	14,0
750	4,0	6,0	24,0	2,0	1,0	6,5	6,0	9,0	12,7	18,0	7,0
1 500	4,0	2,6	9,0	1,0	1,0	1,0	0,5	2,0	8,7	3,0	1,0
2 500	1,3	0,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
3 500	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
4 000	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,0	0,0	0,0	0,0
Mean (Rands)	225	196	364	108	75	189	168	256	360	280	150
Median (Rands)	75	75	75	75	15	150	75	75	350	150	40

Note: Rand values are at years 2002 to 2003 price levels

The average WTP ranged from R75 to R350. Kariega Estuary respondents had the highest average WTP. At this estuary 24% were willing to pay R750 annually. The mean figure was similar to that found for the Kromme Estuary. There were 1% of the respondents from the Kowie area who had a WTP of R4 000 or more annually. These responses are possible outliers. The lowest average WTP figures found related to the Klein Brak. The general impression given by the results was that majority of estuary users were willing to pay a significant sum of money to secure freshwater inflow into South African estuaries.

The median[13] WTP amounts are also reported in Table 7.13. They ranged from R75 to R350. In most cases the median was R75. The Kromme Estuary had the highest median of all, namely R350, but it is the nearest to the average, suggesting that the average of Kromme Estuary was less affected than the others by high bids. By way of contrast, the Kariega Estuary was clearly highly affected by very high bids, because there was a substantial difference between the mean and medium bids.

There was considerable variation in the zero bid responses. The highest proportion of zero WTP or zero bids was made with respect to the low estimate of the benefit scenario for the Klein Brak Estuary, namely 43,6% of the total bids. The lowest proportion of zero WTP was for the high estimate of the benefit scenario for Swartkops. It made up only 9,5% of the total bids. There were no observed differences in numbers of zero bids between high and low scenarios in the Groot Brak and Knysna Estuary cases. This lack of difference suggests the possibility of embedding bias (see Chapter Three).

The WTP frequencies reported in Table 7.13 were derived using different survey teams and related to different estimates of benefit scenarios. It was expected that the high benefit scenarios would receive higher WTP bids than the low benefit scenarios, and they did.

The WTP of the different categories of estuary users are shown in Table 7.14. Most sampled respondents were in favour of paying something. There were major difficulties encountered in identifying "non-users" with a demand for specific estuary services.

Table 7.14: Relationship between WTP and categories of respondent

	Number of respondents under different scenarios										
	Groot Brak		Kariega	Klein Brak		Knysna		Kowie	Kromme	Swartkops	
Category of users	High	Low	High	High	Low	High	Low	High	High	High	Low
Recreation											
WTP=0	24	24	21	21	33	31	31	16	38	15	28
WTP>0	100	100	63	58	46	110	110	81	100	160	147
Commercial/subsistence											
WTP=0	0	0	0	1	5	10	10	1	2	0	0
WTP>0	16	16	1	13	9	36	36	2	2	0	0
Non-users											
WTP=0	6	6	2	4	6	7	7	0	3	0	0
WTP>0	5	5	0	4	2	7	7	0	4	0	0
Recreation and commercial/subsistence											
WTP=0	0	0	6	0	0	0	0	0	0	4	14
WTP>0	0	0	7	0	0	0	0	0	1	21	11

[13] Median is another measurement of central tendency (Neter, Wasserman and Whitmore, 1993). The median is computed where half of the observations lie above the median and another half of the observations lie below the median. In this way, the median is unaffected by large bids included in the data.

There were no major differences between the WTP bids of visitors and residents (see Table 7.15). The majority of the visitors and residents had a positive WTP. The only exception was with respect to the low benefit scenario for the Klein Brak Estuary, where the number of visitor respondents who gave zero bids was the same as the number who gave positive bids.

Table 7.15: Relationship between WTP and nature of respondent

	Number of respondents under different scenarios										
	Groot Brak		Kariega	Klein Brak		Knysna		Kowie	Kromme	Swartkops	
	High	Low	High	High	Low	High	Low	High	High	High	Low
Visitor											
WTP=0	18	18	0	13	21	21	21	10	18	7	22
WTP>0	54	54	14	23	24	49	49	48	48	97	82
Resident											
WTP=0	12	12	29	13	23	27	27	7	25	12	20
WTP>0	67	67	54	43	33	104	104	35	59	84	76

Table 7.16: Relationship between WTP and knowledge of estuary ecology

Knowledge	Number of respondents under different scenarios										
	Groot Brak		Kariega	Klein Brak		Knysna		Kowie	Kromme	Swartkops	
	High	Low	High	High	Low	High	Low	High	High	High	Low
Well informed											
WTP=0	4 (12,50)	4 (12,50)	14 (25,45)	2 (18,18)	3 (27,27)	10 (16,39)	10 (16,39)	1 (16,67)	16 (21,62)	9 (7,89)	15 (13,16)
WTP>0	28 (87,50)	28 (87,50)	41 (74,55)	9 (81,82)	8 (72,73)	51 (83,61)	51 (83,61)	5 (83,33)	58 (78,38)	105 (92,11)	99 (86,84)
Partial knowledge											
WTP=0	15 (19,23)	15 (19,23)	14 (32,56)	10 (20,00)	19 (38,00)	18 (18,75)	18 (18,75)	3 (7,14)	23 (34,33)	9 (10,84)	26 (31,33)
WTP>0	63 (80,77)	63 (80,77)	29 (67,44)	40 (80,00)	31 (62,00)	78 (81,25)	78 (81,25)	39 (92,86)	44 (65,67)	74 (89,16)	57 (68,67)
Poorly informed											
WTP=0	11 (26,83)	11 (26,83)	1 (50,00)	14 (35,00)	22 (55,00)	20 (45,45)	20 (45,45)	13 (25,00)	4 (44,44)	1 (33,33)	1 (33,33)
WTP>0	30 (73,17)	30 (73,17)	1 (50,00)	26 (65,00)	18 (45,00)	24 (54,55)	24 (54,55)	39 (75,00)	5 (55,56)	2 (66,67)	2 (66,67)

Notes: All numbers refer to the number of respondents

The numbers in parentheses are percentages

The summary statistics indicate a positive relationship between WTP and the respondents' ecological knowledge of freshwater inflow into the estuary (see Table 7.16). The proportion of respondents who were well informed about ecological knowledge of freshwater inflow into the estuary was higher than the proportion of respondents who were partially informed. Similarly, the proportion of respondents who were partially informed about ecological knowledge of freshwater inflow into the estuary was higher than the proportion of respondents who were poorly informed.

The principal impact in the high and low estimate of benefit scenarios differed by very little in some cases (see Tables 7.14 to 7.16). The number of respondents who indicated a positive

WTP in a high estimate of benefit scenario was similar to the number who indicated a positive WTP in a low estimate benefit scenario for the Groot Brak and Knysna Estuaries.

An analysis of the zero or protest bids is shown in Table 7.17. A lack of confidence in the government was the main reason for unwillingness to pay by respondents in the Groot Brak, Knysna and Kromme Estuary areas. These were interpreted as protest bids, rather than real bids. Lack of confidence in government was the most frequent reason given by respondents from areas of the seven selected estuaries for their unwillingness to pay. Two sampled respondents from the Kowie Estuary stated that they already paid enough fees for everything else and opposed paying any more.

Table 7.17: Frequency of reasons for zero WTP (zero and protest bids)

Reasons	Number of households from each estuary[1]						
	Groot Brak	Kariega	Klein Brak	Knysna	Kowie	Kromme	Swartkops
Cannot afford the fees	5	14	6	7	6	20	16
Get no or negligible value	7	8	10	2	5	16	0
Abundance of service options	1	4	24	11	1	6	19
Lack of confidence in government	17	7	5	29	4	36	16
Other: pay enough fees already					2		

[1] Respondents were allowed to have more than one reason

The sacrifices that would be made to make the annual payments (for those willing to make payments) are shown in Table 7.18. Reallocation from saving tended to be the main financing sacrifice in all areas. In the case of the Kariega and Swartkops Estuaries, most of the sacrifice would have been made from planned recreational expenditure.

Table 7.18: Frequency of respondents' sacrifices in order to make the payment

	Number of households from each estuary[1]						
Service income reallocated	Groot Brak	Kariega	Klein Brak	Knysna	Kowie	Kromme	Swartkops
Recreation activities	11	56	0	14	11	55	114
Domestic/household living	10	32	1	3	69	29	36
Dis-saving	100	13	74	136	2	64	78

[1] Respondents were allowed to have more than one reason

7.3 WTP estimates and the fitting of WTP functions

7.3.1 Measuring the variables

The WTP responses were subjected to testing for expected validity.[14] In other words, a series of multivariate analyses were conducted with the data of the seven estuaries investigated in

[14] Some content validation and convergent validation assessments were undertaken at the pilot study stage in the process (see Chapter Four).

order to see whether WTP amounts reported were consistent with economic expectation as formulated in terms of other information supplied. In the section below the results of the expected value validation tests are reported.

Observations of the dependent variable were drawn from two sets of information in order to estimate WTP functions for the seven selected estuaries. Firstly, mid-point WTP values were calculated for both the high and low benefit scenarios. The high benefit scenario was the high estimate of the ecological impacts of a change in freshwater inflow. The low benefit scenario was a low estimate of the ecological impact of a change in freshwater inflow. These values were used to fit OLS models to explain the WTP variations. The same data were fitted using a Tobit model, but the dependent variable in this case was restricted to non-negative values. The partial coefficients of OLS and Tobit models measure the changes of WTP per unit change in each explanatory variable. Secondly, the dependent variable was treated as a "yes or no" response to a WTP question, a discrete-choice response. Logit and Probit models were used to fit this WTP response to other data.

For the Groot Brak, Klein Brak, Knysna and Swartkops Estuaries, there were both high and low WTP estimation scenarios generated. For the Kariega, Kowie and Kromme Estuaries, only high WTP estimate scenarios were generated.

The descriptions of the explanatory variables selected for the purpose of carrying out regression analyses are listed in Table 7.19 and their expected relationships with household WTP are shown. These variables included the characteristics of respondents (e.g. race, gender and income), the respondent's knowledge, distance of accommodation from the estuary and the user categories of respondents.

The explanatory variables were both of a qualitative or quantitative nature. Qualitative variables were represented by dummy variables, where a value of 1 indicated the presence of the subject and 0 the absence of the subject, for example, being a male respondent. For quantitative variables, the mid-point value was taken from each category assigned, for example, levies and education level.

Table 7.19: Description of selected variables in the multiple regression analysis

Variable name	Description	Expected sign in regression model
Dependent variables		
WTP_H_Q WTP_L_Q	Amount household would pay for increased freshwater inflow: the amount was taken from mid-point of each category from WTP question in high (H) and low (L) scenario (for OLS and Tobit models)	
WTP_H_C WTP_L_C	"Yes or no" responses taken from the WTP question: 1 = respondent is willing to pay 0 = respondent is not willing to pay in high (H) and low (L) scenario (for Logit and Probit models)	
Independent variables		
Recreation	1 = if respondent uses estuary for recreation purposes 0 = otherwise	+ or -
Comm/subs	1 = if respondent uses estuary for commercial/ subsistence purposes 0 = otherwise	+ or -
Race	1 = if respondent belongs to white racial group 0 = otherwise	+ or -
Male	1 = if gender of respondent is male 0 = otherwise	+ or -
Visitor	1 = if respondent uses estuary as visitor 0 = otherwise	+ or -
Well-informed	1 = if respondent is well-informed regarding the impact of increase of water inflow into estuary 0 = otherwise	+
People/house	Number of people making up the respondent's household	+
Levies	Amount of levies paid in Rands by the respondent's household for fishing, boating, bait collection and other activities per year	+
Distance	Distance in kilometres of respondent's current accommodation	-
V_B_worth	Approximate worth of respondent's vehicles and boat owned at current prices	+
Education	Highest education level attainment of respondent	+
Income	Gross annual pre-tax income of respondent	+

Due to the respondents refusing to supply the information or insufficient numbers of respondents in the relevant category data could not be obtained on all the explanatory factors present at the sites.

7.3.2 Knysna Estuary

7.3.2.1 Estimate of WTP based on a high benefit scenario

(a) OLS and Tobit models

The results of fitting the OLS and Tobit models to data based on the high benefit scenario for service changes induced by changes to water inflow into the Knysna Estuary are summarised in Tables 7.20 and 7.21.

Table 7.20: The fit of WTP function for Knysna Estuary (high benefit scenario) using OLS and Tobit – complete model

Dependent Variable: WTP_H_Q								
Model: Complete model								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std. Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-67,808	131,854	-0,514	0,608	-227,94	164,12	-1,39	0,16
Comm_subs	33,610	66,410	0,506	0,613	92,23	85,47	1,08	0,28
Distance	-4,036	6,769	-0,596	0,552	-2,57	8,24	-0,31	0,75
Education	12,627	7,974	1,584	0,115	15,75	9,64	1,63	0,10
Income	0,000	0,000	1,912	0,057	0,00	0,00	1,86	0,06
Levies	0,528	0,090	5,839	0,000	0,58	0,11	5,36	0,00
Male	25,850	30,052	0,860	0,391	41,99	36,97	1,14	0,26
People/house	-10,150	11,124	-0,912	0,363	-11,13	13,57	-0,82	0,41
Race	-22,642	56,053	-0,404	0,687	1,94	69,55	0,03	0,98
Recreation	10,321	55,389	0,186	0,852	58,58	72,16	0,81	0,42
V_B Worth	6,48E-05	2,38E-04	0,272	0,786	-8,71E-07	2,89E-04	-3,01E-03	1,00
Visitor	-60,236	36,178	-1,665	0,098	-74,50	44,20	-1,69	0,09
Well inform	75,486	34,889	2,164	0,032	74,87	41,85	1,79	0,07
R^2	0,435				0,432			
Adjusted R^2	0,399				0,393			
Log likelihood					-1 078,609			
F-Statistic	12,085							
p-Value (F-statistic)	0,000							

Table 7.21: The fit of WTP function for Knysna Estuary (high benefit scenario) using OLS and Tobit – reduced model

Dependent Variable: WTP_H_Q								
Model: Reduced model								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std.Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-107,709	77,814	-1,384	0,168	-207,453	96,089	-2,159	0,031
Education	12,322	6,832	1,803	0,073	16,831	8,372	2,010	0,044
Income	5,04E-04	1,75E-04	2,878	0,004	5,44E-04	2,16E-04	2,515	0,012
Levies	0,553	0,084	6,550	0,000	0,613	0,102	5,998	0,000
Visitor	-51,132	30,389	-1,683	0,094	-73,529	37,871	-1,942	0,052
Well_inform	86,712	31,433	2,759	0,006	92,854	38,371	2,420	0,016
R^2	0,429				0,424			
Adjusted R^2	0,414				0,406			
Log likelihood					-1 080,193			
F-Statistic	29,256							
p-Value (F-statistic)	0,000							

The p-values indicate whether independent variables are statistically significant. At the 1% level of significance, $p<0,01$ (99% confidence interval) an independent variable is considered highly significant (Mirer, 1995). The complete and reduced OLS models have p-values that are smaller than 0,01. For this reason it was deduced that both models were highly significant.

In order to determine which of the models (complete or reduced OLS) were statistically preferable the reduced model was compared to the complete model. The reduced OLS model is preferred to the complete OLS model when the F-test statistic value is smaller than the critical value. This was indeed the case – the F-test statistic value of 0,29 was smaller than the critical value at the 5% significance level, namely 1,94.

A log-likelihood ratio test was used to determine the goodness of fit of the Tobit models, as well as to determine preference between the complete and reduced Tobit models. Both the complete and reduced Tobit models were significant in explaining an individual's WTP amount, but the latter was a better fit. The log-likelihood ratio statistic value for the comparison of the complete and reduced Tobit models was 3,17. This statistic is smaller than the χ^2 (chi-square)[15] value corresponding to the upper 5% significance level with seven degrees of freedom, namely 14,07. For this reason the null hypothesis could not be rejected (that the variables omitted in the reduced model were equal to zero) and it was deduced that the reduced Tobit model was the preferred one.

(b) Logit and Probit models

The Logit and Probit models were fitted to the WTP data based on the high benefit scenario expressed as binary choices (as described in Table 7.19). The results of fitting these models to this data are shown in Tables 7.22 and 7.23. In an application of the log-likelihood ratio test to determine which of the complete and reduced models was preferred it was found that the χ^2 value, corresponding to the upper 5% significance level with 11 degrees of freedom was 19,68 – greater than the respective test statistic values of 6,35 and 6,5 for the Logit and Tobit models. It was deduced that the null hypotheses would not be rejected and that the reduced models had better predictive abilities than the complete models did.

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15 The Chi-square distribution is a skewed distribution, the degree of skewness depending on the degrees of freedom.

Table 7.22: The fit of WTP function for Knysna Estuary (high benefit scenario) using Logit and Probit – complete model

Dependent Variable: WTP_H_C								
Model: Complete model								
Method	ML – Binary Logit				ML – Binary Probit			
	LOGIT				PROBIT			
Variable	Coefficient	Std.Err.	z-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-2,746	1,813	-1,515	0,130	-1,569	1,080	-1,453	0,146
Comm_subs	1,385	0,821	1,688	0,091	0,840	0,496	1,693	0,091
Distance	0,081	0,102	0,797	0,425	0,045	0,057	0,792	0,428
Education	0,155	0,109	1,418	0,156	0,094	0,065	1,448	0,148
Income	3,16E-06	3,87E-06	0,816	0,414	1,86E-06	2,30E-06	0,811	0,417
Levies	0,010	0,004	2,687	0,007	0,005	0,002	2,911	0,004
Male	0,245	0391	0,627	0,531	0,162	0,234	0,694	0,488
People/house	-0,052	0,153	-0,342	0,732	-0,042	0,091	-0,463	0,643
Race	0,337	0,716	0,471	0,638	0,161	0,434	0,372	0,710
Recreation	0,991	0,647	1,533	0,125	0,611	0,398	1,535	0,125
V_B_worth	-2,75E-06	3,41E-06	-0,807	0,419	-1,55E-06	2,02E-06	-0,769	0,442
Visitor	-0,275	0,493	-0,558	0,577	-0,169	0,295	-0,575	0,565
Well_inform	-0,428	0,518	-0,827	0,408	-0,277	0,306	-0,905	0,366
Log likelihood	-95,279				-95,154			
LR statistic	30,421				30,672			
p-Value (LR stat)	0,002				0,002			
McFadden R^2	0,138				0,139			

Table 7.23: The fit of WTP function for Knysna Estuary (high benefit scenario) using Logit and Probit – reduced model

Dependent Variable: WTP_H_C								
Model: Reduced model								
Method	ML – Binary Logit				ML – Binary Probit			
	LOGIT				PROBIT			
Variable	Coefficient	Std.Err.	z-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-1,996	1,229	-1,624	0,104	-1,173	0,738	-1,590	0,112
Comm_subs	1,129	0,693	1,630	0,103	0,676	0,421	1,605	0,108
Education	0,137	0,085	1,607	0,108	0,082	0,051	1,612	0,107
Levies	0,009	0,003	2,780	0,005	0,005	0,002	3,119	0,002
Recreation	0,899	0,582	1,545	0,122	0,563	0,364	1,545	0,122
Log likelihood	-97,238				-97,216			
LR statistic	26,504				26,548			
p-Value (LR stat)	0,000				0,000			
McFadden R^2	0,120				0,120			

The interpretation of partial coefficients in the Logit and Probit models has been explained in Chapter Four. The coefficients are derived when $\hat{P}$ is at its maximum value (when $d\hat{P}/dX$ is equal to zero) and interpreted as percentage change with respect to the relevant coefficients. Table 7.24 shows these percentage changes.

Table 7.24: Calculated percentage changes of coefficients: Knysna Estuary

Variable	Logit model	Probit model
Comm_subs	28,23%	26,97%
Education	3,42%	3,26%
Levies	0,24%	0,19%
Recreation	22,47%	22,45%

The count R^2 statistic (a measurement of goodness of fit described in Chapter Four) of both the reduced Logit and Probit models was 0,78. This statistic implies that 78% of the observations were correctly predicted in both the reduced Logit and Probit models, that is, that the models had equal predictive powers. The McFadden R^2 statistic is an alternative measurement of goodness of fit for these models. The McFadden R^2 statistics for the both reduced Logit and Probit models were 0,12. In terms of these criteria the goodness of fit is virtually the same for the two models.

(c) Results and interpretation

Since the reduced models are preferred for estimations, only the reduced models are discussed here. In the high WTP estimated scenario for the Knysna Estuary, for every additional year of education attained the mean WTP increases by R12,32 in the reduced OLS model and by R16,83 in the reduced Tobit model and the probability of being WTP increases by 3,26% in the reduced Probit model and by 3,42% in the reduced Logit model.

Extra income earned also has a positive effect on the WTP. For every extra R1 000 the respondent earned, mean WTP increased by R0,50 in the OLS model and by R0,54 in the Tobit model. For every Rand already being paid in levies for estuary related services the mean WTP increased by R0,55 in the reduced OLS model and by R0,61 in the reduced Tobit model, and the probability of being WTP increased by 0,19% in the reduced Probit and by 0,24% in the reduced Logit model.

Residents were willing to pay up to R51,13 more than the visitors were in the reduced OLS model and up to R73,53 more than the visitors were in the reduced Tobit model. People who were well informed on the ecological impacts resulting from change of freshwater inflow into the estuary were willing to pay R86,71 more in the reduced OLS model and R92,85 more in the reduced Tobit model than people who were partially or poorly informed.

WTP probability increased by 26,97% in the reduced Probit model and by 28,23% in the reduced Logit model for people who are commercial and subsistence users and by 22,45% in the reduced Probit model and by 22,47% in the reduced Logit model for people who are recreational users.

The sign of most of the significant variables included in the reduced models (Tables 7.21 and 7.24) accord with expectations – people who were more educated, well informed, had greater wealth (higher income earners, greater investments in the vehicles and boats) and directly affected by the changes were more willing to pay than the less educated and less wealthy.

7.3.2.2 Estimate of WTP based on a low benefit scenario

(a) OLS and Tobit models

The results of fitting the OLS and Tobit models to the data generated under the low benefit scenario are shown in Tables 7.25 and 7.26. Both the complete and reduced OLS models have p-values below the 1% significance level, that is, $p<0,01$. The reduced OLS model was preferred to the complete OLS model on account of failure to reject the null hypothesis using the nested test. In the nested test, in which the complete and reduced OLS models were compared, the F-statistic value of 0,37 was lower than the critical value of 2,10.

The reduced Tobit model was found to be more appropriate for prediction purposes than the complete Tobit model because the χ^2 critical value with upper 5% significance level and six degrees of freedom had a value of 12,59, which was greater than the log-likelihood ratio statistic of 3,25.

Table 7.25: The fit of WTP function for Knysna Estuary (low benefit scenario) using OLS and Tobit – complete model

Dependent Variable: WTP_L_Q								
Model: Complete model								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std.Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-160,641	113,266	-1,418	0,158	-308,276	141,160	-2,184	0,029
Comm_subs	67,177	57,047	1,178	0,241	121,377	73,361	1,655	0,098
Distance	-2,341	5,815	-0,403	0,688	-1,069	7,071	-0,151	0,880
Education	17,052	6,849	2,490	0,014	20,049	8,262	2,427	0,015
Income	0,001	0,000	2,382	0,018	0,001	0,000	2,277	0,023
Levies	0,448	0,078	5,758	0,000	0,486	0,093	5,259	0,000
Male	27,853	25,815	1,079	0,282	42,988	31,744	1,354	0,176
People/house	-7,777	9,556	-0,814	0,417	-8,199	11,643	-0,704	0,481
Race	-30,641	48,151	-0,636	0,525	-7,241	59,780	-0,121	0,904
Recreation	-0,743	47,580	-0,016	0,988	40,537	61,852	0,655	0,512
V_B_worth	0,000	0,000	0,577	0,565	0,000	0,000	0,255	0,799
Visitor	-35,622	31,078	-1,146	0,253	-46,656	37,937	-1,230	0,219
Well_inform	62,622	29,971	2,089	0,038	61,639	35,889	1,717	0,086
R^2	0,484				0,489			
Adjusted R^2	0,451				0,454			
Log likelihood					-1 055,156			
F-Statistic	14,705							
p-Value (F-statistic)	0,000							

Table 7.26: The fit of WTP function for Knysna Estuary (low benefit scenario) using OLS and Tobit – reduced model

Dependent Variable: WTP_L_Q								
Model: Reduced model								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std.Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-210,910	73,969	-2,851	0,005	-312,145	91,518	-3,411	0,001
Comm_subs	75,479	29,132	2,591	0,010	85,055	35,852	2,372	0,018
Education	15,435	5,840	2,643	0,009	19,154	7,147	2,680	0,007
Income	0,001	0,000	3,542	0,001	0,001	0,000	3,049	0,002
Levies	0,469	0,073	6,387	0,000	0,516	0,089	5,817	0,000
Male	24,041	24,836	0,968	0,334	36,651	30,886	1,187	0,235
Well_informed	69,839	27,009	2,586	0,010	78,162	32,848	2,380	0,017
R^2	0,478				0,483			
Adjusted R^2	0,462				0,464			
Log likelihood					-1 056,783			
F-Statistic	29,614							
p-Value (F-statistic)	0,000							

(b) Logit and Probit models

Due to the number of respondents willing to pay non-zero amounts being equal in both the high benefit and low benefit scenarios, the estimation results in the Logit and Probit models were the same for the low benefit (low estimate) scenario and the high benefit (high estimate) scenario (see Tables 7.22 and 7.23).

(c) Results and interpretation

Table 7.26 shows that the commercial/subsistence users believe healthier estuary ecology boost their business activities. Commercial/subsistence users were willing to pay R75,48 in the reduced OLS model and R85,06 in the reduced Tobit model more than the other categories of users. Similarly, education, income, levies and being well informed were significant and positively related to WTP. However, the values yielded under the low benefit scenario were different to those yielded under the high benefit scenario. The "male" variable is not statistically significant at the 10% level.

7.3.3 Groot Brak Estuary

7.3.3.1 Estimate of WTP based on a high benefit scenario

(a) OLS and Tobit models

The results of fitting the OLS and Tobit models to the data generated under the high benefit scenario for the Groot Brak Estuary (see Chapter Five) are shown in Tables 7.27 to 7.28. Both the complete and reduced OLS models have p-values that are statistically significant at the 1% level. For this reason it was deduced that both OLS models were highly significant.

In the nested test (see Equation 4.6), in which the complete and reduced OLS models were compared, the F-test statistic value of 0,72 was lower than the critical value of 2,10. For this reason the null hypothesis could not be rejected and it was deduced that the reduced OLS model was preferred to the complete OLS model.

The log-likelihood ratio test was used to determine preference between the complete and reduced Tobit models. The log-likelihood ratio statistic value was 1,67. As this statistic is smaller than the critical value of 12,59 the null hypothesis could not be rejected and it was deduced that the reduced Tobit model was a preferred fit to the complete Tobit model.

Table 7.27: The fit of the WTP function for Groot Brak Estuary (high benefit scenario) using OLS and Tobit – complete model

Dependent Variable: WTP_H_Q								
Models: Complete models								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std.Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-207,874	214,497	-0,969	0,334	-375,470	254,419	-1,476	0,140
Comm/subs	-42,566	143,128	-0,297	0,767	81,812	168,623	0,485	0,628
Distance	5,362	7,918	0,677	0,499	-0,247	9,251	-0,027	0,979
Education	14,006	14,325	0,978	0,330	9,298	16,027	0,580	0,562
Income	-0,002	0,001	-1,920	0,057	-0,002	0,001	-2,239	0,025
Levies	0,994	0,158	6,276	0,000	1,042	0,175	5,954	0,000
Male	-53,834	60,322	-0,892	0,374	-58,652	68,849	-0,852	0,394
People/house	62,068	19,397	3,200	0,002	79,299	22,404	3,540	0,000
Race	207,257	73,260	2,829	0,005	277,884	85,744	3,241	0,001
Recreation	-116,836	100,733	-1,160	0,248	-10,587	124,272	-0,085	0,932
V_B_worth	0,002	0,001	3,154	0,002	0,002	0,001	3,260	0,001
Visitor	-166,869	64,830	-2,574	0,011	-169,263	74,174	-2,282	0,023
Well_inform	-44,764	71,213	-0,629	0,531	-27,168	81,200	-0,335	0,738
R^2	0,461				0,482			
Adjusted R^2	0,414				0,433			
Log likelihood					-899,911			
F-Statistic	9,821							
p-Value (F-statistic)	0,000							

Table 7.28: The fit of the WTP function for Groot Brak Estuary (high benefit scenario) using OLS and Tobit models – reduced model

Dependent Variable: WTP_H_Q								
Model: Reduced model								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std.Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-198,514	115,716	-1,716	0,088	-323,139	136,750	-2,363	0,018
Income	-0,001	0,001	-1,951	0,053	-0,002	0,001	-2,281	0,023
Levies	0,969	0,139	6,957	0,000	1,061	0,157	6,775	0,000
People/house	63,168	19,218	3,287	0,001	79,676	22,456	3,548	0,000
Race	245,840	68,531	3,587	0,001	303,369	80,733	3,758	0,000
V_B_worth	0,002	0,001	3,191	0,002	0,002	0,001	3,291	0,001
Visitor	-155,400	57,311	-2,712	0,008	-176,558	66,068	-2,672	0,008
R^2	0,444				0,472			
Adjusted R^2	0,421				0,446			
Log likelihood					-900,746			
F-Statistic	19,152							
p-Value (F-statistic)	0,000							

(b) Logit and Probit models

The Logit and Probit models were fitted to the DC WTP variable described in Table 7.19. The results are shown in Tables 7.29 and 7.30. In the log-likelihood ratio tests, it was found that the test statistic values of 14,23 and 14,85, respectively, for the Logit and Probit models were smaller than the χ^2 values of 16,01, corresponding to the upper 5% significance level with seven degrees of freedom (for the Logit and Probit models). In the light of the log-likelihood ratio tests the null hypotheses could not be rejected and it was deduced that both the reduced models had better prediction qualities than the complete models did.

Table 7.29: The fit of the WTP function for Groot Brak Estuary (high benefit scenario) using Logit and Probit – complete model

Dependent Variable: WTP_H_C								
Model: Complete model								
Method	ML – Binary Logit				ML – Binary Probit			
	LOGIT				PROBIT			
Variable	Coefficient	Std.Err.	z-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-0,159	2,077	-0,077	0,939	-0,100	1,202	-0,083	0,934
Comm/subs	34,867	1,28E+07	2,73E-06	1,000	8,151	1,34E+06	6,07E-06	1,000
Distance	-0,110	0,064	-1,719	0,086	-0,066	0,037	-1,780	0,075
Education	-0,169	0,152	-1,111	0,266	-0,104	0,088	-1,180	0,238
Income	-8,22E-06	6,91E-06	-1,189	0,235	-5,13E-06	4,15E-06	-1,238	0,216
Levies	0,006	0,004	1,395	0,163	0,003	0,002	1,484	0,138
Male	-0,028	0,535	-0,052	0,958	-0,009	0,305	-0,030	0,976
People/house	0,357	0,175	2,035	0,042	0,214	0,101	2,131	0,033
Race	1,556	0,666	2,338	0,019	0,952	0,386	2,465	0,014
Recreation	1,819	0,742	2,451	0,014	1,097	0,447	2,455	0,014
V_B_worth	5,69E-06	5,80E-06	0,982	0,326	3,67E-06	3,40E-06	1,077	0,281
Visitor	0,048	0,570	0,084	0,933	0,054	0,328	0,164	0,870
Well_inform	0,547	0,670	0,816	0,415	0,378	0,388	0,976	0,329
Log likelihood	-60,190				-59,835			
LR statistic	30,185				30,896			
p-Value (LR stat)	0,003				0,002			
McFadden R^2	0,200				0,205			

Table 7.30: The fit of the WTP function for Groot Brak Estuary (high benefit scenario) using Logit and Probit – reduced model

Dependent Variable: WTP_H_C								
Model: Reduced model								
Method	ML – Binary Logit				ML – Binary Probit			
	LOGIT				PROBIT			
Variable	Coefficient	Std.Err.	z-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-1,002	1,052	-0,953	0,341	-0,536	0,611	-0,877	0,380
Distance	-0,119	0,061	-1,950	0,051	-0,073	0,035	-2,064	0,039
Levies	0,007	0,004	1,708	0,088	0,004	0,002	1,862	0,063
People/house	0,331	0,168	1,965	0,050	0,188	0,096	1,973	0,049
Race	0,944	0,529	1,786	0,074	0,573	0,312	1,836	0,066
Recreation	0,579	0,568	1,020	0,308	0,346	0,334	1,034	0,301
Log likelihood	-67,307				-67,262			
LR statistic	15,952				16,041			
p-Value (LR stat)	0,007				0,007			
McFadden R^2	0,106				0,107			

The interpretations of the coefficients of the Logit and Probit models are summarised in Table 7.31.

Table 7.31: Calculated percentage changes by coefficients: Groot Brak Estuary

Variable	Logit model	Probit model
Distance	-2,98%	-2,91%
Levies	0,18%	0,16%
People/house	8,28%	7,50%
Race	23,60%	22,86%

The count R^2 statistic of both the reduced Logit and Probit model fits was 0,83 (see Chapter Four for interpretation). It implies that 83% of the probabilities were correctly predicted in the reduced Logit and Probit models. The McFadden R^2 statistics for the reduced Logit and Probit models, respectively, were 0,106 and 0,107. In terms of these criteria (for goodness of fit) the predictive qualities of both reduced models are virtually equal.

(c) Results and interpretation

In the reduced OLS model of the bid function, the coefficient implies that for every additional member included in a family the mean WTP increases by R63 and in the reduced Tobit model it implies that each additional family member increases the mean WTP by R80. In the reduced Logit and Probit models of the bid functions, the coefficients imply that for every additional member included in a family the probability of WTP increases by up to 7,5% (in the reduced Probit model) and by up to 8,28% (in the reduced Logit model).

The results also show that White respondents were willing to pay significantly more (R245,84 in the reduced OLS model and R303,37 in the reduced Tobit model) than other racial groups and had a higher probability of WTP, namely 22,9% in the reduced Probit model and 23,6% in the reduced Logit model. Being a visitor decreased WTP by R155,40 in the OLS model and by R176,56 in the Tobit model.

The results shown in Tables 7.28 and 7.31 also suggest that levies and worth of vehicles/boats currently owned have a positive but small effect on an individuals' WTP. For every Rand increase in estuary-related levies paid, a person is willing to pay an extra R0,969 in the reduced OLS model and an extra R1,061 in the reduced Tobit model, and his or her probability of being willing to pay increased by 0,16% in the reduced Probit model and by 0,18% in the reduced Logit model. Respondents were also willing to pay R0,002 extra per Rand increase in value of vehicles/boats they currently owned. For every additional kilometre of the accommodation away from the estuary, the probability of WTP decreased by 3% in both the reduced Probit and Logit models.

Surprisingly, the WTP declined by R0,001 in the reduced OLS model and by R0,002 in the reduced Tobit model for every additional Rand earned by the respondents.

7.3.3.2 Estimate of WTP based on a low benefit scenario

(a) OLS and Tobit models

The results of fitting the OLS and Tobit models to the data generated under the low benefit scenario are shown in Tables 7.32 and 7.33. The reduced OLS model was preferred to the complete model on account of failure to reject the null hypothesis using the nested test. In the nested test the critical value of 2,29 was greater than the F-statistic value of 0,55.

The reduced Tobit model was found to be superior in predictive quality to the complete Tobit model because the χ^2 critical value, with an upper 5% significance level and five degrees of freedom, had a value of 11,07, which was greater than the log-likelihood ratio statistic of 3,67.

Table 7.32: The fit of the WTP function for Groot Brak Estuary (low benefit scenario) using OLS and Tobit – complete model

Dependent Variable: WTP_L_Q								
Model: Complete model								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std.Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-193,584	172,193	-1,124	0,263	-379,545	208,766	-1,818	0,069
Comm/subs	137,144	114,900	1,194	0,235	270,972	138,592	1,955	0,051
Distance	-1,421	6,356	-0,224	0,823	-6,286	7,423	-0,847	0,397
Education	2,985	11,500	0,260	0,796	0,013	12,835	0,001	0,999
Income	-3,43E-04	0,001	-0,546	0,586	-0,001	0,001	-0,987	0,324
Levies	0,841	0,127	6,616	0,000	0,875	0,140	6,252	0,000
Male	-64,676	48,425	-1,336	0,184	-67,760	55,265	-1,226	0,220
People/house	42,728	15,572	2,744	0,007	57,956	18,056	3,210	0,001
Race	143,822	58,811	2,445	0,016	202,606	68,835	2,943	0,003
Recreation	41,064	80,866	0,508	0,612	158,092	103,613	1,526	0,127
V_B_worth	0,001	0,000	2,769	0,006	0,002	0,001	2,863	0,004
Visitor	-121,937	52,044	-2,343	0,021	-122,189	59,590	-2,051	0,040
Well_inform	-21,884	57,168	-0,383	0,703	-9,580	65,043	-0,147	0,883
R^2	0,502				0,522			
Adjusted R^2	0,458				0,476			
Log likelihood					-872,390			
F-Statistic	11,578							
p-Value (F-statistic)	0,000							

Table 7.33: The fit of the WTP function for Groot Brak Estuary (low benefit scenario) using OLS and Tobit – reduced model

Dependent Variable: WTP_L_Q								
Model: Reduced model								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std.Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-211,107	119,448	-1,767	0,079	-445,833	153,261	-2,909	0,004
Comm_subs	113,459	108,783	1,043	0,299	249,077	132,570	1,879	0,060
Levies	0,809	0,122	6,611	0,000	0,845	0,137	6,172	0,000
People_household	42,291	15,379	2,750	0,007	56,415	18,120	3,114	0,002
Race	151,188	53,445	2,829	0,005	195,611	63,301	3,090	0,002
Recreation	32,236	79,897	0,403	0,687	140,495	103,072	1,363	0,173
V_B_worth	0,001	0,000	3,401	0,001	0,001	0,000	3,037	0,002
Visitor	-133,485	46,063	-2,898	0,004	-145,472	53,611	-2,713	0,007
R^2	0,492				0,510			
Adjusted R^2	0,467				0,482			
Log likelihood					-874,225			
F-Statistic	19,755							
p-Value (F-statistic)	0,000							

(b) Logit and Probit models

Due to there being an equal number of respondents who were willing to pay non-zero amounts in both the high benefit and low benefit scenarios, the estimation results in the Logit and Probit models are the same for the low benefit (high estimate) scenario as they were for the high benefit scenario (low estimate) (see Tables 7.22 to 7.24).

(c) Results and interpretation

Although the variables levies, people/house, race, worth of vehicles and boats and visitors were statistically significant in the Groot Brak high and low estimate scenarios, the magnitude of the coefficients differed.

In the low estimate scenario residents were willing to pay R152,76 more than visitors in the reduced Tobit model and R186,37 more than visitors in the reduced OLS model, and Whites were willing to pay R195,61 more than non-Whites in the reduced Tobit model and R201,83 more than non-Whites in the reduced OLS model.

For every additional R100 paid on estuary-related levies, the WTP amount increased by R84,50 in the reduced Tobit model and R95,90 in the reduced OLS model, and for R10 000 additional value of vehicles/boats currently owned by respondents, the WTP increased by R10 in both reduced OLS and Tobit models. The commercial and subsistence variable was found to be significant in the reduced Tobit model, suggesting people who are commercial and subsistence users would be willing to pay R249,08 more than other categories of users.

7.3.4 Klein Brak Estuary

7.3.4.1 Estimate of WTP based on a high benefit scenario

(a) OLS and Tobit models

Tables 7.34 and 7.35 summarise the results of fitting the OLS and Tobit models to data for the Klein Brak Estuary based on the high benefit scenario. In order to determine which of the complete or reduced OLS models was statistically superior the nesting test was conducted. A F-statistic of 0,25 was found, which was smaller than the critical value of 2,41. For this reason, the null hypothesis could not be rejected and it was deduced that the reduced OLS model was superior in terms of its predictive qualities to the complete model.

The log-likelihood ratio test was used to determine preference between the complete and reduced Tobit models. The log-likelihood ratio test statistic was 2,98. This value is lower than the χ^2 value corresponding to the upper 5% significance level with eight degrees of freedom value, namely 15,50. It was deduced that the null hypothesis could not be rejected and the reduced Tobit model's predictive qualities were superior to those of the complete model.

Table 7.34: The fit of WTP function for Klein Brak Estuary (high benefit scenario) using OLS and Tobit – complete model

Dependent Variable: WTP_H_Q								
Model: Complete model								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std.Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-212,765	137,079	-1,552	0,124	-366,751	166,226	-2,206	0,027
Comm_subs	59,192	93,270	0,635	0,527	126,574	114,208	1,108	0,268
Distance	-1,210	5,699	-0,212	0,832	3,068	6,600	0,465	0,642
Education	10,222	11,578	0,883	0,380	7,601	13,477	0,564	0,573
Income	-2,55E-04	0,001	-0,464	0,644	-1,95E-04	0,001	-0,303	0,762
Levies	-0,788	0,898	-0,878	0,382	-0,898	1,034	-0,869	0,385
Male	56,668	39,447	1,437	0,154	88,474	47,594	1,859	0,063
People/house	23,893	14,088	1,696	0,093	30,747	16,656	1,846	0,065
Race	103,198	75,861	1,360	0,177	173,378	92,153	1,881	0,060
Recreation	14,622	74,026	0,198	0,844	36,444	94,316	0,386	0,699
V_B_worth	1,09E-04	4,42E-04	0,247	0,806	8,94E-05	0,001	0,175	0,861
Visitor	-2,444	41,568	-0,059	0,953	-5,705	49,373	-0,116	0,908
Well_inform	129,891	67,532	1,923	0,058	152,072	77,907	1,952	0,051
R^2	0,159				0,145			
Adjusted R^2	0,045				0,018			
Log likelihood					-526,170			
F-Statistic	1,391							
p-Value (F-statistic)	0,185							

Table 7.35: **The fit of WTP function for Klein Brak Estuary (high benefit scenario) using OLS and Tobit – reduced model**

Dependent Variable: WTP_H_Q								
Model: Reduced model								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std.Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-129,951	76,430	-1,700	0,092	-268,764	98,640	-2,725	0,006
Male	49,348	37,166	1,328	0,187	83,671	46,655	1,793	0,073
People/house	24,335	12,248	1,987	0,050	30,819	15,208	2,026	0,043
Race	126,078	49,928	2,525	0,013	186,585	64,259	2,904	0,004
Well_inform	135,986	58,718	2,316	0,023	156,301	70,748	2,209	0,027
R^2	0,140				0,133			
Adjusted R^2	0,104				0,088			
Log likelihood					-527,659			
F-Statistic	3,907							
p-Value (F-statistic)	0,006							

(b) Logit and Probit models

The Logit and Probit models were fitted to the data based on the high benefit scenario expressed as binary choices. In an application of the log-likelihood ratio test it was found that the χ^2 value of 16,92, corresponding to the upper 5% significance level with nine degrees of freedom, was greater than the respective test statistic values of 3,49 for the Logit and Probit models. It was deduced that the null hypotheses could not be rejected and that both the reduced Logit and Probit models had superior predictive qualities to the complete models. The results are shown in Tables 7.36 and 7.37.

Table 7.36: **The fit of the WTP function for Klein Brak Estuary (high benefit scenario) using Logit and Probit – complete model**

Dependent Variable: WTP_H_C								
Model: Complete model								
Method	ML – Binary Logit				ML – Binary Probit			
	LOGIT				PROBIT			
Variable	Coefficient	Std.Err.	z-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-0,225	2,147	-0,105	0,917	-0,097	1,227	-0,079	0,937
Comm/subs	1,863	1,388	1,343	0,179	1,074	0,765	1,405	0,160
Distance	0,180	0,095	1,896	0,058	0,106	0,052	2,041	0,041
Education	-0,154	0,197	-0,783	0,434	-0,098	0,110	-0,896	0,370
Income	4,09E-06	7,96E-06	0,514	0,608	2,60E-06	4,46E-06	0,584	0,559
Levies	0,002	0,015	0,134	0,893	0,002	0,009	0,220	0,826
Male	0,704	0,528	1,333	0,183	0,418	0,312	1,340	0,180
People/house	0,122	0,196	0,624	0,533	0,074	0,118	0,623	0,533
Race	1,180	0,990	1,192	0,233	0,750	0,600	1,250	0,211
Recreation	0,252	0,848	0,297	0,766	0,177	0,515	0,345	0,730
V_B_worth	1,11E-06	6,54E-06	0,170	0,865	-6,03E-08	3,79E-06	-0,016	0,987
Visitor	0,104	0,568	0,183	0,855	0,068	0,332	0,204	0,839
Well_inform	0,303	0,971	0,312	0,755	0,140	0,553	0,253	0,801
Log likelihood	-49,679				-49,661			
LR statistic	15,853				15,887			
p-Value (LR stat)	0,198				0,196			
McFadden R^2	0,138				0,138			

Table 7.37: The fit of the WTP function for Klein Brak Estuary (high benefit scenario) using Logit and Probit – reduced model

Dependent Variable: WTP_H_C								
Model: Reduced model								
Method	ML – Binary Logit				ML – Binary Probit			
	LOGIT				PROBIT			
Variable	Coefficient	Std.Err.	z-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-0,127	0,431	-0,296	0,767	-0,061	0,263	-0,232	0,817
Comm_subs	1,963	1,087	1,806	0,071	1,052	0,534	1,969	0,049
Distance	0,191	0,089	2,143	0,032	0,113	0,049	2,300	0,021
Male	0,916	0,490	1,869	0,062	0,543	0,290	1,872	0,061
Log likelihood	-51,426				-51,406			
LR statistic	12,358				12,398			
p-Value (LR stat)	0,006				0,006			
McFadden R^2	0,107				0,108			

Interpretations of the coefficients of the Logit and Probit models are summarised in Table 7.38.

Table 7.38: Calculated percentage changes by coefficients: Klein Brak Estuary

Variable	Logit model	Probit model
Comm_subs	49,08%	41,97%
Distance	4,78%	4,75%
Male	22,89%	2,58%

The count R^2 statistic of both the reduced Logit and Probit models was 0,72. This statistic implies that 72% of the observations were correctly predicted in both the reduced Logit and Probit models. The McFadden R^2 statistic for both the reduced models was 0,11. In terms of these criteria (for goodness of fit) the reduced Logit and Probit models have equal predictive quality.

(c) Results and interpretation

The results reported in Table 7.35 (of the reduced OLS and Tobit model fits) show knowledge to be an important influence on WTP. People with more knowledge would probably pay more to conserve estuaries. People who are well informed about estuary ecology would be willing to pay R136,00 more in the reduced OLS model and R156,30 more in the Tobit model. In the reduced OLS model WTP increases by R24,36 and in the reduced Tobit model by R30,82 for every additional family member. In the same models, White respondents were willing to pay R126,08 (OLS model) and R186,59 (Tobit model) more than non-White respondents.

Male respondents were willing to pay R83,67 more than female respondents and the probability of being willing to pay increased from 2,58% in the reduced Probit model to 22,89% in the reduced Logit model. The maximum WTP probability increased by 41,97% in the reduced Probit model, and by 49,08% in the reduced Logit model for people who are commercial/subsistence users.

For every kilometre increase in the distance of the respondent's current accommodation from the estuary, the probabilities of WTP increased by 4,75% in the reduced Probit model and by 4,78% in the reduced Logit model. This result indicates people are willing to pay more the further away they reside from the estuary, the opposite to what was found with respect to the Groot Brak Estuary.

7.3.4.2 Estimate of WTP based on a low benefit scenario

(a) OLS and Tobit models

The results of fitting the OLS and Tobit models to the data based on the low benefit scenario are summarised in Tables 7.39 and 7.40. The reduced OLS model was preferred to the complete model due to a failure to reject the null hypothesis using the nested test. In the nested test, the F-test statistic value of 0,86 was smaller than the critical value of 1,99.

The reduced Tobit model has superior predictive qualities compared to the complete Tobit model because the χ^2 critical value, corresponding to the upper 5% significance level with ten degrees of freedom, has a value of 18,31, which is greater than the log-likelihood ratio statistic value of 13,81 (see Tables 7.39 and 7.40).

Table 7.39: The fit of the WTP function for Klein Brak Estuary (low benefit scenario) using OLS and Tobit – complete model

Dependent Variable: WTP_L_Q								
Model: Complete model								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std.Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-229,885	131,171	-1,753	0,083	-580,811	214,430	-2,709	0,007
Comm_subs	52,668	89,250	0,590	0,557	173,066	149,115	1,161	0,246
Distance	-2,771	5,453	-0,508	0,613	-0,463	7,758	-0,060	0,952
Education	14,363	11,079	1,296	0,198	19,350	16,682	1,160	0,246
Income	-4,07E-04	0,001	-0,775	0,440	-0,001	0,001	-0,912	0,362
Levies	-0,268	0,859	-0,312	0,756	0,202	1,175	0,172	0,863
Male	48,720	37,747	1,291	0,200	119,603	58,642	2,040	0,041
People/house	13,827	13,481	1,026	0,308	5,028	19,948	0,252	0,801
Race	43,430	72,591	0,598	0,551	141,614	114,713	1,235	0,217
Recreation	23,304	70,836	0,329	0,743	116,060	125,288	0,926	0,354
V_B_worth	4,08E-04	4,23E-04	0,966	0,337	0,001	0,001	1,187	0,235
Visitor	-1,737	39,777	-0,044	0,965	-23,322	59,210	-0,394	0,694
Well_inform	122,344	64,622	1,893	0,062	133,135	88,892	1,498	0,134
R^2	0,166				0,146			
Adjusted R^2	0,052				0,018			
Log likelihood					-416,937			
F-Statistic	1,457							
p-Value (F-statistic)	0,156							

Table 7.40: **The fit of the WTP function for Klein Brak Estuary (low benefit scenario) using OLS and Tobit – reduced model**

Dependent Variable: WTP_L_Q								
Model: Reduced model								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std.Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	31,265	28,289	1,105	0,272	-108,159	49,294	-2,194	0,028
Male	46,248	36,127	1,280	0,204	108,815	58,110	1,873	0,061
Well_inform	146,464	56,717	2,582	0,011	201,359	84,152	2,393	0,017
R^2	0,084				0,068			
Adjusted R^2	0,065				0,040			
Log likelihood					-423,844			
F-Statistic	4,480							
p-Value (F-statistic)	0,014							

(b) Logit and Probit models

The Logit and Probit models were fitted to the WTP data expressed as DCs. The results of fitting these models to the data are shown in Tables 7.41 and 7.42. In an application of the log-likelihood ratio test it was found that the χ^2 value, corresponding to the upper 5% confidence level with eight degrees of freedom, was 15,5 – greater than the test statistic value of 9,0 for the Logit model and the test statistic value of 9,2 for the Probit model. It was deduced that the null hypotheses could not be rejected and that both the reduced models were appropriately specified.

Table 7.41: **The fit of the WTP function for Klein Brak Estuary (low benefit scenario) using Logit and Probit – complete model**

Dependent Variable: WTP_L_C								
Model: Complete model								
Method	ML – Binary Logit				ML – Binary Probit			
	LOGIT				PROBIT			
Variable	Coefficient	Std.Err.	z-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-2,202	1,707	-1,290	0,197	-1,290	1,016	-1,270	0,204
Comm/subs	1,483	1,173	1,265	0,206	0,899	0,704	1,278	0,201
Distance	0,078	0,072	1,081	0,280	0,052	0,044	1,189	0,234
Education	0,039	0,141	0,280	0,779	0,020	0,084	0,237	0,813
Income	-4,25E-06	6,61E-06	-0,643	0,520	-2,38E-06	3,99E-06	-0,597	0,550
Levies	0,022	0,016	1,371	0,170	0,013	0,009	1,465	0,143
Male	0,989	0,491	2,012	0,044	0,594	0,297	2,002	0,045
People/house	-0,240	0,176	-1,363	0,173	-0,150	0,108	-1,380	0,168
Race	0,445	0,901	0,493	0,622	0,288	0,550	0,525	0,600
Recreation	1,042	0,935	1,114	0,265	0,628	0,558	1,125	0,261
V_B_worth	6,75E-06	5,58E-06	1,212	0,226	4,00E-06	3,37E-06	1,185	0,236
Visitor	-0,155	0,502	-0,309	0,757	-0,085	0,305	-0,279	0,780
Well_inform	-0,205	0,874	-0,234	0,815	-0,123	0,506	-0,243	0,808
Log likelihood	-58,954				-58,853			
LR statistic	20,430				20,632			
p-Value (LR stat)	0,059				0,056			
McFadden R^2	0,148				0,149			

Table 7.42: The fit of the WTP function for Klein Brak Estuary (low benefit scenario) using Logit and Probit – reduced model

Dependent Variable: WTP_L_C								
Model: Reduced model								
Method	ML – Binary Logit				ML – Binary Probit			
	LOGIT				PROBIT			
Variable	Coefficient	Std.Err.	z-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-0,249	0,725	-0,344	0,731	-0,120	0,429	-0,279	0,780
Comm_subs	0,251	0,628	0,401	0,689	0,171	0,388	0,440	0,660
Levies	0,027	0,015	1,737	0,082	0,016	0,008	1,848	0,065
Male	0,842	0,438	1,924	0,054	0,513	0,269	1,904	0,057
People_household	-0,223	0,133	-1,679	0,093	-0,140	0,081	-1,724	0,085
Log likelihood	-63,456				-63,457			
LR statistic	11,427				11,423			
p-Value (LR stat)	0,022				0,022			
McFadden R^2	0,083				0,083			

Interpretations of the coefficients of the Logit and Probit models are summarised in Table 7.43.

Table 7.43: Calculated percentage changes by coefficients: Klein Brak Estuary

Variable	Logit model	Probit model
Levies	0,67%	0,62%
Male	21,05%	20,47%
People_household	-5,58%	-5,59%

The count R^2 statistic of the reduced Logit and Probit models was 0,66. This statistic implies that 66% of the observations were correctly predicted in the reduced Logit and Probit models. The McFadden R^2 statistic for the Logit and Probit models was 0,083. It was deduced that the predictive qualities of the two reduced models were virtually the same.

(c) Results and interpretation

The respondents who were well informed about the ecological impact of freshwater inflow into the Klein Brak Estuary were willing to pay R146,46 more in the reduced OLS model and R201,36 more in the reduced Tobit model than people who were poorly informed. The male variable was statistically significant in the reduced Tobit model. Male respondents were willing to pay R108,82 more than the female respondents and their probability of being willing to pay was 20,47% higher in the reduced Probit model and 21% higher in the reduced Logit model.

The levies variable was statistically significantly in both the reduced Probit and reduced Logit models. For every Rand the respondents paid for the estuary-related fees, their probabilities of being willing to pay increased up to 0,62% in the reduced Probit model and up to 0,64% in the reduced Logit model. The sign of the variable, the number of people per household, was opposite to that expected in both the reduced Logit and reduced Probit models.

7.3.5 Kromme Estuary - Estimate of WTP based on a high benefit scenario

(a) OLS and Tobit models

The results of fitting the OLS and Tobit models (complete and reduced) to the Kromme Estuary data are shown in Tables 7.44 and 7.45. The complete and reduced OLS models were compared for goodness of fit using the nested test. As the F-test statistic value of 0,29 was smaller than the critical value of 2,17, the null hypothesis could not be rejected and it was deduced that the reduced OLS model was preferred to the complete OLS model.

The log-likelihood ratio test was used to test for preference between complete and reduced Tobit models. The log-likelihood ratio statistic value was 3,13. This statistic was smaller than the χ^2 value of 12,59, corresponding to the upper 5% significance level with six degrees of freedom. It was deduced that the reduced Tobit model had superior explanatory qualities to the complete Tobit model.

Table 7.44: The fit of the WTP function for Kromme Estuary (high benefit scenario) using OLS and Tobit – complete model

Dependent Variable: WTP_H_Q								
Model: Complete model								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std.Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-178,483	227,976	-0,783	0,435	-734,351	350,311	-2,096	0,036
Comm_subs	-29,866	193,495	-0,154	0,878	-114,532	260,120	-0,440	0,660
Distance	11,423	10,786	1,059	0,291	18,860	13,669	1,380	0,168
Education	7,622	15,530	0,491	0,624	13,109	20,913	0,627	0,531
Income	-1,79E-04	2,25E-04	-0,797	0,427	-2,09E-04	2,83E-04	-0,737	0,461
Levies	0,856	0,106	8,055	0,000	0,905	0,134	6,760	0,000
Male	15,483	66,249	0,234	0,816	2,070	83,566	0,025	0,980
People_household	31,421	22,278	1,410	0,161	50,399	28,296	1,781	0,075
Race	-44,073	180,901	-0,244	0,808	254,949	301,191	0,846	0,397
Recreation	-187,019	120,261	-1,555	0,122	-202,897	159,893	-1,269	0,205
V_B_worth	0,001	0,000	2,943	0,004	0,001	0,000	3,061	0,002
Visitor	64,734	62,745	1,032	0,304	55,634	79,259	0,702	0,483
Well_informed	103,911	55,398	1,876	0,063	140,111	70,730	1,981	0,048
R^2	0,577				0,604			
Adjusted R^2	0,540				0,567			
Log likelihood					-814,538			
F-Statistic	15,603							
p-Value (F-statistic)	0,000							

Table 7.45: The fit of the WTP function for Kromme Estuary (high benefit scenario) using OLS and Tobit – reduced model

Dependent Variable: WTP_H_Q								
Model: Reduced model								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std.Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-146,809	111,114	-1,321	0,189	-435,439	156,797	-2,777	0,006
Distance	7,913	9,038	0,876	0,383	16,622	11,873	1,400	0,162
Levies	0,835	0,094	8,851	0,000	0,908	0,123	7,408	0,000
People_household	36,970	19,347	1,911	0,058	47,323	25,177	1,880	0,060
Recreation	-136,550	87,313	-1,564	0,120	-69,301	120,040	-0,577	0,564
V_B_worth	0,001	0,000	3,567	0,001	0,001	0,000	3,791	0,000
Well_informed	91,900	49,207	1,868	0,064	126,066	63,923	1,972	0,049
R^2	0,572				0,595			
Adjusted R^2	0,554				0,575			
Log likelihood					-816,105			
F-Statistic	31,852							
p-Value (F-statistic)	0,000							

(b) Logit and Probit models

The Logit and Probit models were fitted to the WTP data expressed as discrete choices. In an application of the log-likelihood ratio test it was found that the respective test statistic values of 4,61 and 4,46 for the Logit and Probit models were smaller than the χ^2 value, corresponding to the upper 5% significance level with eight degrees of freedom, namely 15,51. It was deduced that the null hypotheses could not be rejected and that both the reduced models had superior predictive power to the complete models. The results of fitting these models to the data are shown in Tables 7.46 and 7.47.

Table 7.46: The fit of the WTP function for Kromme Estuary (high benefit scenario) using Logit and Probit – complete model

Dependent Variable: WTP_H_C								
Model: Complete model								
Method	ML – Binary Logit				ML – Binary Probit			
	LOGIT				PROBIT			
Variable	Coefficient	Std.Err.	z-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-4,833	2,170	-2,227	0,026	-2,851	1,266	-2,252	0,024
Comm_subs	0,897	2,375	0,378	0,706	0,465	1,338	0,348	0,728
Distance	0,140	0,094	1,496	0,135	0,083	0,055	1,517	0,129
Education	0,125	0,137	0,913	0,361	0,071	0,082	0,871	0,384
Income	-1,32E-06	2,05E-06	-0,642	0,521	-8,09E-07	1,19E-06	-0,678	0,498
Levies	-4,95E-04	0,001	-0,542	0,588	-2,25E-04	0,001	-0,424	0,671
Male	-0,303	0,565	-0,537	0,592	-0,167	0,329	-0,508	0,612
People_household	0,407	0,202	2,012	0,044	0,237	0,117	2,029	0,042
Race	1,611	1,505	1,070	0,285	0,970	0,917	1,058	0,290
Recreation	0,453	0,907	0,500	0,617	0,221	0,552	0,400	0,689
V_B_worth	5,11E-06	2,18E-06	2,345	0,019	3,06E-06	1,26E-06	2,424	0,015
Visitor	-0,083	0,533	-0,155	0,877	-0,012	0,313	-0,037	0,970
Well_informed	0,903	0,481	1,877	0,061	0,580	0,286	2,028	0,043
Log likelihood	-75,877				-75,527			
LR statistic	27,987				28,688			
p-Value (LR stat)	0,006				0,004			
McFadden R^2	0,156				0,160			

Table 7.47: The fit of the WTP function for Kromme Estuary (high benefit scenario) using Logit and Probit – reduced model

Dependent Variable: WTP_H_C								
Model: Reduced model								
Method	ML – Binary Logit				ML – Binary Probit			
	LOGIT				PROBIT			
Variable	Coefficient	Std.Err.	z-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-1,617	0,649	-2,491	0,013	-0,993	0,387	-2,568	0,010
Distance	0,154	0,076	2,023	0,043	0,092	0,044	2,078	0,038
People_household	0,263	0,166	1,577	0,115	0,161	0,099	1,625	0,104
V_B_worth	5,33E-06	1,56E-06	3,419	0,001	3,24E-06	9,11E-07	3,555	0,000
Well_informed	0,928	0,417	2,224	0,026	0,582	0,246	2,360	0,018
Log likelihood	-78,182				-77,758			
LR statistic	23,378				24,226			
p-Value (LR stat)	0,000				0,000			
McFadden R^2	0,130				0,135			

Interpretations of the coefficients of the Logit and Probit model fits are summarised in Table 7.48.

Table 7.48: Calculated percentage changes by coefficients: Kromme Estuary

Variable	Logit model	Probit model
Distance	3,85%	3,68%
People_household	6,56%	6,44%
V_B_worth	0,0001%	0,0001%
Well_informed	23,19%	23,21%

The count R^2 statistic of both the reduced Logit and Probit models was 0,71. This statistic indicates that 71% of the observations were correctly predicted in both the reduced Logit and Probit models. The McFadden R^2 statistics for the reduced Logit and Probit models were 0,130 and 0,135, respectively. In terms of these criteria there was little to choose between the models in terms of goodness of fit.

(c) Results and interpretation

For every additional Rand paid in levies for estuary services, WTP increased by R0,835 in the reduced OLS model and by R0,91 in the reduced Tobit model. For every additional member in the family, the WTP increased by about R37 in the reduced OLS model and about R47 in the reduced Tobit model and increased the probability of WTP by 6,44% in the reduced Tobit model and by 6,56% in the reduced OLS model.

The worth of vehicles/boats currently owned is highly statistically significant in all four of the reduced models, but only has a limited impact on the WTP, both in monetary and probability terms. For every R1 000 value increase in vehicles/boats current worth, WTP increased by R1 in the reduced OLS and Tobit models and the probability of WTP increased by 0,1% in the reduced Logit and Probit models.

People who were well informed on the ecological impacts resulting from changes of freshwater inflow into the estuary, were willing to pay R91,9 in the reduced OLS model and R126 in the reduced Tobit model more than people who were partially informed or poorly informed. The WTP probability also increased by 23,2% in both the reduced Logit and Probit models for people who were well informed.

Distance was positively correlated with WTP. This finding is similar to that found in the case of the Klein Brak but the opposite to what would be expected. For every one kilometre distance of accommodation (currently or permanently) away from the estuary, there was a 3,68% increase of WTP in the reduced Probit model and an increase of 3,85% in the reduced Logit model.

7.3.6 Kowie Estuary - Estimate of WTP based on a high benefit scenario

(a) OLS and Tobit models

The results of fitting the OLS and Tobit models to the Kowie Estuary data are shown in Tables 7.49 and 7.50. The complete and reduced OLS models have p-values that are smaller than 0,01, that is, the fits are highly significant. The nested test was used for the determination of preference between the complete and reduced OLS models. The F-statistic value of 0,51 was smaller than its critical value of 2,17. For this reason the null hypothesis could not be rejected and it was deduced that the reduced OLS model was preferred to the complete OLS model.

The reduced Tobit model was found to be more appropriate for predictive purposes than the complete Tobit model. The reason was that the χ^2 critical value of 12,59, corresponding to the upper 5% significance level and six degrees of freedom, was greater than the log-likelihood ratio statistic of 4,272.

Table 7.49: The fit of the WTP function for Kowie Estuary (high benefit scenario) using OLS and Tobit – complete model

Dependent Variable: WTP_H_Q								
Model: Complete model								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std.Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-516,625	370,289	-1,395	0,167	-703,714	405,671	-1,735	0,083
Distance	-14,601	19,760	-0,739	0,462	-26,917	22,325	-1,206	0,228
Education	36,462	23,315	1,564	0,121	48,379	25,346	1,909	0,056
Income	2,51E-04	4,18E-04	0,600	0,550	2,73E-04	4,52E-04	0,604	0,546
Levies	0,377	0,190	1,981	0,051	0,390	0,208	1,873	0,061
Male	29,566	126,959	0,233	0,816	36,177	138,071	0,262	0,793
People/house	20,483	33,835	0,605	0,547	11,960	36,771	0,325	0,745
Race	-274,785	245,954	-1,117	0,267	-430,608	264,188	-1,630	0,103
Recreation	245,264	289,318	0,848	0,399	379,300	322,406	1,176	0,239
V_B_worth	0,001	4,29E-04	1,637	0,105	0,001	4,68E-04	1,971	0,049
Visitor	-218,871	107,085	-2,044	0,044	-263,413	116,776	-2,256	0,024
Well_inform	135,088	191,132	0,707	0,482	151,815	204,748	0,741	0,458
R^2	0,285				0,300			
Adjusted R^2	0,195				0,204			
Log likelihood					-636,472			
F-Statistic	3,182							
p-Value (F-statistic)	0,001							

Table 7.50: The fit of the WTP function for Kowie Estuary (high benefit scenario) using OLS and Tobit – reduced model

Dependent Variable: WTP_H_Q								
Model: Reduced model								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std.Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-357,734	266,736	-1,341	0,183	-497,548	298,721	-1,666	0,096
Education	41,213	21,718	1,898	0,061	49,756	24,181	2,058	0,040
Levies	0,447	0,172	2,605	0,011	0,447	0,195	2,288	0,022
Race	-184,248	203,172	-0,907	0,367	-251,328	228,482	-1,100	0,271
V_B_worth	0,001	3,51E-04	2,430	0,017	0,001	4,00E-04	2,735	0,006
Visitor	-170,972	94,969	-1,800	0,075	-210,095	107,175	-1,960	0,050
R^2	0,260				0,261			
Adjusted R^2	0,220				0,213			
Log likelihood					-638,608			
F-Statistic	6,595							
p-Value (F-statistic)	0,000							

(b) Logit and Probit models

Logit and Probit models were also fitted to the WTP data expressed as binary choices. The results are shown in Tables 7.51 and 7.52. The null hypotheses could not be rejected and the reduced models were preferred over the complete models – it was found that the respective test statistic values of 3,26 and 2,84 for the Logit and Probit models were smaller than the χ^2 value of 14,07, corresponding to the upper 5% significance level with seven degrees of freedom.

In both of the reduced Logit and Probit models all the explanatory variables were found insignificant and the reduced Logit and Probit models had p-values greater than 0,1 (as did the complete Logit and Probit models). For this reason it was deduced that both Logit and Probit models were poor on the predictive score. A possible reason for this was that the observations obtained were unevenly distributed for some of the explanatory variables, for example, the race variable (see Appendix 17).

Table 7.51: The fit of the WTP function for Kowie Estuary using Logit and Probit – complete model

Dependent Variable: WTP_H_C								
Model: Complete model								
Method	ML – Binary Logit				ML – Binary Probit			
	LOGIT				PROBIT			
Variable	Coefficient	Std.Err.	z-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	0,594	2,137	0,278	0,781	0,383	1,281	0,299	0,765
Distance	-0,171	0,114	-1,500	0,134	-0,096	0,064	-1,490	0,136
Education	0,228	0,153	1,491	0,136	0,128	0,088	1,467	0,142
Income	-9,62E-07	2,85E-06	-0,338	0,736	-3,51E-07	1,53E-06	-0,230	0,818
Levies	-2,10E-04	0,001	-0,164	0,870	-6,64E-05	0,001	-0,097	0,923
Male	-0,212	0,853	-0,249	0,804	-0,148	0,475	-0,312	0,755
People/house	-0,157	0,216	-0,725	0,468	-0,077	0,125	-0,617	0,537
Race	-2,844	1,924	-1,478	0,139	-1,677	1,125	-1,491	0,136
Recreation	1,540	1,699	0,907	0,365	0,883	1,027	0,861	0,390
V_B_worth	4,91E-06	3,04E-06	1,615	0,106	2,45E-06	1,59E-06	1,536	0,125
Visitor	-0,556	0,717	-0,775	0,438	-0,281	0,391	-0,717	0,473
Well_inform	0,086	1,259	0,068	0,946	0,062	0,687	0,090	0,928
Log likelihood	-41,086				-41,193			
LR statistic	9,004				8,791			
p-Value (LR stat)	0,621				0,641			
McFadden R^2	0,099				0,096			

Table 7.52: The fit of the WTP function for Kowie Estuary using Logit and Probit – reduced model

Dependent Variable: WTP_H_C								
Model: Reduced model								
Method	ML – Binary Logit				ML – Binary Probit			
	LOGIT				PROBIT			
Variable	Coefficient	Std.Err.	z-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	0,785	1,526	0,514	0,607	0,474	0,907	0,522	0,602
Distance	-0,140	0,103	-1,353	0,176	-0,082	0,061	-1,351	0,177
Education	0,170	0,133	1,276	0,202	0,101	0,078	1,297	0,195
Race	-1,742	1,438	-1,212	0,226	-1,030	0,804	-1,281	0,200
V_B_worth	2,44E-06	1,90E-06	1,282	0,200	1,41E-06	1,05E-06	1,345	0,179
Log likelihood	-42,714				-42,615			
LR statistic	5,748				5,947			
p-Value (LR stat)	0,219				0,203			
McFadden R^2	0,063				0,065			

(c) Results and interpretation

For every additional year of education the respondent attained, the WTP increased by R34,00 in the reduced OLS model and by R49,76 in the reduced Tobit model. Levies and worth of vehicles/boats currently owned were also positively correlated to the WTP. For every Rand paid in levies the WTP increased by R0,42 in the reduced OLS model and by R0,48 in the reduced Tobit model, and for every additional R1 000 increase on the values of vehicles/boats it increased by R1,00 in both reduced models. In the case of the Kowie Estuary, the residents were willing to pay R176 more than the visitors (see Table 7.50).

7.3.7 Swartkops Estuary

7.3.7.1 Estimate of WTP based on a high benefit scenario

(a) OLS and Tobit models

The results of fitting the OLS and Tobit models to data on the Swartkops Estuary are summarised in Tables 7.53 and 7.54. In these tables, the results are shown of fits to the data of complete and reduced OLS models. The two models are then compared using the nested test. As the F-test statistic value of 0,50 was smaller than its critical value of 2,52 the null hypothesis could not be rejected and it was deduced that the reduced OLS model was preferred to the complete OLS model.

The reduced Tobit model was found to be superior for prediction purposes compared to the complete Tobit model. The reason for this was that the χ^2 critical value of 12,59, corresponding to the upper 5% significance level and six degrees of freedom, was greater than the log-likelihood ratio statistic of 2,33.

Table 7.53: The fit of the WTP function for Swartkops Estuary (high benefit scenario) using OLS and Tobit – complete model

Dependent Variable: WTP_H_Q								
Model: Complete model								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std.Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-85,206	116,767	-0,730	0,467	-118,934	123,974	-0,959	0,337
Distance	-2,717	6,278	-0,433	0,666	-3,064	6,617	-0,463	0,643
Education	2,275	7,782	0,292	0,770	3,875	8,375	0,463	0,644
Income	0,001	0,000	2,470	0,014	0,001	0,000	2,682	0,007
Levies	0,824	0,090	9,182	0,000	0,823	0,095	8,686	0,000
Male	76,290	50,218	1,519	0,130	105,437	53,923	1,955	0,051
People/house	6,940	15,628	0,444	0,658	-1,960	16,682	-0,117	0,907
Race	-15,239	55,533	-0,274	0,784	-35,319	58,673	-0,602	0,547
Recreation	46,354	65,322	0,710	0,479	51,288	69,847	0,734	0,463
V_B_worth	-0,001	0,001	-1,821	0,070	-0,001	0,001	-1,962	0,050
Visitor	-47,793	50,959	-0,938	0,350	-36,444	53,632	-0,680	0,497
Well_inform	55,863	44,433	1,257	0,210	71,387	47,129	1,515	0,130
R^2	0,490				0,483			
Adjusted R^2	0,459				0,450			
Log likelihood					-1 285,091			
F-Statistic	16,396							
p-Value (F-statistic)	0,000							

Table 7.54: **The fit of the WTP function for Swartkops Estuary (high benefit scenario) using OLS and Tobit – reduced model**

Dependent Variable: WTP_H_Q								
Model: Reduced model								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std.Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-57,260	52,504	-1,091	0,277	-109,154	58,112	-1,878	0,060
Income	0,001	3,32E-04	3,206	0,002	0,001	0,000	3,360	0,001
Levies	0,838	0,084	9,976	0,000	0,825	0,090	9,169	0,000
Male	62,712	48,614	1,290	0,199	91,950	53,058	1,733	0,083
V_B_worth	-0,001	0,001	-1,836	0,068	-0,001	0,001	-1,959	0,050
Well_inform	81,925	38,495	2,128	0,035	94,826	41,388	2,291	0,022
R^2	0,481				0,475			
Adjusted R^2	0,468				0,459			
Log likelihood					-1 286,258			
F-Statistic	36,026							
p-Value (F-statistic)	0,000							

(b) Logit and Probit models

In an application of the log-likelihood ratio tests, to determine which of the complete and reduced Logit and Probit models were preferred, it was found that the latter was preferred. The χ^2 value of 11,07, corresponding to the upper 5% significance level with five degrees of freedom, was greater than the respective test statistic values of 4,05 and 4,02 for the Logit and Probit models. It was deduced that the null hypotheses could not be rejected and that both the reduced models had better prediction powers than the complete models did. The relevant results are shown in Tables 7.55 to 7.56.

Table 7.55: **The fit of the WTP function for Swartkops Estuary (high benefit scenario) using Logit and Probit – complete model**

Dependent Variable: WTP_H_C								
Model: Complete model								
Method	ML – Binary Logit				ML – Binary Probit			
	LOGIT				PROBIT			
Variable	Coefficient	Std.Err.	z-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	3,042	1,597	1,906	0,057	1,812	0,869	2,086	0,037
Distance	-0,005	0,100	-0,046	0,963	-0,015	0,053	-0,276	0,783
Education	0,049	0,098	0,504	0,615	0,029	0,056	0,515	0,606
Income	1,39E-05	6,06E-06	2,287	0,022	6,56E-06	2,97E-06	2,205	0,027
Levies	-0,001	0,001	-0,915	0,360	-0,001	0,001	-0,827	0,408
Male	1,452	0,705	2,058	0,040	0,741	0,382	1,940	0,052
People/house	-0,748	0,233	-3,205	0,001	-0,416	0,128	-3,247	0,001
Race	-1,613	1,008	-1,601	0,110	-0,934	0,532	-1,757	0,079
Recreation	0,475	0,979	0,485	0,628	0,356	0,502	0,709	0,478
V_B_worth	-1,40E-05	9,09E-06	-1,538	0,124	-7,53E-06	4,51E-06	-1,670	0,095
Visitor	1,023	0,847	1,209	0,227	0,582	0,460	1,264	0,206
Well_inform	1,091	0,687	1,587	0,112	0,619	0,374	1,656	0,098
Log likelihood	-47,870				-48,043			
LR statistic	29,843				29,497			
p-Value (LR stat)	0,002				0,002			
McFadden R^2	0,238				0,235			

Table 7.56: The fit of the WTP function for Swartkops Estuary (high benefit scenario) using Logit and Probit – reduced model

Dependent Variable: WTP_H_C								
Model: Reduced model								
Method	ML – Binary Logit				ML – Binary Probit			
	LOGIT				PROBIT			
Variable	Coefficient	Std.Err.	z-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	4,441	1,299	3,420	0,001	2,599	0,695	3,740	0,000
Income	1,53E-05	5,80E-06	2,632	0,009	7,52E-06	2,89E-06	2,600	0,009
Male	1,416	0,624	2,269	0,023	0,713	0,340	2,094	0,036
People/house	-0,727	0,221	-3,286	0,001	-0,406	0,122	-3,324	0,001
Race	-1,688	0,766	-2,203	0,028	-0,917	0,408	-2,248	0,025
V_B_worth	-1,70E-05	7,81E-06	-2,177	0,030	-8,82E-06	3,96E-06	-2,228	0,026
Well_inform	0,719	0,596	1,206	0,228	0,406	0,306	1,326	0,185
Log likelihood	-49,897				-50,053			
LR statistic	25,788				25,477			
p-Value (LR stat)	0,000				0,000			
McFadden R^2	0,205				0,203			

Interpretations of the coefficients of the Logit and Probit models are presented in Table 7.57.

Table 7.57: Calculated percentage changes by coefficients: Swartkops Estuary

Variable	Logit model	Probit model
Income	3,83E-04%	3,00E-04%
Male	35,40%	28,45%
People/house	-18,18%	-16,20%
Race	-42,20%	-36,59%
V_B_worth	-4,25E-04%	-3,52E-04%

The count R^2 statistics of the reduced Logit and Probit models, respectively, were 0,91 and 0,90, and the McFadden R^2 statistics of the reduced Logit and Probit models were 0,205 and 0,203, respectively, suggesting that there was little to choose between the reduced Logit and Probit models.

(c) Results and interpretation

The results reported in Tables 7.54 and 7.57 imply that the higher the values of the worth of the vehicles/boats owned by respondents, the less willing they are to pay to conserve the estuary and the lower their probabilities of being willing to pay. For every additional R1 000 increase in the values of vehicles/boats, WTP decreased by R1 and the probability of WTP decreased by 0,35% in the reduced Probit model and by 0,43% in the reduced Logit model.

Male respondents were willing to pay up to R92 more for conservation of the estuary in the reduced Tobit model than female respondents and exhibited a 28,45% higher WTP probability than females in the reduced Probit model and a 35,4% higher WTP probability in the reduced Logit model. For the case of the Swartkops Estuary the non-White respondents' probability of being willing to pay was up to 42% higher than that of White respondents.

More in line with what was expected, well informed respondents were willing to pay up to R81,93 more in the reduced OLS model and R94,83 more in the reduced Tobit model than partially and poorly informed respondents. Also in line with expectations, a R1 000 increase of income earned by the respondents increased the WTP amount by R1, and the probability of WTP by 0,3% in the reduced Probit model and by 0,38% in the reduced Logit model. For every extra Rand paid in levies the respondents were willing to pay R0,83 more in the reduced Tobit model and R0,84 more in the reduced OLS model towards a project to conserve the estuary services.

7.3.7.2 Estimate of WTP based on a low benefit scenario

(a) OLS and Tobit models

The results of fitting the OLS and Tobit models to the Swartkops Estuary data generated under the low benefit scenario are shown in Tables 7.58 and 7.59. In an application of the nested test to check whether the complete or reduced OLS model was preferable it was found that that the critical value of 2,52 was greater than the F-test statistic value of 0,47. For this reason the null hypothesis could not be rejected and it was deduced that the reduced OLS model was a preferred fit to the complete OLS model.

In order to determine preference between the complete and reduced Tobit models, the log-likelihood ratio test was used. The log-likelihood ratio test statistic value was 4,65. This statistic was smaller than the χ^2 value, corresponding to the upper 5% significance level with six degrees of freedom, namely 12,59. For this reason the null hypothesis could not be rejected and the reduced Tobit model was preferred to the complete Tobit model.

Table 7.58: The fit of the WTP function for Swartkops Estuary (low benefit scenario) using OLS and Tobit – complete model

Dependent Variable: WTP_L_Q								
Model: Complete model								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std.Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-96,182	84,096	-1,144	0,254	-281,247	109,104	-2,578	0,010
Distance	-2,710	4,521	-0,600	0,550	-2,874	5,294	-0,543	0,587
Education	-1,361	5,605	-0,243	0,808	5,567	7,791	0,715	0,475
Income	0,001	2,72E-04	3,144	0,002	0,001	3,18E-04	3,202	0,001
Levies	0,607	0,065	9,381	0,000	0,615	0,074	8,303	0,000
Male	37,068	36,167	1,025	0,307	63,828	43,320	1,473	0,141
People/house	-0,126	11,255	-0,011	0,991	-11,070	13,310	-0,832	0,406
Race	-59,831	39,995	-1,496	0,136	-80,642	46,523	-1,733	0,083
Recreation	68,561	47,045	1,457	0,147	138,757	60,259	2,303	0,021
V_B_worth	-4,60E-04	4,09E-04	-1,123	0,263	-0,001	4,80E-04	-1,153	0,249
Visitor	3,078	36,700	0,084	0,933	21,722	42,756	0,508	0,611
Well_inform	54,110	32,001	1,691	0,093	80,290	37,246	2,156	0,031
R^2	0,485				0,496			
Adjusted R^2	0,455				0,463			
Log likelihood					-1 095,288			
SSE	6 109 471							
F-Statistic	16,102							
p-Value(F-statistic)	0,000							

Table 7.59: The fit of the WTP function for Swartkops Estuary (low benefit scenario) using OLS and Tobit – reduced model

Dependent Variable: WTP_L_Q								
Model: Reduced model								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std.Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-83,803	37,949	-2,208	0,028	-226,361	52,465	-4,315	0,000
Income	0,001	0,000	3,119	0,002	0,001	0,000	3,451	0,001
Levies	0,593	0,059	10,078	0,000	0,605	0,068	8,853	0,000
Race	-59,547	37,457	-1,590	0,114	-67,171	44,285	-1,517	0,129
Recreation	57,038	43,925	1,299	0,196	142,230	56,939	2,498	0,013
Well_inform	57,724	28,904	1,997	0,047	79,831	34,056	2,344	0,019
R^2	0,478				0,488			
Adjusted R^2	0,464				0,473			
Log likelihood					-1 097,615			
F-Statistic	35,473							
p-Value(F-statistic)	0,000							

(b) Logit and Probit models

The log-likelihood ratio test was carried out to determine which of the complete or reduced Logit and Probit models was preferable. It was found that the χ^2 value of 11,07, corresponding to the upper 5% significance level with five degrees of freedom, was greater than the test statistic value of 8,03 for the Logit model and the test statistic value of 7,37 for the Probit model. It was deduced that the null hypotheses could not be rejected and both the reduced models were preferred to the complete models. The relevant results are shown in Tables 7.60 and 7.61.

Table 7.60: The fit of the WTP function for Swartkops Estuary (low benefit scenario) using Logit and Probit – complete model

Dependent Variable: WTP_L_C								
Model: Complete model								
Method	ML – Binary Logit				ML – Binary Probit			
	LOGIT				PROBIT			
Variable	Coefficient	Std.Err.	z-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-0,423	1,165	-0,363	0,717	-0,084	0,687	-0,122	0,903
Distance	0,001	0,071	0,017	0,986	-0,002	0,041	-0,040	0,968
Education	0,120	0,078	1,533	0,125	0,061	0,045	1,348	0,178
Income	1,09E-05	4,56E-06	2,391	0,017	5,63E-06	2,44E-06	2,304	0,021
Levies	-0,001	0,001	-1,078	0,281	-0,001	0,001	-1,165	0,244
Male	0,685	0,570	1,202	0,229	0,382	0,327	1,169	0,242
People/house	-0,538	0,176	-3,066	0,002	-0,303	0,100	-3,021	0,003
Race	-0,887	0,661	-1,342	0,180	-0,441	0,360	-1,224	0,221
Recreation	1,274	0,632	2,017	0,044	0,762	0,367	2,077	0,038
V_B_worth	-8,32E-06	7,47E-06	-1,114	0,265	-4,67E-06	4,02E-06	-1,164	0,245
Visitor	0,912	0,613	1,488	0,137	0,421	0,345	1,221	0,222
Well_inform	1,174	0,534	2,198	0,028	0,618	0,290	2,132	0,033
Log likelihood	-79,700				-80,372			
LR statistic	46,183				44,839			
p-Value (LR stat)	0,000				0,000			
McFadden R^2	0,225				0,218			

Table 7.61: The fit of the WTP function for Swartkops Estuary (low benefit scenario) using Logit and Probit – reduced model

Dependent Variable: WTP_L_C								
Model: Reduced model								
Method	ML – Binary Logit				ML – Binary Probit			
	LOGIT				PROBIT			
Variable	Coefficient	Std.Err.	z-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-0,289	1,084	-0,267	0,79	-0,010	0,644	-0,015	0,988
Education	0,076	0,072	1,055	0,292	0,037	0,042	0,874	0,382
Income	5,40E-06	3,68E-06	1,468	0,142	2,80E-06	1,99E-06	1,410	0,159
People_house	-0,441	0,16	-2,753	0,006	-0,256	0,094	-2,728	0,006
Recreation	1,144	0,523	2,188	0,029	0,695	0,315	2,203	0,028
Visitor	1,216	0,497	2,448	0,014	0,607	0,266	2,280	0,023
Well_inform	0,956	0,482	1,983	0,047	0,533	0,266	2,005	0,045
Log likelihood	-83,717				-84,057			
LR statistic	38,149				37,469			
p-Value (LR stat)	0,000				0,000			
McFadden R^2	0,186				0,182			

Interpretations of the coefficients of the Logit and Probit models are presented in Table 7.62.

Table 7.62: Calculated percentage changes by coefficients: Swartkops Estuary

Variable	Logit model	Probit model
People_house	-11,03%	-10,23%
Recreation	28,60%	27,73%
Visitor	30,40%	24,20%
Well_inform	23,90%	21,25%

The count R^2 statistics of the reduced Logit and Probit models, respectively, were 0,91 and 0,83. The respective McFadden R^2 statistics of the reduced Logit and Probit models were 0,186 and 0,182. On the grounds of the higher count R^2 and McFadden R^2 statistics, it was deduced that the reduced Logit model was a superior predictive model compared to the reduced Probit model.

(c) Results and interpretation

The race variable was not significant in the reduced OLS and Tobit models (though it was in the complete models). In the reduced Logit and Probit models, education and income were also not significant.

Income and levies were positively correlated to WTP. WTP increased by R1 in both the reduced OLS and Tobit models for every extra R1 000 earned by the respondents. For every extra one Rand payment in levies the WTP increased by R0,59 in the reduced OLS model and by R0,61 in the reduced Tobit model. Recreational users were willing to pay about R142 more than non-recreational users. WTP probabilities of recreational users increased by 27,73% in the reduced Probit model and by 28,6% in the reduced Logit model over those of non-recreational users. Visitors' WTP probability was 24,20% in the reduced Probit model and 30,4% in the reduced Logit model – higher than that for residents.

Well informed respondents were willing to pay about R57,72 more than uninformed respondents in the reduced OLS model and R79,83 more in the reduced Tobit model, and they had a 21,25% higher probability of being willing to pay in the reduced Probit model and a 24% higher probability of being willing to pay in the reduced Logit model. Surprisingly, in the case of the Swartkops Estuary, the probability of being willing to pay declined for each additional member of the family. For every additional member included in a family the probability of being willing to pay decreased by 10,23% in the reduced Probit model and by 11,03% in the reduced Logit model.

7.3.8 Kariega Estuary - Estimate of WTP based on a high benefit scenario

(a) OLS and Tobit models

The results of fitting the OLS and Tobit models to data on the Kariega Estuary are shown in Tables 7.63 and 7.64. The nested test was used to determine preference between the complete and reduced OLS models. As the F-test statistic value of 0,76 was smaller than the critical value of 2,13, it was deduced that the null hypothesis could not be rejected and that the reduced OLS model was a better fit than the complete OLS model.

In the application of log-likelihood ratio test it was found that the log-likelihood ratio statistic value of 4,91 was smaller than the χ^2 value of 14,07, corresponding to the upper 5%

significance level with seven degrees of freedom. For this reason the null hypothesis could not be rejected and the reduced Tobit model was preferred to the complete Tobit model.

Table 7.63: The fit of WTP function for Kariega Estuary (high benefit scenario) using OLS and Tobit – complete model

Dependent Variable: WTP_H_Q								
Model: Complete model								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std.Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-246,000	226,179	-1,088	0,280	-479,712	286,415	-1,675	0,094
Distance	10,976	25,050	0,438	0,662	18,304	28,593	0,640	0,522
Education	-13,799	16,455	-0,839	0,404	-22,620	20,482	-1,104	0,269
Income	7,71E-04	4,08E-04	1,890	0,062	8,56E-04	4,86E-04	1,760	0,078
Levies	1,198	0,136	8,818	0,000	1,324	0,157	8,407	0,000
Male	1,470	59,284	0,025	0,980	-17,197	73,294	-0,235	0,815
People/house	54,143	16,203	3,342	0,001	81,501	20,073	4,060	0,000
Race	142,877	81,861	1,745	0,084	214,330	102,148	2,098	0,036
Recreation	94,968	72,537	1,309	0,194	134,037	93,769	1,429	0,153
V_B_worth	-2,26E-04	6,28E-04	-0,360	0,720	-2,54E-04	7,38E-04	-0,344	0,731
Visitor	-120,297	226,477	-0,531	0,597	-152,204	258,483	-0,589	0,556
Well_inform	-75,387	58,071	-1,298	0,198	-49,370	72,283	-0,683	0,495
R^2	0,750				0,766			
Adjusted R^2	0,719				0,734			
Log likelihood					-516,609			
F-Statistic	23,992							
p-Value(F-statistic)	0,000							

Table 7.64: The fit of WTP function for Kariega Estuary (high benefit scenario) using OLS and Tobit – reduced model

Dependent Variable: WTP_H_Q								
Model: Reduced model								
Method	Least Squares				ML – Censored Normal			
	OLS				Tobit			
Variable	Coefficient	Std.Err.	t-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-387,847	94,164	-4,119	0,000	-728,435	128,875	-5,652	0,000
Income	4,90E-04	3,16E-04	1,553	0,124	5,66E-04	3,86E-04	1,466	0,143
Levies	1,166	0,129	9,059	0,000	1,271	0,154	8,255	0,000
People/house	63,331	14,724	4,301	0,000	97,902	18,929	5,172	0,000
Race	131,721	75,599	1,742	0,085	207,47	98,505	2,106	0,035
R^2	0,735				0,752			
Adjusted R^2	0,724				0,739			
Log likelihood					-519,064			
F-Statistic	65,784							
p-Value (F-statistic)	0							

(b) Logit and Probit models

The log-likelihood ratio tests were used to determine preference of fits between the complete and reduced Logit and Probit models. It was found that the log-likelihood ratio statistics of 3,234 and 3,198, respectively, for the Logit and Probit models were smaller than the χ^2 value of 12,59, corresponding to the upper 5% significance level with six degrees of freedom. For this reason, the null hypotheses could not be rejected and it was deduced that both the reduced models had better predictive powers than the complete models did. The results are summarised in Tables 7.65 and 7.66.

Table 7.65: The fit of WTP function for Kariega Estuary (high benefit scenario) using Logit and Probit – complete model

Dependent Variable: WTP_H_C								
Model: Complete model								
Method	ML – Binary Logit				ML – Binary Probit			
	LOGIT				PROBIT			
Variable	Coefficient	Std.Err.	z-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-3,762	2,586	-1,454	0,146	-2,253	1,543	-1,461	0,144
Distance	1,021	0,661	1,545	0,122	0,612	0,380	1,611	0,107
Education	-0,135	0,182	-0,739	0,460	-0,082	0,109	-0,749	0,454
Income	4,06E-07	5,11E-06	0,079	0,937	-2,71E-07	2,84E-06	-0,095	0,924
Levies	0,006	0,002	2,503	0,012	0,003	0,001	2,582	0,010
Male	-0,607	0,703	-0,864	0,388	-0,387	0,413	-0,939	0,348
People/house	0,624	0,205	3,036	0,002	0,380	0,120	3,162	0,002
Race	1,899	0,955	1,989	0,047	1,148	0,555	2,067	0,039
Recreation	1,229	0,745	1,651	0,099	0,744	0,441	1,686	0,092
V_B_worth	-6,93E-06	7,06E-06	-0,981	0,327	-3,29E-06	3,92E-06	-0,840	0,401
Visitor	31,022	1,12E+08	2,78E-07	1,000	4,072	3,32E+06	1,23E-06	1,000
Well_inform	0,586	0,714	0,821	0,412	0,341	0,425	0,802	0,423
Log likelihood	-35,936				-35,758			
LR statistic	48,557				48,915			
p-Value (LR stat)	0,000				0,000			
McFadden R^2	0,403				0,406			

Table 7.66: The fit of WTP function for Kariega Estuary using Logit and Probit – reduced model

Dependent Variable: WTP_H_C								
Model: Reduced model								
Method	ML – Binary Logit				ML – Binary Probit			
	LOGIT				PROBIT			
Variable	Coefficient	Std.Err.	z-Statistic	p-Value	Coefficient	Std.Err.	z-Statistic	p-Value
Constant	-4,907	1,427	-3,438	0,001	-2,932	0,822	-3,569	0,000
Distance	0,698	0,527	1,324	0,186	0,400	0,314	1,276	0,202
Levies	0,005	0,002	2,453	0,014	0,003	0,001	2,582	0,010
People/house	0,630	0,197	3,199	0,001	0,381	0,112	3,416	0,001
Race	1,179	0,797	1,479	0,139	0,707	0,466	1,515	0,130
Recreation	1,031	0,684	1,508	0,132	0,612	0,403	1,517	0,130
Log likelihood	-37,553				-37,357			
LR statistic	45,323				45,716			
p-Value (LRstat)	0,000				0,000			
McFadden R^2	0,376				0,380			

Interpretations of the coefficients of the Logit and Probit models are presented in Table 7.67.

Table 7.67: Calculated percentage changes by coefficients: Kariega Estuary

Variable	Logit model	Probit model
Distance	17,45%	15,96%
Levies	0,13%	0,12%
People/house	15,75%	15,20%

The count R^2 statistics for the reduced Logit and Probit models were 0,80 and 0,81, respectively, and the McFadden R^2 statistics 0,376 and 0,380, respectively, that is virtually equivalent.

(c) Results and interpretation

The results of the Kariega Estuary fits are shown in Tables 7.64 and 7.67. Both levies and number of members per household were highly significant explanatory variables of WTP. For every extra R1 paid by respondents in levies the WTP increased by R1,17 in the reduced OLS model and by R1,27 in the reduced Tobit model and the probability of WTP increased by 0,12% in the reduced Probit model and by 0,13% in the reduced Logit model. For every additional member making up a household the WTP increased by R63,33 in the reduced OLS model and by R97,9 in the reduced Tobit model, and the probability of being willing to pay increased by 15,2% in the reduced Probit model and by 15,75% in the reduced Logit model. White respondents were willing to pay R131,72 more than non-Whites in the reduced OLS model and R207,47 more in the reduced Tobit model. For every one kilometre distance further away from the estuary, the probability of an individual being willing to pay increased by 16% in the reduced Probit model and by 17% in the reduced Logit model.

7.4 An assessment of the credibility of the results

The credibility of the stated WTP results are normally assessed in terms of the validity and reliability tests undertaken (see Chapter Three). If the bids (WTP) can be explained by the characteristics of the sample and according to the expectations, the method is deemed valid. If the method is replicated in exactly the same manner and the results are similar, the method is deemed reliable (Hanley and Spash, 1993).

7.4.1 Validity

Construct validity refers to how well a valuation method explains the values generated (Hanley and Spash, 1993:116). The aim is to assess the overall acceptability of the models. Three criteria were used to test for construct validity:

- The model is well fitted based on the statistical significance of the model, that is, the fitted model had an adjusted R^2 value greater than 15% (0,15) (Hanley and Spash, 1993).
- The reduced model contains the significant variables that it would be expected to.
- The signs of the coefficients in the reduced model accord with expectations (see Table 7.19).

Four ratings were constructed in terms of these criteria:

- Strong support: if all of the above criteria are met.
- Moderate support: if any two of the above criteria are met.
- Weak support: if only one of the above criteria is met.
- No support: none of above criteria is met.

The validity ratings of the seven estuaries using the abovementioned criteria are summarised in Table 7.68.

Table 7.68: Sample validity rating

Estuary	Validity of the results
Groot Brak: High benefit scenario	Moderate support
Groot Brak: Low benefit scenario	Moderate support
Kariega: High benefit scenario	Moderate support
Klein Brak: High benefit scenario	Weak support
Klein Brak: Low benefit scenario	Weak support
Knysna: High benefit scenario	Strong support
Knysna: Low benefit scenario	Moderate support
Kowie: High benefit scenario	Weak support
Kromme: High benefit scenario	Moderate support
Swartkops: High benefit scenario	Moderate support
Swartkops: Low benefit scenario	Weak support

These ratings vary from strong to weak support. There was only strong support found for one estimate, the Knysna high estimate scenario. Two possible explanations for the lack of expectations-based support for the other cases are insufficiency of the sample sizes (see Chapter Five) and failure to tease out biases in the CVM studies (see Chapter Three for discussion).

7.4.2 Reliability (repeatability) issue

The repeatability test on the acceptability of a CVM model is that when applied repeatedly in the same or very similar situations, the difference in results should be statistically insignificant between these applications (Hanley and Spash, 1993). This test could not be carried out because the applications were not repeated at the same estuaries, but different ones.

7.5 Conclusion

The predicted mean and median WTPs of the 11 estimates made using reduced Tobit models are shown in Table 7.69.

The Tobit models were preferred to OLS models in estimating the WTP functions, because they avoided the problem of negative WTP predictions, by using censored data (see Chapter Four) and reduced Tobit models were preferred to complete ones because of their superior predictive qualities. Qualitatively, the Logit models provide similarly statistically preferable results to the ones generated using Probit models. In some of the cases the reduced Probit models provided marginally better fits to the data than the Logit ones – in terms of higher count R^2 and/or McFadden R^2 statistics.

Table 7.69: Predicted mean and median WTP

Estuary	Mean of predicted WTP	Median of predicted WTP
Kariega: High benefit scenario	R380	R211
Kromme: High benefit scenario	R373	R287
Kowie: High benefit scenario	R325	R290
Swartkops: High benefit scenario	R308	R244
Groot Brak: High benefit scenario	R272	R192
Knysna: High benefit scenario	R199	R149
Klein Brak: High benefit scenario	R129	R120
Groot Brak: Low benefit scenario	R232	R172
Swartkops: Low benefit scenario	R177	R132
Knysna: Low benefit scenario	R176	R132
Klein Brak: Low benefit scenario	R 96	R101
Average	R243	R185
Standard deviation	R 92	R 63

Notes: The values related in the period from November 2002 to June 2003

The predicted median WTP for changes in freshwater inflow into the seven estuaries selected vary widely – from R291 in the case of the Kowie high benefit scenario to R101 in the case of the Klein Brak low benefit estimate scenario. For most of the estuaries there are considerable differences between the mean and median predicted WTP (Table 7.69). There are many possible reasons for the differences, of which one is different estuary characteristics, and another, respondents interpreting the questionnaire differently for different interviewers.

The following results stood out in Tables 7.20 to 7.67:

- Vehicle and boat wealth had a surprisingly small effect on the WTP.
- Income was weakly positively correlated with the WTP in most, but not all cases. It was negatively related to WTP in the high benefit estimate scenario of the Groot Brak Estuary.
- In most cases WTP and probability of being willing to pay were positively correlated with levies that had already been paid for access to estuary services.
- Education level and knowledge of estuary ecology was positively correlated to WTP and increased the probability of a person being willing to pay for freshwater inflow.
- Recreational and commercial/subsistence users were willing to pay and likely to make a positive payment. In the case of high benefit estimate scenario of the Knysna Estuary,

commercial/subsistence users were more likely to make a payment than recreational users for a healthier estuary.

- Visitors were less willing to pay than the residents in Knysna, Groot Brak and Kowie Estuaries, but there was a higher probability of visitors to the Swartkops Estuary being willing to pay than residents.
- White respondents were willing to pay more than non-Whites in Groot Brak, Kariega and Klein Brak Estuaries (about R126 to R303 more) and also more likely to be willing to pay for freshwater inflow (about 23% to 29% higher), but the opposite was true in the Swartkops case.
- The WTP amount and probability of being willing to pay increases in proportion with the number of members per household (except in the low benefit scenario of the Klein Brak and both scenarios of the Swartkops case).
- Distance from estuary was not consistently correlated with the WTP amounts.

The expectation-based validity tests showed strong support for one of the estimates, moderate support for six of the estimates and weak support for the remaining four.

It is clear that people's WTP for freshwater inflow into different estuaries in South Africa is influenced by many different factors and that much work still remains to be done in uncovering the relative importance of these factors.

CHAPTER EIGHT: CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusion on values

The objectives of this study were to develop a method of valuing freshwater inflow that would better inform estuary managers on economic issues relating to the problem of water deprivation, develop capacity to apply the method and inform the affected public on the nature of the problem of estuary freshwater deprivation. The first of these aims was addressed by describing the problem of freshwater deprivation (Chapter One), explaining how economics can better inform estuary managers (Chapter Two), identifying an appropriate method of valuation (Chapter Three) and demonstrating how to apply this method (Chapters Four to Seven). The second and third of these aims were addressed by training four students in the application of the method of CV to value changes in freshwater inflow into South African estuaries and the communication of information on the deprivation problem to identified target populations.

The primary objective of a CV is to determine an estimate of the TWTP. The TWTP for the specified changes proposed at the seven selected estuaries are calculated below based on the results of the CVs reported in Chapter Seven. These estimates are calculated for each estuary as the product of the median (rather than mean) WTP per annum per household and the total number of user households. The preference for medians over means was based on a desire to avoid bias induced by (possibly) unrealistic large bid values in the upper tail of the distribution (Hanley and Spash, 1993).

The respective TWTP amounts and WTP probabilities of the seven selected estuaries are shown in Table 8.1 below. The valuations are listed in descending order. The highest TWTP is for freshwater inflow into the Swartkops Estuary: high estimate scenario. This estuary is also the one with the highest estimated number of users. The lowest TWTP is for freshwater inflow into the Klein Brak, low estimate scenario.

Table 8.1: TWTP – select estuaries in South Africa[1]

Estuary	Predicted median of WTP* p.a.	Estimates of number of households	TWTP p.a.	Probability of being WTP
Swartkops: High benefit scenario (-)	R244	5 000	R1 220 170	90%
Kromme: High benefit scenario (+)	R287	3 200	R 918 400	71%
Kowie: High benefit scenario (+)	R290	3 234	R 937 860	N/A
Swartkops: Low benefit scenario (-)	R132	5 000	R 660 000	79%
Knysna: High benefit scenario (-)	R149	3 891	R 579 759	76%
Groot Brak: High benefit scenario (-)	R192	2 730	R 524 160	80%
Knysna: Low benefit scenario (-)	R132	3 891	R 513 612	76%
Groot Brak: Low benefit scenario (-)	R172	2 730	R 469 560	80%
Kariega: High benefit scenario (+)	R211	2 000	R 421 308	71%
Klein Brak: High benefit scenario (-)	R120	1 178	R 141 360	74%
Klein Brak: Low benefit scenario (-)	R101	1 178	R 118 941	56%

Notes: * Values are estimated on the basis of Table 7.69

1 Information on how to view the data on which the results are based is provided in the appendices

The values relate to the period from November 2002 to June 2003

Signs after estuary names indicate specified increase (+) or decrease (-) in water inflow

N/A= not applicable because there are no significant explanatory variables in the reduced Probit model

The per m^3 per annum Rand value of water was calculated as defined by the P2 measure in Chapter Two, viz., the TWTP p.a. divided by the change in inflow (m^3) proposed (specified) for each estuary. These values are shown in descending order in Table 8.2 below.

Table 8.2: Value of water per m^3 – select estuaries in South Africa

Estuary	TWTP p.a.	Change in inflow (millions of m^3 p.a.)	Value/m^3
Groot Brak: Low benefit scenario (-)	R 469 560	5	R0,094
Swartkops: High benefit scenario (-)	R1 220 170	13,5	R0,090
Kowie: High benefit scenario (+)	R 937 860	13	R0,072
Kariega: High benefit scenario (+)	R 421 308	7,4	R0,057
Swartkops: Low benefit scenario (-)	R 660 000	13,5	R0,049
Klein Brak: High benefit scenario (-)	R 141 360	11,2	R0,013
Knysna: High benefit scenario (-)	R 579 759	46	R0,013
Kromme: High benefit scenario (+)	R 918 400	75,5	R0,012
Knysna: Low benefit scenario (-)	R 513 612	46	R0,011
Klein Brak: Low benefit scenario (-)	R 118 941	11,2	R0,011
Keurbooms: High benefit scenario (-)	R 751 964	78,54	R0,010

Notes: Values relate to the period from November 2002 to June 2003, except for the Keurbooms, where the values relate to the year 2000 and to a pilot study. Signs after estuary names indicate specified increase (+) or decrease (-) in water inflow.

The CVs generated a wide range of values. The values range from just over 1 cent per m^3, in the case of the Klein Brak: low estimate (of impact) scenario and Keurbooms: high estimate scenario, to 10,5 cents per m^3, in the case of the Groot Brak: high estimate scenario. The median estimate of the 11 valuations, excluding the pilot study, is 4,9 cents per m^3 and the mean estimate is 4,78 cents per m^3.

The relatively high value found for inflow into the Groot Brak Estuary can in part be explained by the fact that the users of this estuary have recently experienced the adverse consequences of freshwater reductions due to the construction of a new storage dam on the Groot Brak River. The values may have been even higher were there not several substitute estuaries in the area, especially the Klein Brak.

The values generated in Tables 8.1 and 8.2 include very small amounts for non-user WTP because very little could be determined about this demand and they are based on responses from people of different communities and substantially different incomes. There probably is a starting point bias toward zero built into the values because, for many respondents, this is what they have been paying for freshwater inflow into estuaries in the past.

During the same period as these valuations were being conducted by the Water Research Commission team, a CSIR team were estimating related values for some of the same estuaries, namely the Swartkops and Knysna Estuaries (Cooper, Jayiya, van Niekerk, de Wit, Leaner and Moshe, 2003). One of the values they estimated was for the consumptive and use values of estuaries and marine fish (see Table 8.3).

Table 8.3: Consumptive and use values of fish (estuarine and marine) for the Swartkops and Knysna Estuaries

Estuary	Consumptive and use values (Rands)	Hectares affected (ha)	Value per hectare R/ha
Swartkops	55 700 836	682	81 673
Knysna	46 624 387	1 633	28 551

Values in 2002 Rands

Source: Cooper et al (2003: 42-43)

Another of the values they estimated was that houses with a view of the Knysna Estuary enjoyed an average premium on resale of R200 000 in excess of houses without a view of the estuary (Cooper *et al*, 2003:44). The latter estimate was deduced from interviews with estate agents operating in the Knysna area.

8.1.1 Expected findings

1 Sensitivity of estuary to water reductions

It would be expected that estuaries most prone to high impacts from changes in freshwater inflow would yield the highest value per m^3, for example, temporary open/closed estuaries (see Chapters One and Five). To some extent the results correspond with this expectation. The Groot Brak Estuary heads the value list (Table 8.2) and it is particularly affected by freshwater inflow reductions. The Knysna estuarine bay, on the other hand, is only marginally affected by freshwater inflow reductions, and is near the bottom of the value list.

2 Direction of specified change of water inflow

On theoretical grounds, specified increases in water inflow were expected to yield higher than true estimates of the value of water and specified decreases were expected to yield lower than true estimates (see Chapter Two). However, the results did not reflect this expectation.

3 Size of user population

By definition estuary user population is an important determinant of TWTP value and the results shown in Tables 8.1 and 8.2 confirm this. The Swartkops, Kromme and Kowie Estuaries, adjacent to which large populations live, top the TWTP valuations, while the estuaries with smaller nearby populations, like the Klein Brak and Kariega, are at the bottom of the list.

8.1.2 Confidence in results

It has been repeatedly stressed in this report that CVs are subject to many biases and, for this reason, need to be subjected to many tests for validity and reliability. The method and nature of these tests were described in Chapters Three, Four and Seven. Chapter Three showed the method to have considerable potential for error. It was noted that the question format used was likely to yield conservative values. Chapter Four showed that the technique could be applied to estuaries and that a pilot study yielded findings that mostly accorded with expectations.

Chapter Seven subjected the CVs to expectations-based tests. The different scenarios valued scored very differently under this test (Chapter Seven). Strong support was found for valuations of the Groot Brak: low estimate scenario, Knysna high and low estimate scenarios and Kowie: high estimate scenario. Moderate support was found for valuations of the Groot Brak: high estimate scenario, Kariega high estimate scenario, Kromme: high estimate scenario and Swartkops: low estimate scenario. Little support was found for valuations of the Klein Brak low and high estimate scenarios and Swartkops: high estimate scenario.

The reliability of the estimates could not be assessed because only one survey was conducted per estuary.

8.2 Conclusion on the appropriateness of applying the CV method to value freshwater inflow into estuaries

Given that most of the respondents used the estuaries in many different ways and that it was not possible to capture their WTP for most of these uses through any revealed preference mechanism, the application of the CVM was appropriate. It was recognised from the outset that many problems would be encountered (see Chapter Three). As could have been expected, some inconsistencies were found in the administration of a pilot study at the Keurbooms (see Chapter Four). However, these were not of a nature that suggested the CVM was an inappropriate valuation method.

8.3 Conclusion on the administration of the surveys

Master's level students administered the surveys. While every effort was made to ensure consistency in generating the same information bases for decision making and eliciting authentic responses, it was inevitable that some inconsistency occurred. The different respondents did not share a common base of information on which to make their decisions. For instance, it was clear that uneducated Black subsistence users and well-educated wealthy White recreation users were basing their decisions on entirely different bases of information.

8.4 Recommendations

1 Research perspective

(a) It is important that the description of the scientific impact of changes in freshwater inflow be as accurate as possible, because the values generated from CVMs are sensitive to this information. The case of the Swartkops shows this particularly well. The valuation of the high benefit scenario (9 cents/m^3) was almost twice that of the low benefit scenario (4,9 cents/m^3) for inflow into the Swartkops Estuary. For this reason it is recommended that future CVs of this nature devote a good deal of attention to generating accurate information on the impact of changes in freshwater inflow.

(b) The sample sizes were found to be too small and should be increased in line with those indicated by statistical theory – in most cases at least double those used in this study.

(c) The training of the people undertaking the surveys is a crucial aspect of the process, as is the tailoring of the questionnaire to the people from whom responses are being sought. It was the opinion of the survey team that the questionnaires should ideally be administered in the home language of the respondent.

2 Management perspective

(a) The main argument of this report relating to river flow management is that allocations of freshwater to South African estuaries be guided by current estimates of the marginal social costs and marginal social values of this inflow. As both of these estimates may be readily determined the research challenge that lies ahead is to generate as many of them as possible. In this connection three recommendations are made:

- that marginal social costs of freshwater inflow be estimated for those estuaries where it has been found that the marginal social valuations exceed R0,05 per m^3.
- that regular estimates of both measures be made because they both change over time
- that comparisons between marginal social benefits and costs utilise information generated in the water markets currently being developed in selected river basins in South Africa (see Armitage, 1999 and Louw, 2002 for further discussion).

(b) In a pilot study of the value of the freshwater flowing into the Keurbooms estuary (Chapter Four), it was found (using a reduced Tobit model) that in order to prevent a reduction in inflow of 78 540 000 m^3 of freshwater into the Keurbooms Estuary, 2 650 five-person households were willing to pay an average of R283,76 per annum each in the year 2000. This payment translates into a recreational demand for freshwater inflow into the Keurbooms of about R0,01 per m^3 water in the year 2000.

In order to guide the allocation of inflow into the Keurbooms Estuary, this marginal social value information must be compared with marginal social cost information. One of the principal alternative uses for the river water that flows into the Keurbooms Estuary is for agriculture – for the irrigation of fruit orchards, vegetables and pasture. In Hosking *et al* (2002) the value of this water for agriculture was estimated using the income capitalisation method. It was argued in the year 2000 that farmers in the Klipdrif area were prepared to pay R0,125 per m^3 of irrigated water over and above the R0,053 per m^3 of water for transfer and storage costs. As this water was abstracted above the Keurbooms Estuary its value is an opportunity cost of water inflow into the estuary.

It follows that in the year 2000 that the estimated marginal social value of river water flowing into the Keurbooms estuary was significantly less than the estimated marginal social cost, and that there was no efficiency case for limiting upstream abstraction by farmers on the grounds that the water was more valuable flowing into the estuary. An important qualification with respect to this deduction is that both the value and cost measures were generated through a pilot study. Considerable publicity has been given to the freshwater deprivation problem at the Keurbooms, and for this reason, it is surprising to find the marginal social value of the Keurbooms freshwater inflow into the estuary at the lower end of the range of estimates generated in this study (see Table 8.2).

(c) Based on the observations made by the field workers who collected the data for this study and the estimated bid functions, it is also recommended that resources continue to be committed to educating the public affected by estuary services on the link between these and freshwater inflow into the estuaries. Many of the respondents held the view that because the water flowing into estuaries had always been free there was no case for now charging them for this water. For this reason they were resistant to the idea that they should pay a price for this water.

REFERENCES

ACKS, K. (1995). *Tools for resolving public opposition to projects.* New York: Real Estate Reviews.

ADAMS, J.B. (1991). The distribution of estuarine macrophytes in relation to freshwater in a number of Eastern Cape estuaries. Unpublished MSc Thesis. Department of Botany, University of Port Elizabeth.

ADAMS, J.B. (2001). "The importance and freshwater requirements of South Africa's estuaries", *SA Waterbulletin*, 26 (6):16-19.

ALLANSON, B.R. AND BAIRD, D. (1999). *Estuaries of South Africa.* Cape Town: Cambridge University Press.

AMIGUES, J., BOULATOFF, C., DESAIGUES, B., GAUTHIER, C. AND KIETH, J.E. (2002). "The benefits andf costs of riparian analysis habitat preservation: a willingness to accept/willingness to pay contingent valuation approach", *Ecological Economics*, 43: 17-31.

ARMITAGE, R.M. (1999). *An economic analysis of surface irrigation water rights transfers in selected areas of South Africa.* Water Research Commission, Reoport No. 870/1/99

ARNOTT, G. (2003). Bird book illustrator, Kenton-on-sea. Personal communication.

ARROW, K., SOLOW, R., PORTNEY, P.R., LEARNER, E.E., RADNER, R. AND SCHUMAN, H. (1993). *Report on the NOAA Panel on Contingent Valuation*, Federal Register.

AZEVEDO, C.D., HERRIGES, J.A. AND KLING, C.L. (2003). "Combining revealed and stated preferences: Tests and their interpretations", *American Journal of Agricultural Economics*, 85: 525-537.

BACON, P.R. (1999). "The role of wetlands in the water cycle", *http://www.ramsar.org/cop7_doc_16.1_e.htm.*

BAIRD, D., MARAIS, J.F.K. AND BATE, G.C. (1992). *An environmental analysis for the Kromme River area to assist in the preparation of structure plan.* Institute for Coastal Research. Report No. C.16: 1-56.

BAIRD, D. (2001). "Estuaries of South Africa", in Dupra, V., Smith, S.V., Marshall Crossland, J.I. and Crossland, C.J. (eds.): In *LOICZ Reports and studies*. (18): 37-59.

BAIRD, D. (2002). *Estuaries of South Africa*. University of Port Elizabeth.

BALL, R. (2003). Albany Coast Water Board. Personal communication.

BARBIER, E.B., ACREMAN, M. AND KNOWLER, D. (1997). *Economic valuation of wetlands*. University of New York.

BATE, G., WHITFIELD, A., COLLOTY, B. AND TAYLOR, R. (2003). Photohouse, Swartkops and Kariega estuaries, *http://www.upe.ac.za/cerm*.

BATEMAN, I.J. AND WALLIS, K.G. (1999). 'Introduction and Overview'. In Bateman, I.J. and Willis, K.G. (eds.), *Valuing Environmental Preferences*, Oxford: Oxford University Press: 1-14.

BATEMAN, I.J., JONES, A.P., LOVETT, A.A., LAKE, I. AND DAY B.H. (2002). "Applying geographical information systems (GIS) to environmental and resource economics", *Environmental and Resource Economics*, 22: 219-269.

BATEMAN, I.J., LANGFORD, I.H. AND RASBASH, J. (1999). "Willingness-to-pay question format effects in contingent valuation studies", in Bateman, I.J and Willis, K.G. (eds): *Valuing environmental preferences*, Oxford: Oxford University Press: 511-539.

BERNDT, E.R. (1991). *The practice of econometrics: classic and contemporary*. Massachusetts: Addison-Wesley.

BICKERTON, I.B. AND PIERCE, S.M. (1988). "Report No. 33: Krom (CMS 45), Seekoei (CMS 46) and Kabeljous (CMS 47)", in Heydorn, A.E.F. and Morant, P.D. (eds): *Estuaries of the Cape. Part 2. Synopses of available information on individual systems*. CSIR Research Report No. 432: 109.

BISHOP, R.C. AND HEBERLEIN, T.A. (1979). "Measuring values of extra-market goods: Are indirect measures biased?", *American Journal of Agricultural Economics*, 61: 926-30.

BOYLE, K.J. AND BERGSTROM, J.C. (1999). "Doubt, Doubts and Doubters: The Genesis of a New Research Agenda", in Bateman, I.J and Willis, K.G. (eds): *Valuing environmental preferences*, Oxford: Oxford University Press: 183-206.

BREEDLOVE, J. (1999). *Natural Resources: Assessing non-market values through contingent valuation*. Washington: National Council for Science and the Environment.

BREEN, C. AND MCKENZIE, M. (2001). *Managing estuaries in South Africa*. Institute of Natural Resources, University of Natal.

BRIERLEY, A. (2003). Ndlambe Municipality. Personal communication.

CARSON, T.C., FLORES, N.E. AND MITCHELL, R.C. (1999). 'The theory and measurement of passive use value.' In Bateman, I.J. and Willis, K.G. (eds.), *Valuing Environmental Preferences*, (eds.), Oxford: Oxford University Press: 97-130.

CHAPMAN, R.A., LE MAITRE, D.C. AND VERSVELD, D.B. (1998). *Alien invading plant and water resources in South Africa: A preliminary assessment*. Stellenbosch: CSIR Division of Water, Environment and Forestry Technology.

COCHRANE, W.G. (1977). *Sampling techniques*. 3rd edition, New York: Wiley.

COOPER, J., JAYIYA, T., VAN NIEKERK, L., DE WIT, M., LEANER, J. AND MOSHE, D. (2003). *An assessment of the economic values of different uses of estuaries in South Africa*. Cape Town: CSIR.

COWAN, G.I., DINI, J., VAN DER WALT, M.M. AND KYLE, R. (1995). *National Report of South Africa*. Pretoria: Department of Environmental Affairs and Tourism.

COASTAL MANAGEMENT POLICY PROGRAMME, (1998). *Coastal Policy Green Paper: Towards sustainable coastal development in South Africa*. Pretoria: Department of Environmental Affairs and Tourism.

COWLEY, P. AND DANIEL, C. (2001). "Estuaries of the Ndlambe Municipality", *INR Investigation Report*. No 229.

CROWLEY, T. (2003). City Engineers Department, Nelson Mandela Metropolitan. Personal communication.

DAVIDS, A.S. (2002). GIS using 1996 census data, Human Sciences Research Council. Pretoria.

DAY, J.H. (1980). "What is an estuary?", *South African Journal of Science*, 76: 198.

DAY, J.H. (ed.) (1981). "Summaries of current knowledge of 43 estuaries in southern Africa", *Estuarine ecology with particular reference to southern Africa*. Cape Town: A.A. Balkema.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY, (2002a). "Monthly volume figures of water flow into Swartkops river as captured at station MIH012 in Uitenhage Nivens bridge". Personal Communication.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY, (2002b). "Monthly volume figures of freshwater inflow into the Kariega river as captured at station P3H001 in Smithfield gauging weir". Personal Communication.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY, (2002c). "Monthly volume figures of fresh water inflow for the Knysna river, Great Brak river and Little Brak river". Personal Communication.

DU PREEZ, M. (2002). An economic evaluation of the environmental use of water: selected case studies in the eastern and southern cape. Unpublished PhD Thesis, University of Port Elizabeth.

FEATHER, P. AND HELLERSTEIN, D. (1997). "Calibrating benefits function to assess the conservation reserve programme", *American Journal of Agricultural Economics*, 79: 151-162.

FIELD, B.C. (1994). *Environmental economics - an introduction*. New York: McGraw-Hill.

FORBES, V.R. (1998). "Recreation and resource utilisation of Eastern Cape estuaries and development towards a management strategy", Unpublished Masters dissertation, University of Port Elizabeth.

FOUCHIE, F. (2003). Nature Conservation officer. Kenton-on-sea. Personal communication.

GOUWS, V. (2002). Great Brak and Little Brak Municipality. Personal communication.

GREEN, W.H. (2003). *Econometric analysis*. 5th edition. New Jersey: Prentice Hall.

GRINDLEY, J. (1976). Notes on discussion regarding the Kowie Estuary held at Port Alfred on 16 November 1976. Unpublished Report.

GRIMBEEK, P. (2002). Great Brak and Little Brak Tourism Board. Personal communication.

GUJARATI, D. N. (2003). *Basic Econometrics*. 4th edition. New York: McGraw-Hill.

HAIR, J.F., ANDERSON, R.E., TATHAM R.L. AND BLACK, W.C. (1998). *Multivariate data analysis*. 5th edition. New Jersey: Prentice-Hall.

HANLEY, N. AND SPASH, C.L. (1993). *Cost benefit analysis and the environment*. Vermont: Edward Elgar.

HANEMANN, W.M. (1992). Preface, in Navrud, S. (ed.), *Pricing the European Environment*. Oslo: Scandinavian University Press.

HANNEMANN, W.M. AND KANNINEN, B. (1999). "The statistical analysis of discrete-response CV data." In Bateman, I.J. and Willis, K.G. (eds.), *Valuing Environmental Preferences*, Oxford: Oxford University Press: 302-441.

HATTINGH, R., WHITFIELD, A., VAN DRIEL, D., ARCHIBALD, C. HAY, D., BATE, G., SCHUMANN, E. (2002). "CERM Research Priorities", *http://www.upe.ac.za/cerm/cerm6.html*.

HAUSMAN, J.A. (1981). *Contingent Valuation: A critical assessment*. Elsevier Science Publishers BV, Amsterdam.

HEYDORN, A. AND GRINDLEY, J. (1982). *Estuaries of the Cape: Kowie*. Stellenbosch: National Research Institute for Oceanology.

HEYMANS, J. (1992). Energy Flow Model and Network Analysis of the Kromme Estuary. St. Francis Bay, South Africa. Unpublished Masters Dissertation. University of Port Elizabeth.

HILL, R.C., GRIFFITHS, W.E. AND JUDGE, G.G. (2001). *Undergraduate econometrics*. 2nd edition. New York: John Wiley & Sons.

HOSKING, S.G., DU PREEZ, M., CAMPBELL, E.E., WOOLDRIDGE, T.H. AND DU PLESSIS, L.L. (2002). Evaluating the Environmental use of water-selected case studies in the Eastern and Southern Cape. Pretoria: Water Research Commission. Report Number 1045/1/02.

HUIZINGA, P. AND VAN NIEKERK. L. (1999). Great Brak Estuary Management Programme, Environmentek: CSIR, Stellenbosch.

JOHNSON, R. (2003). Bait collector. Swartkops estuary. Personal communication.

JOUBERT, P. (2002). National Parks Board, Knysna. Personal communication.

KEAT, R. (2002). "Values and preferences in neo-classical environmental economics". In Foster, J (ed.), *Valuing Nature – Economics, Ethics and the Environment*. London: Routledge: 32-47.

KENTON-ON-SEA TOURISM OFFICE. (2003).Street map of Kenton-on-sea, supplied by the Tourism Office.

KING, D.M. AND MAZZOTTA, M. (2003). Ecosystem Valuation. *http://www.ecosystemvaluation.org/*

KNYSNA TOURISM BOARD. (2002). Statistics of visitors to Knysna, supplied by staff of the Knysna Tourism Board.

KOWIE ESTUARY MANAGEMENT PLAN. (1999).
http:/www.inr.ac.za/estuaries/management/Kowie/Kowieplan.html.

LAMBERTH, S.J. AND TURPIE, K.J. (2003). *The role of estuaries in South African fisheries: Economic importance and management implication.* Water Research Commission Report, No. 756/2/03.

LARDNER-BURKE, J. (2003). Diaz Cross Bird Club. Kenton-on-sea. Personal communication.

LIEBENBERG, N. (2002). Mossel Bay Municipality. Personal communication.

LOFGREN, K-G. (1995). Market and externalities. In: Folmer, H. and Gabel, H.L. (eds.) *Principles of environmental and resource economics.* Cheltenham: Edward Elgar: 17-45.

LOOMIS, J.B. (1998). "Estimating the public values for instream flow: Economic techniques and dollar values", *Journal of the American Water Resources Association*, 34(5): 1007-1014.

LOUW, D.B. (2002). *The development of a methodology to determine the true value of water and the impact of a potential water market on the efficient utilisation of water in the Berg River Basin.* Water Research Commission, Report No. 943/1/02.

MANDER, M. (2000). Environmental economics researcher, Institute for Natural Resources, University of Natal, Pietermaritzburg. Personal communication.

MANDER, M., COX, D., TURPIE, J. AND BREEN, C. (2002). *Incorporating economic considerations into quantification, allocation and management of the environmental water reserve.* Pretoria: Water research Commission. Report Number 978/1/02.

MAP STUDIO. (2000). Street map of Port Elizabeth, supplied by Map Studio, Port Elizabeth.

MCCARTHY, D. (2002). Knysna Municipality. Personal communication.

MENDENHALL, W. AND SINCICH, T. (1996). *A second course in statistics- Regression analysis.* 5th edition. New Jersey: Prentice-Hall.

MIRER, T.W. (1995). *Economic statistics and econometrics.* 3rd edition. New Jersey: Prentice-Hall.

MOSER, M., PRENTICE, C. AND FRAZIER, S. (1999). "A Global Overview of Wetland Loss and Degradation". Ramsar, Wetlands International, *http://www.ramsar.org/about_wetland_loss.htm.*

MOUTON, E. (2003). Water Systems Management Services. Bushmans river mouth. Personal Communication.

NATIONAL WATER ACT. (1998). Department of Water Affairs and Forestry. Pretoria: Government Printer.

NETER, J., WASSERMAN, W. AND WHITMORE, G. (1993). *Applied statistics.* 4th Edition. New Jersey: Prentice-Hall.

NOBLE, R.G. AND HEMENS, J. (1978). *Inland water ecosystems in South Africa – a review of research needs.* South African National Scientific Programmes. Report No. 34.

OGILVY, J. (2002). Knysna Tourism Board. Personal communication.

PATERSON, B. (2002). Port Alfred Municipality. Personal Communication.

PERMAN, R., MA, Y. AND MCGILVRAY, J. (1996). *Natural Resource and Environmental Economics.* Longman. London and New York.

PINDYCK, R.S. AND RUBINFELD, D.L. (1998). *Econometric models and economic forecasts.* 4th edition. New York: McGraw-Hill.

REDDERING, J.S.V. AND ESTERHYSEN, K. (1983). *Sedimentation in the Kromme estuary.* University of Port Elizabeth, ROSIE Report No. 6: 1-92.

REDDERING, J.S.V. AND ESTERHYSEN, K. (1988). "The Swartkops estuary: physical description and history". In: Baird, D., Marais, J.F.K. and Martin, A.P. (eds.). *The Swartkops estuary: Proceedings of a symposium held on 14 and 15 September 1987 at the University of Port Elizabeth.* Port Elizabeth: University of Port Elizabeth: 23-51.

REID, T.R. (1998). "Feeding the Planet", *National Geographic*, (4): 54-71.

RENCHER, A.C. (2000). *Linear model in statistics.* New York: John Wiley & Sons.

SCHALACHER, T.A. AND WOOLDRIDGE, T.H. (1996). *Ecological responses to reductions in freshwater supply and quality in South Africa's estuaries: lessons for management and conservation.* Uppsala: Opulus Press.

SHECHTER, M. (2000). Valuing the environment. In: Folmer, H. and Gabel, H.L. (eds.) *Principles of environmental and resource economics.* Cheltenham: Edward Elgar: 72-103.

SWITZER, T., WALDRON, H.N. AND ALLANSON, B.R. (2001). "Monitoring the health of the Knysna marine ecosystem", *South African Journal of Science*, 97: 28.

THE BAY WINDOW - BLUEWATER BAY. (2003). February edition, 23:4.

TIETENBERG, T. (2000). *Environmental and Natural Resource Economics.* 5th edition. Addison Wesley Longman.

TIGER BAY BOAT REGISTRATION OFFICE. (2003). Once a month count of people and boats at the Swartkops estuary in 2003.

TURPIE, J.K. AND MARTIN, A.P. (1998). "Birds of the Swartkops Estuary: Past & Present". In: *Swartkops river water resource management plan – hydrological characteristics.* Stellenbosch. CSIR, Environmentek: 120-141.

VAN DER MERWE, M. (2003). Kenton-on-sea Post Office. Personal communication.

VERBEEK, M. (2000). *A guide to modern econometrics.* Chichester: John Wiley & Sons.

VERMEULEN, K. (2003). Water and Forestry Department – Knysna. Personal communication.

WATTAGE, P. (2001). *A targeted literature review – contingent valuation method.* Portsmouth: University of Portsmouth.

WHITEHEAD, J.C., HAAB, T.C. AND HUANG, J.C. (1998). Part-Whole Bias in Contingent Valuation: Will Scope Effects Be Detected with Inexpensive Survey Methods? *Southern Economic Journal*, 65(1): 160-168

WHITFIELD, A.K. (1992). "A characterization of Southern African estuarine systems", *South African Journal of Aquatic Sciences,* . 18: 89-103.

WHITFIELD, A.K. (2000). *Available Scientific information on individual South African estuarine systems.* Water Research Commission Report. No. 577/3/00

WHITFIELD, A.K. AND WOOLDRIDGE, T.H. (1994). *Changes to freshwater supplies to southern African estuaries: some theoretical and practical considerations.* Fredensborg: Olsen & Olsen.

WHITFIELD, A.K. AND WOOD, A.D. (2003). *Studies on the River-Estuary Interface Region of Selected Eastern Cape Estuaries.* Water Research Report, WRC Report No. 756/1/03.

WOOLDRIDGE, T.H. (2002). Zoology Department, University of Port Elizabeth. Personal communications.

WOOLDRIDGE, T.H. (2003). Zoology Department, University of Port Elizabeth. Personal communications.

YOUNG, B. (2003). Port Alfred Tourism. Personal communication.

ZWAMBORN, J. (1980). *Small-craft harbours and launching sites.* Preliminary evaluation. Pretoria: CSIR Report.

APPENDIX 1: "RAMSAR CONVENTION" DEFINITIONS FOR WETLANDS

Since the initiation of the Ramsar Convention in 1971, its membership has grown substantially (136 member countries by the end of 2003) and so too its influence over policy decisions affecting the management of wetlands worldwide (Barbier *et al*, 1997:69). The Convention adopted a very broad approach in determining the "wetlands" that came under its guidance and Article 2 of the Convention notes that wetlands may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands.

The Ramsar definition covers a wide range of habitat types, including rivers, shallow coastal waters and coral reefs, but excludes the deep sea. The wide range of wetland types covered by the Ramsar Convention can be divided into five broad wetland types/systems (Barbier *et al*, 1997:70):

- **Estuaries** – where rivers meet the sea and salinity is intermediate between salt and freshwater, for example, deltas, mudflats and salt marshes.
- **Marine** – not influenced by river flows, for example, shorelines and coral reefs.
- **Riverine** – land periodically inundated by river overtopping, for example, water meadows, flooded forests and oxbow lakes.
- **Palustrine** – where there is more or less permanent water, for example, papyrus swamp, marshes and fen – low-lying flat marshy land.
- **Lacustrine** – areas of permanent water with little flow, for example, ponds, kettle lakes, volcanic crater lakes.

As wetlands may change over time, the category in which they fall may also change.

APPENDIX 2: ESTUARY FISHERIES – SOUTH AND EAST COAST OF SOUTH AFRICA

About 160 species of fish are found in South African estuaries (Lamberth and Turpie, 2003:5). Catches of estuary-associated fish species differ from west to east around the South African coast. The different types of fishing conducted in the estuaries along the South African coast are line fishing, cast netting, gillnetting, seine-netting and traditional fisheries. The numbers of "anglers" participating in the various types of fishing are described in Table A1.

Line fishing is undertaken from the shore or from boats (canoes to ski boats) using hand lines or rods (Lamberth and Turpie, 2003:7). No commercial line fishing is permitted in estuaries, but subsistence and recreational line fishing is popular. It is estimated that in 1997 there were 7 400 line anglers along the South Coast and 9 300 along the East Coast and that these anglers fished for an average of 18 days per year (Lamberth and Turpie, 2003:8). Recreational shore-anglers and recreational boat-anglers use this form of fishing most often. Estimates of the other types of anglers are shown in Table A1.

Table A1: Estimated numbers of anglers participating in various types of fishing in different estuaries along the South African coast (legally and illegally)

Type of fishery	South Coast	East Coast	Total
Line fishing	7 400	9 300	16 700
Cast netting	300	600	900
Gillnetting	50	? 50+	~100
Seine-netting	<5	0	~5
Traditional methods	0	0	0
Total	7 455	9 350	16 805

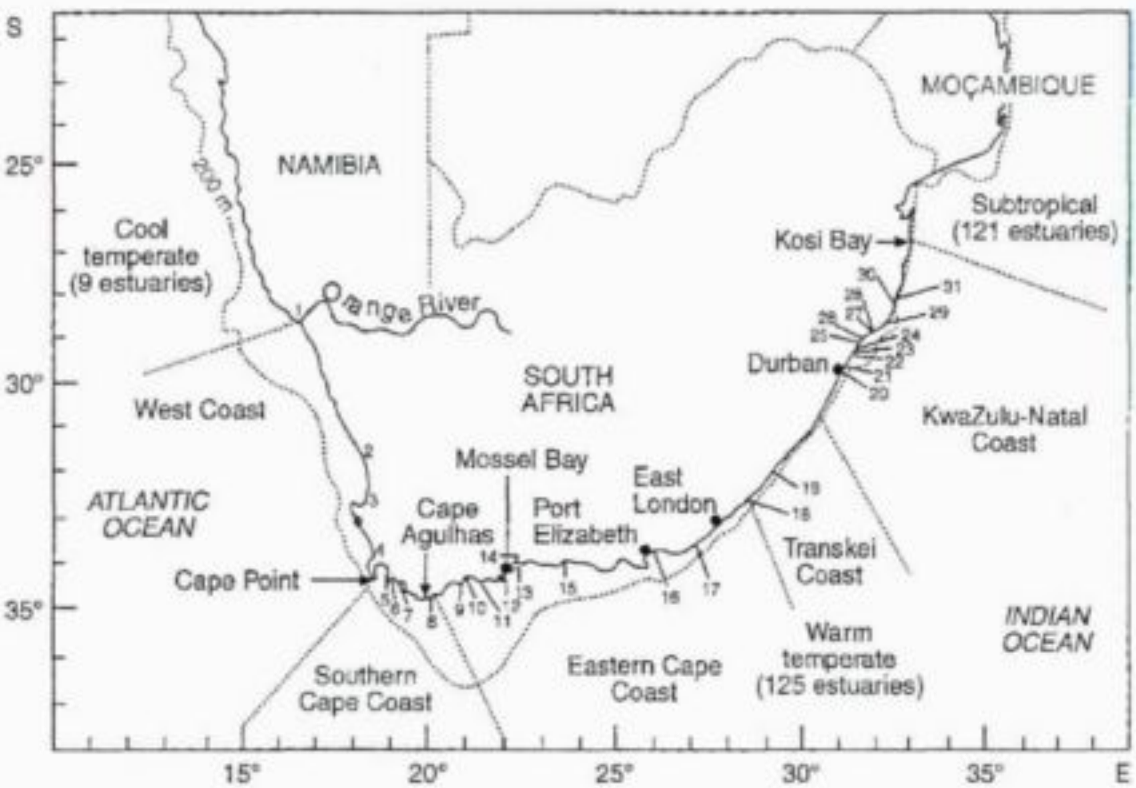
Source: Lamberth and Turpie (2003:8)

Cast netting is used by recreational and subsistence anglers to catch bait fish such as harder (southern mullet). On the South Coast approximately 300 shore-anglers use cast nets regularly making up 8 972 angler-days yearly, or about 30 days on average per angler. On the East Coast there is estimated to be about 600 anglers fishing about 18 days on average per angler (Lamberth and Turpie, 2003:8).

Gillnetting is a form of fishing using nylon nets cast either from a boat or walking out from the shore, in the hope that a shoal of fish will swim into them and become caught in the net (Lamberth and Turpie, 2003:9). These nets may either drift or be anchored. Along the South Coast this form of fishing is found in the Breede, Duiwenhoks, Goukou, Gouritz, Little Brak and Great Brak Estuaries, but little of this form of fishing is done along the East Coast.

Seine netting is an active form of fishing. During seine-netting woven nylon nets are either rowed or walked out to encircle a shoal of fish. The net is then dragged to shore by a group of 6-30 people, depending on the size of the net and the length of the haul. This form of fishing is mostly undertaken for commercial purposes. At the moment there are no seine-net permits for the South and East coast estuaries. Traditional fishing includes methods such as fish traps, spears and baskets, but these methods are rarely used on the South and East coasts.

Different climatic areas (see Figure A1) as well as different estuary types affect "catches" in estuaries. Larger estuaries allow larger catches of fish, especially in the cool temperate region of South Africa (Lamberth and Turpie, 2003:12). The size of a catch in permanently open estuaries is also higher than in temporarily open/closed estuaries.



1. Orange/Gariep	11. Goukou	21. Umgeni
2. Olifants	12. Gouritz	22. Nonoti
3. Berg	13. Klein Brak	23. Zinkwazi
4. Rietvlei/Diep	14. Groot Brak	24. Thukela (was Tugela)
5. Kleinmond	15. Knysna	25. Amatikulu/Nyoni
6. Bot	16. Swartkops	26. Umlalazi
7. Klein	17. Keiskamma	27. Richard's Bay
8. Heuningnes	18. Great Kei	28. Mhlatuze
9. Breede	19. Mbashe	29. Nhlabane
10. Duiwenhoks	20. Durban Bay	30. Msunduzi/Mfolozi
		31. St Lucia

Figure A1: Map of South Africa showing the areas and estuaries (numbered)

Source: Lamberth and Turpie (2003:2)

On the South Coast, spotted grunter constitutes 45% of the catch weight, harder 18%, white steenbras (*Lithognathus)* 10% and dusky cob 6%. On the East Coast, catch weights are dominated by the dusky cob (48%) and spotted grunter (31%).

Table A2: Estuarine area and estimated annual total catches for various fisheries

Region	Number of estuaries	Area (ha)	Total annual catch (tons)				Total
			Angling	Cast net	Gillnet	Seine-net	
South Coast	52	12 866	410	31	152	12	605
East Coast	54	3 764	224	20	52		296

Source: Lamberth and Turpie (2003:11)

The South Coast provides a much larger estuary area for fishing. As would be expected the total fish caught (in tons) far exceeds that of the East Coast. Both areas have a large number of estuaries, but the average size of estuary is much larger on the South Coast. However, the catch rate in kilograms (kg) per ha is higher for the East Coast (78kg per ha) than for the South Coast (47kg per ha) (see Table A2).

It is estimated that 2 482 tons of fish are caught in South African estuaries each year and this catch has a value of R433 million per year at 1997 prices (see Table A3) (Lamberth and Turpie, 2003:18). This translates into about R6 000 per recreational angler per year and about R2 800 per commercial angler per year. Almost 99% of this catch is through recreational angling. Net and traditional fisheries account for the outstanding 1%. There are about 72 000 anglers in the recreational fishery and 1 350 in commercial fisheries (Lamberth and Turpie, 2003:18).

Table A3: Estimated annual value of estuarine fisheries in regions along the Republic of South Africa (RSA) coast

Type of fishery	Value in 000s Rands (1997)						
	West Coast	South Coast	East Coast	Transkei	KwaZulu-Natal	Total	%
Angling	5 804	169 818	92 657	58 484	101 735	428 499	99
Cast net	7	96	61	39	160	363	0,1
Gillnet	1 925	467	159	100	913	3 564	0,8
Seine	0	37	0	0	222	259	0,1
Fish traps	0	0	0	0	225	225	0,1
Spear	0	0	0	0	49	49	<0,1
Total (Rands)	7 736	170 418	92 877	58 623	103 306	432 959	
%	1,8	39,4	21,5	13,5	23,9		

Source: Lamberth and Turpie (2003:18)

APPENDIX 3: WETLAND LOSS IN EUROPE AND THE USA

Wetland loss in Europe during the 20th Century has been considerable (Table A4).

Table A4: Wetland loss in Europe

Country	Period	% loss of wetlands
Netherlands	1950 – 1985	55
France	1900 – 1993	67
Germany	1950 – 1985	57
Spain	1948 – 1990	60
Italy	1938 – 1984	66
Greece	1920 – 1991	63

Source: Bacon (1999)

The loss of wetlands has not only been a European phenomenon. The USA has lost some 87 million ha (54%) of its original wetlands, primarily due to agriculture (Bacon, 1999). As a wetland is degraded the ability of the wetland to provide goods and services to society is reduced and the wetland is unable to support the same level of biodiversity. Limiting water deprivation in wetlands is critical in the conservation of wetland ecosystems.

APPENDIX 4: NOTABLE CONTRIBUTIONS TO THE DEVELOPMENT OF CVM

Hanemann (1992) has traced the empirical roots of the contingent valuation method back to 1958 with the funding of a study in the Delaware River basin area by the US National Park Service. The method slowly took root during the 1960s but rapidly grew in popularity during the 1970s (Wattage, 2001:5). In 1963 it was used to estimate the benefit of outdoor recreation (Wattage, 2001:7). By the 1980s and 1990s the method was well established (Bateman and Wallis, 1999: 1). One of the reasons for its popularity was its capacity to measure both passive use and existence values of environmental goods goods (Breedlove, 1999:5).

The 1980s and 1990s were also periods during which great strides forward were made in developing alternative ways of applying the technique. However, they also were periods of critical review for the technique in which disagreement emerged about the basic validity of the CV technique (Bateman and Wallis, 1999:4). Particularly intense debate followed the high valuation of the oil spill damage (from a passive user perspective) caused by the running aground of an Exxon Company oil tanker on the night of 24 March 1989 in Prince William Sound (Bateman and Wallis, 1999:3). Against this background, in 1992, the NOAA commissioned a prestigious 'Blue-Ribbon Panel' of eminent economists to investigate the CV method, co-chaired by Kenneth Arrow and Robert Solow. The report of this panel gave the method qualified support, but only if the studies were conducted in accordance with a rigorous set of guidelines (Arrow, Solow, Portney, Leamer, Radner and Schuman, 1993).

It has also been realised that the method is very sensitive to many discretionary elements. For instance, Duffield and Patterson (1991) showed that there was a problem of variance estimation and one of sample design in DC methods and found that the decision of which functional form to use is crucial to a successful CV study. Pilot studies were recommended as a useful method of limiting typical problems encountered. Cooper and Loomis (1992) showed that DC models were sensitive to the sample design and to substitute measures of WTP. Their paper focused on the sensitivity of mean WTP to changes in the size of the bid. A sensitivity analysis was conducted by taking out bid values from the upper and lower ranges and the effects of specifying wider bid intervals were studied. Responses to ten WTP questions from three diverse surveys were analysed. Using an estimator of WTP, which allowed for both negative and positive values, WTP was re-estimated for each question with up to the four lowest values removed, and up to the four highest values removed. Also, WTP was re-approximated with every other bid value removed. They concluded that the tail of the distribution was "fat" and that there was a positive relationship between fatness of tail of the distribution and the impact on WTP of removing the upper bids (Wattage, 2001:14). The effect on mean WTP was relatively small, but increasing the intervals between bid values had rather unpredictable consequences for the WTP. Their findings emphasised the importance of proper sample design.

Kealy and Turner (1993) showed that there were differences in results generated from open-ended and closed-ended questions. They jointly estimated the WTP responses to open and closed-ended questions asked from one sample of individuals. Their explanations for differences in WTP values included differences in strategic behaviour, question format and the respondents' ability or willingness to think. Results showed that no differences were found in WTP for estimates in the case of private goods, as there was no incentive for strategic behaviour where respondents were familiar with the good before bidding for it. This study added credibility to the CV method as a method for determining the value of public goods.

Diamond *et al* (1993) have queried whether CVs actually measured economic preferences. They found a strong embedding effect – WTP was the same whether one item or several items were valued. Their explanation for this effect was that respondents were influenced by the "warm glow" effect when answering questions about their valuation of the environment.

The US Environmental Protection Agency (EPA) has played a key role in CVM development (Wattage, 2001:8). Almost all the CV studies funded under the EPA were designed to test various aspects of the CV method in order to establish its theoretical and empirical soundness. Efforts of EPA and many researchers since then have contributed significantly on the development of an overall framework, based on a theory of individual behaviour in CV market settings (Wattage, 2001:8).

APPENDIX 5: DIFFERENT QUESTIONS USED TO CONDUCT A CV

The CV process must determine the WTP for a good in question. Examples of various question formats are shown and discussed below (Arrow *et al*, 1993).

1 Open-ended elicitation

What is the maximum amount that you would be prepared to pay every year (through a local tax) to improve the access to the Knysna Estuary in the ways just described? (Arrow *et al*, 1993:50).

ARGUMENTS FOR:

- Straightforward.
- Does not suggest to respondents what the value of the change may be.
- A maximum WTP can be identified for each respondent.
- The results may be assessed using straightforward statistical techniques.

ARGUMENTS AGAINST:

- Can induce large non-response rates, protest answers, zero answers and outliers (unrealistically large bids) and unreliable responses.
- May be difficult for respondents to come up with a true maximum WTP as they have never had to value the good before.
- Assistance in answering may be biased if the interviewer has a certain goal in mind.

2 Closed-ended (single-bounded) DC

Would you pay R5,00 every year, through a local levy, to improve the infrastructure needed to launch boats into the Knysna Estuary?
Yes/No

ARGUMENTS FOR:

- Helps respondents to make a judgement about a given price, thereby simplifying the cognitive task faced by respondents.
- Is typical of a transaction process.
- Provides incentives for a truthful answer of preference.
- Minimises non-response and avoids outliers.
- The approach received the endorsement of the NOAA.

ARGUMENTS AGAINST:

- Empirical studies have shown that values obtained from DC elicitation are significantly larger than those resulting from comparable open-ended questions.
- Some degree of yea-saying is possible.
- DC formats are relatively inefficient, as larger samples are needed, which makes surveys more expensive.
- There may also be a starting point bias, that is, answers are "anchored" at the initial figure proposed by the questioner.

3 Double-bounded DC

Would you pay R5,00 every year, through a local levy, to improve the infrastructure needed to launch boats into the Knysna Estuary? (The price is varied randomly across the sample.)
If Yes: And would you pay R10,00?
If No: And would you pay R1,00?

ARGUMENTS FOR:

- More efficient than single-bounded DC as more information is elicited about each respondent's WTP. For example, we know that a person's actual value lies between R5,00 and R10,00 if she accepted to pay R5,00 in the first question but rejected R10,00 in the second.

ARGUMENTS AGAINST:

- All the limitations of the single-bounded DC still apply. An added problem is the possible loss of truth in telling due to the fact that the follow up question not being viewed by respondents as independent of the choice situation.
- Anchoring and yea saying remain complications.
- Not suitable for mail surveys because of the follow-up approach.

4 Bidding game elicitation

Would you pay R10,00 per year, through a local tax, to improve the landscape around the Knysna Estuary?

If Yes: Interviewer keeps increasing bid until the respondent answers No. The maximum WTP bid is the one prior to that.

If No: Interviewer keeps decreasing the bid until the respondent answers Yes. The maximum WTP bid is the one prior to that.

ARGUMENTS FOR:

- Facilitates the respondents' thought processes and encourages them to consider their preferences carefully.

ARGUMENTS AGAINST:

- Anchoring bias may exist, that is, the starting values and succeeding bids used may influence respondents.
- It can lead to large number of outliers and "yea-saying" (giving affirmative but possibly false responses).
- Bidding games cannot be used in mail surveys and other self-completed questionnaires.

5 Payment card elicitation

Which of the amounts listed below best describes your maximum WTP each year, through a local levy, to improve the landscape around Leisure Island, Knysna in the ways just described? OR Please tick next to the amounts you are certain you would be willing to pay and cross next to those you would not be willing to pay. Leave blank those amounts you are unsure whether you would be willing to pay or not.

R0,00
R0,50
R1,00
R2,00
R3,00
R4,00
R5,00
R7,50
R10,00
R15,00
R20,00
R40,00
R50,00
R75,00
R100,00
>R150,00

ARGUMENTS FOR:

- Avoids starting point bias (bids linked to researcher's statement of the first amount).
- Number of outliers is reduced in comparison to other formats.
- Some versions of the payment card show how values in the card relate to actual household expenditure or taxes.

ARGUMENTS AGAINST:

- It is vulnerable to biases relating to the range of the numbers used in the card.
- It cannot be used in telephone interviews.

APPENDIX 6: TYPES OF FOLLOW-UP QUESTIONS

Follow-up questions can be used to determine reasons for WTP and unwillingness-to-pay. Examples of each are shown below (Arrow *et al*, 1993:53):

Using WTP follow-up questions to determine valid responses

Possible reasons for unwillingness to pay	Valid (tick)	Protest (cross)
I/our household cannot afford to pay		
The change is too small to be of importance		
I/we think this problem is not a priority		
I am/we would be satisfied with the future situation		
I am/we are not interested in this matter		
I do not live near here		
There are many other similar goods around		
Spending should be on all similar areas, not just one		
I object to paying higher taxes		
Everyone should pay for this not just local people		
The government should pay for this		
The water company should pay for this		
I need more information/time to answer the question		

Possible reasons for WTP	Valid (tick)	Protest (cross)
I/we think this problem is important		
I/we would like to avoid further deterioration of the environment		
I am/we are very interested in this river		
I/we use this river for recreational purposes		
I/we may want to use this river in future		
We should protect the river environment for the animals/plants		
We should protect the river environment for future generations		
We should protect the river environment for other people to enjoy		
I/we get satisfaction from giving to a good cause ("warm glow")		
I/we will not really have to pay any extra amount		
My answers reflect my views to protect all rivers		

APPENDIX 7: QUESTIONS TO ASSESS CONTENT VALIDITY

A framework of questions to be asked in assessing the content validity of a questionnaire is described below (Bateman *et al*, 2002:80).

Issues of scenario design:

- Is the good offered clearly specified to and understood by respondents?
- Is the information provided enough and reasonable to describe the provision and payment scenario?
- Is the trade-off between money and the good plausible?
- Are substitutes and the consequences of non-payment adequately described?

Elicitation Issues:

- Is the chosen measure of well-being appropriate (WTP and WTA)?
- Is the chosen survey format appropriate?

Institutional context:

- Are the methods of provision and allied institutional arrangements plausible?
- Are the respondents likely to have an expectation of having to pay for the good if it is provided?
- Are respondents likely to feel that they are providing an input to the decision-making process?

Sampling:

- Has the correct population been identified and adequately sampled?

Survey format:

- Is the choice of survey mode appropriate?
- Is the survey administration and data preparation of a sufficiently high standard?
- Does the questionnaire design collect adequate data concerning variables that are likely to explain WTP, so as to permit construct validity testing (including the elicitation of attitude and response reason data)?

APPENDIX 8: BLUE-RIBBON GUIDELINES

1 For a single DC question (yes-no type) format, a total sample size of at least 1 000 respondents is required. Clustering and stratification should be accounted for and tests for interviewer and wording biases are needed.

2 High non-response rates would render the survey unreliable.

3 Face-to-face interviewing is likely to yield the most reliable results.

4 Full reporting of data and questionnaires is required for good practice.

5 Pilot surveying and presenting are essential elements in any CVM study.

6 A conservative design more likely to underestimate WTP is preferred to one likely to overestimate WTP.

7 A WTP format is preferred.

8 The valuation question should be posed as a vote on a referendum, that is, a DC question related to the payment of a particular level of taxation.

9 Accurate information on the valuation situation must be presented to respondents, with particular care required over the use of photographs.

10 Respondents must be reminded of the status of any undamaged possible substitute commodities.

11 Time-dependent measurement "noise" should be reduced, by averaging across independently drawn samples taken at different points in time.

12 A "no-answer" option should be explicitly allowed in addition to the "yes" and "no" vote options on the main valuation question.

13 Yes and no responses should be followed by the open-ended question: "why did you vote yes or no?"

14 On cross-tabulation, the survey should include a variety of other questions that help to interpret the responses to the primary valuation question, that is, income, distance to site, prior knowledge of the site, etc.

15 Respondents must be reminded of alternative expenditure possibilities, especially when "warm glow" effects are likely to be present, that is, purchase of moral satisfaction through the act of charitable giving.

Source: Barbier et al (1997)

APPENDIX 9: CORRELATION MATRIX TABLE (SPEARMAN RANK ORDER CORRELATIONS BETWEEN VARIABLES OF LEVIES, WORTH OF VEHICLES AND BOATS OWNED AND GROSS ANNUAL PRE-TAX INCOME)

Variable	Levies	Worth of vehicles and boats owned	Gross annual Pre-tax income
Levies	1,00	**0,32**	**0,35**
Worth of vehicles and boats owned	**0,32**	1,00	**0,65**
Gross annual Pre-tax income	**0,35**	**0,65**	1,00

Notes: Bold correlations are significant at $p < 0,05$

APPENDIX 10: CORRELATION MATRIX TABLE (PEARSON PRODUCT-MOMENT CORRELATION BETWEEN DISTANCE VARIABLES)

Variable	Distance (mouth)	Distance (closest point)	Distance (main road)	Distance (beach)	Distance (CBD)
Distance (mouth)	1,00	**0,88**	**0,77**	**-0,36**	**0,37**
Distance (closest point)	**0,88**	1,00	**0,84**	**-0,34**	**0,47**
Distance (main road)	**0,77**	**0,84**	1,00	**-0,50**	**0,52**
Distance (beach)	**-0,36**	**-0,34**	**-0,50**	1,00	-0,14
Distance (CBD)	**0,37**	**0,47**	**0,52**	-0,14	1,00

Note: Bold correlations are significant at $p < 0,05$

APPENDIX 11: CHARACTERISATION OF SOUTH AFRICAN ESTUARIES

South African Estuaries' Characteristics (2002)

	Region [1]	Mouth type [1]	Scientific Info [1]	Plant importance [2]	Fish importance [2]	Bird importance [2]	Invertebrate importance [2]	Conservation importance [2]	Urban/Resort/Rural	% gradient status	Condition [1]	Demand for development [2]	Protected/Partially/Not [2]	Size [2]
Orange														
Olifants														
Groot Berg														
Rietvlei/Diep					•									
Sout				•			•					•		•
Houtbaai						•	•					•		
Wildevoëlvlei						•						•		
Bokramspruit					•	•						•		•
Schuster				•		•						•		•
Krom						•						•		•
Silwermyn						•	•					•		
Sand												•		
Eerste														
Lourens														
Sir Lowry's Pass						•						•		
Steenbras				•		•						•		
Rooiels												•		
Buffels (Oos)												•		
Palmiet														
Bot/Kleinmond												•		
Onrus												•		
Klein												•		
Uilskraals														
Ratel												•		
Heuningnes														
Klipdrifsfontein				•								•		•
Breë (Breede)														
Duiwenhoks												•		
Goukou (Kafferkuils)												•		
Gouritz														
Blinde												•		•
Hartenbos														
Klein Brak														
Groot Brak														
Maalgate						•						•		
Gwaing						•						•		•
Kaaimans												•		
Wilderness System														•
Swartvlei														
Goukamma														
Knysna														
Noetsie												•		
Piesang														
Keurbooms														

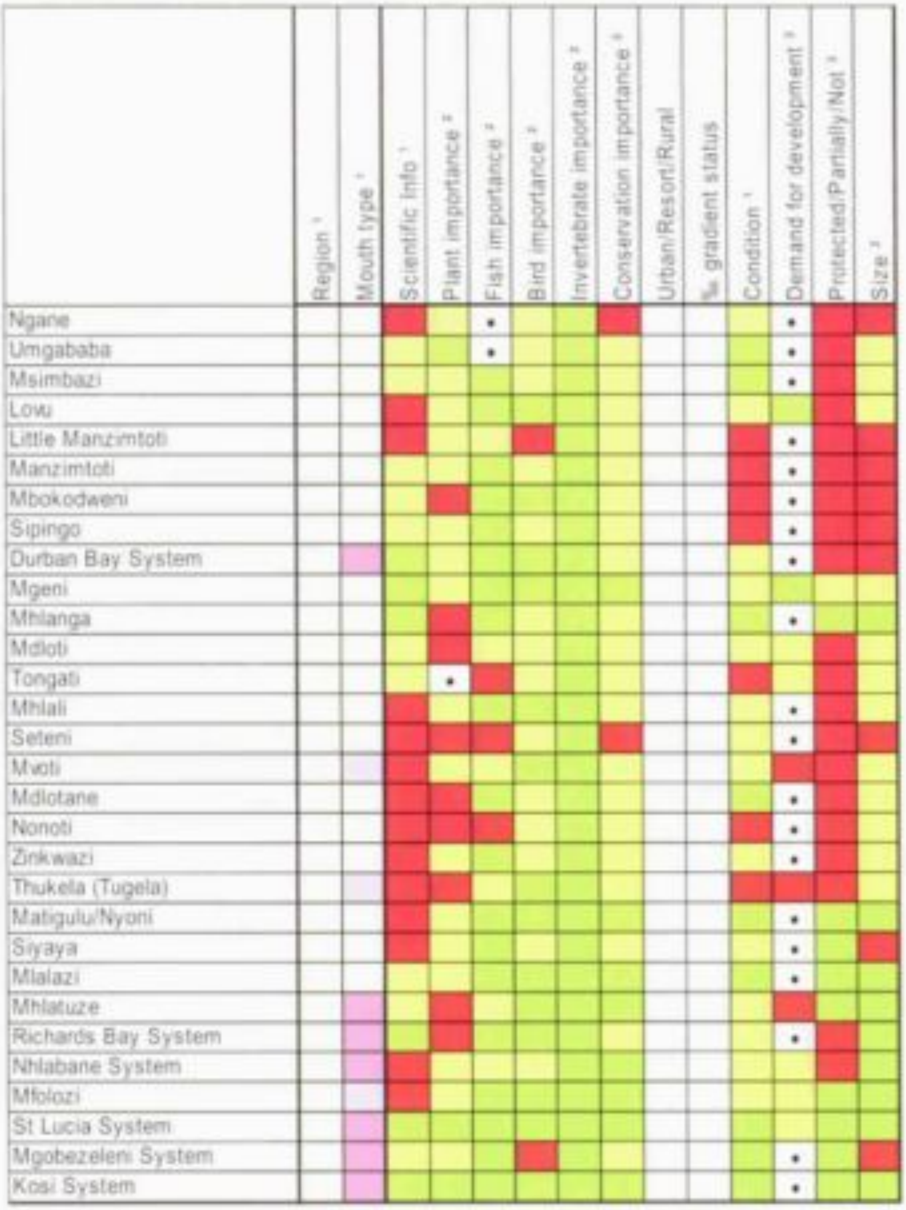
Source: Whitfield (2000)

	Region [1]	Mouth type [1]	Scientific Info [1]	Plant importance [2]	Fish importance [2]	Bird importance [2]	Invertebrate importance [2]	Conservation importance [3]	Urban/Resort/Rural	% gradient status	Condition [1]	Demand for development [3]	Protected/Partially/Not [3]	Size [2]
Matjies				•										•
Sout (Oos)														
Groot (Wes)												•		
Bloukrans						•						•		•
Lottering						•						•		
Elansbos						•						•		
Storms												•		•
Elands				•		•								•
Groot (Oos)						•								•
Tsitsikamma						•								•
Klipdrif												•		•
Slang				•		•		•				•		•
Kromme														
Seekoei					•									
Kabeljous												•		
Gamtoos														
Van Stadens														
Maitland												•		
Bakens (Baakens)				•		•	•	•				•		•
Papenkuils (Papkuils ???)				•	•		•	•				•		
Swartkops														
Coega (Ngcura)												•		
Sundays														
Boknes												•		
Bushmans (Boesmans)														
Kariega														
Kasuka (Kasouga)												•		
Kowie														
Rufane						•						•		•
Riet						•						•		•
Kleinemonde (Wes)												•		
Kleinemonde (Oos)												•		
Klein Palmiet			•	•	•	•	•	•				•		•
Great Fish														
Old Womans							•					•		•
Mpekweni												•		
Mtati												•		
Mgwalana												•		
Bira												•		
Gqutywa												•		
Ngculura							•	•				•		
Mtana												•		
Keiskamma														
Ngqinisa												•		
Kiwane						•						•		
Tyolomnqa												•		

	Region [1]	Mouth type [1]	Scientific Info [1]	Plant importance [2]	Fish importance [2]	Bird importance [2]	Invertebrate importance [2]	Conservation importance [2]	Urban/Resort/Rural	‰ gradient status	Condition [1]	Demand for development [2]	Protected/Partially/Not [2]	Size [2]
Shelbertsstroom				•		•		•				•		•
Lilyvale				•		•						•		
Ross' Creek				•		•		•				•		•
Ncera				•								•		
Mlele				•								•		
Mcantsi				•								•		
Gxulu												•		
Goda												•		
Hlozi				•								•		
Hickmans												•		
Buffalo														
Blind						•						•		
Hlaze						•						•		
Nahoon														
Qinira														
Gqunube														
Kwelera														
Bulura												•		
Cunge				•		•						•		
Cintsa												•		
Cefane				•								•		
Kwenxura												•		
Nyara												•		
Haga-haga						•						•		
Mtendwe						•						•		
Quko												•		
Morgan				•								•		
Cwili				•		•						•		
Great Kei														
Gxara						•						•		
Ngogwane						•						•		
Qolora												•		
Ncizele						•						•		
Kobonqaba						•						•		
Ngqusi/Inxaxo												•		
Cebe												•		•
Gqunqe					•	•						•		
Zalu				•	•	•	•	•				•		•
Ngqwara												•		
Sihlontlweni (Gcini)					•	•						•		
Qora						•						•		
Jujura						•						•		
Ngadla						•						•		
Shixini						•						•		
Nqabara					•	•						•		
Ngoma (Kobule)					•	•						•		

	Region [1]	Mouth type [1]	Scientific Info [1]	Plant importance [2]	Fish importance [2]	Bird importance [2]	Invertebrate importance [2]	Conservation importance [2]	Urban/Resort/Rural	% gradient status	Condition [1]	Demand for development [3]	Protected/Partially/Not [3]	Size [2]
Mpahlane					•	•						•		
Mzamba						•						•		
Mtentwana					•	•						•		
Mtamvuna					•									
Zolwane					•							•		
Sandlundlu												•		
Ku-boboyi												•		
Tongazi												•		
Kandandhlovu												•		
Mpenjati												•		
Umhlangankulu												•		
Kaba												•		
Mbizana												•		
Mvutshini				•								•		
Bilanhlolo												•		
Uvuzana				•								•		
Kongweni												•		
Vungu												•		
Mhlangeni				•								•		
Zotsha												•		
Boboyi												•		
Mbango				•								•		
Mzimkulu														
Mtentweni						•						•		
Mhlangamkulu						•						•		
Damba						•						•		
Koshwana						•						•		
Intshambili						•						•		
Mzumbe						•						•		
Mhlabatshane						•						•		
Mhlungwa												•		
Mfazazana												•		
Kwa-Makosi												•		
Mnamfu				•								•		
Mtwalume												•		
Mvuzi				•								•		
Fafa												•		
Mdesingane				•	•							•		
Sezela												•		
Mkumbane												•		
Mzinto												•		
Mzimayi												•		
Mpambanyoni												•		
Mahlongwa												•		
Mahlongwana												•		
Mkomazi														

	Region [1]	Mouth type [1]	Scientific Info [1]	Plant importance [2]	Fish importance [2]	Bird importance [2]	Invertebrate importance [2]	Conservation importance [2]	Urban/Resort/Rural	‰ gradient status	Condition [1]	Demand for development [3]	Protected/Partially/Not [3]	Size [2]
Mendu					•	•						•		
Mbashe												•		
Ku-mpenzu						•						•		
Mbhanyana (Ku-bhula)						•						•		
Ntlonyane						•						•		
Nkanya						•						•		
Xora (Xhora)						•						•		
Bulungula					•							•		
Ku-amanzimuzama					•	•						•		
Mncwasa					•	•						•		
Mpako					•	•						•		
Nenga						•						•		
Mapuzi						•						•		
Mtata						•								
Mdumbi						•						•		
Lwandilana					•	•						•		
Lwandile					•	•						•		
Mtakatye					•	•						•		
Hluleka (Majusini)					•	•						•		
Mnenu					•	•						•		
Mtonga					•	•						•		
Mpande						•						•		
Sinangwana						•						•		
Mngazana						•						•		
Mngazi						•						•		
Bulolo						•						•		•
Mtambane					•	•						•		
Mzimvubu						•								
Ntlupeni						•						•		
Nkodusweni					•	•						•		
Mntafufu						•						•		
Mzintlava					•	•								
Umzimpunzi					•	•						•		
Mbotyi						•						•		
Mkozi					•	•						•		
Myekane					•	•						•		
Lupatana					•	•						•		
Mkweni					•	•						•		
Msikaba						•								
Mgwegwe						•						•		
Mgwetyana						•						•		
Mtentu						•						•		
Sikombe					•	•						•		
Kwanyana					•	•						•		
Mnyameni					•	•						•		
Mpahlanyana					•	•						•		



Region & Mouth Type

- cool temperate / River mouth
- warm temperate / Permanently Open
- subtropical / Temporary Open/Closed
- Estuarine Bay / Lake
- Canal / Other

All other columns (except the ones specified above and below)

- High / Good / Protected
- Medium / Moderate / Partially protected
- Low / Poor / Not protected

• No info available

APPENDIX 12: AN EXAMPLE OF A QUESTIONNAIRE USED IN THE SURVEY – ADMINISTERED BY UPE – ONE RELATING TO THE PUBLIC ISSUE OF FRESHWATER INFLOW INTO THE GROOT BRAK ESTUARY

INSTRUCTIONS TO PERSON ADMINISTERING THE QUESTIONNAIRE

(a) Name of person administering questionnaire (not respondent) ________________

(b) No respondent's name is to be recorded and the information given by them is to be treated as confidential.

(c) There are 19 questions. Please tick the appropriate blocks.

1 Category of user/respondent

4

Category of user/respondent	
Recreation Boat sports Swimmer Angler/bait collect Birder Proximity/view	1
Commercial/subsistence	2
Non-users	3

2 Race of respondent

5

Race	
Blacks	1
Whites	2
Coloureds	3
Indians	4
Other	5

3 Gender of respondent

6

Gender	
Male	1
Female	2

4 Visitor or resident?

7

4.1	Visitor	1
4.2	Resident	2

5 What do you think will happen if there is a significant reduction of freshwater inflow into the estuary?

8

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

Fill in the gaps in the person's knowledge – impacts to be read to the respondent

The reduction of 27% of current freshwater inflow into the estuary can be expected to have consequences of the following magnitudes:

For boaters
1 Mouth will close

For swimmers
1 Minimal change – possible damming of water and entrapment of pollutants

For anglers/bait collectors
1 A 100% reduction of angling fish (due to shrinkage of nursery area)
2 A 100% reduction in mud prawn bait availability

For birders
1 A 100% reduction in wading birds which feed in the inter-tidal zone.

From the perspective of view and people staying near the estuary
1 Minimal change

From the perspective of the world generally
1 No change

6 Do you use the estuary for recreation, or making a living?

Recreation		9
Making a living		10

7 If yes, how often per year do you use it on average?

11

Days	
1	1
2 - 7	2
8 - 14	3
21 - 28	4
29 - 59	5
60 +	6

8 How many people make up your household?

12

Number of members of household	
1	1
2	2
3	3
4	4
5	5
6	6
7+	7

9 Of the members of your household, how many use the estuary in some way or other in the year – for recreation or making a living?

13

Number of members of household	
1	1
2	2
3	3
4	4
5	5
6	6
7+	7

10 Rate the relative importance you attach to the following activities/attributes of the estuary:
ex imp = extremely important
v imp = very important
m imp = moderate importance
unimp= unimportant

	Activities/attributes	ex imp	v imp	m imp	unimp		
10.1	Boat sports (excluding fishing)	4	3	2	1		14
10.2	Swimming	4	3	2	1		15
10.3	Fishing	4	3	2	1		16
10.4	Viewing estuary	4	3	2	1		17
10.5	Proximity – banks for picnics or accommodation close to it	4	3	2	1		18
10.6	Bird watching	4	3	2	1		19
10.7	Commercial – all business activities	4	3	2	1		20
10.8	Preservation of unique features	4	3	2	1		21
10.9	Other (specify)	4	3	2	1	specify	22

11 How much does your household pay per year in levies for use/access to the estuary in fishing, boating, bait collection and other fees?

23

Rand payments	
0 – 50	1
51 – 100	2
101 – 200	3
201 – 400	4

401 – 500	5
501 – 800	6
801 – 1 000	7
1 001 +	8

Working box

Background information (per annum or per visit) – for example, 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)

12 What levy per year are you willing to pay (including what you already do pay) for a project to prevent a decrease in river water inflow (due to urban and agricultural abstraction or reduced flows through forestry or vegetation changes) into the estuary of 27% over what currently flows into the estuary to prevent a reduction in the proportion of MAR inflow into the estuary from 82% to 60%.

The levy would be collected by the local authority from all users who derive benefit directly or indirectly, including those providing visitors access to the Groot Brak Estuary. This levy would be collected in rates and user fees to those accessing the water. It would be used to fund the "purchase" of 5 million m^3 of water, that is, enough freshwater inflow to bring about the changes in estuary services indicated.

You are requested to make two estimates – one where the benefits of this project are as follows (a high estimate) and another where the benefits are not as great (low estimate).

(12a) High estimate of benefits
(Describe)

For boaters
1 Mouth will close

For swimmers
1 Minimal change – possible damming of water and entrapment of pollutants

For anglers/bait collectors
1 A 100% reduction of angling fish (due to shrinkage of nursery area)
2 A 100% reduction in mud prawn bait availability

For birders
1 A 100% reduction in wading birds which feed in the inter-tidal zone

From the perspective of view and people staying near the estuary
1 Minimal change

From the perspective of the world generally
1 No change

24

Amount willing to pay under high estimate scenario (rand)			
0	0		
1 – 10	1		
11 – 20	2		
21 – 30	3		
31 – 50	4		
51 – 100	5		
101 – 200	6		
201 – 500	7		
501 – 1 000	8		
1 001 – 2 000	9		
2 001 – 3 000	10		
3 001 – 4 000	11		
4 001 + (specify)	12	specify	25

(12b) Low estimate of benefits
(Describe)

For boaters
1 Mouth will close

For swimmers
1 Minimal change – possible damming of water and entrapment of pollutants

For anglers/bait collectors

1 An 80% reduction of angling fish (due to shrinkage of nursery area)
2 An 80% reduction in mud prawn bait availability

For birders
1 An 80% reduction in wading birds which feed in the inter-tidal zone.

From the perspective of view and people staying near the estuary
1 Minimal change

From the perspective of the world generally
1 No change

26

Amount willing to pay under low estimate scenario (rand)			
0	0		
1 – 10	1		
11 – 20	2		
21 – 30	3		
31 – 50	4		
51 – 100	5		
101 – 200	6		
201 – 500	7		
501 – 1 000	8		
1 001 – 2 000	9		
2 001 – 3 000	10		
3 001 – 4 000	11		
4 001 + (specify)	12	specify	27

13 If your answer to either of the above (question 12) is zero, what are your reasons? (You may have more than one.)

	Reason		
13.1	Cannot afford the fees	1	28
13.2	Get no or negligible value out of estuary services	2	29
13.3	Abundance of service options – no scarcity, therefore why pay	3	30
13.4	Lack of confidence in government to collect and use fees collected for the water purchase	4	31

14 What would your household sacrifice in order to make this payment? (The money has to come from somewhere – the budget constraint – may tick more than one block.)

	Service income would be reallocated from			
14.1	Recreation activities	1		32
14.2	Domestic/household living	2		33
14.3	Dis-saving	3		34
14.4	Other (specify)	4	specify	35

15 Distance in kilometres of respondent's current accommodation (not necessarily place of permanent abode) from the estuary.

36

Distance from estuary (km)	
0 - 1	1
1 - 3	2
3 -10	3
10 +	4

16 Approximate worth of respondents' vehicles and boats owned at current prices

37

Total value (rand)	
0	0
1 – 2 000	1
2 001 – 10 000	2
10 001 – 50 000	3
50 001 – 100 000	4
100 001 – 200 000	5
200 001 – 400 000	6
400 001 +	7

17 Highest educational level attainment of respondent

38

Educational level	
No schooling	1
Completed 7 – 11 years or schooling	2
Completed 12 years of schooling	3
Completed schooling plus 3 or more years tertiary schooling	4

18 Gross annual pre-tax income of respondent

39

Pre tax income (rand)	
0 – 50 000	1
50 001 – 100 000	2
100 001 – 150 000	3
150 001 – 200 000	4
200 001 – 250 000	5
250 001 – 350 000	6
350 001 – 500 000	7
500 001+	8

19 Do you have any other comments you would like to contribute on this public issue?

____

40

Questionnaire compiled by members of the Departments of Economics and Zoology, UPE. Questions about this project may be directed to Prof SG Hosking, tel 041-504 2205

Appendix 13: Users' comments on Swartkops Estuary

In the survey respondents were also asked to make comments on the freshwater issue around estuaries. As this was not a compulsory section, some respondents made comments, others did not. A selection of some of the comments made by users of the Swartkops Estuary follows.

Values

- Very refreshing environment
- Attracted by abundance of fish stocks here during nights after a rainy day
- Windy days disturb business as most people stay away from estuary
- We need these bait digging jobs
- We dig mostly pencil and pink prawn. We cook these for food also
- Complaints and moaning by some people that we are taking too many prawns out of the estuary are not true.
- There are many opportunities for income earning here. It is better than staying at home
- This water provides me my daily food
- More government support is needed here
- Recreational anglers want to buy bait from us for cheap, for as little as R10 for a two litre container of bait.
- Have problems with people who do not fish hanging around the estuary
- There are no problems during weekdays. It is quiet and good for quality time
- Residents living close to the estuary must contribute more than anyone else to show their interest in the area.
- Willing to participate only if government proves that project can be implemented successfully
- Abalone poachers destroying sea life and estuary environment.
- There has to be national effort in a big project like this
- Fish, prawns and other estuary products must not be overexploited by users.
- The general public has to be regularly informed about the environment and projects proposed around the environment.
- The project is good but rich people and those who can afford must pay, the poor must not be asked to pay.
- Swartkops is one of the best fishing spots in South Africa
- When in dire need of money, some bait diggers have sold to other bait collectors the proper digging equipment given them free of charge
- The more users there are, the more money can be collected
- Thank you to UPE/WRC for showing such a concern on our beautiful environment

- We as residents we are exposed to all kinds of risk. After people have partied and returned to their homes we are left to clean up all the mess.
- We are already paying a lot as it is. Paying further levies may just be too much.
- We want our children to enjoy this place all their lives. It should remain as fresh as it is.
- Initially users may not show an interest to contribute but eventually this is likely to change and lots of users will be willing to contribute
- People will always support what they love

Policy issues

- Permits for all bait collectors
- Limit of five bloodworms per day is not good. We must be allowed to dig at least 10 a day.
- They must stop chasing us when we are trying to earn a living
- Corner Bait and Fish shop owner has no permit but sells bait, why is he not arrested
- The fishing and boating fees we pay annually must be used to contribute to such projects.
- Government should introduce a small entry fee into the estuary
- You just have to prescribe a levy and every user concerned should pay it. Obviously one can expect a small percentage of non-payment.
- Big fines must be imposed on all illegal users of estuary
- If the government cannot fund the project, it must mobilise the money from other sources.
- Fees currently paid by users could be raised slightly to contribute to the project.
- The fishing and sea-food industry must support a project like this
- It will be better to levy a small affordable amount that can be collected for a long period of time.

Management issues

- Littering is a problem
- Excessive bait collection
- Illegal bait digging methods
- We have a committee comprised of residents, anglers and business representatives. The committee's objective is to address complaints around the estuary.
- Law enforcement must be tightened
- There are plenty of tsotsis in the area
- Smell in the river a problem that must be fixed. It is unnatural. Lilies start to grow from contaminated water.

- Drinking and then driving speed boats should not be allowed. Keep illegal anglers, poachers and boaters out of the estuary.
- Different users should be controlled and monitored differently
- Very little freshwater flows into the estuary nowadays
- Water pollution is a future threat
- The Groendal Dam has not been opened for a long time and therefore the water in the estuary is pure seawater.
- Bait not sold should be eaten or thrown back into the river to serve as some food for fish.
- Too many angling club competitions at North End Lake, Swartkops and Redhouse.
- Government will be forced to give a good financial report of what it has done with fees collected previously before users can commit themselves to pay further contributions for a project like this.
- What can the Working for Water program contribute?
- There ought to be a significant amount of freshwater flowing from the Kliet, Chatty and Kruis Rivers.

APPENDIX 14: AN ACCOUNT OF FIELD EXPERIENCES AT SWARTKOPS ESTUARY – MOSES MLANGENI

Conducting a survey at the Swartkops Estuary turned out to be an enjoyable research experience. The atmosphere is so fresh and inspiring. However, being a black researcher in a predominantly white neighbourhood a few hurdles were initially encountered, but later hostilities were reduced. The first three days of the survey involved walking around the neighbourhood to get a feel for what kind of users existed and the general attitude of residents prior to commencing the survey. No interviews were conducted during these three days.

On the fourth day the interviews started and a number of residents at Swartkops Village were surveyed. After interviewing several residents, anglers along the estuary banks were targeted. On the same afternoon, after pacing up and down the riverbank along Strand Road, policemen interrupted an interview with an angler. They demanded to search my bag, saying they had been informed by a resident that a stranger with a black bag was walking up and down the riverbank for a long time. Afterwards the police left and the interview continued. This incident showed that crime was a concern in the area. Other incidents were less disturbing, for example, being rudely chased away by anglers or viewers as one approached them to ask for an interview.

Prior telephonic arrangements with some estuary users, especially sports clubs and owners of commercial enterprises, made the surveying process easier. Interviews were much more relaxed when one attended meetings of the angling, yachting and surfing clubs. Members were briefed about the survey before the meeting would start and then the interviews would be done after the meetings. Although a majority of users were adults, there were a high number of young people using the estuary. The 20 to 24 age group have the highest population numbers in the Swartkops residential area (Davids, 2002). On a normal weekend one is likely to find more than 50 households fishing on the estuary banks, another 50 fishing inside the estuary from their boats, and numerous viewers driving by slowly or parking on Strand Road overlooking the estuary.

Interviews with most individuals using the estuary was difficult in that either the respondents wanted to spend a long time chatting about other related but not relevant issues or they were in a hurry to get the interview over and done with so that they could continue with their activities.

Appendix 15: Users' comments on the Kariega Estuary

Values

- The project could bring about much needed improvements in the natural environment around the estuary.
- The estuary needs natural floods, not irregular supplies of freshwater.
- Bait collection by small children is not good.
- Encouraging seeing that there are people and institutions concerned and doing something about our environment.
- Freshwater is a very important topic in this area
- Please do not disturb the natural processes no matter what you are doing
- Wastage of water can't be tolerated here.
- Reality of project depends on money. This can be a very costly exercise to implement, requiring multi-millions.
- Project will be very welcome in this area.
- An increase in fish stocks in the estuary will be appreciated here.
- Why is the project only being thought of now? Kenton has had no freshwater supplies for a very long period of time
- This project could create jobs for locals
- If there is freshwater that can be sourced elsewhere, it would be preferred to use that to supply the people first before the estuary.
- There is a lot of swimming here. If freshwater inflow implies that the estuary will be deeper then children may no longer be able to swim here.
- As long as residents are not made to bear the full burden of the project, there should be no problems.
- Good thinking but potentially expensive project
- Issue of freshwater can't be ignored here
- Most anglers in this area are mainly interested in sea fish.
- We have lived here for 14 years. There has been very little freshwater in that period. We do need freshwater inflow. Wasting of freshwater is not tolerated in these areas
- Leave everything to nature. It may take long to correct but a strong flood is what is needed here.
- Kariega Estuary is not a rich hunting ground for birds because it is too sandy. However, there are places further upstream where one finds some of the most beautiful bird species.
- I enjoy walking along the riverbank. It is very refreshing here.
- Other citizens must be mobilised to support the conservation of this estuary.
- At long last we are not sitting and watching our environment going down.

- Project will show users that abusing environment is costly.
- We are unemployed here, that is why we are not willing to pay anything, we do not have money. Otherwise the project sounds very interesting.
- We are pensioners and we still support our children. We may not be able to contribute but we are supportive of the project.
- Nature usually suffers because we people interfere with it a lot. Where we have messed up we must fix.
- We need more natural floods in this area as there used to be before.
- I am too old for any recreational activity but it is good to hear that some people are interested in fixing up the mess created by human activity on the environment.
- Far more interested in the freshwater supplies for home use than for environmental use.
- Latent desire to ensure that both rivers are usable assets for community, for swimming and other recreation.
- We need freshwater, both for the people and the environment around the people.

Policy issues

- Every household in Kenton has to have a water tank with a minimum capacity of 10 000m^3
- Government needs to play a role regularly in natural resources or they will be degraded by users.
- All estuaries must be valued as a matter of urgency, to find out their current state.
- Government must first implement the project at its own cost then charge levies thereafter to recover its expenditure.
- We need reports on the use of the taxes we pay. Then more will be willing to contribute.
- Visitors to estuaries must be charged admission fees. Residents must have membership that they pay as annual levies.

Management issues

- High salinity levels.
- No freshwater inflow 60% of the time.
- Lots of weirs and dams upstream
- Lot of farmers in the area although no longer farming, farms now converted to game reserves
- Peak season sees lots of visitors coming to the area.
- Money needs to be spent on cleaning mouth of estuary
- There are a great number of extremely wealthy residents of Kenton and this is where finance must be sought. We live in a very mediocre place in Ellengone.

- Ecological balance must be attained at all times at the estuary
- Majority of users may be unaware of freshwater issues. If educated then project can receive a lot of support.
- Boat activities causing pollution and disturbing river life, destroying banks.
- Interested to know where the increase in freshwater will come from
- Boating should be banned on this estuary.
- We may have an increase in population at Kenton, there are not enough facilities to handle big population. More drinkable water needed. River can be a waste disposal channel if population increases significantly. That would lead to deterioration of water quality and an increase in water pollution.
- A natural flood will be the cheapest way to balance the system.
- There is a gradual increase of sandbanks
- Vegetation is slowly degrading; there are several weirs and dams upstream draining water for farming purposes and salinity is severe.
- Underlying geology in the Kenton area is unsuitable for large-scale abstraction of underground water.
- Asking people to pay for freshwater inflow may not be well received. Educating users must be prioritised
- There is water scarcity in this area. Our desalination plant certainly needs some freshwater.
- First, the project must have a positive impact on environment, then contribution by users will be justified.
- Interested in knowing how long we will be expected to contribute to the project.
- A lot has been said before and not much has been done. The estuary remains highly saline. Let the work begin.
- Willing to pay but not indefinitely.
- As a resident I am very worried that our environment is being degraded by irresponsible outsiders.
- Interested on the proposed start date of implementation of the project.
- This place is small and there are no jobs. Development projects bring hopes for jobs, that is why we will support such projects as yours.
- Water is generally expensive here because it is not from dams but is pumped from underground.
- I would like to see more control of rivers.
- I have nothing much to say because nothing gets done.
- There may be a need to break up dams up the river to increase freshwater inflow.
- Sand banks are being caused by strong winds.
- Impact on environment must be monitored always.

- Local nature conservation officialdom is ineffective, lazy and untrustworthy. If the control and policing of the estuary and adjacent seashore were to be privatised, something positive may be attained. I would change my view on contributing if and when effective conservation policing were introduced. At present the estuary, river and seashore are being raped with impunity.

APPENDIX 16: PERSONAL ACCOUNT OF FIELD EXPERIENCES DURING SURVEY OF THE KARIEGA ESTUARY – MOSES MLANGENI

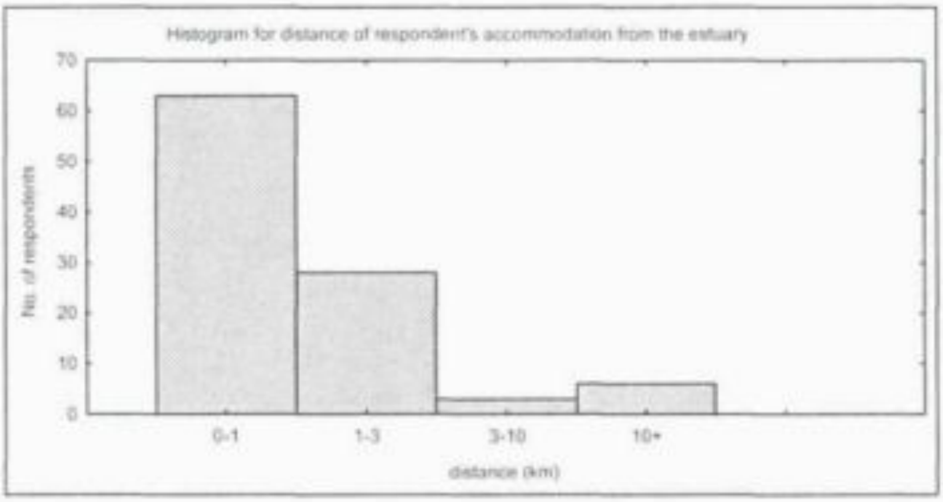
Woodlands Country Cottages, which is close to the Kariega Estuary, was my base during the survey. From here the river mouth, the town centre and the residential developments around the estuary were easily accessible. The Kenton tourism office in town was a good starting point. The resourceful tourism officer in charge, Erica McNulty, provided a list of residents to call and arrange interviews. Residents in the estuary care committee were also listed. That is how the interviews began, first with a few arranged interviews with residents. After these few interviews, estuary users close to the mouth and slipways were targeted and interviewed in the act of using the estuary.

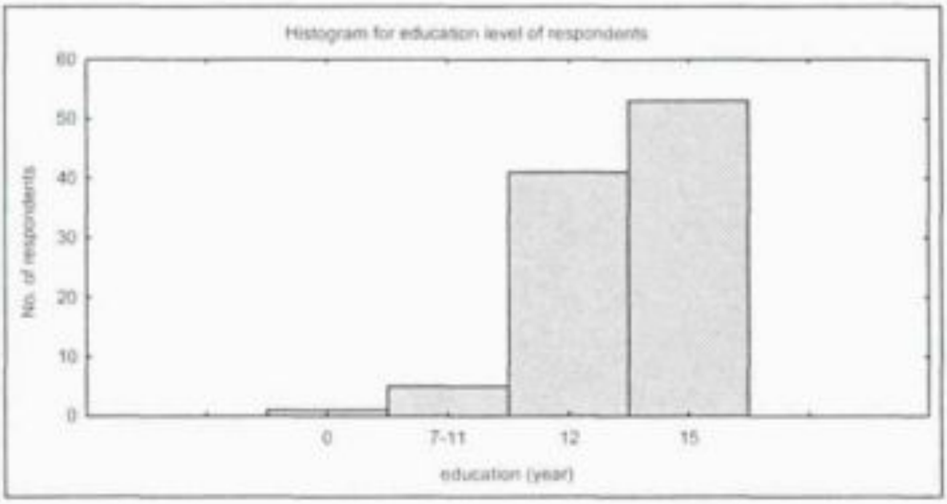
In the days that followed commercial enterprises, which included guesthouses, bait shop, bottle store and restaurants were interviewed. A lot of driving around was involved at this stage in order to get to these places. Two days were set aside for interviews with subsistence users in Ekuphumuleni and Marselle. Interviews were randomly selected here, stopping wherever there was low risk of robbery or attack and where residents were willing to participate. Because the estuary is in a small community, residents know one another very well.

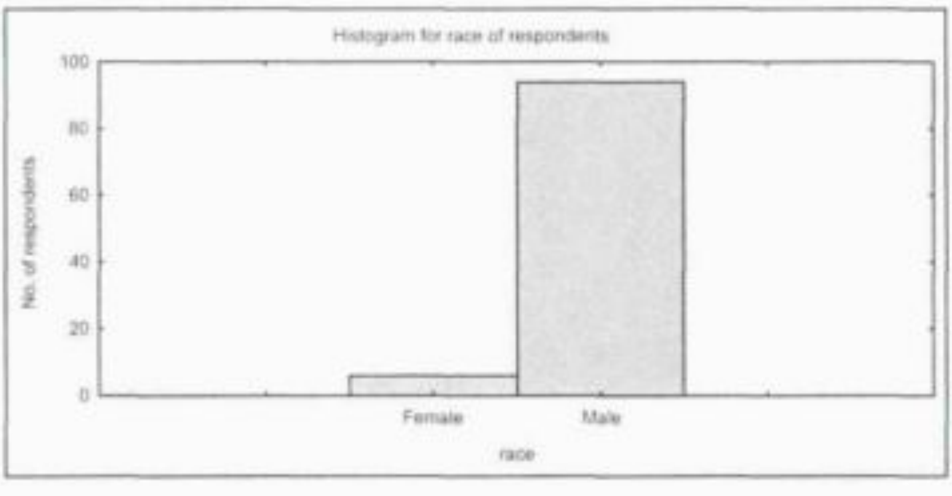
The survey was conducted mainly during March 2003. Due to the timing of the survey 86% of people selected were residents and only 14% were visitors. Residents said during main holiday periods like Easter and Christmas the percentage of visitors to the estuary increased significantly.

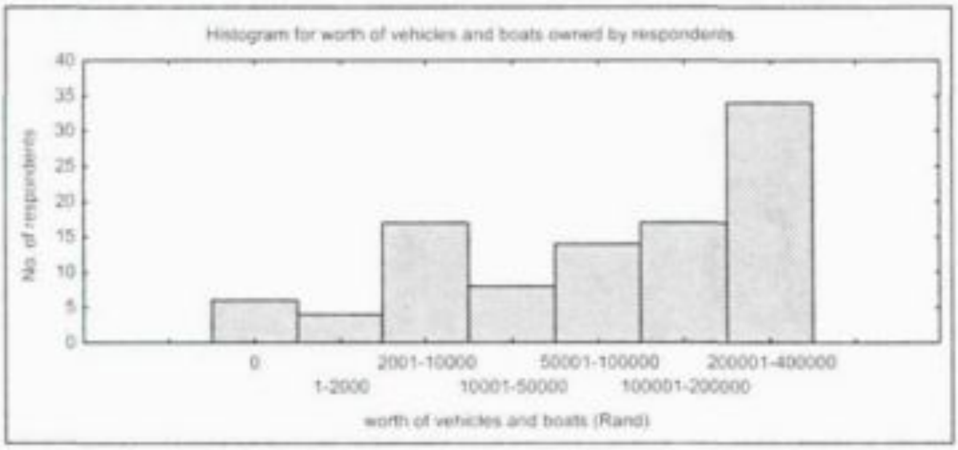
The survey was done in a combination of ways, including on-site interviews with residents and estuary visitors as well as telephonic interviews with certain targeted users. Most users were willing to be interviewed. The problem of driving up and down a survey area, or even walking up and down the street, seeking willing participants, was overcome by getting into the local phone book and phoning names in the area, asking for appointments for certain times and certain days. In this way a researcher can reach most residents around the estuary, although there were residents curious enough to enquire what the study was about and volunteered to participate in the interview. Some users were approached randomly as they were using the estuary. Some of the users were initially suspicious of the study, especially because of the WTP question, which some interpreted as meaning they would be required to pay some money in the near future for using the estuary.

APPENDIX 17: HISTOGRAMS FOR VARIABLES OF DISTANCE, EDUCATION, RACE AND WORTH OF VEHICLES AND BOATS








Histogram for worth of vehicles and boats owned by respondents
No. of respondents
0
5
10
15
20
25
30
35
40
0
1-2000
2001-10000
10001-50000
50001-100000
100001-200000
200001-400000
worth of vehicles and boats (Rand)

APPENDIX 18: ACCESS TO THE DATA

The information reported in Chapter Seven is stored at the Department of Economics and Economic History, University of Port Elizabeth, and may be accessed through Prof SG Hosking.

REFERENCES TO APPENDICES (NOT IN MAIN LIST)

BOYLE, K.J., WELSH, M.P. AND BISHOP, R.C. (1988). "Validation of empirical measures of welfare change: comment and extension", *Land economics*, 64(1): 94-8.

COOPER, J.C. AND LOOMIS, J. (1992). "Sensitivity of Willingness-to-pay estimates to bid design in dichotomous choice contingent valuation models", *Land economics*, 68: 211-24.

DAVIS, R.K. (1963). "Recreation planning as an economic problem", *Natural Resources Journal*, 3: 239-49.

DIAMOND, P.A., HAUSMAN, J.A., LEONARD, G.K. AND DENNING, M.A. (1993). "Does contingent valuation measure preferences? Experimental evidence", in Hausman, J.A. (ed.), *Contingent valuation: A critical assessment*, North-Holland, New York City: 41-85.

DUFFIELD, J.W. AND PATTERSON, D.A. (1991). "Inference and optimal design for a welfare measure in dichotomous choice contingent valuation", *Land economics*, 67: 225-39.

KEALY, M.J. AND TURNER, R.W. (1993). "A test of the equality of close-ended and open-ended contingent valuations", *American Journal of Agricultural Economics*, 75: 321-31.