A Preliminary Consideration of Use and Non-Use Values Circumscribing the Lake Hume Water and Foreshore Management Plan

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Key words: Water quality; Non-market valuation; Travel cost method; Hedonic Pricing

Abstract:
Lake Hume is a significant water storage located at the headwaters of the River Murray. It provides irrigation water, urban water supplies, flood mitigation and recreational benefits to a large and economically significant region. Water quality in Lake Hume has recently been the subject of intense investigation in response to continued evidence of eutrophication, in the form of blue-green algal blooms. As part of this investigation Goulburn-Murray Water has published a draft management plan that endeavours to explore a range of options that might potentially improve water quality. This paper reports the results of some preliminary estimates of recreational and other non-market values of visitors and residents which will ultimately assist in framing the final management strategy.

1.0 Introduction

There are few natural resources that have attracted more attention from Australian policy makers in the last decade than water. Of particular significance have been concerns about the continued and excessive extraction of water for productive pursuits and the consequent deterioration in the quantity and quality of the resource available for other users. This has manifested in a series of reforms, the most recent being the responses of the various states to the National Water Initiative, with its strong focus on allocating additional water to achieve environmental amenity.

At the regional level, state and federal agencies are responding to the shift away from water 'development' to water 'management' by reappraising the manner in which infrastructure has been historically utilised. In particular, water infrastructure which formerly has been geared towards the productive requirements of irrigation is being viewed as an instrument for achieving other ends. In some instances 'early' releases from storages are now being used to better mimic natural flows and thereby rejuvenate degraded wetlands (see, for example, MDBC 2005). However, these changes have not gone without attracting criticism from other constituents who see water held in storages as a recreational good, or security for irrigation.

The potential for conflict over the management of water storages has prompted some agencies to embark on significant consultation exercises to both test the preferences of the wider community and inform the citizenry of potential changes. In this context, Goulburn-Murray Water (GMW), the NSW Department of Infrastructure, Planning and Natural Resources (DIPNR) and the Murray-Darling Basin Commission (MDBC) released an *Issues Summary Paper* as part of the development of a land an on-water management plan for Lake Hume in January 2005. The purpose of the issues paper was to "help involve people in the development of the management Plan for Lake Hume" (GMW 2005, p.1). In order to gather pertinent data on the values held by different parties affected by the management of Lake Hume, a group structure was designed to elicit information from various sources. Amongst these, was a group of technical advisors responsible for identifying and filling important knowledge gaps about the operation of Lake Hume. This paper presents the results of work conducted to better inform agencies about the likely magnitude of recreation values ascribed to Lake Hume and offers some preliminary findings on the impact of the Lake on land values in the region. One of the primary motivations of the work was to establish the impact of variations in water quality on these values.

The paper itself comprises seven main parts. In section two we summarise the salient features of Lake Hume and the range of values considered in this study. Section three provides an overview of the methodological elements of the work. Comments on data sampling and a description of the operational components of the study are offered in section four with results being presented in section five. An analysis of these results in the context of the Management Plan is provided in section six before offering some brief concluding remarks in section seven.

2.0 Lake Hume and its Value

Lake Hume is located upstream of Albury and is the major regulating structure on the River Murray. Construction of the Dam commenced in 1919 with storage capacity being increased in 1924 and 1961 such that the dam now has the potential to store 3038 GL (MDBC 2004). The dam was originally designed to enhance navigation and foster irrigation development. In addition, it has developed into a major recreational site being popular for a range of water pursuits (Loder & Bayly 1979).

The dam typically fills in winter and spring with average inflows being approximately equal to storage capacity. Additional flows derive from diversions from Dartmouth Dam via the Mitta Valley and transfers from the Snowy Mountains Scheme. Water is generally drawn down for irrigation during late Spring and Summer – this is also the peak recreational season (Pak-Poy & Kneebone 1990).

The operation of the storage to service the needs of irrigators has given rise to several environmental concerns. Firstly, the wetting and drying cycles of ephemeral wetlands below the Dam has been radically modified by the management regime. Second, the 'peaks' and 'troughs' have been removed from the Murray flow pattern impacting on a range of ecological systems (Gippel and Blackham 2002). Third, accelerated channel erosion has been observed in the Mitta Mitta River as a results of the drawdown of water in Dartmouth Dam to top up Hume. Fourth, bank instability in the River Murray has also been attributed to the rapid draw down of water from Hume.

In addition, to disturbing flow parameters in downstream environments, there is also concern about the deterioration of water quality within the reservoir itself. In a review of the biophysical studies undertaken of Lake Hume, Howitt, Baldwin and Hawking (2005) chronicle the changes in major water quality parameters. Of particular interest they found that:

- Turbidity levels have increased, primarily due to the transformation of the catchment above the dam;
- Inorganic suspended materials enter primarily from the River Murray followed by the Mitta Mitta River, with most material being deposited within the Lake;
- Surface water temperatures are warmer in the Lake than in waters upstream, the difference being as much as 3-4 degrees Celsius at the dam wall in the warmer months;
- Stratification, where warm water overlies cooler bodies of water, is common and the maximum temperature difference between surface and bottom water is in the order of 3-8 degrees Celsius in summer;
- Stratification potentially gives rise to cold water pollution downstream but also depletes oxygen concentrations in the water at the bottom of the Lake;
- Hypoxia (the depletion of oxygen in the bottom waters) has been shown to mobilize and/or transform nutrients associated with algal blooms deriving from lake sediments;

- There are likely to be considerable stores of phosphorous in the sediment of the Lake;
- The early 2000's were punctuated by a number of High Alert cyanobacteria blooms in the Lake, occurring when the dam was at low levels;
- The pH of the water in the Lake shows signs of gradual decline with acidification of water looming as a potential problem.

Any decline in water quality within the Lake, particularly in the form of blue-green algal blooms, is of interest from an economic perspective on several fronts. The presence of blue-green algae significantly increases the cost of producing potable water and the population of Albury-Wodonga must foot this bill. In addition, there is likely to be detrimental impact on recreational users, which clearly embodies an economic dimension.

And yet improving water quality in Lake Hume is no easy task. A survey of the current activities associated with the water in the Lake, the land in upstream catchments and the bed of the Lake implies that enhancing water quality must come at some cost to current users. In particular, agricultural practices that abut the foreshore and the upstream catchment may require significant modification. The deforestation of these regions accompanied by extensive livestock grazing is often cited as a cause of gully and bank erosion, which adds to the sediment in the lake – the main source of nutrients. Grazing stock also add nutrients and pathogens to the water through urine and faeces extruded on the foreshore or in the upper catchment. However, given the substantial stores of nutrients in the existing sediment any adjustments to human activity may fail to yield results for decades or possibly centuries.

In order to appreciate the impact of any changes emanating from a land and on-water management plan it is necessary to establish the agricultural land use values attributed to the status quo. In addition, it was anticipated that enumerating the recreational benefits of enhanced water quality and specifying the costs of water treatment would provide insights into the effect of measures to enhance water quality via altered behaviour[1].

3.0 Measuring Values

Agricultural landuse values

Water quality in Lake Hume is, in part, a function of the agricultural land use activities that circumscribe the lake – albeit a delayed response. The main agricultural practice is cattle grazing with some grazing of sheep. In Victoria, landholders hold licenses to use the foreshore land. On the northern side of the Lake (in NSW), landholders have freehold title above the full supply level and easements to access land when the water is below its peak capacity. Fluctuations in the level of the Lake provide opportunistic grazing for riparian

[1] The work undertaken in this case was not a complete benefit cost analysis. Rather, the intent was to provide some of the groups involved in the collaborative development of the management plan access to additional information that was not readily available elsewhere.

landholders as well as access to water for stock and domestic purposes (GMW 2005, p. 13).

Focus sessions with landholders revealed that some placed considerable value on the grazing and water access enjoyed by having land that abuts the Lake. Assuming that property markets operate reasonably competitively, a proxy for these values could be attained by unbundling the value of land in the area and isolating that component that related to Lake access. This would then provide an estimate of the capitalised value of these access rights and give policy makers some idea of the economic consequences of decisions that might limit landholder access in the future.

In addition to providing insights to the value of agricultural access to the land that adjoins the Lake, applying this technique offered the potential to investigate the aesthetic values of the Lake from the perspective of nearby landholders.

This approach to value estimation is termed hedonic pricing. It generally involve a special survey to collect data (or the use of existing data if it is available) on house and land attributes, including environmental data and the estimation of a hedonic price equation indicating the price of houses and land as a function of attributes using regression analysis. Implicit prices for each attribute can then be calculated through partial derivatives. These implicit prices are generally used as willingness to pay values, which are considered a reasonable approximation when prices do not vary with the amount of environmental quality, when changes in environmental quality are small or when households are similar[2] (Abelson 1996).

The outcome of statistical approaches to hedonic pricing may be sensitive to variable selection, variable measurement and the choice of functional form and full hedonic price studies require considerable data and resources. As identified by Bennett (2005, pp. 245-246) there are relatively few published cases where the hedonic price method has been invoked in Australia. In part, this reflects the difficulty of assembling data that is capable of accounting for the multiple attributes that make up a real estate transaction.

Recreational values

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[2] "However, the implicit price schedule is not a demand curve, but a set of points on a demand curves of many households. Only if households have similar demand functions (i.e. similar incomes, preferences etc) will the implicit price curve be the same as the demand curve. If household demands for environmental goods differ, the benefits of non-marginal changes in the supply of environmental goods are the sum of the appropriate areas under the demand curve for each household. This would generally be different from the product of the estimated hedonic price per unit of environmental good and the change in the number of units provided. Ideally we would then estimate the aggregate demand schedule for the environmental good" (Abelson 1996).

As noted earlier, Lake Hume attracts large numbers of recreational users who enjoy water pursuits such as swimming, boating, fishing and canoeing. In order to gauge the economic value of these activities the study proposed using the travel cost method (TCM). The TCM comprises two steps. The first step is to examine the relationship between the rate of visitation to a site and the return costs of travelling to the site. This gives rise to what is referred to as the "whole experience" demand curve (Sinden and Worrell 1979; Hufschmidt et al 1983) and can be used to define one point on the true demand curve for the subject site i.e. the number of visits to the site at the current price level (Hufschmidt et al 1983).

The visitation rate – travel cost relationship can then be used to estimate other points on the demand curve i.e. the number of visits that would be made to the site if varying levels of hypothetical entry fees were being charged (Bennett et al 1996). This step allows the entire Marshallian or normal demand curve to be derived. The area under the demand curve estimates the consumer surplus or economic benefit that accrues to the visitors to the site.

Water treatment costs
The identification of algae in raw water is usually followed by the dosing of potable water with powder-activated carbon. Data on the expenditures by local water authorities to deal with algae incidents have been sourced, although not reported in this paper.

4.0 Sampling and Operationalising TCM and Hedonic Pricing
As noted earlier, the chosen techniques rest on being able to statistically unbundle the relationships between behaviour in related markets and the value/item of interest. In the case of the hedonic pricing exercise, the goal is to establish the part-worth value of 'lake frontage' and 'lake views' as a component of the wider property market in the region. By way of contrast, the travel cost component of the work endeavours to establish the value of recreational visits based on visitation patterns and travel costs associated with visiting the site. Each exercise has specific data requirements and the procedures undertaken to source these data are briefly described here.

Hedonic pricing data
Data for the hedonic pricing models was collected between October and December 2005. In the first instance, property data were obtained from a proprietary source that listed over 275 sales in the region of interest. The data set comprised information on the purchase price, zoning, location, area and the identity of the purchaser. Accordingly, it was anticipated that this would provide a useful foundation to which additional information, like housing details, travel distances to major centres, agricultural improvements and the like could later be added. In order to expand upon the original property data, the real estate records were matched with listed phone numbers and a brief supplementary questionnaire was developed. This was also expected to provide the opportunity to collect data that could be used to account for the heterogeneity of purchasers.

The questionnaire specifically sought information about the productive and recreational benefits of lake's frontage and the extent to which the property owners had access and views of the Lake. *A priori*, it was anticipated that these attributes would be positively related to property values in the region.

Unfortunately, the process of matching records with phone lists proved problematic, not least because the original data set was outdated in some cases. To overcome these difficulties an attempt was made to expand the data set by collecting information via in-person visits to properties in the vicinity of Lake Hume. Given the budget for the work, this was limited to single site visits during daylight hours by trained field staff. Despite the low non-response rate from respondents who were contactable, this procedure yielded a little over 100 complete responses at the conclusion of the data collection phase.

Travel cost data

Travel cost data were collected throughout January 2006. This comprised the administration of an in-person survey at several sites and at varying times around the foreshore of the Lake. Popular boat ramps, picnic areas and viewing points were the main locales.

Respondents were asked the usual array of questions for an exercise of this nature – i.e. distance travelled, primary purpose of the visit, number of individuals in their group and the like. In addition, respondents were asked specific details about their contingent visitation behaviour in relation to the presence of algal blooms and the water level of the Lake relative to its full capacity. In the case of algal blooms, respondents were asked a simple dichotomous choice question as to whether they would have undertaken the visit if they were aware of a blue-green algae alert. Accordingly, these data could be used to estimate any aggregate reduction in demand for recreational services.

The impact of the water level on visitations was measured by asking a series of questions. First, respondents were asked if they checked information about the level of the dam before visiting. Second, for those who gathered such information in advance, a series of iterative questions were asked to establish the 'reservation level' at which visitations would cease. The iterative questions were administered consecutively in ascending and descending order to minimise the impact of any starting point bias from this type of question.

5.0 Results

The following analysis is divided into the two main elements of the study – considering land use values via the hedonic pricing approach and recreational values using the TCM.

Hedonic Pricing

A number of hedonic price models were analysed. Earlier models included a wide number of variables with latter models omitting statistically insignificant variables. Model 1 (below) included 16 explanatory variables. Most of these were in binary form with zero representing absence and one representing presence of the particular attribute. For zoning, zero represented non-urban and one represented urban.

Table 1 – Hedonic Pricing Results

	MODEL 1		MODEL 2	
Multiple R	0.664894		0.598802	
R Square	0.44208403		0.358563	
Adjusted R Square	0.30475087		0.333893	
Standard Error	259364.093		253870.2	
Observations	82		82	
F-stat	3.219062		14.53401	
F- significance	0.000433		1.31E-07	
	Coefficients	*P-value*	*Coefficients*	*P-value*
Intercept	390,817	0.07	219,898	0.004283
Area (ha)	1,887	0.00	1,807	1.66E-05
Zoning	-67,659	0.48		
FRONTAGE	-58,826	0.45		
Views	-110,448	0.15		
HOUSE	285,628	0.00	247,718	6.25E-05
POWER	-96,190	0.57		
PHONE	110,455	0.45		
TOWN WATER	-132,872	0.33		
SEWAGE	101,512	0.36		
STOCKYARDS	-139,118	0.40		
MACHINARY SHEDS	129,705	0.30		
SHEDS	-27,373	0.86		
OTHER	-147,023	0.35		
RD SEALED	15,994	0.92		
HOW FAR (kms)	-12,771	0.13	-9,725	0.010141
HOW LONG (minutes)	1,313	0.88		

From Table 1 it can be seen that model 1 has an adjusted R squared of 30% indicating that only 30% of the variation in property price is explained by the estimated equation. Furthermore, most explanatory variables, including the presence or absence of a view or lake frontage are statistically insignificant at the 5% level. Nevertheless, the F statistic indicating that all coefficients in the equation are significant at the 1% level.

Model 2 which focuses on statistically significant or close to significant variables from Model 1 provides marginally more explanatory power, with an adjusted R squared of 33% and a significant F statistic. The three explanatory variables, area, presence of a house and the distance of the property to a major town are all statistically significant at the 1% level.

In all models that were analysed frontage to the Lake proved insignificant at the 5% level. In some models the presence of a view to Lake Hume was a statistically significant variable, however, the sign did not meet *a prior* expectation. This suggests some underlying multi-collinearity between some of the variables in the data set.

Travel Cost Method
For the travel cost study the data was sorted into eight zones, as shown in Table 2. The pattern of visitation of the sample was extrapolated to the estimated annual visits of 100,000. Population of each zone was obtained from ABS regional profile data for each zone. The visitation rate for each zone was then estimated by dividing the estimated annual visits for each zone by the population for each zone.

The travel cost estimate from each zone was based on the return distance to Lake Hume from a mid-point in each zone, estimated number of cars per group and occupants per car and operating costs of a standard vehicle per km. An estimate of the opportunity cost of time was added to the standard vehicle cost estimated. This estimate of opportunity cost of time was based on the composition of vehicle occupants (adults and children), estimated travel time and a per adult and per child opportunity cost of time.

Travel costs and opportunity costs of people's time were apportioned based on whether the visit to Lake Hume was the primary purpose of the group's trip or not.

Table 2 - Travel Cost – Visitation Rate Data

Zone	No. of Groups	Sample Visits	Annual Visits	Popn.	Sample Visits per (000) Popn.	Annual Visits per (000) Popn.	Return Distance (km)	Estimated Travel Time (Hours)	Apportion Travel Cost and Opportunity Cost of Time
1.Albury	19	120	7,752	72,811	1.6	106.5	44	0.6	5.1
2. Ballarat/Geelong	19	141	9,109	406,466	0.3	22.4	820	11.7	77.1
3. Central Victoria	23	212	13,695	198,504	1.1	69.0	518	7.4	67.3
4. Melbourne	113	737	47,610	3,418,022	0.2	13.9	672	9.6	75.2
5. SW and Mornington Peninsula	9	85	5,491	266,074	0.3	20.6	978	14.0	106.9
6. SW NSW	13	94	6,072	283,298	0.3	21.4	484	6.9	45.4
7. Wodonga	20	132	8,527	47,528	2.8	179.4	58	0.8	5.8
8. Sydney	3	27	1,744	4,198,543	0.0	0.4	1,168	16.7	157.4
Total	219	1,548	100,000						

Notes:

1. Travel time was calculated based on vehicle travelling 70 kilometers per hour.
2. Cost of travel time was assumed to be 35% of the average hourly wage rate. The opportunity cost of travel time for children was assumed to be 25% of that for adults. This approach was based on Cesario (1976) and Abelson (1986).
3. Distances travelled are based on approximate travel distances in UBD (2001) Concise Motoring Atlas of Australia.
4. Populations are based on ABS regional profile estimates.
5. A vehicle travel cost of $0.20 per km used.

Table 3 – Regression Analysis of the Annual Visitation Rate - Travel Cost Relationship

	TC Co-effic. (P value)	Constant (P value)	R squared	F stat
Base	-0.03 (0.003)	5.3 (0.00007)	0.80	24.4
50% Water Level	-0.03 (0.04)	5.2 (0.003)	0.53	6.7
10% Water Level	-0.04 (0.0003)	5.1 (0.00003)	0.89	53.1
Algae Alert	-0.03 (0.0001)	4.31 (0.00005)	0.84	31.3

Note: The preferred functional form for all travel cost visitation rate relationships was log-linear

Four functional forms were used for the visitation rate- travel cost relationships and the demand curve i.e. linear, log-linear, linear-log and double log. In addition to estimating the base visitation from the data, additional estimates were made under a scenario when the reservoir was at 50% of its full capacity, when it held 10% of capacity and when an algae alert was known to the respondent.

For the visitation rate – travel cost relationship, log-linear was the preferred function form for all scenarios (with the exception of the 50% water level scenario where the linear-log functional form was preferable) based on P-value, R squared and F stats. However, for simplicity a common functional form (log-linear) has been reported here.

Table 4 – Regression Analysis of Demand Curves

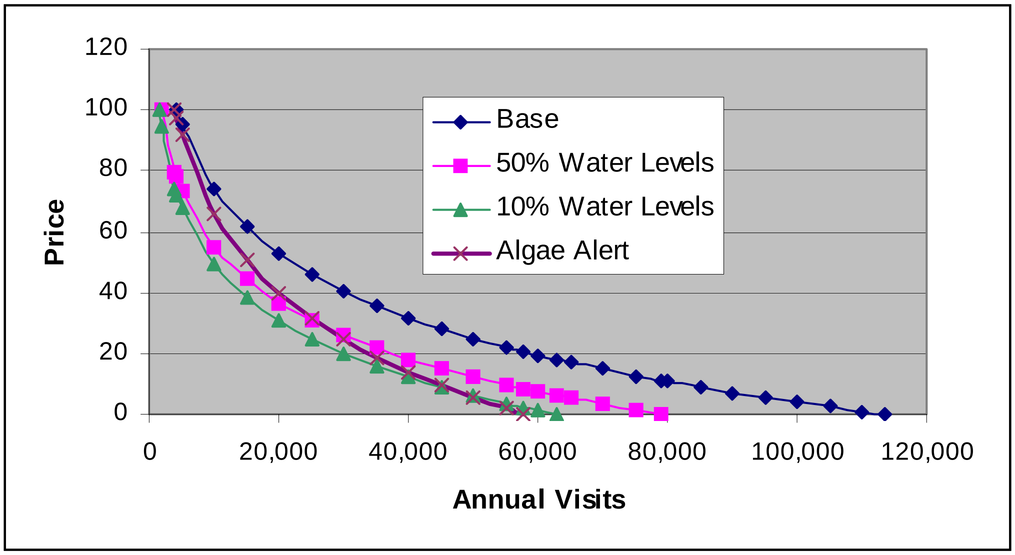
	LN Visits (P value)	Constant (P value)	R squared	F stat
Base	-30.4 (5.63E-62)	354.4 (3.44E-63)	1.0	44444403
50% Water Level	-26.6 (5.63E-62)	300.3 (2.03E-63)	1.0	44444403
10% Water Level	-26.7 (5.63E-62)	295.6 (1.92E-63)	1.0	44444403
Algae Alert	-37.4 (5.63E-62)	410.5 (5.10E-63)	1.0	44444403

Note: The preferred functional form for all demand curve was linear-log.

The use of the log-linear function form for the visitation rate- travel cost relationship, resulted in the linear-log function form being preferable for the demand curve estimates, with highly significant coefficients and constants and perfect explanatory power of regressions.

The demand curves for the base situation and three scenarios are depicted graphically in Figure 1 below.

Figure 1 – Demand For Visitation to Lake Hume Dam



The area under the demand curves gives the total annual consumer surplus for each scenario and enables calculation of the consumer surplus per visit. Because the linear log function form results in the demand curve being asymptotic to the price axis an arbitrary price cut-off (of $100) was necessary to enable calculation of the area under the demand curves. The resulting estimates are given in Table 5.

Table 5 – Consumer Surplus Estimates

Scenario	Annual Consumer Surplus	Consumer Surplus Per Visit
Base	$3,304,254	$33
50%	$2,042,103	$20
10%	$1,638,803	$16
Algal alert	$1,993,998	$20

6.0 Discussion

The hedonic price analysis was unable to establish any significant plausible relationship between property value and Lake frontage or views of the Lake. This stands in contrasts with anecdotal evidence from real estate agents that both attributes add at least some value to properties enjoying these features. As we have already suggested, one possible explanation for this resides in the data itself which provided a relatively restricted sample for analysis. While data on 101 properties was collected, it was not always complete. Moreover, a large number of complete responses were proffered by smaller properties, presumably less concerned about revealing the values ascribed to their lake-related activities. Some characteristics of the data are summarised below.

Table 6 – Characteristics of the Hedonic Pricing Data

Item	No.
Sample	101
Useable sample	82
Properties larger than 3 ha	18
Lake Frontage	19
View of the Lake	55
Urban properties	54
Properties with houses	49

In addition to problems with the sample, it is also feasible that the value of lake frontage is less significant than originally hypothesised. From an agricultural perspective fluctuating water levels bring both benefits and costs – the latter in the form of constant repairs to fencing to enclose stock, moving pumps and the like. Moreover, the costs associated with maintaining the foreshore when recalcitrant campers and boat users treat all foreshore as common property can be non-trivial. As one landholder poignantly noted "*it's like being a part-time park ranger*".

By way of contrast, the TCM models were statistically significant and met all *a priori* expectations. Importantly, the analysis estimated that the demand curve for visits to Lake Hume would shift leftwards as conditions at the dam decline, either because of the reduction in the water level or the presence of an algae alert. The end result would not only be reduced visitation levels and hence a reduction in total annual consumer surplus, but also a reduced consumer surplus per visit for those who persisted in visiting the site at times of reduced environmental quality. This is the pattern that would be expected when environmental quality of a recreation site is reduced (Asian Development Bank 1996).

The TCM information provides important indicative data on the impact of degraded water quality in Lake Hume. These data can assist decision makers in establishing the acceptable trade-offs between maintenance of the status quo and alternative management of the site. More specifically, the data indicate that retaining additional water in storage in Lake Hume bestows significant benefits on recreational users, as does a reduced incidence of algal blooms. Clearly, resolving the balance between managing the site to accommodate these preferences and using the infrastructure to meet the needs of other users remains the challenge of the groups currently developing the management plan for the Lake.

It should be noted that there are several caveats to these findings. First, there is an indirect overlap between what is valued by the TCM and what is valued by the hedonic pricing method. This arises because recreation benefits assessed by means of the TCM may be partially capitalised in property value improvements. Double counting will occur if both values are estimated, however, this overlap is not complete. The property valuation method fails to pick up significant relationships beyond a relatively small zone of influence while the travel cost method performs better with greater distances, but does not capture the value of views for properties close to the subject land (or the cost of noise and congestion) (Allen et al 1985). In the current context the performance of the hedonic pricing models renders this caveat obsolete.

Second, the data collection phase for this study was concentrated at a time when the reservoir enjoyed relatively high levels of storage and in a season of peak recreational use. This occurred because of the operational constraints imposed on the work. Consequently, the available data is skewed in favour of respondents who make use of the resource during the summer months and when there is ample water in storage[3].

7.0 Concluding Remarks

The management of water held in storages is under scrutiny in many regions, often in response to concerns about the deleterious environmental impacts of water infrastructure and its historical management. In the case of Lake Hume, the response of agencies has been to assemble a number of groups to develop a management plan that might best address the conflicting aspirations of water users.

On the one hand there is a presumption that access to the lake's frontage bestows benefits to landholders, particularly agricultural users who enjoy opportunities grazing and access to stock and domestic water supplies. Similarly, is has been assumed that property owners gains some aesthetic benefits from views of the water body. This paper explores these values by applying a hedonic pricing technique on the assumption that such values would be capitalised into the price paid for real property in the study region. Nevertheless, the data provided no evidence of these hypothesised relationships.

Alternatively, it was hypothesised that the water held in the reservoir also bestowed benefits on recreational users of the resource. To assess the extent of this benefit the TCM was employed. Modelling of these data point to recreational values of about $3 million p.a. when the Lake is near capacity and when the threat of algal contamination is low. In addition, a diminution of the water level to about half reduces the value of these benefits by about a third, as does a single incidence of blue-green algae.

The challenge for policy makers is to harness this information in order to develop a management regime which appropriate addresses the suite of demands on the water held in Lake Hume. In light of the probably longevity of some of the drivers of the eutrophication of the Lake and its sediment, this remains a formidable challenge.

[3] The alternative, of sampling across several seasons with varying water levels is not feasible in the current context. Moreover, the resources attendant on such an approach makes it implausible for most applications of the TCM. In this case we have employed contingent questions on the level of the reservoir to form estimates of different demand functions.

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