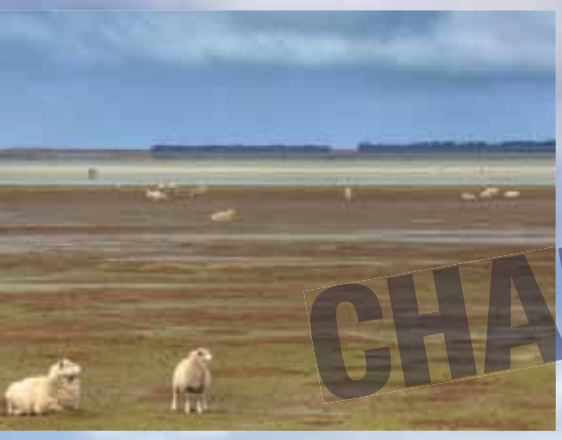
TE WAIHORA/LAKE ELLESMERE
State of the Lake and Future Management

Edited by **KENNETH F.D. HUGHEY** and **KENNETH J.W. TAYLOR**



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Edited by **KENNETH F.D. HUGHEY** and **KENNETH J.W. TAYLOR**
Lincoln University Environment Canterbury

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CONTENTS

SHELLEY McMURTRIE

SHUTTERSTOCK

01 INTRODUCTION

KENNETH F.D. HUGHEY Lincoln University **KENNETH J.W. TAYLOR** Environment Canterbury

Te Waihora/Lake Ellesmere[1] is a large coastal lake, intermittently open to the sea. It is highly regarded for its conservation and related values, some of which are of international significance. Its function as a sink for nutrients from its large predominantly agriculturally based catchment, currently undergoing accelerated intensification, is also recognised, at least implicitly. It is the resulting conflict from these value sets which is mainly responsible for the ongoing debate about the future of the lake, a debate long fuelled by rhetoric and informed by a body of science which highlights the lake's complexity as a biophysical system, but has many gaps. It is a debate that now has substantial statutory implications, arising from factors which include:

- the requirements of conservation, and indigenous needs and entitlements which are growing in prominence and statutory (including property rights based) legitimacy;
- public interest in legal processes associated with further major intensification of agriculture planned for the catchment;
- a recent Environment Court decision in which serious questions about the overall biological health of the lake were raised; and
- the consequences arising from the need for Environment Canterbury to obtain resource consents for the lake operating regime.

In addition, in recent times the Waihora Ellesmere Trust (WET), a community based group advocating for improved management of the lake, has been established. It is within these diverse contexts that this State of Te Waihora/Lake Ellesmere report has been prepared—it results from the 2007 Waihora/Ellesmere Living Lake Symposium, held from 31 October-3 November 2007 at Lincoln University, Canterbury. The symposium was initiated and organised by the WET (see www.wet.org.nz).

The Living Lake Symposium had several key objectives:

- To determine the overall state of the lake, by first defining the key value sets, and indicators that could be reported against;
- To suggest future management actions that would address key issues affecting the defined values;
- To provide a forum within which lay individuals, scientists and managers could openly debate issues; and
- To provide a launching pad for integrated and focused future management of the lake and its environs.

The programme incorporated three keynote speakers: Dr Larry Hildebrand from Environment Canada, Dr Hamish Rennie from Lincoln University, and Dr Bryan Jenkins from Environment Canterbury—their addresses made a major contribution to the symposium although none are included in this report, because it is focused primarily on the science and the management options associated with the lake.

The format of this report is designed to be readily updateable. Ten of the principal presentations in the main sessions of day two of the symposium are included in this report—two Power Point presentations (both regarding water quantity and related issues) are provided as appendices to improve completeness. Over time, however, topic areas not available as full papers for this report, e.g., surface water quantity, will be written up and included in detail. Similarly, the papers herein will themselves be updated as new and significant data become available. Each subject area will be reconsidered within the same structure and context as has been provided here. One paper, 'Te Waihora/Lake Ellesmere: An integrated view of the current state and possible futures', was presented on the final formal day of the symposium and it is included as the concluding chapter of this report.

Finally, the Waihora Ellesmere Trust and many of the others attending the symposium saw merit in reconvening the event around two years after the initial symposium, to report on progress with management, indicator monitoring, scientific understanding and other matters. We support that suggestion.

In terms of report format it is important that readers note the following:

- All authors were provided with 'briefs of work' and were requested to contextualise their work with that contained within the Taylor (1996) report on the lake—this was more easily achievable for some than others. Given some lack of consistency between symposium presentations and final papers it is our intention that a revised set of agreed indicators will be considered and included in any follow-up symposium and associated reports—some considerable work will be required in some areas to achieve this objective;
- Only the wildlife and integration papers included in this report have been formally peer reviewed; and
- All other papers have been standardised and style edited-some changes have been suggested by the report editors and made by the paper authors.

Finally, an attempt has been made to present the papers in a logical sequence of 11 chapters: chapter 1 sets the scene; chapters 2-7 cover the biophysical science dimensions (groundwater, water quality, native vegetation, native fisheries, trout, wildlife); chapters 8-10 deal with the human dimensions (Ngāi Tahu, recreation, economics); and chapter 11 deals with integration of the findings from the previous chapters and setting the scene for future management.

[1] Note that the Geographic Place Names Board has defined the name as Lake Ellesmere (Te Waihora). It is not our intention to debate the nomenclature, but rather to put the focus where we consider it should lie, within the lake's initial historical and cultural context for indigenous Maori.

10 ECONOMIC values

SHELLEY McMURTRIE

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This paper describes some economic values associated with Te Waihora/Lake Ellesmere including agriculture, commercial fishing, recreation and mahinga kai. In each case it gives a descriptive or quantitative value of the resource, any known changes in these values over the last decade, and considers the impacts on these values of proposed changes to the management of the lake and inflowing waterways. Commercial fishing output is worth $640,000 per year, and lake-associated quota is worth $3.3 million. The impact on these values of a conservation regime is not known. Farming production around the lake is worth $34 million per year. A proposed conservation regime with higher average water levels could reduce net farming benefits by $0.8 million per year with a Net Present Value of $14 million. These figures are very approximate. There is little information on recreational values. Recreational fishing values have declined with the quality of the fishery from an estimated $2.0 million per year in 1978/79 to $150,000 per year in 2003. There are very little data on lake values to tangata whenua, but the enormous effort and considerable expense they have incurred in trying to protect the lake implies very high values. Completing fences to exclude stock from the major stems of waterways feeding the lake would cost $0.75 million, while fencing drainage ditches would double this cost. Diverting water from irrigation to increase the flows in rivers and streams in perpetuity would have an opportunity cost of $8-12 million per cumec. An extra 1.5 cumecs of flow is required to maintain minimum flows in all tributaries even in a dry year.

10.1 Introduction

This paper addresses the economic values associated with Te Waihora/Lake Ellesmere, and in doing so:

- Describes the existing management regime of the lake including who pays, what the pattern of openings is and what the management issues are.
- Describes the economic values which are currently generated by the lake. The primary commercial value relates to fisheries, but there are also the wider cultural values associated with mahinga kai[1], recreational activity (including fishing, shooting and water sports), and conservation values over and above these.
- Describes the current value of lake-edge farming. This was originally defined as the drainage district, but this is extremely broad and covers an area of many thousands of ha, most of which is little affected by management of Te Waihora/Lake Ellesmere, and will be flooded only when it proves impossible to open the lake in spite of it having exceeded its trigger level because of countervailing sea conditions. We have modified this original area to look only at productive values of land which is below 4.6 m above mean sea level. This height is rather arbitrary, but was selected in earlier work as being the level below which land is sometimes affected by lake-related flooding. For the purposes of measuring farm production we included that area of land bounded by the sealed roads around the lake.
- Considers what other economic values could be generated by using the lake either in its current state or in an altered state.
- Assesses the impact on these economic values of changing the lake management regime.

10.2 Background

Te Waihora/Lake Ellesmere is a lake which some consider has undergone considerable degradation in recent decades. Various options are being put forward to improve the quality of the lake and its tributaries, and in this report we discuss the financial and also the non-market values associated with some of these changes.

We have looked at four principal areas including agriculture, commercial fishing, recreation and mahinga kai. In each case we have tried to establish the current value, either in a descriptive or commercial form, of the resource, any known changes in these values over the last decade, and the impacts on these values of the proposed changes to the management of the lake and inflowing waterways.

10.3 Management regime

This section outlines the current opening regime and who pays for the opening.

Opening Regime

The National Water Conservation (Lake Ellesmere) Order 1990 restricts consents for openings and closings being issued other than:

- To allow the lake to be artificially opened if the height exceeds 1.05 m a.m.s.l. in the period August-March or 1.13 m a.m.s.l. in the period April-July
- To allow the lake to be artificially opened any time from 15 Sept-15 October
- To allow the lake to be artificially closed when the level is below 0.6 m a.m.s.l.

In terms of practicality, the lake cannot be successfully opened if the level is not high enough (there is insufficient hydraulic head to scour the channel) or if weather conditions are not appropriate (the sea can close the channel almost immediately).

Currently a group, comprising representatives of Ngāi Tahu, Fish & Game, DOC, ratepayers and lake fishermen is contacted by Environment Canterbury (ECan) when the lake meets its trigger levels to decide whether it should be opened under the terms of a five year consent which was granted in 2006, and allows openings at the heights specified by the Water Conservation Order. To date the lake has never been artificially closed.

Costs of opening and allocation of costs

At present the costs of opening the lake are paid for as follows:

- 15 % the wider community in the ECan area through a general rate;
- 15% the wider community through a Selwyn District works and services rate; and
- 70% the landowners within the Te Waihora/Lake Ellesmere Rating District.

The landowners pay a variable rate levied on capital value according to the capital value of the land and its height above mean lake level (Figure 1). The areas within various contours, and the rates on capital are shown in Table 2. The relative rates were set in 1959. They represent the assessed relative benefits going to varying classes of land, and an assumption that benefit is related to capital value. As can be seen from the Rate Levied ($ / $100,000 of capital value) columns in Table 1, land of a given value in Class A is deemed to receive almost twice the benefits from lake opening of an equivalent valued piece of land in Class C, and 15 times the benefit to land of an equivalent value in Class E.

The annual costs of the lake openings from 2000-2007 averaged $164,000, but this is believed to be considerably less than the long-term average cost. The current rate on landowners in the Te Waihora/Lake Ellesmere rating districts totals $101,000, which is less than their share of the expected long-term average cost. It has been held at this

[1] Mahinga kai refers to traditional food gathering species and associated resources, places and practices and can therefore include all the values associated with the lake including all the forms of food, plants, birdsand insects that are related to the major food gathering species and resources.

TABLE 1. **Te Waihora/Lake Ellesmere rating area contributing to lake openings.**

Land Height Range (metres above mean sea level)	Rating			Area (Ha)	Location
	Class	Rate Levied*			
		ChCh	SDC		
< 1.98 m (a)	A	130	98	6,245	Low, adjacent to lake and regularly flooded
< 1.98 m (b)	B	108	82	727	Low, away from lake margin, flooded at high lake levels or with wind surge
1.98 – 2.74 m	C	69	53	4,175	
> 2.74 (up to 4.57 m in parts)	D	17	-}		
> 2.74 (up to 4.57 m in parts)	E	9	7	}2,894	
Total Rating Area				**14,041**	

* $ / $100,000 of capital value

TABLE 2. **Cost per ha in various areas (2004 rating values).**

Land height range (metres above mean sea level)	Rating Class	Area (ha)	CapitalValue	Value / ha	Total Rate (2006–07)	Rate per ha / yr
< 1.98 m (a)	A	6,245	$34 m	$5,000	$35,000	$ 5.63
< 1.98 m (b)	B	727	$13 m	$18,000	$11,000	$15.40
1.98–2.74 m	C	4,175	$91 m	$22,000	$49,000	$11.75
> 2.74	D&E	2,894	$82 m	$28,000	$6,000	$ 2.03
Total Rating Area		**14,041**	**$220 m**	**$16,000**	**$101,000**	**$ 7.21**

Note: Capital value is value of land plus buildings.

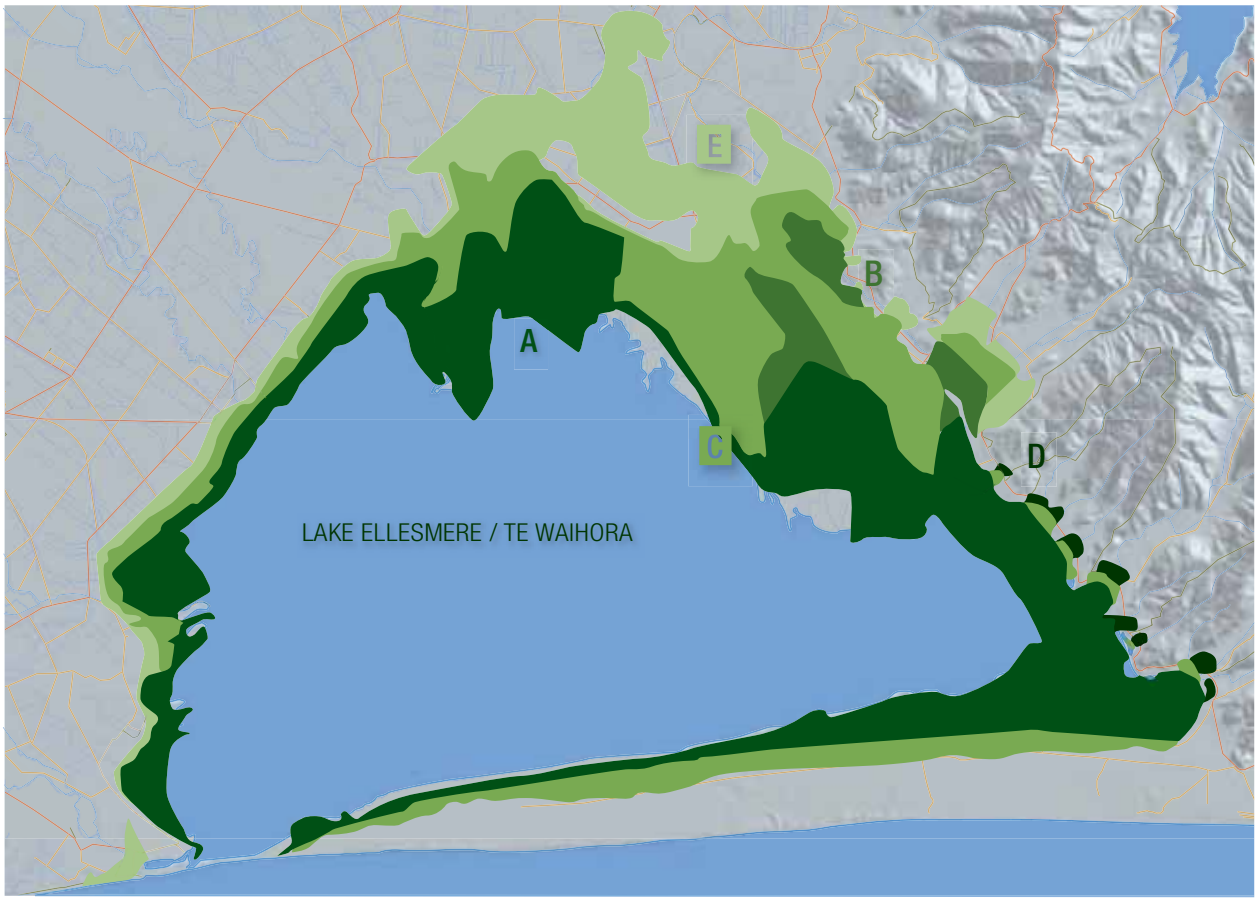

FIGURE 1. Land in the Te Waihora/Lake Ellesmere rating area. Refer to Table 1 and 2 for further information regarding the rating areas. Base Map sourced from ECan.

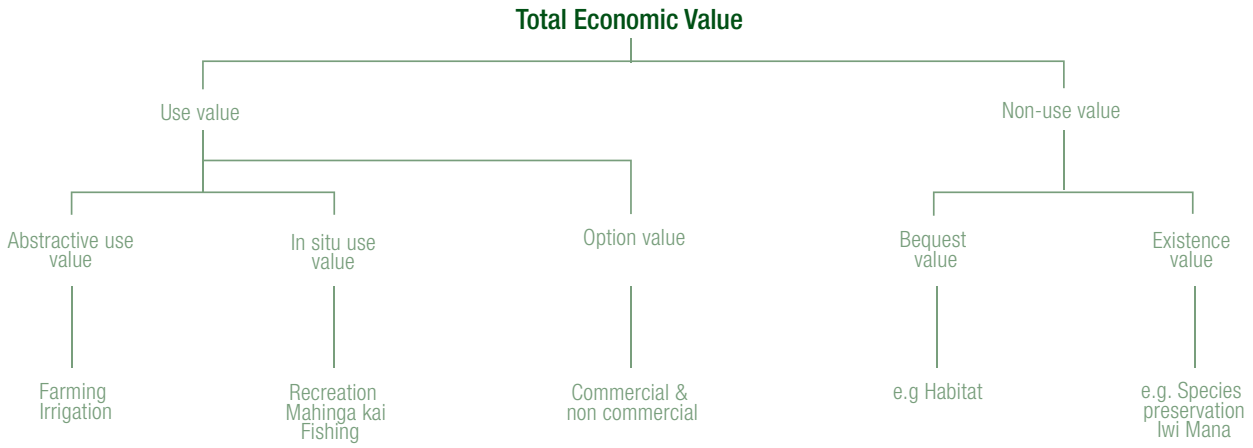

FIGURE 2. The Components of Economic Value[2].

low level because a series of years with low opening costs has led to a substantial buffer fund being built up. Once the buffer fund is run down (e.g. from a series of high-cost years), rates will return to their expected long-run average. Current rates are equivalent to $7.20 / ha / yr for land in the Te Waihora/Lake Ellesmere rating district. The rates per ha per year range from $2 on the high land which is little affected by floods, to $11.75 on the mid height land which has good soils and is moderately affected by flooding, to $15.40 on the low land which is of higher quality but some distance from the lake, to $5.63 on low land which is close to the lake but is of poor quality and hence does not benefit as much from flood protection as does higher quality land.

Management issues related to opening

The issues have not substantively changed in many years. There are multiple and competing objectives. Farmers want low lake levels to provide additional grazing, reduced flooding and make land subject to high water tables easier to work; fishermen want lake openings at appropriate times to allow recruitment of eels and flounders; tangata whenua want higher water levels to improve fishing and other aspects of mahinga kai; and, DOC wants a range of levels to provide the best habitat for different guilds (groups) of birds and to reduce grazing pressure where this will lead to re-establishment of indigenous vegetation.

10.4 Economic values

This section describes the framework for economic value analysis (see Figure 2 above). The major commercial use values are associated with agriculture and fishing, although there is also a very small amount of commercial recreation. Data for these values have been gathered from those involved in these activities. Non-commercial use values relate to water sports, angling, hunting and mahinga kai. Earlier studies provide information on values per recreational visit at other sites, and where possible these have been combined with information on current and potential recreational use of the lake to give an indication of the scale of recreational values associated with the lake. Mahinga kai is identified as a source of large, but non-quantifiable, value.

Non-use values include those typically ascribed to habitat, and knowledge of the existence of things which are not used. Te Waihora/Lake Ellesmere has a particularly large non-use value to Maori, who derive mana from the existence of this source of mahinga kai. The non-use value is believed to be far in excess of the pure use value derived from exercising their traditional rights to the lake.

Subsequent sections describe what is known about values for each of these aspects.

10.5 Commercial fisheries

Employment

The commercial fishing activity has declined steadily to the point where there are now only 5 somewhat-less-than-fulltime jobs and three part-time jobs associated with the fishery, or about five to six full time equivalent jobs in total.

The fish are processed in factories in both Selwyn District and in Christchurch, and some of the eels are exported live. Fish from Te Waihora/Lake Ellesmere are a significant part of the activity of at least one of these plants.

Previous work (e.g. on mussel farming) and regional economic models suggest that the total regional employment impact of fishing, after taking into account processing and all multiplier effects of both fish catching and processing, is anything from 4-10 times the direct employment in fishing. Hence the fishery probably supports the equivalent of at least 25 Full Time equivalent jobs in the region.

Value of species caught

The principal species caught are eels, yellow-eyed mullet and flounders (Table 3).

Eels

The current quota for eels is 121 tonnes. Between 90 and 100 % of quota is caught

[2] Based on a framework provided by Dr G Kerr, Lincoln University (pers. comm.).

TABLE 3. **Summary of commercial fishing values by species.**

	Quota (tonnes)	Catch (Tonnes / yr)	Catch Value ($ / yr)	Quota Lease Value (ACE) ($ / yr)	Value of Quota $
Eels	122 (lake)	122	430,000	$120,000	$2,800,000
Flounders		135	200,000	$20,000	$430,000
Mullet		5	6,500	$1,300	$30,000

TABLE 4. **Agricultural production within the sealed road boundary area (very approximate values).**

Land Use	Area (ha)	Gross Farm Income ($ / ha / yr)	Gross Farm Income ($m / year)
Sheep, beef, deer & grazing - high productivity*	6,000	2,000	12.0
Sheep, beef, deer & grazing - low productivity*	4,147	300	1.2
Dairy	2,588	5,000	12.9
Arable	945	2,500	2.4
Poultry, pigs, bees, other , new farming	127	10,000	1.3
Fruit & Vegetables	164	15,000	2.5
Racehorses & grazing	110	10,000	1.1
Lifestyle	137	2,000	0.3
Forestry	31	1,000	0.1
Total	**14,250**		**34**

Sources: Areas from ECan interrogation of Agribase data; $ per ha from farmers and farm advisers for sheep, beef, dairy and arable. Other figures are extreme approximations.

each year, and its approximate landed value is $430,000 / yr. The current market value of Annual Catch Entitlement (ACE) is believed to be of the order of $120,000 per year, and this represents the pure profit (i.e. the value over and above costs) arising from the eel fishery. The difference of $310,000 / year represents the returns to fishing itself, and has to cover the costs of fishing equipment, operating costs and labour.

The market value of Quota is about $23,000 per tonne. Hence the total value of the quota is $2.8 million. This value represents the current value of the stream of future pure profits arising from the eel fishery.

Flounders

The annual catch of flounders from Te Waihora/Lake Ellesmere varies enormously from year to year, and in the last decade has ranged from 3-143 tonnes with an average yield of 78 tonnes per year. The preceding decade (1986-95) was much the same, and the decade 1976-85 had a range of 20-285 tonnes per year and an average of 135 tonnes per year. At an average landed price of $2.60 / kg (including imputed ACE costs), this fishery has an annual value of $200,000. The pure economic surplus (i.e. revenue after deducting all costs including labour) is estimated to be about $20,000 per year, and the total Quota Value for the average 78 tonnes of flat fish caught on the lake is believed to be around $430,000.

Fish take about two years from entering the lake to reach maturity, and the catch is believed to be strongly dependent on the lake being open in the September-October period for recruitment of young fish. Notwithstanding that, statistical analysis reveals only weak correlation between the duration and timing of opening periods and the catch quantity.

Mullet

The current quota for mullet in Area 3 is 8 tonnes, and it is believed that the vast majority of these are caught in the lake. While data are not precise, it is believed that the annual catch is approximately 6.4 tonnes. This species is not particularly highly regarded by the market, and the market is quite small. The landed value ranges from $0.5-$3 / kg with an assumed average of $1 / kg. Hence the annual catch has a value of around $6,500. Quota (ACE) leases for about $0.20 / kg / year, and on this basis we estimate that the total value of the 6.4 tonnes of quota caught in the lake is of the order of $30,000.

10.6 Agriculture

Production values

ECan has provided estimates of areas in each type of farming use around the lake. We have discussed with several farmers their typical production per ha on land strongly affected by the lake level, and have used this to estimate production values / ha for this land, while for other farm land we have used more typical estimates of production per Ha/ha[3]. We have multiplied together the areas and the production / ha to get total production values for farming in the area bounded by the sealed roads around the lake (see attached map). The agricultural production from this 14,250 ha[4] (Table 4) is estimated to be very approximately $34 million per year, but the error margin is at least 20 per cent. Almost 40 per cent of the income is from dairying.

[3] Pers. comm.. S Ford. Agricultural Economist. Average figures for good quality irrigated and dryland farming have been used.
[4] This is approximately the same area as the Lake Ellesmere Rating District, although the boundaries differ slightly with the rating map including an area of less affected land, almost all of which is above the 2748 m contour.

While the figures are highly approximate, changing assumptions about incomes per ha or the areas of grazing which are high productivity or low productivity is unlikely to shift the result outside the range $25-45 million per year.

Effects of the lake on farm production

It is not possible to accurately quantify the effects of the lake on agricultural production. Areas closest to the lake are obviously the most severely affected (Table 5), and this is recognized by the way in which lake openings are funded. As described earlier, worse affected land is charged a higher rate per $ of capital value, but the most affected land tends to be of much lower value per ha because of the risk of flooding and the effects of flooding on the soils.

Production values at risk

Land use and survey maps can be combined with the rating maps to show which land uses are most severely affected by high lake levels and, more particularly, by any change to the management regime which increases lake opening levels. By multiplying the land use in ha by the estimated production value / ha we can estimate the value of production at risk between each contour (see Table 6).

Impacts of changes to lake management

At present the lake is (generally) opened at water levels above 1.05 m during the period August-March, and above 1.13 m in the period April-July. Suggestions have been made that the opening level could be increased, or that the lake could be held at higher levels for longer periods. It is the latter of these two that is examined as part of the "Conservation Strategy" outlined in Hughey *et al.* (2009).

The greatest impacts on production of a higher average lake level will be on land which is at present often dry but is regularly flooded. It is likely that the loss of production on land below 0.76 m is minor because it has limited grazing value even when dry. The 1,672 ha of land between 0.76 and 1.0 m will be significantly affected. Less than 50 ha of the land described as being used for dairy farming and 65 ha of the land used for arable farming is in this range, although in both cases the land is part of a larger farm and probably none of the land in this height range is actually used for those purposes. Production is primarily sheep and beef, and production values are believed to average less than $130 / ha / year[5]. Hence if this land became unusable for farming, the direct loss of production would be of the order of $230,000 / year.

Photo ***Sheep and beef farming are the major component of the $17 million of farm production at risk from flooding.*** *Photography* ***Shutterstock.***

Most farmers with low contour land manage that as part of a larger farm. They will have additional losses because they will have to change their management practices and will be unable to manage their properties as effectively as before. One farmer suggested that losing this low level land could reduce gross income by perhaps $500 / ha / year of low land. The losses due to required management changes could raise the potential losses on all the land < 1.0 m to perhaps $300,000 / year if the average lake level was sufficiently raised so as to make land below 1.0 effectively useless for farming. At a 5 % discount rate[6], this $300,000 has a Net Present Value of $5 million.

There will be more significant direct production effects on the 4,072 ha of land in the range 1.0-1.7m. There is approximately 650 ha of dairying land in this range and 70 ha of arable land, with the other 3,350 ha being sheep and beef or straight sheep farming, with one deer farm. The loss of this land to agriculture would lead to a direct loss of production of the order of perhaps $3,000 / ha / year for dairying and $500 / year for grazing (significantly less than average because the soils and pastures are of less than average quality). On this basis, the value of production at risk in this area is around

[5] Discussion with two farmers with significant land in the area below the 1.5 m mark revealed average incomes (including their higher land) of the order of $150 / ha, implying a significantly lower figure on the low land.

[6] Analysis of public sector projects typically uses discount rates of 10 % with sensitivity testing of 7.5%. This is justified on the grounds that this approximates the opportunity cost of capital. Research into agriculture has estimated the typical long-run returns to capital to be of the order of 3-5%, and for this reason a 5 per cent discount rate has been used here.

TABLE 5. Relative drainage charges / $ capital value and / ha in various areas (2004 rating values).

Height Range	Rating Class	Area (ha)	Relative Flood Impact	Rate Charge ($000/yr)	Proportion of total Drainage rate
< 1.98 m (a)	A	6,245	30	35	35
< 1.98 m (b)	B	727		11	11
1.98 – 2.74 m	C	4,175		49	48
> 2.74	D}	2,894		} 6	} 6
	E}			}--	}--
Total Rating Area		**14,041**		**101**	**100**

TABLE 6. Land Use and Production Values in each height band.

Zone (metres above mean sea level)	Land Use (ha)					Production at Risk	
	Sheep /Beef /Deer	Dairy	Arable	Other	Total	($m / yr)	NPV ($m)*
< 0.3						Trivial	< 0.1 m
0.3 – 0.76						Minor	< $0.5 m
0.76 – 1.0	1,672	0	0	0	1,672	$0.3m	$ 5 m
1.0 - 1.70	3,350	650	70	0	4,072	$3.7m	$ 63 m
1.7 – 2.74	3,424	900	70	150	4,521	$13m	$223 m

*Assumes 5 % discount rate

$3.7 million / year, with a net present value of $63 million. The lowest land in this band probably has significantly less productive value than does the higher land.

The next band of land is the 4,521 ha from 1.7 m-2.74 m, which includes a further 900 ha of dairying ($5,000 / ha), 70 ha of arable and 150 ha of other production such as pigs, fruit and vegetables and lifestyle blocks. The balance of 3,420 ha is grazed ($2,000 / ha). On this basis the production at risk in this area is $13 million / year, and a net present value of $223 million. The lowest land in this band probably has significantly less productive value than does the higher land. A raised lake level will lead to some direct loss of production through land being flooded more frequently[7] and some loss of production through a higher water table making the land more difficult to work.

Higher land further back from the lake will be less affected by the high water table, but the effects can be felt for a very considerable distance back from the lake. It is not possible to put a value either on the area of land so affected, or the loss of value / ha.

Benefits at risk

Production is not an estimate of net benefits[8], because production requires the use of expensive inputs and labour. The benefits also accrue over successive years into the future. One way of estimating the net present value (NPV) of the stream of future benefits is to consider the value of the land.

Low level land has been valued, on the basis of recent open-market purchases and exchanges of lake-front land by DOC, at around $700 / ha. If we use this as the basis of lost agricultural benefits, then the loss of 1,672 ha of land between 0.75 and 1.0 m reduces benefits by $1.2 million (NPV). Even if we add in the 2,600 ha between 0.3-0.75 m at a value of $1.8 m, we still have a total of under $3 million. On this basis, it seems likely that our earlier estimate of $0.3 million / year of lost agricultural production, with a NPV of $5 million significantly overstates lost agricultural benefit.

Land and buildings in the next highest block of land (1.0-1.7 m) had an estimated 2004 rateable capital value of $33 million[9], which is again significantly less than the $44 million NPV of lost agricultural production. Land and buildings in the range 1.7-2.7 m had a capital value in 2004 estimated to be $105 million, which again is far less than the $223 million NPV of lost production.

Estimate of agricultural costs under conservation regime

The "Conservation" regime outlined in the Hughey *et al.* (2009) would involve higher average water levels, but no increase in levels at which the lake is opened. It would also involve fencing stock out of all waterways. It would permit "conservation" grazing around the lake edge, which is taken to mean "grazing that enhances conservation values and is done without regard to any loss of agricultural production". Finally, the conservation regime could involve higher stream flows. Both fencing costs and higher stream flows are considered in section 8 of this report.

We assume that for practical purposes the conservation regime would lead to the loss of all grazing on land below 1.0 m, and the loss of half the production on land from 1.0-1.2 m. We assume that a rise in average

[7] Even if the nominal lake level is below 1.7 m.
[8] Benefits can perhaps be best thought of as net profits after all expenses.
[9] The 2004 rateable capital value of all land below 1.98 m is $47 million. If land below 1.0 m is worth $1.2 million, then the land from 1.0-1.98 m is worth $46 million and the pro-rata share of the land from 1.0-1.7 m is $33 million.

Photo ***Fencing main stems of major streams to exclude stock would significantly improve water conservation values at a cost of only $0.75 million.***
Photography ***Colin Hill.***

TABLE 7. **Potential loss of production and benefits from changes to the lake management regime.**

Zone (m a.m.s.l.)	Production at Risk		Benefit at Risk based on capital value	Potential Loss Under Conservation Management Regime (N.B. large error margin)				
	($m / yr)	NPV * ($m)	$m NPV	% loss	Production		Benefit	
					$m/year	$m NPV	$m/year	$m NPV
NPV								
< 0.3	Trivial	< 0.1	0.1	100	<0.1	0.1		0.1
0.3 – 0.76	Minor	< 0.1	0.1	100	<0.1	0.1		0.1
0.76 – 1.0	0.3	5	1.0	100	0.3	5.2		1.0
1.0 - 1.2	1	12	9	50	0.4	6.0		4.6
1.2 - 1.7	3	52	23	15	0.5	7.7		3.5
1.7 – 2.74	13	224	105	5	0.7	11.2		5.2
Total	**17**	**290**	**138**		**1.8**	**30**	**0.8**	**14**

*Assumes 5 % discount rate

ground water levels could reduce farming production by around 15 % in the 1.2-1.7 m range. The total value of this loss of production could be about $1.8 million / yr or a Net Present Value of $30 million (Table 7). The savings in farm production expenses in the long term mean that the loss of benefits could be around $0.8 million per year with a Net Present Value of $14 million. We emphasise that these are preliminary estimates, which have as their objective the development of an analytical framework and to get some preliminary idea of the likely scale of costs. Considerably more work is needed to verify some of these figures.

We also emphasise that these figures do not equate to the current costs of flooding, but rather to the changes in costs that could arise from the implementation of a conservation regime.

10.7 Recreational values

Recreational benefits for fishing have been assessed in several New Zealand studies. These suggest an average value per fisher-day of $36. The information on other recreation is more limited, but suggests average figures of around $21 per day.

Little information on the number of current recreational uses is available (see also Booth 2009). Power-boating and water skiing have reportedly declined (presumably with the availability of alternative venues such as Lake Hood), but the completion of a section of the Little River Rail Trail has increased recreation, albeit recreation which is much less intimately connected with the lake (Table 8).

10.8 Tangata Whenua values

Ngāi Tahu values associated with the lake include its role in providing mahinga kai, its spiritual significance as a taonga held on behalf of both Ngāi Tahu and the wider community, and the importance of a healthy lake as a source of mana to the iwi.

These values are very significant, but are not quantifiable in financial terms. The significance of the values to Ngāi Tahu are evidenced by:

- The enormous efforts they have made over many years to regain tino rangatiratanga over the mahinga kai
- Their work to include the lake in the Treaty Settlement

- Their work with DOC in developing the Joint Management Plan for the lake
- Their on-going involvement in efforts to improve lake management
- Their research input into understanding the cultural health of the lake.

The only quantitative data available are that the iwi take fish with a market value from $5,000-$30,000 depending on the year (and the accuracy of the data). However, as with recreational fishing, the values associated with gathering the fish may be much greater than their market value.

One source suggests that perhaps somewhere between 50 and 150 members of the iwi use Te Waihora/Lake Ellesmere for mahinga kai, but this is very much a guestimate because formal records have not recently been kept (see Table 9).

10.9 Other values affected by lake management regimes

Changes to the way in which Te Waihora/Lake Ellesmere is managed are expected to involve both costs and benefits. Costs are likely to be incurred by upstream users. They could include reduced irrigation (to increase instream flows) and fencing costs.

Fencing

Fencing costs vary according to whether they are designed to contain sheep or cattle. Advice from ECan suggests that average fencing costs are likely to be about $3,600 / km. The length of fencing required varies depending on the level of improvement required, and whether the objective is to remove stock from rivers, creeks, drainage ditches or ephemeral streams. We also note that fencing will on the one hand make access for cleaning drains more difficult and on the other is likely to increase the shading in the ditches and hence reduce the growth of weed in the drains and so reduce the frequency of cleaning required.

A review of the major streams is currently being undertaken by ECan. This work will not be finished for some time. However, we have undertaken an initial assessment of the extent of fencing required on the basis of catchments for which reasonable data are available. We estimate that approximately 215 km of fencing would be required on the main stems of the major streams[10] to exclude stock and significantly improve the water conservation values. The cost of this fencing would be around $0.75 million. Fencing of major and minor drainage ditches could double this length and cost.

Higher water flows and effects on irrigation values

The estimate of Opportunity Cost in this section compares the value of water instream with its potential value in irrigation. However, this is not necessarily the trade-off that needs to be made, certainly at present. There is strong evidence that many existing irrigators could reduce their use of irrigation water by applying the water more efficiently. This reduced water could be applied at little cost in terms of lost production, and possibly at little financial cost, or even a financial saving, in terms of abstracting and applying water. Hence improved flows in streams could potentially be obtained at little cost in terms of lost agricultural production.

In the long term, the increasing scarcity of water and an apparently insatiable desire for increased irrigation are likely to lead to water values at least as high as those discussed below. If there are further increases in the efficiency with which water can be used, this is likely to drive up the value of water still further than has been assumed in this analysis, although the prices currently being paid for shares in existing irrigation schemes are probably only affordable to farmers who use the water in ways that are efficient, at least by current standards. Current information suggests that water from Central Plains delivered to the gate could cost up to $7,000 / ha.

Opportunity cost

In principle one could estimate an economic cost of increasing water flows by estimating the reduction in irrigation abstraction required to obtain these flows. ECan[11] has calculated the reduction in abstraction required to maintain the flows at their minimum levels. For the 2005-06 irrigation season, when there was a "reasonable" (average?) summer demand on top of a very dry winter and hence a low water table, a very provisional estimate is that to maintain water flows and acceptable river flows would have required a reduction in all irrigation in the area between the Rakaia and the Selwyn by around 40% (apart from those in the Rakaia riparian strip, whose water depends almost entirely on flows in the Rakaia). This estimate is based on a number of assumptions, including that current water abstraction is 60% of permitted take[12].

One could also, in principle, model the amount of supplementary water required in each of the last 20-30 years rainfall conditions to maintain all spring-fed rivers and the Selwyn at minimum flows assuming all irrigation consents were exercised to the full (comparison of this flow with the actual or calculated flows at full irrigation). The supplementary water could be of the order of 1-1.5 cumecs. It is interesting to compare this with the costs of obtaining this much water from irrigation schemes such as the Opuha and Waimakariri (where consents are traded, presumably at marginal value), recalling that the irrigation rights give access to sources of water of varying reliability and that the market price reflects the value

TABLE 8. **Economic Values of recreational use of Te Waihora/Lake Ellesmere.**

Year	Angler Days	Value ($000 / year)
1978/79	55,800	2,008
1995	12,000	432
2002	4,000	144

[10] Silverstream/Snakes/McGraths, Boggy Creek, Irwell, Harts Creek/Birdlings Brook/tributaries, Selwyn, LI & LII, Lower Halswell.
[11] Howard, (ECan) pers. comm. This estimate is based on a number of assumptions, including that current water abstraction is 60% of permitted take. We do not actually know whether this is true in any year, let alone a dry year.
[12] Reliable data on this percentage are not available for any year, let alone a dry year.

TABLE 9. Approximate customary harvest (data supplied by Ngāi Tahu). Weights of fish assume average weights of 450 g and 1 kg for flounders and eels respectively.

Year	Patiki (Flounders)		Tuna (eels)	
	Approx weight (kg)	Approximate market value ($)	Approx weight (kg)	Approximate Market value ($)
2003	540	1,400	1400	5,000
2004	990	2,600	800	2,800
2005	5130	13,500	4700	16,600
2006	1215	3,200	1700	6,000

to a farmer of having access to this water. Alternatively, we can consider the differences in land values for land which has water available compared to land that does not.

Irrigation schemes provide irrigation "shares", and one share typically provides around 6,000 m3 / ha over a season of variable length (240 days in the Waimakariri case). Two cumecs over that long an irrigation period is the equivalent of about 6,900 shares[13]. The current cost of shares plus an amount to cover operating costs into the future is about $4,000 / share[14]. Hence the cost of acquiring this water is about $25 million. It should also be noted that this water is not particularly reliable in the period January-April, and hence the value of a guaranteed flow is even higher than this.

An alternative assessment is based on the design criteria for an irrigation scheme, which typically proposed provides 0.6 l / sec / ha. Hence 1 cumec provides sufficient water to irrigate 1,700 ha. A report for the Ritso Society (from Creighton Anderson-valuers) suggests that land in Selwyn-Ashburton area with irrigation available is worth $5-6,000 / ha more than land without irrigation. Current information suggests that the Central Plains Water Scheme costs for water delivered could be as high as $7,000 / ha. Based on these figures, the net present value of increasing the long-term flow of water in rivers could be of the order of $8-12 million per additional cumec.

Fishing

Fish and Game North Canterbury has the objective of increasing the number of anglers using the lake and its tributaries by 1-2,000 per year. If each angler fishes 5-10 times / year and a fishing day has a value of $35, then the related value generated is in the range $175,000-$700,000 / year.

Other recreation

While other research suggests possible recreation values of $25 / day, there is no information available on the number of users or how these might change with the changes in lake management discussed by Hughey *et al.* (2008) in the Integration Report.

Mahinga kai and other Maori values

The changes in lake management discussed in Hughey *et al.* (2008) are expected to improve these values but, as described earlier in this report, it is not possible to put a financial value on these changes.

Environmental services

Examples of environmental services include provision of enhanced wetland for migratory birds. Again, it is not possible to put a value on these changes.

10.10 Conclusions

Accurate quantification of economic values associated with Te Waihora/lake Ellesmere is problematic. However, "broad brush" estimates can be made in relation to fishing and agriculture. The effects of a conservation-oriented lake management regime on fishing cannot be determined, but economic impacts on farming have been outlined. Higher average lake levels would reduce net farming benefits by 2-3%, while stock exclusion from all tributary inflows in the study are would have substantial "one-off" costs. Increasing tributary flows by foregoing irrigation abstraction would also have substantial opportunity costs.

Tangata whenua values are already high but are not easily quantified in economic terms.

There is clearly scope for research on the costs and benefits of change to lake management across a range of values. Calculation of "value shifts" would provide critical information to underpin the evaluation of intervention options.

10.11 References

Booth, K. 2009. Recreation values. *In:* Hughey, K.F.D. and Taylor, K.J.W. (eds.). *Te Waihora/Lake Ellesmere: State of the Lake and Future Management.* EOS Ecology, Christchurch. Pp. 85-100.

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[13] Two m3/sec x 60secs/min x 60mins/hr x 24 hrs/day x 240 days/season = 41 x 106 cubic metres = 6,900 shares.
[14] Trading is quite limited, but reasonable parcels of shares have traded at $2,500-$3,500. Future annual operating costs of perhaps $100 / year have been converted to a single lump sum of $1,000.

Te Waihora/Lake Ellesmere is a large coastal lake, intermittently open to the sea. It is highly regarded for its conservation and related values, some of which are of international significance. Its function as a sink for nutrients from its large predominantly agriculturally based catchment, currently undergoing accelerated intensification, is also recognised, at least implicitly. It is the resulting conflict from these value sets which is mainly responsible for the ongoing debate about the future of the lake.

This book serves to quantify the nature of this debate by documenting changes to lake values, both over time and spatially. It provides a standardised approach to reporting these changes, set against indicators that are value-specific. Ultimately, it provides a template for thinking about future management scenarios for the lake and its environs. Given this approach the book ultimately serves as a resource for helping understand the ever-changing and current and possible future states of the lake, under a variety of management requirements and implications.