FINAL REPORT:

REGIONAL ECONOMIC ANALYSIS – USES OF WATER IN THE WAITAKI CATCHMENT

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Table of Contents

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The authors of the *National Cost Benefit Analysis of Proposals to Take Water from the Waitaki River* (SKM, 2004) have offered every assistance in understanding their processes and the basis for their conclusions, and we thank them for the time and input.

Executive summary

1. This report extends the *National Cost Benefit Analysis of Proposals to Take Water from the Waitaki River* by Sinclair Knight Merz (SKM 2004). In this report, we seek to understand how the regional benefits and costs differ from the national costs and benefits and to understand matters such as distributional impacts of the costs and benefits, including social impacts.

2. The report describes analysis of various allocation scenarios for water from the Waitaki River, from the region's point of view. The region is defined as North Otago and South Canterbury, covering the Waitaki District Council, Waimate District Council, Mackenzie District Council and Timaru District Council areas. The report comprises regional cost benefit analysis (is the allocation efficient?) and a regional economic impact analysis (how does the regional economy change?). The report is intended to be read in conjunction with the *National Cost Benefit Analysis* (SKM, 2004), and should not be viewed as a stand alone document.

3. This report therefore combines two separate, but complementary, types of economic analysis. The cost benefit analysis compares the stream of benefits and costs that are expected to flow from the different scenarios under consideration over a 30 year time period, discounting effects in different years to arrive at a net present value (NPV) for each scenario. In comparison, the economic impact analysis traces the effects of new activity (irrigation and/or new hydro-electricity development) through a model that provides static snapshots of the local economy at different phases in each scenario (eg construction and ongoing operation). The economic impact analysis provides estimates for the regional economy of changes in gross output (ie the value of new production), value added (gross output less the value of inputs consumed) and consequent effects on employment. Net present value, which seeks to identify the scenario that maximises the worth derived from water over a period of years, is not the same as value added, which identifies the maximum productive value at specific points in time. The two types of analysis may point to different scenarios as being the most preferred, depending on whether efficiency (NPV) or locally distributed impacts are the primary consideration.

4. The SKM model was revised to reflect regional as well as national outcomes. Some minor changes were made to assumptions and the way in which the model estimates some parameters. It was run under the set of seven irrigation scenarios used by SKM, with and without the installation of new hydro-electricity development on the lower Waitaki (modelled on the former proposals for Project Aqua). SKM developed the scenarios based on resource consent applications that were current in late 2003. In the case of the New Hydro scenario, the example costs and benefits were based on the costs and impact stream generated during investigation of Project Aqua. As Project Aqua is no longer proceeding it is likely that the final format of any hydro development will be

different from that of Project Aqua. The New Hydro scenario should therefore be considered an example of a hydro scheme, rather than a definitive case of how hydro-electricity capacity would develop in the Waitaki Catchment.

5. The analysis tests the sensitivity of its results to changes in key assumptions. It also illustrates the potential offered by irrigation to the region to develop high value land uses (for instance more horticulture and seed crops and less grazing) and other added value processing through an additional ‘high agricultural output’ scenario. This latter scenario has not been assessed in a cost-benefit sense in the modified SKM model.

Economic impact analysis

6. The economic impact analysis tracks the changes in economic activity resulting from the injection of new activity from either new hydro development or new irrigation. These can be viewed in context against a regional economy (as defined for this study) that in 2003 produced $3.8 billion of output and $1.5 billion of value added, and was home to around 2% of the national population. Primary production and food processing together accounted for around 33% of the region’s value added and employment. The utilities sector (predominantly electricity generation and distribution) accounted for around 3% of value added and 0.2% of employment, reflecting its greater capital intensity.

7. Changes in the study area economy as a result of the different scenarios assessed are shown in Table 1, Figure 1 and Figure 2 below. Table 1 shows the estimated changes in annual output, employment and value added in the peak year under each scenario (which varies between the different scenarios). The figures show the annual changes (peak and non-peak) tracked over time. Figure 1 excludes value added from the New Hydro generation, as this has little engagement in the local economy, and low employment impact after the construction phase. Figure 2 includes this value added from new generation to illustrate its relative scale.

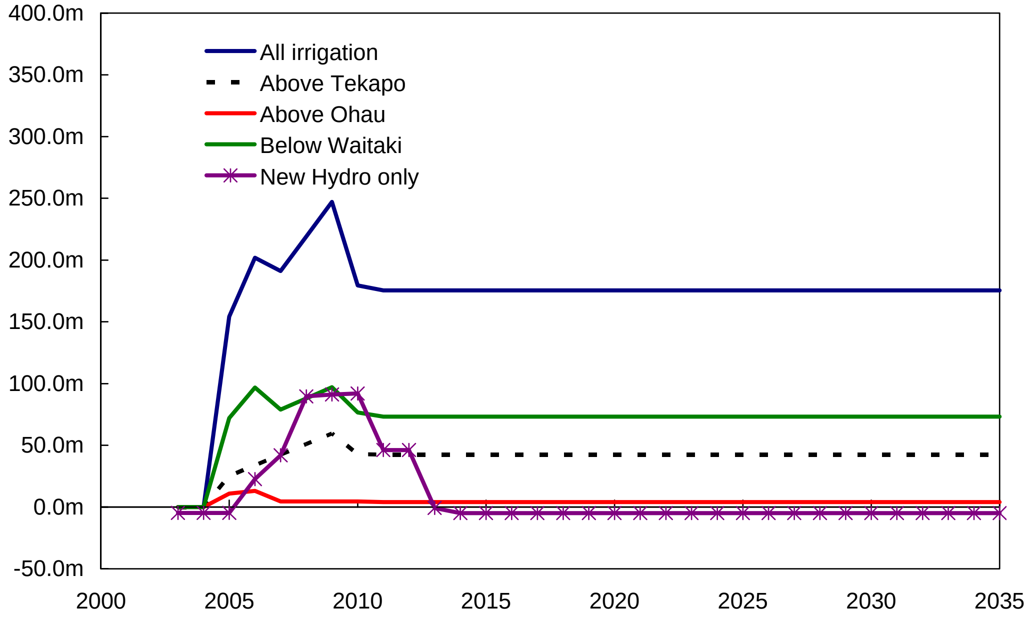
Table 1. Input-output scenario analyses: Summary results of changes to the regional economy

	Output ($m)	*Employment (FTEs)*	*Value added ($m)*
Scenario (peak year)	*On-going*	*On-going*	*On-going*
All irrigation (2009)	$466.1m	3,939.3	$175.5m
Irrigation with IRR>5% (2009)	$330.1m	2,781.4	$124.3m
Irrigation above Tekapo (2009)	$112.0m	935.4	$42.4m
Irrigation above Ohau (2006)	$11.1m	102.3	$4.1m
Irrigation above Benmore (2006)	$5.6m	51.3	$2.1m
Irrigation below Waitaki (2009)	$194.6m	1,646.9	$73.2m
New Hydro only (2010)	$202.4m	40.9	$199.6m

Source: NZIER

Figure 1. Total change in value added in regional economy

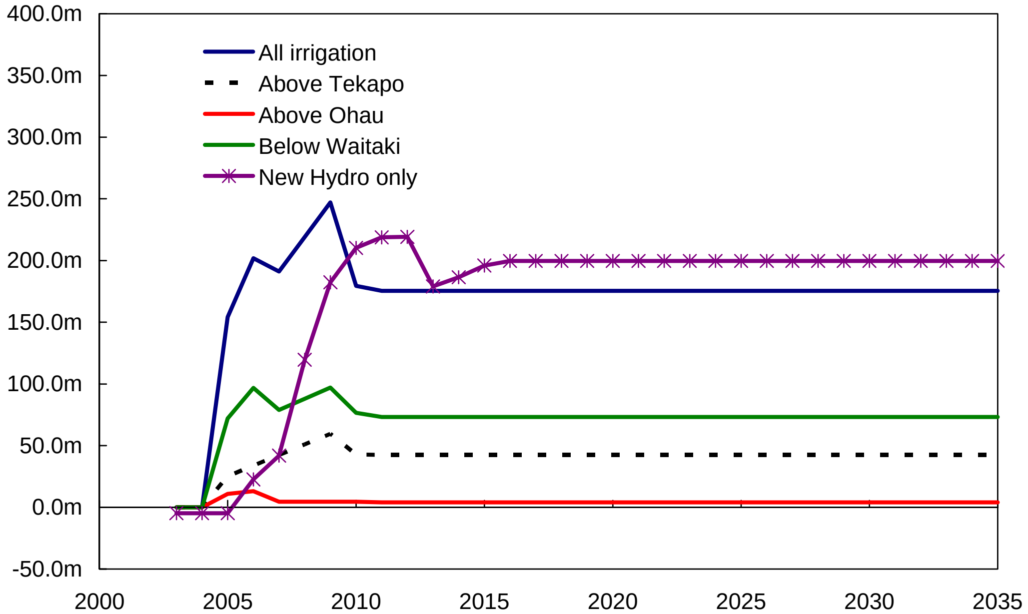
Dollar millions; New Hydro energy value added excluded



Source: NZIER

Figure 2. Total change in value added in regional economy

Dollar millions; New Hydro energy value added included



Source: NZIER

8. The economic impact analysis shows significant change in the economy of the study area, given the limitations of assumptions and methodology used. Irrigation produces enduring change spread widely through the regional economy, with a relatively small boom during construction. Hydro development produces large impacts in the short term, but with little in the way of ongoing increase in economic activity outside the energy sector.

9. Of the irrigation scenarios, the ‘All’ irrigation scenario has the largest long run impacts. The New Hydro-only scenario more than matches the ‘all irrigation’ scenario in terms of economy-wide impact on value added. However, over 90% of New Hydro scenario’s value added increase is a return on capital, which depending on ownership largely accrues to owners outside the region. To the extent that farm businesses are more likely to be owned by local residents, agricultural value added increases are more likely to be spent and re-spent in the local economy.

10. There are well-documented limitations in the economic impact methodology, because of its inability to distinguish real trade creation from trade diversion effects in the region. This makes the predicted level of impact likely to be higher than that which will actually occur, because high impacts will result in some resource input prices rising, increasing costs for, or drawing resources away from,

other parts of the economy. Similarly, the methodology does not allow the tracking of impacts over time in Figure 1 and Figure 2 to reflect dynamic effects (eg. the dependence of particular years' activity on previous years' profitability) so these results cannot be compared to a discounted analysis. However, these limitations are common to all the options considered in this study, so the impact analysis is still informative of the relative outcome across the different scenarios.

11. The addition of a 'high agricultural output' scenario illustrates the potential offered by irrigation to the region to develop high value land-uses (for instance more horticulture and seed crops). Under this 'blue skies' scenario, the impacts from irrigation are significantly higher in the long term future beyond 2020 showing almost a 30% increase in value added (over and above the current situation) and a comparable 38% increase in employment. Such a scenario would imply profound changes in the local market for labour and other resources, with correspondingly higher offsetting impacts on other sectors.

Regional cost benefit analysis

12. A regional cost benefit analysis requires identifying not only what benefits and costs arise from different water uses in the Waitaki valley, but also where they are incurred. Regional effects have been defined for this study as those which enhance or restrict the income prospects (and value) of properties and individuals in the Waitaki region, including farms, residential and commercial premises. The key feature of this approach is that returns to both energy and farming have been included in the analysis, regardless of where they are owned. In effect we have regarded the owners of energy assets, new and existing, as members of the community because they have assets there, employ people, and pay property taxes (rates) in the same way that any other business entity does in the region.

13. There are limitations to cost benefit analysis, in that it gives an indication of the efficiency of resource allocation, but does not reflect the way in which the benefits from the development accrue as a result of ownership of the assets. It measures the benefits of increased production but not whether those benefits will stay in the region. Whether benefits stay in a region depends on ownership of assets. Cost benefit analysis is neutral over who owns the assets. Decision makers should refer to the economic impact analysis to understand the implications of the way in which the developments influence the wider regional economy.

14. The analysis has also revealed limitations in undertaking regional cost benefit analyses as opposed to national cost benefit analyses. Although there is a well

established literature on conducting national cost benefit analyses, there are few precedents for regional cost benefit analyses except in the case of investment appraisal for local government bodies, which is a different context from that considered here. The results below show that although numbers derived may differ between the national and regional levels, the rank ordering of preferences has not been altered by the use of a regional viewpoint.

15. Table 2 shows the outcome from the New Hydro scenario discounted at real rates of 7.5% (consistent with that used in the SKM national cost benefit analysis) and 10% (consistent with the Treasury's long-standing practice). The New Hydro scenario produces an additional net present value (NPV) of $904m at a discount rate of 7.5% and $426m at a discount rate of 10% relative to the *status quo* in a regional analysis.

Table 2. Net present value of New Hydro, (30 year period of analysis) ($million)

Irrigation Demand	Irrigation Area (ha)	Water used (cumecs)	Net present value		
			Regional Primary Production	Regional Energy	Net Regional
New Hydro (no extra irrigation) 7.5% discount rate	-	218	-$50.4m	$954.7m	$904.4m
New Hydro (no extra irrigation 10% discount rate		218	-$41.9m	$468.4m	$426.5m

16. Table 3 shows the outcomes of irrigation when no new hydro generation capacity has been installed. It shows that at a 7.5% discount rate irrigation scenarios mostly produce a positive NPV on a regional basis with a maximum positive value of $111 million. The irrigation scenarios show substantial gains to primary production in the region, but this is offset by large costs in terms of lost energy production. However at 10% the values are almost all negative, with some primary production values negative even before the energy losses are included (Table 4).

Table 3. Net present value of irrigation with New Hydro not installed (7.5% discount rate, 30 year period of analysis) ($million)

Irrigation Demand (New Hydro not installed)	Irrigation Area (ha)	Water used (cumecs)	Net present value		
			Regional Primary Production	Regional Energy	Net Regional
All Irrigation Demands	124,250	24.1	$247.0m	-$135.4m	$111.5m
All Irrigation Demands >5% IRR[a]	76,250	16.7	$104.7m	-$11.2m	$93.5m
Takes above Tekapo	30,000	4.0	$105.8m	-$88.4m	$17.4m
Takes above Ohau	10,000	1.9	$26.2m	-$31.4m	-$5.2m
Takes above Benmore	2,000	0.4	$4.9m	-$3.5m	$1.5m
Takes Below Waitaki Dam	44,500	9.6	$67.2m	$0.0m	$67.2m

Table 4. Net present value of irrigation with New Hydro not installed (10% discount rate, 30 year period of analysis) ($million)

Irrigation Demand (New Hydro not installed)	Irrigation Area (ha)	Water used (cumecs)	Net present value		
			Regional Primary Production	Regional Energy	Net Regional
All Irrigation Demands	124,250	24.1	$39.1m	-$94.8m	-$55.7m
All Irrigation Demands >5% IRR[a]	76,250	16.7	-$30.9m	-$7.9m	-$38.7m
Takes above Tekapo	30,000	4.0	$51.1m	-$61.5m	-$10.4m
Takes above Ohau	10,000	1.9	$15.5m	-$22.4m	-$6.9m
Takes above Benmore	2,000	0.4	$2.6m	-$2.5m	$0.1m
Takes Below Waitaki Dam	44,500	9.6	-$6.0m	$0.0m	-$6.0m

17. Table 5 and Table 6 outline a similar analysis to Table 3 and 4, but this time with New Hydro installed together with the irrigation schemes. In order for an irrigation option to add value the combined outcome must have a higher NPV than that of New Hydro alone because New Hydro is also contributing to the outcomes. To show this more clearly the New Hydro results have been subtracted from the irrigation scenario results. The resulting Net Regional Outcomes show that *without integration* the irrigation does not add value nationally or regionally in the presence of New Hydro. Only the scenario where irrigation is integrated with New Hydro produces a NPV greater than the outcome with New Hydro alone, and this only at a 7.5% discount rate.

Table 5. Net present value of options with New Hydro installed (7.5% discount rate, 30 year period of analysis) ($million) (irrigation minus New Hydro outcome)

Irrigation Demand (New Hydro installed)	Irrigation Area (ha)	Water used (cumecs)	Net present value		
			Net Regional	Regional Primary Production	Regional Energy
All Irrigation Demands	124,250	24.1	-$73.9m	$247.0m	-$320.8m
All Irrigation Demands >5% IRR[a]	76,250	16.7	-$32.2m	$104.7m	-$136.9m
Takes above Tekapo	30,000	4.0	-$16.0m	$105.8m	-$121.8m
Takes above Ohau	10,000	1.9	-$19.5m	$26.2m	-$45.6m
Takes above Benmore	2,000	0.4	-$2.0m	$4.9m	-$6.9m
Takes Below Waitaki Dam	44,500	9.6	-$3.5m	$67.3m	-$70.7m
Below Waitaki integrated with.New Hydro	44,500	9.6	$28.7m	$85.8m	-$57.1m

Table 6. Net present value of options with New Hydro installed (10% discount rate, 30 year period of analysis) ($million) (irrigation minus New Hydro outcome)

Irrigation Demand (New Hydro installed)	Irrigation Area (ha)	Water used (cumecs)	Net present value		
			Net Regional	Regional Primary Productio n	Regional Energy
All Irrigation Demands	124,250	24.1	-$176.2m	$39.1m	-$215.4m
All Irrigation Demands >5% IRR[a]	76,250	16.7	-$120.8m	-$30.9m	-$90.0m
Takes above Tekapo	30,000	4.0	-$31.8m	$51.1m	-$82.9m
Takes above Ohau	10,000	1.9	-$16.1m	$15.5m	-$31.6m
Takes above Benmore	2,000	0.4	-$2.1m	$2.6m	-$4.7m
Takes Below Waitaki Dam	44,500	9.6	-$52.2m	-$6.0m	-$46.2m
Below Waitaki integrated w.New Hydro	44,500	9.6	-$29.2m	$8.1m	-$37.3m

18. Sensitivity testing for the discount rate and the assumptions of agricultural production (Table 7) indicates that the New Hydro outcomes are positive at the regional level under all the changes made. The table shows the absolute level of

outcome of each scenario, not the movement relative to the results under the core set of assumptions. The sensitivity results should be qualified with the comment that the final costs of the New Hydro scheme may be higher even than the +50% tested in this report. The net present values of the irrigation options are very sensitive to assumptions about agricultural gross margins and discount rate applied.

Table 7. Summary of regional outcomes with changes to assumptions

Irrigation Demand	Discount Rate 5%	Discount Rate 12.5%	High Agricultural Assumptions (7.5% discount rate)	Low Agricultural Assumptions (7.5% discount rate)
New Hydro	++	++	++	++
All Irrigation Demands	++	--	++	--
All Irrigation Demands >5% IRR[a]	++	--	++	--
Takes above Tekapo	++	--	++	--
Takes above Ohau	+	-	++	--
Takes above Benmore	+	-	+	-
Takes Below Waitaki Dam	++	--	++	--
Below Waitaki integrated w.New Hydro	++	--	++	++

++=sig. positive outcome (>$10m); **+**= positive outcome(<$10m); **-**= negative outcome($0 to -$10m; **--**=sig. negative outcome (more than -$10m)

Social and environment impacts

19. Both irrigation and hydro have significant environmental and social impacts. The regional impact of these is shown in Table 8 below.

Table 8. Summary of regional implications of social and environmental impacts

Criteria	Incremental impact from Irrigation Development	Incremental impact from New Hydro	Regional Impact
Envirmt[1]	Negative – long-term impacts related to reduced water quality from discharge. Some potential for mitigation	Negative – long-term impacts related to reduced water quantity and flow regime change. Some potential for mitigation	Mix of regional and national. Many impacts national, but some bias toward regional through proximity and greater use
Social[2]	Positive outcome related to increased population within the region relative to status quo. Also benefits through changes in regional economy	Disruption to local and regional level populations during construction period relative to status quo. Longer term impacts unclear	All regional impacts
Recreation / Tourism[2]	Minimal effect from irrigation development on recreation and tourism opportunities across study area	Reduced amenity in lower catchment related to a reduction in water quantity and change in flow regime. Increased congestion between users and loss of 'big river' experience. Partly offset by new recreational opportunities from calmer, more predictable river flow. Minimal change in upper catchment.	Mix of regional and national. Small bias toward regional incidence

Adapted from SKM (2004)

Summary

20. Regional analyses require different components to inform different resource use objectives: cost benefit analysis to indicate relative efficiency of resource use options, economic impact analysis to illustrate likely spread of new activities, and environmental/social impact assessment to inform on effects on community wellbeing that cannot readily be assessed through monetary measures. The different analyses' approaches will not necessarily point to the same preference ordering amongst the potential options: the option that creates the most jobs may not be the most valuable or efficient.

21. In these circumstances the choice between options can be informed by comparing each option's relative performance under each type of analysis. This allows explicit comparison of the relative weight to be given to each criterion – efficiency, distributional impact, and environmental effect – and the trade-offs to be made in the decisions that are made between the achievement of each one.

22. This study has revealed limitations in both cost benefit analysis and economic impact analysis in addressing the question of how best, from a regional perspective, to allocate and use water. As these limitations are common to all the options examined here, the results can be considered more indicative of the relative ranking of different options than of the absolute levels that any particular option is likely to realise.

23. Results from the economic impact analysis indicate significant change in the economy of the study area. Irrigation produces enduring changes felt widely across the regional economy, with a relatively small boom during construction. Hydro development produces large impacts in the short term, but with little in the way of ongoing increase in economic activity outside the energy sector.

24. In terms of economy-wide impact on value added, the New Hydro-only scenario more than matches the All irrigation scenario. However, more than 90% of the New Hydro scenario's value added increase is a return on capital, which, depending on ownership, is likely to accrue to owners outside the region. To the extent that farm businesses are more likely to be owned by local residents, agricultural value added increases are more likely to be spent and re-spent in the local economy.

25. The regional cost benefit results make no assumptions as to whether the benefits stay in the region, which is to a large extent dependent on ownership. Given that caveat, New Hydro shows a large positive outcome in the regional cost benefit

analysis under those items quantified, and the positive nature of this outcome appears relatively insensitive to the assumptions used. However New Hydro has a number of negative unquantified outcomes. Of these:

- The environmental outcomes are negative and mostly *national*, with significant regional impacts such as lowering groundwater tables alongside the river, flooding and erosion changes.

- The recreational impacts are mixed, but there are a number of negatives which are *disproportionately borne by the regional community*, because of limited substitutes available at the local level.

- The social impacts are significant and negative and are *all borne by the regional community.* Employment impacts will occur during construction with some benefit to the local economy. Population effects associated with this employment will be short term and may cause more complications than benefits for the host community and their social services in the absence of mitigation measures to accompany the new hydro development.

- The economic impacts are primarily value added through energy, with limited engagement in the regional economy, and very limited employment creation. Economic impacts in the construction phase are significant but not enduring.

26. The quantified irrigation regional outcomes are largely positive at the lower discount rates in the without-New Hydro scenarios. However when New Hydro is added to the system, the quantified results become largely negative because of the additional costs of the hydro generation system losing access to the water. The irrigation takes also produce some unquantified outcomes. Of these:

- The environmental outcomes are mixed, with some positives in terms of soil erosion, but negatives in terms of water quality, landscape and potentially some impacts on the braided river ecosystems. These impacts are of *mixed national and regional incidence*.

- The recreational outcomes are largely neutral, and those impacts which do occur are of *mixed regional and national incidence, with some bias toward regional*.

- The social outcomes are significant and positive, although there are some short term impacts such as community structure changes and management of change strategies may be required at the regional and local levels. These benefits are *all experienced regionally*.

- The impacts on the regional economy are significant and ongoing. Employment creation is expected to be significant, and the economy is expected to be larger and possibly more diverse post development.

27. The analysis at the regional level presents a contrast of two types of proposal. The New Hydro scenario is a robust proposal in terms of the monetary cost benefit analysis outcomes but has some negative social, recreational and environmental impacts and limited regional economic impacts. The irrigation proposals are more marginal in terms of monetary cost benefit outcomes because they are very sensitive to assumptions, and while they have some environmental impacts, there are significant and positive social impacts in the region and significant and ongoing regional economic impacts in terms of changes to the regional economy's size and structure.

28. A key point is the fact that the irrigation proposals are viable without New Hydro but not with New Hydro at the lower discount rates. So crucial considerations from a regional perspective are whether New Hydro is likely to proceed in the near future, and what form it will take, as this will determine the size of the net benefit (or cost) of irrigation takes.

29. If New Hydro is *not to proceed* then from a regional point of view allocation to irrigation is desirable in most respects with a 7.5% discount rate, but not at 10% discount rate.If a New Hydro project *were to proceed*, allocation to irrigation becomes less desirable in terms of monetary cost benefit outcomes apart from the integrated proposals. However irrigation has positive regional social and economic impacts.

Further research

30. These outcomes are predicated on the New Hydro scenario being based on a Project Aqua type development as proposed. Given that Aqua did not proceed, it can be inferred that the costings used here are unrealistically low. If smaller projects at this location were viable in future the opportunity costs of competing takes would be lower and the combined energy project/irrigation allocations would be more attractive. Further analysis could be undertaken of smaller hydro projects to assess their feasible scale and impact on the combined irrigation/hydro development scenarios.

31. The irrigation demands from above Tekapo (based on the Aoraki Water Trust proposal) are based on demand modelling, and use water at approximately 60% of the rate per unit area as used for the other schemes in the modelled scenarios. Independent demand modelling could be undertaken for three generic areas (South Canterbury, Mackenzie and North Otago) to develop more accurate estimates of irrigation requirements for other schemes so that irrigation demand was treated on a more consistent basis across all schemes.

32. More detailed area-specific social impact assessments would also help to better understand the nature of the social changes likely to occur with irrigation development.

33. There are limitations in the estimates of energy losses associated with irrigation takes in both the national and regional studies. The underlying model does not incorporate the seasonality of takes, their association with seasonality of energy prices, and the consequent variation in national costs of any energy losses. Consideration of flows at time steps which are finer than the annual level, and include irrigation demand modelling, would help further describe the magnitude of energy losses associated with irrigation.

1. Background

The Waitaki Catchment is a major water resource in the New Zealand context. It provides a significant part of New Zealand's energy requirements, but also supports irrigation, recreation and natural values. The demands on the river are sometimes competing, but sometimes complementary, and its management requires a sophisticated understanding of the values involved. The management of the Waitaki has come under increasing pressure with a number of consent applications for development using the water resource.

In order to improve the management of the resource, the Government has passed the Resource Management (Waitaki Catchment) Amendment Act which provides for the establishment of the Waitaki Catchment Water Allocation Board. The Board will develop a regional plan for water allocation from the catchment. Once the plan has been developed, Environment Canterbury will consider the individual consent applications and make allocations in accordance with the plan. Plan preparation requires information on the economic, environmental and social impacts of development in the catchment to assist in decision making.

In September 2003 the Ministry of Economic Development commissioned Sinclair Knight Merz (SKM) to undertake a study into the costs and benefits of water use in the Waitaki Catchment. The study was aimed primarily at understanding the impacts of the different competing uses for the water in the catchment, including the proposed Project Aqua. SKM reported national level costs and benefits for seven allocation options, comparing them with a base case development scenario.

The Ministry for the Environment (MfE) commissioned this complementary study to address the regional social and economic benefits. The aim of this study is to illustrate how the regional benefits and costs differ from the national costs and benefits. Of particular interest is extending the results to understand matters such as distributional impacts of the costs and benefits, and social impacts of different water uses.

This study is an analysis of the various allocation scenarios from the Waitaki from the region's point of view. The region is defined as North Otago and South Canterbury, covering the Waitaki District Council, Waimate District Council, Mackenzie District Council and Timaru District Council areas. The report comprises regional cost benefit analysis and a regional economic impact analysis for the seven main development scenarios used by SKM.

The scenarios addressed were:

- base case
- New Hydro with no additional irrigation (1)
- all possible irrigation demands without New Hydro (2)
- all irrigation demands with an internal rate of return greater than 5% without New Hydro (3)
- New Hydro integrated with proposed irrigation development downstream of the Waitaki Dam (4)
- additional irrigation above the Waitaki Dam upstream of Tekapo (5), upstream of Ohau (6) and upstream of Benmore (7).

The scenarios use existing proposals for hydro and irrigation development as a basis for estimating costs and benefits. In the case of the New Hydro scenario, the example costs and benefits were based on the costs and impact stream generated during investigation of Project Aqua. As Project Aqua is no longer proceeding it is likely that the final format of any hydro development will be different from that of Project Aqua. The New Hydro scenario should therefore be considered an example of a hydro scheme, rather than a definitive case of how hydro would develop.

2. Study objectives

The study had three objectives:

- define the regional costs and benefits of the seven water allocation scenarios used in the national cost benefit analysis (SKM 2004), comparing and contrasting the regional with the national costs and benefits

- identify the distributional nature of the regional costs and benefits, and any particular issues which arise as a result

- identify any other regional and local social impacts which will arise as a result of development in the catchment, including changes to business and community structure.

This report has four main sections:

- methodology – discusses both the conceptual basis of the approach, and the practicalities of gathering information and developing the models

- results – provides the results for the cost benefit analysis in economic, recreation and tourism, environmental and social outcomes

- regional economic impact – discusses the impacts of the different scenarios on the regional economy in terms of output, added value, and employment changes. The social implications of these changes are also described

- conclusions – summarises the results and gives recommendations for further research.

The report is intended to be read in conjunction with the *National Cost Benefit Analysis,* and should not be viewed as a stand alone document.

3. Methodology

3.1 Cost benefit analysis and economic impact analysis

This report undertakes both a cost benefit analysis (CBA) and an economic impact analysis (EIA). These are different types of analysis:

- A CBA measures whether we are better or worse off as a result of a particular decision. This is called a 'change in welfare', and is measured by combining all of the costs and all of the benefits into one equation. Where the answer is positive, we can say that society is, in aggregate, better off as a result of a decision. CBA uses techniques such as discounted cash flow analysis to make costs and benefits commensurate across different time periods.

- EIA measures the change in activity in an economy as a result of a particular decision, rather than whether we are better off as a result of those changes. Thus a change in output or a change in value added (GDP) will contain an element of benefit, but will not all be a benefit. An EIA allows decision makers to understand how an economy will react, and to draw their own conclusions as to the desirability of those changes. For example a large increase in employment demand may not be desirable if demand cannot be met.

The cost benefit analysis compares the stream of benefits and costs that are expected to flow from the different scenarios under consideration over a 30-year time period, discounting effects in different years to arrive at a net present value (NPV) for each scenario. In comparison, the economic impact analysis traces the effects of new activity (irrigation and/or new hydro-electricity development) through a model that provides static snapshots of the local economy at different phases in each scenario (eg construction and on-going operation). The impact analysis provides estimates for the regional economy of changes in gross output (ie the value of new production), value added (gross output less the value of inputs consumed) and consequent effects on employment. Net present value, which seeks to identify the scenario that maximises the worth derived from water over a period of years, is not the same as value added, which identifies the maximum productive value at specific points in time. The two types of analysis may point to different scenarios as being the most preferred, depending on whether efficiency (NPV) or locally distributed impacts are the primary consideration.

3.2 Regional costs and benefits

Any new investment project, whether for irrigation, electricity generation or other productive activity, brings new money into the locality and impacts on local business patterns, manifested in increases in the volume of output, in income generated, and jobs created in the region. Appraisal of societal issues (such as allocation of public resources like water) usually employs cost benefit analysis (CBA), which focuses on the net effect on resource use efficiency and economic welfare (or wellbeing) brought about by the new project.

The outcome of a CBA is always dependent on the point of view from which the analysis is undertaken. When an individual undertakes a CBA they do not take into account effects that fall on other parties (externalities), and costs and benefits which are transferred to them from other parties (transfers) represent real gains. However as we take a wider view of the community whose welfare is of interest, distinguishing externalities and transfers becomes more important in establishing net outcomes.

SKM have undertaken a national CBA. This takes into account all changes to all parties affected in the country. Matters such as investment in new electricity generation are represented as changes in the investment profile and price of electricity generation, rather than a straight return through selling electricity. This is because at the national level the investment in new hydro-electricity generation on the Waitaki river transfers benefits from an alternative generation type to the new Waitaki hydro-electricity project, and the gain to the nation is the degree to which the specific project is cheaper than the alternative.

Regional interests, however, experience a change in welfare in a different way. They are less impacted by the change in generation profile, they receive only a share of some national benefit, and they regard transfers from outside the region as a real gain. Their experience of the costs and benefits is different, and it is important that these differences are understood and incorporated in any decision on the way water is allocated from the resource.

3.2.1 Components of a regional analysis

A regional cost benefit analysis requires identifying not only what benefits and costs arise from different water uses in the Waitaki valley, but also where they are incurred. This is relatively straight-forward for economic impact analysis, because the regional input-output model is designed to trace how activities in the region give rise to further rounds of spending in, and leakage from, the target region. It is less straightforward in the case of cost benefit analysis that estimates effects on economic welfare, because there is no inherent process in such analysis for identifying welfare flows into, and out of, the region.

A very important consideration is the question of how we define a community. The reality is that an entity which has property in an area, which employs people locally, and which pays local taxes such as rates, is legitimately a member of the community. We cannot distinguish between these entities simply as a matter of degree, and therefore we include assets such as those owned by Meridian whose ownership is largely outside the region, as well as farms and processing companies which may also be partly or wholly externally owned. The alternative approach of using ownership fails on the basis that it is neither practical nor consistent. The practical difficulties arise because of the mobility of labour, capital and owners – it would be extremely difficult to trace the residence of owners of the factors of production, particularly where part ownership occurs privately. Micro-tracing of ownership therefore rarely occurs unless it is the specific purpose of the study, such as assessments of foreign investment proposals.

This analysis focuses on businesses and consumers as representing the region affected by Waitaki water uses.. This also means that at the regional level, generation benefits need to be valued as output times unit price, because this revenue, net of costs, is capitalised into the value of generation property and determines its contribution to local community activities through rateable values.

3.2.2 Regionalising a national cost benefit analysis

To produce a regional cost benefit analysis consistent with the SKM national analysis, it is necessary to attribute the items within that analysis to the region or elsewhere according to whether they affect proprietary interests in the study area. Such attribution is outlined below. Recreational, tourism and social benefits were attributed in a qualitative sense. This exercise used only desktop material because of time constraints.

Benefits

- investment avoided with New Hydro in place (ie the present value benefit of delaying investment in more costly alternative generation):
  - includes capital, operations and maintenance, incremental fuel cost
  - is assumed to occur entirely elsewhere in New Zealand and is excluded from the regional analysis

- value of electricity produced by new use of water for generation: at a national level this is subsumed within the investment avoided item, as this is the opportunity cost of water diverted from hydro-generation; at a regional level the value of electricity needs to be estimated directly, as this is the benefit from the costs incurred in new generation investment

- economy-wide benefits of reduced electricity charges (ie the reduction in price and increased consumption from having more low cost hydro-capacity in the market):

  – as calculated by SKM, these are very small – about 0.1% of the total benefits resulting from New Hydro

  – most of the benefit would accrue elsewhere in New Zealand

  – some benefit would be enjoyed by property-occupying consumers in the Waitaki region, in proportion to the region's share of electricity use; this is not publicly recorded, but the share of national business activity or population (1.9%) could be used as a proxy in the regional analysis

- increased agricultural output from expanded irrigation:

  – equivalent to increase in net cash surplus from additional farm production for export

  – accrues to local farm businesses, and would raise capital value of properties in study area so is included in the regional analysis.[1]

Costs

- electricity investments with New Hydro installed:

  – capital expenditure, operations and maintenance of New Hydro: although expenditures originate from outside the region, they are enhancing the value of property within the Waitaki region, and hence contribute to the economic surplus for the region and have been included in the regional analysis

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[1] Note SKM does not distinguish any welfare gain to processing or marketing activities associated with this increased output as this would require complex general equilibrium modelling to estimate fully. Ignoring such welfare gains would be justifiable if any such processing is insufficient to generate efficiency improvements, or if there is no significant processing within the region. The increase in capital value is not included in the analysis as this would result in double counting of the benefits.

- incremental transmission costs: costs accrue beyond the region and are not included in the regional analysis

- reserve generation plant: costs (if any) accrue outside the region and have been excluded from the regional analysis

- agricultural contraction on land acquired for hydro development: a reduction in land value to counter the increase in value from generation development, that accrues within the Waitaki region

- on-farm mitigation infrastructure: these maintain the welfare of neighbouring farms against disruption, and are a distinct part of the cost of electricity generation that affects welfare within Waitaki region

- operations and maintenance of mitigation infrastructure: as for mitigation infrastructure, these affect welfare in the Waitaki region.

- irrigation development investment:
  - off-farm infrastructure: costs incurred from within the Waitaki region
  - on-farm infrastructure: costs incurred from within the Waitaki region
  - on-farm transitional effects: costs incurred from within the Waitaki region
  - operations and maintenance: costs incurred from within the Waitaki region
  - lost generation capacity: reduces value of existing dams in the region so is included in the regional analysis; this lost generation also affects power price elsewhere, but by negligible amount.

Key differences

The principal differences between a national and a regional cost benefit analysis in the Waitaki water case are therefore:

- value of new generation capacity:
  - in a regional analysis this is the difference between the revenue stream from new generation within the Waitaki region, and the costs incurred in the region in providing that revenue. We have used the wholesale price series at Benmore developed by Concept Consulting (February, 2004) to represent the stream of benefits from new generation capacity

– in a national analysis this is the difference between the investment cost incurred across New Zealand if New Hydro proceeds in the Waitaki Catchment, and the avoided additional investments in higher cost generation capacity that would be necessary to meet future demand in the absence of the hydro-electricity project in the Waitaki Catchment

- only a fraction of the economy-wide gain from reduced power prices accrues as a benefit in Waitaki region: in this analysis 1.9% of the national estimate is attributed to Waitaki, in proportion to its share of national population.

For the sake of clarity in understanding the results, we have provided the results as a breakdown of the costs and benefits at the national and regional level using this approach, but also give a breakdown of the regional costs and benefits to different subgroups in the community – the general community, primary production sector and the energy sector.

3.2.3 Modifying the SKM model from a regional perspective

The SKM model was obtained and modification made to accommodate the attribution of the costs and benefits into regional and national impact. Where possible the base format has been retained, and the model analytical process is entirely consistent with the SKM approach. As such the national results reported in this study are the same results SKM would report using the same assumptions. However some alterations have been made which mean the national results differ from those in the SKM report. These are:

- some minor changes to SKM's assumptions in regard to gross margins, capital costs of transition, water use, on-farm infrastructure costs and land use mixes. Changes were kept to a minimum, and only made where information came to light in the course of our research which indicated that changes were required. The changes to the SKM assumptions are detailed in Appendix B

- some changes to the model approach used by SKM in their draft report (March 2004). These include altering the stream of electricity generation opportunity costs to reflect the uptake of the irrigation water[2], and matching the electricity losses from New Hydro to the profile of generation installation. SKM use the same approach in their final report (November 2004).

[2] Modelled by matching it to the stream of capital expenditure

The model develops both regional and national costs and benefits, and stratifies the costs and benefits by sector to allow the information to be incorporated in the model of the regional economy as outlined above.

Individual interviews were undertaken with 19 farmers covering a range of land uses and geographic distribution, and including both dryland and irrigated properties. These interviews involved a general discussion of farming practice, followed by a detailed analysis of accounts[3] to identify the sectoral and geographic nature of each item of income and expenditure. This data was aggregated into a grazing, arable and dairy budget, using weightings to reflect the geographic and land use spread in the aggregated budgets. Development budgets were stratified in the same way using case studies of actual on-farm development, and using local consultant experience.

The model was altered to report results at the national and regional levels, and by groups within the region. Within the region we report results at the level of the general community (no specific sector), primary production and energy.

The net present values of the different scenarios are calculated using two discount rates: 7.5% real pre-tax discount rate, consistent with that used in the SKM model; and 10% real before tax, in accord with long-standing Treasury practice.

3.3 Economic impact modelling

3.3.1 Regionalising an economic impact analysis

Economic impact analysis is generally based on an input–output model of the economy under study. Such a model describes the interrelationships between sectors within the economy and the relationships of these sectors to economic activities outside the economy of interest. The economy being studied may range in size from the national economy down to a single city or some entity even smaller (subject to reliability of data). Using a matrix or tabular format, it can be shown how the outputs from each sector of the economy are distributed among other sectors of the economy, and the portion that flows out of the economy. In addition, it shows how each sector procures its production inputs from the other sectors within the economy, and from outside the economy.

[3] Or a modal budget where accounts were not available

The essence of the input–output analysis is a set of accounts representing the transactions among the sectors being considered. Given this basic accounting framework, input–output analysis can estimate the impacts of various changes on the economy of interest together with the analysis of the effects of resource constraints, labour and capital requirements, economic multipliers, and a variety of similar areas of analysis.

Regionalising an input–output model has two principal stages:

- creating a model of input–output relationships in the region of interest, usually by 'downsizing' a national model according to the relative size of different sectors in the regional economy, as indicated by sectoral employment or output figures

- improving on the generalised input–output model to allow for spending and productivity characteristics specific to the impacts being investigated.

In the Waitaki study, the first point is addressed by constructing an inter-industry model of a regional economy comprising the four territorial authorities of Waimate, Waitaki, Mackenzie and Timaru.[4] The second point is addressed by seeking advice from a variety of sources about the expenditure implied by different scenarios, and its likely sourcing within and outside the Waitaki region.

3.3.2 High regional development scenario

In the course of initial consultation on the project, it became clear that regional stakeholders were concerned about the extent to which allocation decisions would foreclose future options for them. This reflects a concern that while we may base a decision on the best information available now, there is no way of telling what will happen in the future. The particular concern among the regional stakeholders was that the SKM analysis does not take account of the potential options that irrigation development offers for a region. This includes the potential to develop a range of downstream processing and value chain initiatives, and the potential new uses for the irrigated land that are not currently considered feasible or realistic. In this latter context the vineyard development in Marlborough is cited as something which could not have been foreseen 20 years ago. Countering this to some extent, much

[4] Further disaggregation to smaller sub-regions or TLA areas is fraught by problems with limited data, and the complete absence of a statistical basis for assessing the flows of inputs and outputs between these sub-regions.

primary product processing exhibits strong economies of scale and there is no guarantee that any new processing will take place within the local economy. The place of options and high value development in the context of the analysis, therefore, requires some careful thought, together with the institutional reforms which would allow their real world development.

To address these concerns this analysis has developed a ‘what if” scenario of regional development. This aims to demonstrate the potential offered by irrigation to the region to develop high value land uses and other added value processing. The SKM model does not lend itself to staged development such as would be required to incorporate a subsequent move from low value irrigated land use to high value options in future years. However the model has been altered to incorporate a separate scenario which addresses the impact on the region of a future high value development scenario. This scenario allows us to calculate the annual outcomes from such a development and overall impact on the regional economy. This scenario has not been assessed in a cost-benefit sense, because of the difficulties in accommodating two transition states within the model. However it does allow decision makers to understand the magnitude of the regional impacts of such a future development scenario. The assumptions used in the high regional development scenario are detailed in Appendix C. Note that we make no judgement regarding the likelihood of the scenario occurring, merely that the results are those which would be derived if the land use mix and returns were as assumed.

3.3.3 Constructing an input–output model of the Waitaki economy

The essence of the input–output schema is a set of accounts representing the transactions among the sectors being considered. Given this basic accounting framework, input–output analysis can be used to estimate the impacts of various changes on the economy of interest together with the analysis of the effects of resource constraints, labour and capital requirements, economic multipliers, and a variety of similar areas of analysis. It is therefore useful to give an indication of the likely consequences, both for the entire economy and across the individual sectors, of a major injection of activity into a regional economy, such as that provided by construction and operation of a new hydro-generation plant, or by the lift in agricultural production enabled by a new irrigation scheme. More detailed discussion of the construction of the regional model is given in Appendix F.

3.3.4 Attribution of expenditures inside and outside the Waitaki region

Attribution of expenditure on energy inside and outside the Waitaki region was made with reference to information provided by Meridian Energy Ltd and its own assessment of the proportions spent within the North Otago/South Canterbury region (58%), that spent elsewhere in New Zealand (10%), and that spent on imported goods and services (32%). This information also provided a breakdown of spending across different sectors. These within-region proportions were then applied to a profile of capital investment on Project Aqua from 2006 to 2012 (drawn from the SKM model modified for the regional analysis), to derive local sectoral spending within the region brought about by a scheme like Project Aqua.

Attribution of expenditures on off-farm irrigation inside and outside the region was made with reference to costing information for various schemes, and with discussion with some of the scheme proponents on the source of purchases made, suggesting a roughly equal split between equipment purchases from outside the region (eg on pipes, screens and so on) and expenditures made within the region (eg on construction and ancillary works). Applying this and a broad breakdown of type of expenditure to a profile of capital costs under different irrigation scenarios (drawn from the SKM model modified for this analysis) provided estimates of direct impacts from the different irrigation scenarios.

Because economic impact analysis depends on the expenditures incurred with each option rather than on the surpluses generated by each one, there is no direct way in an input–output model to allow for the investments in one option encroaching on another. For instance, input–output models do not show the price impacts that may arise if demand for construction staff by both irrigation and hydro-works should coincide and raise the cost of labour in the locality. Nor are they dynamic, in the sense of showing how increased profits in one year flow through to enhanced expenditure in subsequent years.

The forward impact profiles are therefore a combination of the separate scheme proponents' expectations of their own schemes, regardless of the extent to which each scheme is affected by other schemes at the same time. Unlike the cost benefit analysis, in which water abstracted for irrigation can have a negative effect on generation potential, input–output models do not show any 'crowding out' of one investment by another. The practical implication of this is that impact estimates are likely to be at the top end of likely impacts for the region, because they conceal the extent to which individual schemes may be reduced because of resource constraints and price effects that change their economic viability. They also conceal the extent to which local resource scarcities are met by bringing resources in from outside the region, increasing the amount of ‘leakage’ associated with the scheme.

3.4 Social impacts

Different water allocations and development scenarios will have different impacts on parts of the community. The scope of the study and timing of the study did not allow for any detailed analysis of social impacts, and this part of the study is therefore somewhat restricted compared with the ideal. Taylor Baines and Associates have used information compiled from previous studies on development in rural communities to understand the implications of hydro and irrigation development on demographic and social changes in local communities. This was combined with the data on land use change, business structure and employment changes generated through the regional modelling to detail the likely nature of change in these communities.

4. Cost benefit results

4.1 Economic cost and benefits

The revised model was run under the set of seven scenarios used by SKM. The results are reproduced below, showing the national outcome, the regional outcome, and the outcome for the primary production sector and the energy sector. Full results are detailed in Appendix D.

Tables 9 to 11 show the outcomes against a baseline with only *status quo* energy infrastructure installed. In other words, they show the mutually exclusive outcomes of either adding New Hydro (based on Project Aqua), or one of the irrigation scenarios without New Hydro.

- The tables show that discounted at 7.5% New Hydro produces an additional net present value (NPV) of $300 million relative to the *status quo* in a national analysis, but $900 million at a regional analysis. This comprises gains in the energy sector of $950 million, and losses in the primary production sector of $50 million. Discounted at 10% the results are approximately half as large as at 7.5%, but still positive.

- At 7.5% irrigation takes mostly produce a positive NPV on a regional basis, ranging from a positive $111 million in the scenario where only takes with an internal rate of return >5% are included, down to a NPV of -$5 million for takes above Ohau. At 10% the results are all negative, apart from Benmore which is approximately neutral.

- At 7.5% the ‘above Ohau’ scenario is the only one to make negative returns at the regional level. This is positive under the assumptions used for primary production, but negative when electricity losses are included.

- At 7.5% the irrigation scenarios show substantial gains to primary production in the region, but these are offset by large costs in terms of lost energy production. At 10% only those scenarios with low capital cost assumptions (above Tekapo, Ohau and Benmore) are able to make a positive return to primary production.

Table 9. Net present value of New Hydro, (30 year period of analysis) ($million)

Irrigation Demand	Irrigation Area (ha)	Water used (cumecs)	Net present value			
			Regional Primary Production	Regional Energy	Net Regional	Net National (from SKM)
New Hydro (no extra irrigation) 7.5% discount rate	-	218	-$50.4m	$954.7m	$904.4m	$301.6m
New Hydro (no extra irrigation 10% discount rate		218	-$41.9m	$468.4m	$426.5m	$125.7m

Table 10. Net present value of irrigation with New Hydro not installed (7.5% discount rate, 30 year period of analysis) ($million)

Irrigation Demand (New Hydro not installed)	Irrigation Area (ha)	Water used (cumecs)	Net present value			
			Regional Primary Production	Regional Energy	Net Regional	Net National
All Irrigation Demands	124,250	24.1	$247.0m	-$135.4m	$111.5m	$111.5m
All Irrigation Demands >5% IRR[a]	76,250	16.7	$104.7m	-$11.2m	$93.5m	$93.5m
Takes above Tekapo	30,000	4.0	$105.8m	-$88.4m	$17.4m	$17.4m
Takes above Ohau	10,000	1.9	$26.2m	-$31.4m	-$5.2m	-$5.2m
Takes above Benmore	2,000	0.4	$4.9m	-$3.5m	$1.5m	$1.5m
Takes Below Waitaki Dam	44,500	9.6	$67.2m	$0.0m	$67.2m	$67.2m

Table 11. Net present value of irrigation with New Hydro not installed (10% Discount Rate, 30 year period of analysis) ($million)

Irrigation Demand (New Hydro not installed)	Irrigation Area (ha)	Water used (cumecs)	Net present value			
			Regional Primary Production	Regional Energy	Net Regional	Net National
All Irrigation Demands	124,250	24.1	$39.1m	-$94.8m	-$55.7m	-$55.7m
All Irrigation Demands >5% IRR[a]	76,250	16.7	-$30.9m	-$7.9m	-$38.7m	-$38.7m
Takes above Tekapo	30,000	4.0	$51.1m	-$61.5m	-$10.4m	-$10.4m
Takes above Ohau	10,000	1.9	$15.5m	-$22.4m	-$6.9m	-$6.9m
Takes above Benmore	2,000	0.4	$2.6m	-$2.5m	$0.1m	$0.1m
Takes Below Waitaki Dam	44,500	9.6	-$6.0m	$0.0m	-$6.0m	-$6.0m

Table 12 and Table 13 outline a similar analysis, but this time with New Hydro installed. In other words, these show the combined outcomes of installing New Hydro and one of the irrigation scenarios. This is the same analysis as is contained in the fourth column of the SKM result tables (headed Project Aqua). In order for an irrigation project to add value it must have a higher NPV than that of New Hydro alone, because New Hydro is also contributing to the combined outcomes. To show this we have subtracted the outcome with irrigation from that with New Hydro in the right hand columns in the tables, to arrive at the net regional outcome. If the result is positive then the irrigation adds value overall despite the extra energy losses, and if the result is negative the irrigation does not add value overall.

Table 12. Net present value of options with New Hydro installed (7.5% discount rate, 30 year period of analysis) ($million) (irrigation minus New Hydro outcome)

Irrigation Demand (New Hydro installed)	Irrigation Area (ha)	Water used (cumecs)	Net present value			
			Regional Primary Production	Regional Energy	Net Regional	Net national
All Irrigation Demands	124,250	24.1	$247.0m	-$320.8m	-$73.9m	-$73.8m
All Irrigation Demands >5% IRR[a]	76,250	16.7	$104.7m	-$136.9m	-$32.2m	-$32.2
Takes above Tekapo	30,000	4.0	$105.8m	-$121.8m	-$16.0m	-$16.0m
Takes above Ohau	10,000	1.9	$26.2m	-$45.6m	-$19.5m	-$19.4m
Takes above Benmore	2,000	0.4	$4.9m	-$6.9m	-$2.0m	-$1.9m
Takes Below Waitaki Dam	44,500	9.6	$67.3m	-$70.7m	-$3.5m	$3.5m
Below Waitaki integrated with.New Hydro	44,500	9.6	$85.8m	-$57.1m	$28.7m	$28.7m

Table 13. Net present value of options with New Hydro installed (10% discount rate, 30 year period of analysis) ($million) (irrigation minus New Hydro outcome)

Irrigation Demand (New Hydro installed)	Irrigation Area (ha)	Water used (cumecs)	Net present value			
			Regional Primary Productio n	Regional Energy	Total Regional	Total national
All Irrigation Demands	124,250	24.1	$39.1m	-$215.4m	-$176.2m	-$176.3m
All Irrigation Demands >5% IRR[a]	76,250	16.7	-$30.9m	-$90.0m	-$120.8m	-$120.8m
Takes above Tekapo	30,000	4.0	$51.1m	-$82.9m	-$31.8m	-$31.8m
Takes above Ohau	10,000	1.9	$15.5m	-$31.6m	-$16.1m	-$16.1m
Takes above Benmore	2,000	0.4	$2.6m	-$4.7m	-$2.1m	-$2.1m
Takes Below Waitaki Dam	44,500	9.6	-$6.0m	-$46.2m	-$52.2m	-$52.2m
Below Waitaki integrated w.New Hydro	44,500	9.6	$8.1m	-$37.3m	-$29.2m	-$29.3m

The results show that:

- Without integration the irrigation does not add value nationally or regionally in the presence of New Hydro under any scenario. Only the scenario where irrigation is integrated with New Hydro produces a NPV greater than the New Hydro NPV, but again this is only at 7.5% discount rate. At a 10% discount rate relatively high capital costs of some schemes in this option result in negative returns to irrigation, which means that despite low energy losses it does not add value overall.

- Some of these results are well within the margins of error for the analysis, and the sensitivity testing below shows that small differences between scenarios should not be taken as an absolute indication that the project is not worthwhile.

- Losses in the energy sector which were observed in results without New Hydro are exacerbated by the installation of New Hydro. This results in many irrigation scenarios becoming negative relative to New Hydro on its own even at 7.5%.

The results of sensitivity testing are shown in Appendix E. The sensitivity results of the regional outcomes are:

- New Hydro – is most sensitive to discount rate changes, with the regional outcome varying from $182 million (12.5%) to $2,004 million (5%) (

- Table 49 Appendix E). The results were relatively insensitive to assumption changes about the impact of agricultural contraction and other losses. A separate test on the sensitivity to capital costs suggests that at 20% the national and regional benefits are still positive, but at +50% the results are positive at the regional level but negative at the national level. (Table 49 and Table 50, Appendix E, show that only with 12.5% discount rate will +50% capital cost produce a negative NPV at the regional level for New Hydro).

- All irrigation – the outcomes for all irrigation scenarios are most sensitive to the assumptions regarding agricultural returns and capital expenditure. The outcomes range from $-177 million to +$514m (no New Hydro) (See Table 53, Table 57 and Table 58, Appendix E). The discount rate change to 5% does make these scenarios positive at the regional level (relative to New Hydro) with New Hydro installed, and the discount rate at 12.5% makes all outcomes negative.

- Irrigation >5% IRR – changing the discount rate to 5% makes this set of irrigation schemes positive, even relative to New Hydro with New Hydro installed. A change to 12.5% makes it negative with and without New Hydro. This scenario is strongly positive with the most optimistic agricultural assumptions, but negative (-$60m, Table 58, Appendix E) with the most negative set of assumptions.

- Takes above Tekapo – this scenario does not become positive relative to New Hydro with the change of discount rate to 5%, although without New Hydro it is strongly positive. Altering this scenario to use a similar amount of water to that of other scenarios results in a negative NPV of -$38 million (without New Hydro), a change from the base scenario assumption NPV of +$17 million. This scenario is therefore highly sensitive to the water use assumptions, and it is likely that other scenarios would show similar sensitivity. Independent demand modelling for each of the schemes above Waitaki would be worthwhile.

- Takes above Ohau – this scenario does not become positive at a 5% discount rate nor does it become positive with or without New Hydro under even the most favourable discount rate. However the high agricultural assumptions do result in a positive outcome for this scenario.

- Takes above Benmore – this scenario is positive in the ‘no New Hydro’ scenario at both the 5% and 12.5% discount rate, but is not positive relative to New Hydro (New Hydro installed) under either rate. The use of the least favourable agricultural assumptions results in a -$5.4 million deficit at the regional level in the ‘no New Hydro’ scenario.

- Takes below Waitaki – the results from this scenario are sensitive to discount rate (positive with and without New Hydro at 5%, negative with and without New Hydro at 12.5%), and similarly to agricultural assumptions.

The sensitivity to assumptions is summarised in Table 14 below, and shown in greater detail in Appendix E. The table shows the absolute level of outcome of each scenario, not the movement relative to the results under the core set of assumptions.

Table 14. Summary of regional net present values under sensitivity testing of assumptions (no New Hydro)

Irrigation Demand	Discount Rate 5%	Discount Rate 12.5%	High Agricultural Assumptions (7.5% discount rate)	Low Agricultural Assumptions (7.5% discount rate)
New Hydro	++	++	++	++
All Irrigation Demands	++	--	++	--
All Irrigation Demands >5% IRR[a]	++	--	++	--
Takes above Tekapo	++	--	++	--
Takes above Ohau	+	-	++	--
Takes above Benmore	+	-	+	-
Takes Below Waitaki Dam	++	--	++	--
Below Waitaki integrated w.New Hydro	++	--	++	++
++=sig. positive outcome (>$10m); **+**= positive outcome(<$10m); **-**= negative outcome($0 to -$10m; **--**=sig. negative outcome (more than -$10m)				

4.2 Domestic, commercial and industrial use

Several domestic schemes and private supplies are sourced directly from the Waitaki, and commercial use of water is an important component of the water allocation mix in the area. SKM undertook an analysis of the value of water for commercial manufacturing, which showed that its value for this purpose is an order of magnitude higher than for irrigation or energy production.

We have not included commercial, manufacturing and domestic supply directly in this study, effectively assuming its allocation will be equivalent in all scenarios. However we note the importance of its inclusion in any allocation regime, including any increases in requirements for water associated with any increased production, processing and population from irrigation development.

4.3 Tourism and recreational cost and benefits

4.3.1 Tourism

Tourism impacts from the various development scenarios are complex to assess, because the tourism flows in the region are changing rapidly, and there is limited information on which particular characteristics of the catchment are most valued by tourists as part of the visitor experience.

The Waitaki and Mackenzie/Timaru districts have grown strongly in terms of guests and guest nights, matching or exceeding national growth in guest nights and guest arrivals. These areas expect continued growth in tourism, and major initiatives are planned by district tourism organisations, including promotion of the area around an alternative route to and from Queenstown via the Lower Waitaki and Omarama.

SKM note the potential for negative regional effects on tourism with construction of New Hydro. These effects would be associated with the noise, dust and traffic disruptions on State Highway 82. There is also likely to be pressure placed on local accommodation facilities by construction activities with visitors being turned away. Loss of tourism business activity may be experienced by local operators from disruption of their business by construction activities, although it is expected this could be at least partly offset by mitigation, including careful relocation of businesses. If the mitigation is financial and a business closes there is no reason to expect it to stay in the region – both the capital and business skills are likely to be lost. There are some potential positive effects from the industrial tourism attraction associated with a large construction project.

For the operational phase of New Hydro, SKM note that the impacts are more varied and are associated with the changes in river flows and offsetting mitigation works. Negative impacts include those to jet boaters, the reduced 'big river' angling experience, issues with wetlands, increased conflicts between recreational users, and increased impact from recreational users on birds. Positive impacts are noted to include increased accessibility to the river for less experienced anglers, increased safety of river access, development of recreational lakes, an improved system of vegetation management, and riparian plantings.

Changes to tourism from irrigation development are less comprehensively studied than those from New Hydro. Issues associated with construction of New Hydro would be expected to occur with irrigation scheme infrastructure development, although at a smaller scale. Some changes, such as enhanced river flows associated with the Aoraki Water Trust proposal to take water into South Canterbury may be positive although unproven, and others may be negative, associated with adverse water quality impacts. Other issues, such as landscape changes in the Mackenzie from a barren brown to green associated with irrigation development may be positive or negative depending on visual expectations of visitors. It could also be that irrigation development enables the development of gastronomic tourism such as occurs with winery development. However, in the absence of firm information on the impacts of these proposals on resources and on the resulting development, this is largely speculative. No conclusion is therefore drawn about the impacts of irrigation on tourism at a regional level and this issue warrants further analysis for specific proposals.

The net tourism impacts of New Hydro and of irrigation development are difficult to determine. Overall SKM have concluded a combination of no impacts and that the issue needs further consideration. At a regional level there is insufficient information on which to determine how the local tourism industry will be affected. However it should be noted that impacts from local loss of visitor nights, which may not be important at the national level because of substitution effects, are costs at the regional level. To the extent that decision makers accept that local tourism arrivals will be adversely or positively impacted, these impacts are likely to be disproportionately higher at the regional level.

4.3.2 Fishery

The fishery is an important part of recreation on the Waitaki River. This comprises the trout and salmon fishery, with the trout fishery including both rainbow and brown trout, which is relatively rare in the New Zealand situation. The salmon fishery is considered to be of national significance, and some consider the river to be of international significance in this regard.

SKM (2004, p. 112) estimate the use-value of the Waitaki River's fishery as between $475,000 and $1.3 million per annum (based on the NIWA 1994/5 angling day estimates). Thus at least two-thirds of this use value is attributable to anglers from the region (ie. between $317,000 and $867,000 pa).

The impact of the New Hydro and irrigation proposals are both considered to be minor on the fish populations *per se*. There may however be impacts on the fishing experience associated with lower flows, both positive and negative. These were summarised by SKM as neutral or unknown for the upper Waitaki under both irrigation and New Hydro, and for the Lower Waitaki a loss under irrigation and a significant loss under New Hydro. There is also the potential for water quality changes from intensification to adversely impact on the fishery, particularly with the spring fed streams in the Mackenzie and Hakataramea.

Proposals to take water into South Canterbury could significantly alter the flow regimes in several lowland rivers of South Canterbury. This may have positive impacts on the fishery in that area, although no firm studies have been undertaken on these impacts and this aspect is unproven.

In the lower Waitaki the users of the fishery are predominantly from the local region (55% in respect of the trout fishery and 45% for the salmon fishery). Impacts on the fishery will therefore be disproportionately[5] regional impacts. Importantly 61% of salmon anglers and 37% of trout anglers fished only the Waitaki River. We can deduce that a high proportion of these will be local, and damage to the Waitaki river fishery would be considerably more important to those people because of a lower potential for substitutability of similar fishing experiences.

4.3.3 Jet boating

The jet boat experience on the Lower Waitaki river is considered important because it offers a 'big river' opportunity on a large, fast flowing braided river over considerable distance. It is expected that New Hydro would impact adversely on this experience, although this would be mitigated somewhat by flushing flows released down the river. The irrigation takes are not expected to have a significant impact on jet boating.

Both national and international jet boating events are regularly held on the lower Waitaki. SKM (2004, p. 113) note that without a New Zealand study of the recreational value of boating it is difficult to quantitatively assess its level of significance. Thirty-three percent of jet boaters are local, indicating again that the impact would be disproportionately local. However the substitutability of the jet boat experience may be higher, with a low proportion of users reporting exclusive use of the river. A decline in the number of jet boaters using the river from other parts of New Zealand and overseas may reduce turnover for accommodation and other businesses in the region.

4.3.4 Shooting and hunting

The lower Waitaki is considered an outstanding publicly accessible game bird hunting and waterfowl habitat. SKM note that hunting is a major non-river use of the Waitaki, and that it appears to attract a higher proportion of non-local hunters than the regional average. The Waitaki River accounts for approximately 31% of all game bird and hunting activity in the Central South Island region. Of licences issued, approximately 28% are issued in the Oamaru/Kurow/Waimate area.

SKM indicate that any impact on the hunting and shooting activity is likely to be neutral or unknown, although reduced river flows and variability will reduce the overall wetland area, diversity and distribution which may affect the populations

[5] Disproportionate to population.

and distribution of wetland bird species. This is likely to adversely impact on the hunting experience, and the data above indicates that any impact will fall disproportionately on the regional community.

4.3.5 Swimming

SKM does not consider that swimming constitutes a nationally significant recreational value for the river. Three percent of respondents who participated in the 2002 *Lower Waitaki River Recreation Survey* reported swimming as their main activity, while 7% of respondents from the 2002 *Waitaki Community Survey* stated that swimming was their main reason for visiting the river (SKM 2004 p. 115). No impact is expected on swimming under irrigation scenarios, but New Hydro will have both negative and positive impacts. Negative impacts arise as a result of loss of swimming holes in the river associated with the intake structure. Positive impacts should occur as a result of the establishment of lakes at Kurow and Duntroon, and because the lower flows may make the river safer for swimming. The lakes, however, were a design component of Project Aqua, and may not arise with other New Hydro developments.

It is expected that these impacts will be largely local impacts since it appears unlikely that the Lower Waitaki river is a destination swimming area.

4.3.6 Camping

There are four commercial camp grounds along the lower river – Kurow Holiday Park (11,167 overnight stays in 2001), Duntroon Domain Recreation Reserve, Waitaki Mouth Motor Camp and Glenavy Motor Camp – and the Dansey’s Pass Camp Ground (some distance from the river – 20,000 overnight stays in 2001). Freedom campers also use the upper hydro lakes in significant numbers over the summer. These campers are predominantly drawn from Waitaki, wider Otago and South Canterbury.

Any decline in recreational use of the Lower Waitaki River is likely to affect occupancy rates at these camp grounds and other accommodation facilities in the Waitaki district. In turn this would have negative effects on local employment at these facilities and reduce the supplies they purchase locally. These costs would be more significant at the regional level than nationally as both visitors from outside the region and local residents may choose to fish, hunt, or jet boat or shoot in other places outside the region.

There may also be a further cost at the regional level as these negative effects on recreational activities, and on the amenity values of the river from hydro-electricity development or water quality degradation associated with irrigation, could restrict future tourism growth in the Waitaki Catchment.

4.3.7 Canoeing and kayaking

SKM notes the potential for canoeing/kayaking to be adversely impacted by New Hydro, although also note that the Waitaki is not considered a high value resource for these activities. No information is available regarding the local impacts of any changes to these activities, but it is expected that any impacts will be disproportionately experienced at the regional level. A rowing course was proposed as part of the mitigation package for Project Aqua, and were this to occur it would offer recreational benefits to the region.

4.3.8 Value of recreational activities

Kerr (2004) reviewed the recreational use of the lower Waitaki, and concluded that the value of recreation on the river was in the order of $1.7 million to $1.9 million per annum. Converted to a NPV the values in this part of the river are likely to lie between $17.2 million (lower bound estimates, 10% discount rate) and $30 million (upper bound estimates, 7.5% discount rate).

Table 15. Summary of recreational impacts

Location	Value/indicator	Status Quo	Irrigation	Hydro-electricity	Regional Impact cf. National Impact[6]
Upper Waitaki	Salmon Fishery	0	0?	0	Disproportionately regional
	Brown Trout Fishery	0	0	0	
	Rainbow trout fishery	0	0	0	
	Jet Boating	0	0	0	
	River Swimming	0	0	0	
	Camping	0	0	0	
	Canoeing/Kayaking	0	0	0	?
	Overall congestion among	0	0	0	
	Hunting	0	0?	0?	Disproportionately regional
	Local Tourism	0	0?	0	Mostly regional
Lower Waitaki	Salmon Fishery	0	0	✓×	Disproportionately regional
	Brown Tout Fishery	0	0	✓×	Disproportionately regional
	Rainbow trout fishery	0	0	×	Disproportionately regional
	Jet Boating	0	0	×	Disproportionately regional
	Swimming	0	0	×✓	Mostly regional
	Camping	0	0?	0	Disproportionately regional?
	Canoeing/Kayaking	0	0	?×	Disproportionately regional
	Overall congestion among	0	0	×	Disproportionately regional
	Hunting	0	0?	0?	Disproportionately regional
	Local Tourism	0?	0?	0?	Mostly regional

Scenario 1	Maintenance of the Status Quo
Scenario 2	Additional allocations of water for irrigation
Scenario 3	Additional allocations of water for New Hydro

Legend

Significant Loss	Loss	Insignificant or No Change	Gain	Significant Gain		Some Gains & Losses	Needs Further Consideration
××	×	0	✓	✓✓		✓×	?

Adapted from SKM (2004)

4.4 Environmental cost and benefits

Values associated with the environment can be divided into three main types:

- use type values – where the environment provides some service which itself is valued by the community, such as water services, recreational opportunities, amenity values etc
- option values – where the environment does not provide a service at the moment, but it provides the option of uses or services which the community

[6] Relative to population size

may need in the future. We include bequest values in here as an intergenerational option value

- existence values – where the environment is valued independently of the use or service it provides or may provide. Thus people who may never see or use a particular part of the environment value its retention for its own sake.

In this analysis we have regarded the use type values accruing primarily to the regional community, and to a lesser extent the national community. With option values[7] we have regarded the resource as being preserved for non-specific future users, so the benefits are national. For existence type values the benefit is to the whole national community, since the benefit is independent of the individual and their location.

4.4.1 Irrigation sector expansion environmental impacts

Irrigation sector expansion environmental impacts include:

- water quality – this may be affected primarily through increased nutrient and microbial run-off, and leaching to groundwater. While some mitigation is possible, intensification has been associated with degradation of water body water quality elsewhere in the country. Loss of water quality has both regional and national costs through impacts on recreation and other amenity values, human health and vulnerable ecosystems

- visual character – irrigation of the dry Mackenzie country to create greener landscapes may be seen by some as detracting from the general appearance and visual character of a nationally significant landscape. More intensive land uses will continue to change the landscape character of rural North Otago and South Canterbury. Regional impacts will be greater by virtue of greater exposure of the local population to the change in amenity, but changes in the Mackenzie are primarily national costs experienced by visitors and non-visitors.

- braided river ecosystems – little impact is expected on the braided river ecosystems from irrigation development other than as a by-product of increased farm productivity and incomes affecting demand for catchment works to

[7] Some environmental option values may accrue at the regional level in a different manner to the national level, but these are difficult to foresee at this stage and so are largely speculative.

reduced flooding, and increased food sources for native and game birds. Where impacts occur they are largely national impacts

- soil erosion – irrigation can have positive impacts in preventing soil erosion and building up soil organic matter. This has both regional value (use values) but also national values (option value).

- wetlands – impacts are expected to be mixed and depend very much on where water is abstracted. Losses include increased nutrient levels and lower river flows. Ecosystem impacts are largely a national benefit, while recreational impacts are discussed elsewhere

- indigenous grassland ecosystems – unprotected grasslands could be developed and lost under irrigation development, representing a national cost

- salmonids – little impact is expected on salmonids although large consents from rivers and tributaries in the upper Waitaki could create additional pressure. Irrigation could impact on a number of tributary streams such as the Hakataramea and small streams along the Tekapo River in particular, which are an important brown trout fishery. Any impacts are largely recreational, as discussed elsewhere

- indigenous fish – little change is expected in relation to indigenous fish under irrigation scenarios, although significant abstraction from rivers and tributaries will reduce habitat for native fish. The effects are very dependent on where the water is abstracted.

4.4.2 Hydro sector impacts

For hydro sector impacts only, the New Hydro scenario (based on Project Aqua) is considered in detail here. It is accepted that a smaller hydro scheme using a different design and technology is a possible option for the future but it is difficult to assess such an option without clear project parameters in a specific proposal.

- lake levels and river flows – under the New Hydro scenario there is the potential for more frequent lower lake levels and lower flows in the upper Waitaki (although still within the resource consent conditions of the existing consents), and lower flows will definitely occur in the lower Waitaki, with a similar minimum flow but lower median flows and reduced variability in flows. Flows of 900m3/s are expected to occur less often, and maximum daily flood flows will reduce by 45% from 2649m3/s to 1458m3/s. This will result in a reduction in the number of braids in the river, with channel morphologies and positions becoming more stable. There will be reduced supply of gravel from tributaries, and a reduced rate of bedload transport. Chronic bank erosion will increase and there will be an increased likelihood and extent of northward extension of the river outlet channel. Overall there is likely to be no noticeable change in water clarity. These impacts as largely regional since the key issues of erosion and change in the outlet will be local effects

- water quality – this may be affected primarily through decreased flows and ability to dilute nutrient and microbial contaminants. This may cause some costs for private potable takes from the river, but municipal takes have planned treatment upgrades, so no additional costs are likely to be incurred. Any impacts would largely be regional impacts

- braided river ecosystems – while some changes will potentially occur through increased predation and conflict between birds, stock and human usage, and a reduction in bird species diversity, these are expected to be mitigated as part of the management programme for the river. Impacts here are likely to be national impacts

- wetlands – of the 190 hectares of river terrace wetlands, 30 hectares of locally significant wetlands will be destroyed by the construction of the canals, and 50–84 hectares will be affected by groundwater changes associated with construction and changed river flow regimes. The ecosystem values lost are largely national costs

- dryland turf – the construction will destroy approximately half the remaining turf land in Kurow and while some mitigation will occur there will be a loss in ecosystem values. These are largely national values

- salmonids – the changes in flow and the change in invertebrate species may have a minor impact on trout populations, but overall there is not anticipated to be major change. There may be a change to the balance of numbers between brown and rainbow trout, and salmon are more likely to be affected adversely by reductions in spawning habitat, although there should still be sufficient habitat for successful spawning. Any other impacts are discussed in the recreational section

- indigenous fish – overall total indigenous fish numbers are likely to be unchanged, although density may increase. Favourable flow changes will compensate for any loss associated with a reduction in riparian and wetland environments. Any impacts would be national impacts.

These impacts are summarised in Table 16 (adapted from SKM 2004).

Table 16. Summary of environmental impacts

Location	Value	Status Quo	Irrigation	Hydro-electricity	Regional Impact cf. National Impact[8]
All catchment	Landscape Visual Character	0	×	0	National with sig. regional
	Braided River Geomorphology	×	0	××	Mostly regional
	Braided River Ecosystem (Birds, insects)	×	✓×	×?	National
	Salmonids	0	?	××?	In recreational impacts
	Native Fish	✓×	?	×?	National
	Water Quality	✓×	×	×?	Regional and national
	Groundwater Availability	✓×	✓✓	××	Regional
	Wetlands	×	✓×	××	National
	Native Grassland Ecosystems and Dryland Turf	×	×	××	National
	Soil Erosion	×	✓✓	×	National and regional

Scenario 1	Maintenance of the Status Quo
Scenario 2	Additional allocations of water for irrigation
Scenario 3	Additional allocations of water for New Hydro

Legend						
Significant Loss	Loss	Insignificant or No Change	Gain	Significant Gain	Some Gains & Losses	Needs Further Consideration
××	×	0	✓	✓✓	✓×	?

4.5 Social costs and benefits

The basis for determining social impacts varies on a case by case basis, with criteria necessarily established from research in the impacted community as well as from comparative cases and the general literature. Social assessors have some well established variables that they utilise on a regular basis. See for instance the list of 28 variables developed by Burdge, 2004. These variables provide a basis for developing data and assessment criteria in different contexts.

The hydro and irrigation proposals will have significantly different levels of social impact at the regional level.

[8] Relative to population size.

4.5.1 Irrigation social cost and benefits

Irrigation should have a positive effect on the demographics of the Waitaki Valley as it would arrest the expected population decline. The additional population and employment will not only stimulate economic growth in the region by increasing the value of production, but also strengthen its social structure and networks through ensuring that voluntary organisations and essential services such as health and education are more viable. The potential costs of this irrigation development, however, could be resource conflicts over the use of land and water, and possible social disharmony between long term residents and newcomers. Canals and any reservoirs could affect amenity values for existing residents. During the construction period there could be noise, dust, traffic congestion, disruption to farming systems, and pressures on local accommodation facilities from construction workers.

Social impacts in the longer term are driven largely by land use change. Under the 'all irrigation demands' scenario it is projected that 124, 250 hectares presently used for dryland grazing (112,350 ha) and arable (11,900 ha) production will become irrigated. The additional irrigated area under this scenario would almost triple the number of hectares irrigated in the region from 65,120 in June 2002 to 190,000 hectares.

These irrigation schemes are projected to change land use patterns in the region by adding irrigated grazing 64,270 hectares (52% of the additional irrigated area), dairy 38,410 hectares (31%), 8,300 hectares dairy support (7%), deer 4,120 hectares (3%) and arable 9,150 hectares (7%). Almost all of the conversion to dairying is expected to occur in the Aoraki Water Trust area (8,400 ha), the North Otago Downlands area (20,000 ha), the North Bank–Elephant Hill (4,200 ha) area, and the Waihao Downs (4,760 ha) area.

Under this type of scenario for land use change the following social impacts can be expected in the region:

- more intensive use of existing grazing and arable properties by some current owners
- other current owners converting their predominantly dryland grazing production systems to dairy or dairy support
- some older farmers, particularly of smaller dryland grazing properties, selling to purchasers who will convert the properties to dairy production
- an inflow of newcomers to the district to purchase properties and work on farms, particularly for dairying

- the arrest of rural population decline in non-irrigated areas and strengthened viability of educational, health and other community services in nearby townships
- the age structure of both the residential population and the farmers and farm workers occupational group is likely to become more youthful overall
- conversion to dairying will create more expenditure and employment in the region, provide greater access to higher quality jobs and improve household incomes relative to the rest of the country
- value conflicts between dryland farmers and dairy farmers because of their different lifestyles, work routines and rates of community participation
- participation in community activities and membership of voluntary organisations and clubs may decline in the short term, as newcomers adjust to their new circumstances, but strengthen in the longer term
- value conflicts between some urban residents (Oamaru and Timaru) and farming communities over the environmental impacts of intensive farming systems.

Previous research showed that there can be a lag effect as the service sector in rural areas adjusts to the supply of new irrigated farming systems. They can even miss out altogether as farmers look further afield for farm sales and farm supplies (including building contractors, irrigation equipment and vet supplies), potentially reducing the regional benefits derived from increased agricultural production. While this may prove to be a local issue, particularly for business development in the Mackenzie basin, we do not assess it as a regional issue as the region already has substantial irrigated areas and service sectors have largely adjusted. The region also has major meat works and a dairy processing factory. Some grapes are likely to leave the region in the early phases of viticulture production.

These social costs and benefits are all experienced regionally.

4.5.2 Hydro social costs and benefits

Hydro-electric development is only likely to arrest population decline in the Waitaki Valley over its seven year construction period. The influx of construction workers will put pressure on accommodation in the district, but increase turnover and employment in some local business enterprises. There will also be social disruption to rural communities from the stress of change and as they adjust to the different values and lifestyles of construction workers and their families. The physical impacts of construction (eg dust, noise, traffic, congestion, relocation of farms and impacts on farming systems, and loss of recreation activities) will disturb the everyday lives of residents of the Lower Waitaki, and some households and business enterprises in Kurow will be forced to relocate (with associated psychological impacts). These social costs of construction will have a significant impact on rural communities in the Lower Waitaki. Offsetting these costs will be benefits from direct and indirect employment generated by hydro-electric development, but the magnitude of those benefits will be reduced at the regional level if a large proportion of the workforce comes from outside the region (the actual effect will depend on employment strategies such as training for regional employment, and on the constructor's hiring policies). There could also be benefits from mitigation activities targeted at households, farms and businesses but these would be reduced if the recipients left the region. Mitigation activities targeted at the community level would most likely remain a regional benefit.

These social costs and benefits from hydro development are all experienced regionally.

These impacts are summarised in Table 17 below.

Table 17. Summary of social impacts

Location	**Value / indicator**	**Status Quo**	**Irrigation**	**Hydro-electricity**	**Regional Impact cf. National Impact[9]**
Upper Waitaki	Resident Population – long term	×	✓✓	0	All regional
	Changes to Community Structure – short term	0	✓×	×?	All regional
	Changes to community structure – long term	×	✓	0	All regional
Lower	Resident Population –long term	××	✓	0	All regional
	Changes to Community Structure – short term	0	✓×	××	All regional
	Changes to community structure – long term	×	✓	×?	All regional

Scenario 1	Maintenance of the Status Quo
Scenario 2	Additional allocations of water for irrigation
Scenario 3	Additional allocations of water for New Hydro

Adapted from SKM (2004)

Legend						
Significant Loss	Loss	Insignificant or No Change	Gain	Significant Gain	Some Gains & Losses	Needs Further Consideration
××	×	0	✓	✓✓	✓×	?

[9] Relative to population size.

5. Regional economic impact results

The economic impact analysis examined the expenditure patterns from the various options over a period of years (2006–2013). The input–output model shows how the initial (or direct) injection of expenditures from the various proposals gives rise to increases in full-time employment and value added in the region, over what would be expected in the absence of a particular proposal. The model also allows the calculation of economic multipliers that show the indirect effects of subsequent rounds of expenditure from that initial injection, on output, employment and valued added in the region. Each year a new direct injection occurs, with results that show the initial gain in the region over and above what would have occurred in the absence of the investment. In other words the results are cumulative: if in one year the effect is to create five new jobs and next year the result is eight new jobs, the net gain from year to year is three new jobs.

The purpose of this part of the study has been to develop an understanding of how the regional impacts of the different scenarios are incurred. The model produces regional economic structure, and changes in output, employment and added value (GDP) for both the capital and production changes.[10] Because of the sheer volume of data this information has not been all included in the report, but we have summarised the results in the graphs attached (Figures 3, 4 and 5).

5.1 Initial impacts

In broad terms, the impacts considered in this analysis can be categorised as one of two types: those arising from changes in agricultural capital spending and production, and those arising from changes in electricity generation capital spending and production. For each type of impact, a series of capital expenditures (on New Hydro or irrigation infrastructure) provides the basis for an increase in sectoral output and a requisite increase in input demands. The agricultural capital expenditures and increases in production are shown in Table 18.

[10] In national accounting, output is the value of production and value added is the difference between the value of outputs and the value of inputs in productive activity. Value added differs from private accounting concepts of profit and net surplus by including both labour costs and depreciation. It is the sum of factor incomes and can be thought of as comprising returns to various factor inputs: operating surplus (return to business owners), compensation of employees (return to labour), fixed capital consumption (return on existing capital assets) and indirect taxes net of subsidies received. It ignores direct taxes paid by any of these factors.

Table 18. Agriculture initial impacts

	All irrigation	Irrigation with IRR>5%	Irrigation above Tekapo	Irrigation above Ohau	Irrigation above Benmore	Irrigation below Waitaki	Agriculture high output
Irrigation capital expenditure							
2003	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m
2004	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m
2005	138.8m	100.7m	21.6m	11.4m	2.3m	62.3m	46.3m
2006	140.6m	101.9m	21.7m	11.7m	2.4m	63.7m	46.3m
2007	91.2m	65.7m	21.8m	0.5m	0.2m	29.6m	46.3m
2008	91.7m	66.1m	21.9m	0.5m	0.2m	30.1m	46.3m
2009	92.3m	66.4m	22.1m	0.5m	0.2m	30.6m	46.3m
2010	5.2m	3.5m	0.6m	0.5m	0.2m	4.3m	0.0m
Agricultural output							
2003	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m
2004	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m
2005	48.6m	35.8m	8.7m	2.3m	1.2m	24.7m	87.6m
2006	97.2m	71.6m	17.5m	4.6m	2.3m	49.4m	175.2m
2007	125.4m	90.5m	26.2m	4.6m	2.3m	58.3m	262.9m
2008	153.7m	109.4m	34.9m	4.6m	2.3m	67.1m	350.5m
2009	181.9m	128.3m	43.7m	4.6m	2.3m	76.0m	438.1m
2010	181.9m	128.3m	43.7m	4.6m	2.3m	76.0m	438.1m

Source: NZIER, Harris Consulting

Similarly, Table 19 shows the initial impacts associated with the construction and ongoing operation of the New Hydro scheme. In addition to these, New Hydro also has a revenue stream which lifts to a peak level of $215.1 million post-commissioning.

Table 19 New Hydro initial impacts

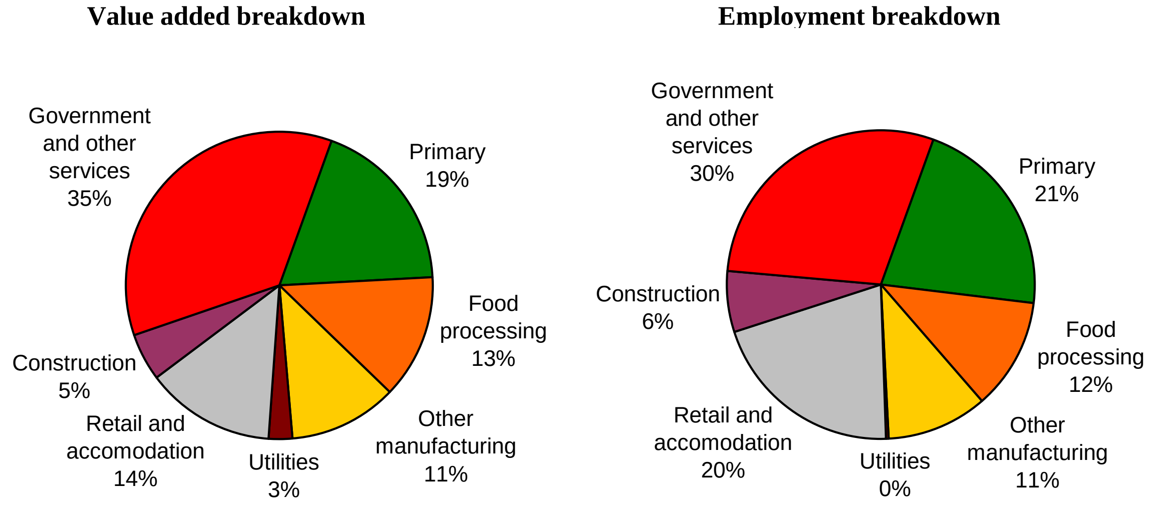
	Capital	Intermediate purchases
2003	0.0m	0.0m
2004	0.0m	0.0m
2005	0.0m	0.0m
2006	70.0m	0.0m
2007	120.0m	0.0m
2008	240.0m	1.9m
2009	240.0m	5.6m
2010	240.0m	7.2m
2011	120.0m	10.6m
2012	120.0m	10.6m
2013	0.0m	10.6m

Source: NZIER, Harris Consulting

5.2 The Waitaki Catchment economy

Figure 3 shows the broad composition of the Waitaki Catchment area economy in terms of both value added and employment in 2003. The importance of the rural economy is notable, with more than 30% of local value added and employment based in primary production and food processing. The utilities sector, comprising mainly electricity generation, transmission and distribution, contributes 3% of local value added, but only 0.2% of employment, reflecting its capital-intensive nature.

Figure 3. Composition of the study area economy in 2003



Source: NZIER, Statistics New Zealand

Table 20 shows the composition of the local economy in more detail, and includes the economy's composition in terms of output.[11] Amongst the rural producers, livestock and cropping farming makes the most significant contribution to local value added, and also provides input to the substantial meat processing sector.

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[11] Note that only regional employment data is available directly from Statistics New Zealand. Output and value added figures are estimates of the author.

Table 20. Study area economy

	2003 Employment (FTEs)	2003 Output ($m)	2003 Value added ($m)
Horticulture and fruit growing	480	20.3m	11.5m
Livestock and cropping farming	3272	272.1m	106.5m
Dairy cattle farming	836	70.6m	37.7m
Other farming	479	43.1m	18.9m
Services to agriculture	746	43.7m	20.6m
Other primary production	511	214.0m	92.1m
Meat product manufacturing	2321	496.4m	120.7m
Dairy product manufacturing	588	341.9m	48.2m
Fruit and vegetable processing	614	144.8m	36.2m
Other manufacturing	3162	518.1m	175.0m
Electricity, gas and water supply	74	48.7m	39.5m
Construction	1906	246.8m	75.7m
Wholesale trade	1009	142.8m	64.0m
Retail trade	3444	215.3m	112.2m
Accommodation, restaurants and bars	1605	81.3m	34.6m
Transport, storage and communication services	1403	206.1m	107.5m
Finance, insurance, business and property services	2204	380.0m	246.2m
Ownership of owner-occupied dwellings	9.42	0.0m	0.0m
Central government administration and defence	453	44.0m	24.5m
Local government administration	213	45.8m	20.7m
Education, health and community services	3623	184.6m	131.4m
Personal and other community services	798	58.2m	25.9m
Total	29750	3818.5m	1549.9m

Source: NZIER, Statistics New Zealand

5.3 Aggregate results

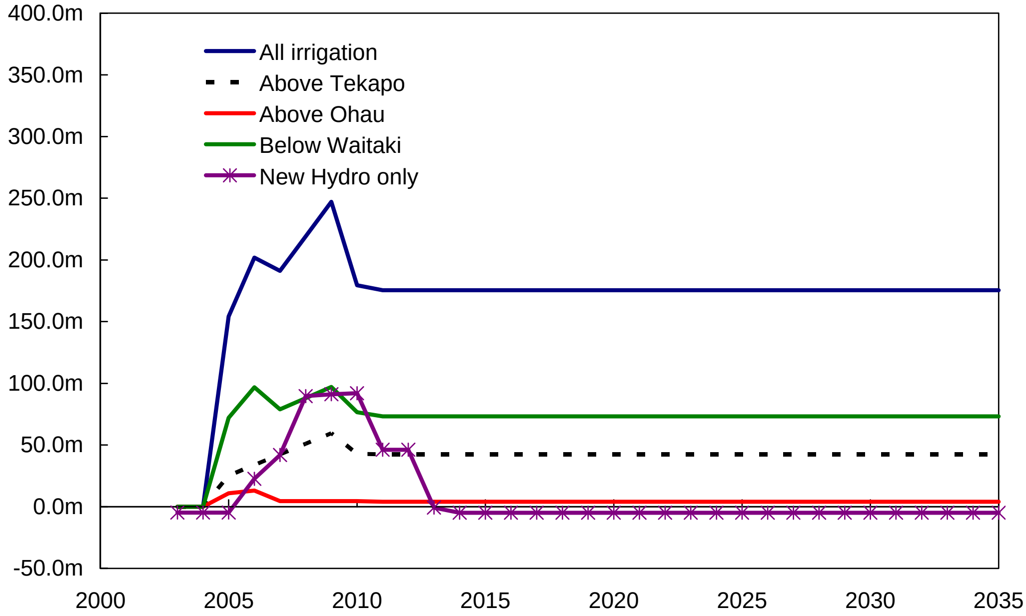
Figures 4 and 5 show the total economic impact of five of the scenarios over the time period for which they take place, in terms of value added. Each scenario is characterised by a bulge in the early years, reflecting the capital spending associated with the irrigation development, or the hydro development in the case of New Hydro. In the case of irrigation development the peaks are likely to be ameliorated somewhat by staged development, where the assumptions used in this analysis assume all schemes commence development from year 2 onward.

The distinction between the figures is the exclusion of the value added created by energy generation through New Hydro in Figure 4. Conversely, in Figure 5, the

New Hydro-only scenario includes the value added generated by energy. These two figures are presented because the value added created by energy through New Hydro has little engagement in the local economy as illustrated by its low employment impacts after the initial construction phase.

Figure 4. Total change in value added in regional economy

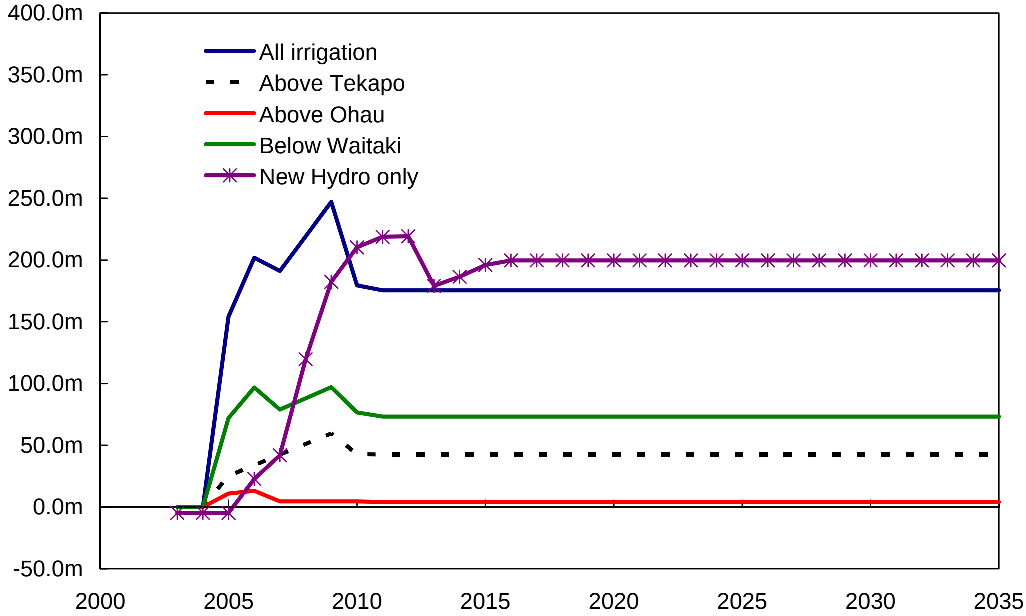
Dollar millions; New Hydro energy value added excluded



Source: NZIER

Figure 5. Total change in value added in regional economy

Dollar millions; New Hydro energy value added included



Source: NZIER

Of the irrigation scenarios examined, the 'all irrigation' scenario, would have the most profound impact on the local economy in terms of economy-wide changes in value added, raising the incremental value added per annum by $176 million for the period after the initial construction boost. The New Hydro-only scenario more than matches the 'all irrigation' scenario in terms of economy-wide impacts on value added. However, close to 99% of the value added of New Hydro – around $205m per annum – is estimated to represent the return on capital (including depreciation) of the original investment, which therefore accrues to the investors outside the region. The value added increase associated with increased agricultural production, however, represents a return to farmers on their entrepreneurial input and investment in land and farm machinery. Agricultural value added is thus the source of a significant income stream for farmers, and a considerable portion of this income is spent (and re-spent) in the local economy.

The agriculture high output scenario, if it could be realised, would increase local agricultural value added by a little over $450 million at its peak, which is reached in 2022. It hinges on the same development of irrigation infrastructure as the 'all irrigation' scenario, but assumes more radical land use transformation and production growth in outer years.

Table 21 shows the summary results for each of output, employment and value added, and compares the total change with the current level in the economy. For each scenario results are reported both for the ‘peak’ year (ie the year in which the scenario has the greatest impact) and the year at which incremental output (or employment or value added) stabilises at a particular level. Changes presented reflect the total increase in output (or employment or value added) associated with each scenario’s initial increase in activity (whether it be a lift in capital expenditure or production). These total increases comprise both the direct impacts of an increase in production (which arise as additional demands are placed on suppliers to the affected producer) and on the indirect, or flow-on impacts, that occur as these and subsequent additional demands filter through the economy.

Several observations can be made of these results. First, the increases in output, value added and employment are relatively similar for each scenario. This largely reflects the input–output methodology in which expansions in output (and therefore in requisite inputs) occur in a linear fashion; effectively, the base year ratios of employment:output and value added:output, for each sector, are assumed to be constant as output expands (or contracts). The assumptions used in input–output analysis and their implications are discussed fully in Appendix F.

The incremental increases in output under some of the scenarios represent significant changes above current levels, and caution should be exercised when viewing these results. Further to the input-output modelling assumption that all inputs and outputs expand (or contract) linearly is the related assumption that the factors of production (namely, labour and capital) are available in unlimited supply. This assumption becomes more problematic (i) the smaller the regional economy under consideration (since the local supply of surplus labour is less likely to be able to meet an expansion in labour demand); and (ii) the larger the size of the shock (ie exogenous increase in production) being applied.[12] In particular, the increases in activity associated with the ‘all irrigation’, Irrigation with IRR>5% and the Agriculture High Output scenarios should be considered to stretch the applicability of the input-output methodology. For instance, under the agriculture high output scenario, regional output increases 29.2 % above the 2003 level, with associated lifts in employment and value added of 38.8% and 29.2%, respectively. The respective levels of total impact of these scenarios should be treated as upper

[12] For these reasons, input-output analysis is designed for investigation of a marginal increase in demand – that is, an exogenous demand increase of a single unit. The assumptions noted become weaker as the size of the exogenous change increases and it becomes non-marginal.

bounds that could not be realised in practice without increasing price of local labour, diverting labour from other sectors, or importing labour from outside the region, with consequences for the local housing market.

Table 21. Input–output scenario analyses: Summary results

Scenario levels and percentage change from base

	Output ($m)		***Employment (FTEs)***		***Value added ($m)***	
Base (1993)	3818.5m		29750		1549.9m	
Scenario (peak year)	***Peak***	***On-going***	***Peak***	***On-going***	***Peak***	***On-going***
All irrigation (2009)	629.3m	466.1m	5,681.0	3,939.3	247.2m	175.5m
Percentage change from base	16.5	12.2	19.1	13.2	15.9	11.3
Irrigation with IRR>5% (2009)	447.6m	330.1m	4,035.4	2,781.4	175.8m	124.3m
Percentage change from base	11.7	8.6	13.6	9.3	11.3	8.0
Irrigation above Tekapo (2009)	151.1m	112.0m	1,351.9	935.4	59.6m	42.4m
Percentage change from base	4.0	2.9	4.5	3.1	3.8	2.7
Irrigation above Ohau (2006)	31.8m	11.1m	323.1	102.3	13.2m	4.1m
Percentage change from base	0.8	0.3	1.1	0.3	0.8	0.3
Irrigation above Benmore	9.9m	5.6m	97.1	51.3	3.9m	2.1m
Percentage change from base	0.3	0.1	0.3	0.2	0.3	0.1
Irrigation below Waitaki (2009)	248.8m	194.6m	2,225.1	1,646.9	97.0m	73.2m
Percentage change from base	6.5	5.1	7.5	5.5	6.3	4.7
Agriculture high output (2022)	1115.6m	1115.6m	11,555.8	11,555.8	452.6m	452.6m
Percentage change from base	29.2	29.2	38.8	38.8	29.2	29.2
New Hydro only (2010)	359.6m	202.4m	1,787.1	40.9	219.2m	199.6m
Percentage change from base	9.4	5.3	6.0	0.1	12.9	12.9

Source: NZIER

However, the figures in Table 21 should not be thought redundant. The assumptions noted apply across all scenarios, not just those with the largest impacts. Thus, although the levels of total impact for each scenario may overstate the actual ‘true’ impact, the ranking of the various options should be left unaffected. This analysis therefore represents a valid means of comparing the various options relating to the use of the Waitaki River’s water.

5.4 Sectoral impacts

The aggregate impacts presented in Table 21 are sums of the underlying changes in sectoral output, employment and value added. Each scenario gives rise to a different pattern of sectoral impacts, depending on the size and the nature of the initial impact.

Table 22 shows the upstream impacts of the increases in agricultural production in value added terms. Upstream impacts are those effects that occur as agriculture demands increased inputs so that it can lift its level of production. Downstream effects, on the other hand, occur when an increase in production lifts the level of downstream processing required in order to add value to that extra production; in the case of agriculture, the increase in agricultural output (eg raw milk, lambs, wool) requires additional processing by the primary processing sectors, which in turn will lead to further downstream effects. Table 24 and Table 25 show the sectoral increases in value added that arise from the initial injection of capital into irrigation and hydro developments, respectively.

These tables show that the impacts of increased agricultural production are spread throughout the economy. While the most marked changes are in the agricultural sector, the services sector (finance, insurance etc), wholesale and retail trade and manufacturing all experience significant increases.

Table 22. Upstream sectoral impacts of increased agricultural production

Value added, $m, on-going impact

Sector	Agriculture high output	Aqua only	Below Waitaki	Above Benmore	Above Ohau	Above Tekapo	IRR>5%	All irrigation
Horticulture and fruit growing	72.3m	-0.4m	0.6m	0.0m	0.0m	0.4m	1.1m	1.5m
Livestock and cropping farming	71.3m	-0.9m	14.2m	0.9m	1.7m	5.8m	23.3m	33.1m
Dairy cattle farming	86.2m	-1.3m	23.5m	0.2m	0.4m	14.7m	41.4m	56.8m
Other farming	6.7m	-0.1m	1.5m	0.0m	0.0m	2.3m	1.9m	4.2m
Services to agriculture	9.3m	-0.1m	1.1m	0.0m	0.1m	0.6m	1.8m	2.6m
Other primary production	3.0m	0.0m	0.6m	0.0m	0.0m	0.3m	1.0m	1.3m
Meat product manufacturing	1.8m	0.0m	0.3m	0.0m	0.0m	0.2m	0.5m	0.7m
Dairy product manufacturing	0.5m	0.0m	0.1m	0.0m	0.0m	0.0m	0.1m	0.2m
Fruit and vegetable processing	0.6m	0.0m	0.1m	0.0m	0.0m	0.1m	0.2m	0.2m
Other manufacturing	13.4m	-0.2m	2.3m	0.0m	0.1m	1.4m	4.0m	5.6m
Electricity, gas and water supply	10.1m	-0.1m	1.4m	0.0m	0.1m	0.8m	2.3m	3.3m
Construction	1.0m	0.0m	0.2m	0.0m	0.0m	0.1m	0.3m	0.4m
Wholesale trade	8.7m	-0.1m	1.4m	0.0m	0.1m	0.8m	2.4m	3.4m
Retail trade	18.4m	-0.2m	2.9m	0.1m	0.1m	1.7m	5.0m	7.0m
Accommodation, restaurants and bars	3.0m	0.0m	0.5m	0.0m	0.0m	0.3m	0.8m	1.1m
Transport, storage and communication services	10.3m	-0.1m	1.4m	0.0m	0.1m	0.9m	2.4m	3.4m
Finance, insurance, business and property services	25.0m	-0.3m	3.6m	0.1m	0.2m	2.1m	6.2m	8.7m
Ownership of owner-occupied dwellings	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m
Central government administration and defence	0.5m	0.0m	0.1m	0.0m	0.0m	0.1m	0.1m	0.2m
Local government administration	0.2m	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m	0.1m
Education, health and community services	5.4m	-0.1m	0.9m	0.0m	0.0m	0.5m	1.6m	2.2m
Personal and other community services	3.7m	0.0m	0.5m	0.0m	0.0m	0.3m	0.9m	1.3m
Total	351.4m	-3.8m	57.2m	1.5m	2.9m	33.5m	97.4m	137.2m

Source: NZIER

Table 23. Downstream sectoral impacts of increased agricultural production

Value added, $m, on-going impact

Sector	Agriculture high output	Aqua only	Below Waitaki	Above Benmore	Above Ohau	Above Tekapo	IRR>5%	All irrigation
Horticulture and fruit growing	70.0m	-0.4m	0.1m	0.0m	0.0m	0.1m	0.1m	0.2m
Livestock and cropping farming	70.6m	-0.9m	13.9m	0.8m	1.7m	5.7m	22.7m	32.3m
Dairy cattle farming	90.1m	-1.3m	23.5m	0.2m	0.4m	14.8m	41.4m	56.8m
Other farming	4.0m	0.0m	1.0m	0.0m	0.0m	2.0m	1.0m	3.1m
Services to agriculture	1.1m	0.0m	0.1m	0.0m	0.0m	0.1m	0.2m	0.3m
Other primary production	2.7m	0.0m	0.2m	0.0m	0.0m	0.1m	0.3m	0.4m
Meat product manufacturing	26.5m	-0.3m	5.1m	0.3m	0.6m	2.5m	8.2m	12.0m
Dairy product manufacturing	22.2m	-0.3m	5.7m	0.1m	0.1m	3.5m	9.9m	13.7m
Fruit and vegetable processing	3.7m	0.0m	0.1m	0.0m	0.0m	0.1m	0.2m	0.3m
Other manufacturing	8.8m	-0.1m	0.9m	0.0m	0.1m	0.5m	1.5m	2.2m
Electricity, gas and water supply	0.1m	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m
Construction	0.9m	0.0m	0.1m	0.0m	0.0m	0.1m	0.2m	0.2m
Wholesale trade	3.5m	0.0m	0.6m	0.0m	0.0m	0.3m	1.1m	1.5m
Retail trade	5.0m	0.0m	0.2m	0.0m	0.0m	0.1m	0.3m	0.5m
Accommodation, restaurants and bars	4.4m	0.0m	0.3m	0.0m	0.0m	0.2m	0.4m	0.6m
Transport, storage and communication services	0.6m	0.0m	0.1m	0.0m	0.0m	0.0m	0.1m	0.2m
Finance, insurance, business and property services	1.0m	0.0m	0.1m	0.0m	0.0m	0.1m	0.2m	0.3m
Ownership of owner-occupied dwellings	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m
Central government administration and defence	0.2m	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m
Local government administration	0.1m	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m
Education, health and community services	1.1m	0.0m	0.0m	0.0m	0.0m	0.0m	0.1m	0.1m
Personal and other community services	0.2m	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m	0.1m
Total	316.6m	-3.5m	52.0m	1.5m	3.0m	30.1m	88.1m	124.7m

Source: NZIER

Table 24. Sectoral impacts of irrigation capital expenditure

Value added, $m, peak year impact

Sector	Agriculture high output	Below Waitaki	Above Benmore	Above Ohau	Above Tekapo	IRR>5%	All irrigation
Peak year	2006	2006	2006	2006	2009	2006	2006
Horticulture and fruit growing	0.2m	0.2m	0.0m	0.0m	0.1m	0.4m	0.5m
Livestock and cropping farming	0.5m	0.7m	0.0m	0.1m	0.2m	1.1m	1.5m
Dairy cattle farming	0.1m	0.1m	0.0m	0.0m	0.0m	0.2m	0.3m
Other farming	0.2m	0.3m	0.0m	0.0m	0.1m	0.4m	0.6m
Services to agriculture	11.0m	15.1m	0.6m	2.8m	5.2m	24.2m	33.3m
Other primary production	0.3m	0.5m	0.0m	0.1m	0.2m	0.7m	1.0m
Meat product manufacturing	0.2m	0.3m	0.0m	0.1m	0.1m	0.5m	0.6m
Dairy product manufacturing	0.1m	0.1m	0.0m	0.0m	0.0m	0.1m	0.2m
Fruit and vegetable processing	0.1m	0.1m	0.0m	0.0m	0.0m	0.2m	0.3m
Other manufacturing	2.5m	3.5m	0.1m	0.6m	1.2m	5.6m	7.7m
Electricity, gas and water supply	0.7m	1.0m	0.0m	0.2m	0.3m	1.6m	2.2m
Construction	6.9m	9.5m	0.4m	1.7m	3.3m	15.2m	21.0m
Wholesale trade	1.2m	1.6m	0.1m	0.3m	0.6m	2.6m	3.6m
Retail trade	2.3m	3.2m	0.1m	0.6m	1.1m	5.1m	7.0m
Accommodation, restaurants and bars	0.4m	0.5m	0.0m	0.1m	0.2m	0.9m	1.2m
Transport, storage and communication services	1.3m	1.8m	0.1m	0.3m	0.6m	2.9m	4.0m
Finance, insurance, business and property services	6.7m	9.3m	0.4m	1.7m	3.2m	14.9m	20.5m
Ownership of owner-occupied dwellings	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m	0.0m
Central government administration and defence	0.1m	0.1m	0.0m	0.0m	0.0m	0.1m	0.2m
Local government administration	0.0m	0.1m	0.0m	0.0m	0.0m	0.1m	0.1m
Education, health and community services	0.6m	0.8m	0.0m	0.2m	0.3m	1.3m	1.8m
Personal and other community services	0.5m	0.6m	0.0m	0.1m	0.2m	1.0m	1.4m
Total	35.9m	49.5m	1.9m	9.1m	17.1m	79.2m	109.2m

Source: NZIER

Table 25. Sectoral impacts of New Hydro development

Direct and indirect effects	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Output ($m)											
Aqua generation	0.0m	0.0m	0.0m	0.0m	0.0m	31.7m	96.8m	125.6m	183.2m	183.5m	190.4m
Electrical connection	0.0m	0.0m	0.0m	1.7m	3.0m	6.0m	6.1m	6.1m	3.2m	3.2m	0.3m
Machinery	0.0m	0.0m	0.0m	2.2m	3.7m	7.5m	7.6m	7.6m	4.0m	4.0m	0.3m
Building	0.0m	0.0m	0.0m	24.7m	42.3m	85.2m	86.5m	87.1m	46.0m	46.0m	3.7m
Construction	0.0m	0.0m	0.0m	39.1m	67.1m	135.3m	137.3m	138.3m	73.0m	73.0m	5.9m
Professional services	0.0m	0.0m	0.0m	2.2m	3.7m	7.5m	7.6m	7.6m	4.0m	4.0m	0.3m
Total	*0.0m*	*0.0m*	*0.0m*	*69.9m*	*119.8m*	*273.1m*	*341.9m*	*372.3m*	*313.5m*	*313.8m*	*201.0m*
Employment (FTEs)											
Aqua employment	0.0	0.0	0.0	0.0	0.0	28.1	84.2	109.3	159.4	159.4	159.4
Electrical connection	0.0	0.0	0.0	2.6	4.5	9.1	9.2	9.3	4.9	4.9	0.4
Machinery	0.0	0.0	0.0	13.2	22.6	45.6	46.3	46.6	24.6	24.6	2.0
Building	0.0	0.0	0.0	190.4	326.4	657.9	668.1	672.6	355.2	355.2	28.7
Construction	0.0	0.0	0.0	302.3	518.3	1044.6	1060.7	1067.9	563.9	563.9	45.6
Professional services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	*0.0*	*0.0*	*0.0*	*508.6*	*871.9*	*1785.3*	*1868.5*	*1905.7*	*1108.0*	*1108.0*	*236.2*
Value added ($m)											
Aqua value added	0.0m	0.0m	0.0m	0.0m	0.0m	29.9m	91.2m	118.3m	172.6m	173.0m	179.9m
Electrical connection	0.0m	0.0m	0.0m	1.4m	2.4m	4.9m	4.9m	5.0m	2.6m	2.6m	0.2m
Machinery	0.0m	0.0m	0.0m	0.8m	1.4m	2.9m	2.9m	2.9m	1.5m	1.5m	0.1m
Building	0.0m	0.0m	0.0m	9.4m	16.1m	32.5m	33.0m	33.3m	17.6m	17.6m	1.4m
Construction	0.0m	0.0m	0.0m	14.9m	25.6m	51.7m	52.4m	52.8m	27.9m	27.9m	2.3m
Professional services	0.0m	0.0m	0.0m	0.8m	1.4m	2.9m	2.9m	2.9m	1.5m	1.5m	0.1m
Total	*0.0m*	*0.0m*	*0.0m*	*27.4m*	*47.0m*	*124.6m*	*187.4m*	*215.2m*	*223.7m*	*224.1m*	*184.0m*

Source: NZIER

5.5 Social impacts

Key social statistics for the study area are shown in Table 26 below. These show that the region is suffering a declining population, and that the population is ageing, with relatively fewer young people and more old people that the national average.

Table 26. Regional population statistics

Area	Existing Population (2001)	Change between census 1996 - 2001	Change as proportion of current	Age <15	Age >65
Mackenzie	6717	-360	-5.4%	20.7%	11.9%
Timaru	41967	-663	-1.6%	21%	17.6%
Waimate	7098	-522	-7.4%	21.8%	17.6%
Waitaki	20088	-1485	-7.4%	19.9%	19.4%
Total	***75870***	***-3030***	-4.0%	***21%***	***18%***
National			4.3%	22.7%	12.1%

The social impacts will be driven largely by the changes in employment, which in turn drives population and demographic changes. Both hydro-electricity construction and irrigation will have substantial employment impacts at the regional level. The major difference is that hydro-electricity impacts follow a classic boom–bust scenario, peaking at a total of 1,900 full time equivalent (FTEs) (net direct and indirect regional impact) between 2008 and 2012 but reducing rapidly thereafter. Population impacts associated with this employment will also be short term and will be likely to cause more complications than benefits for the host communities and their social services. It should be noted that these impacts do not include the impact of mitigation packages associated with New Hydro development. While this is consistent with the methodology adopted by this report and the SKM approach, the mitigation on its own may have significant impacts which would need to be offset against the social and other impacts incurred by the project.

On the other hand, irrigation has a smaller total employment impact but this impact will be sustained over time. The SKM report estimates that for the Waitaki Valley each 1,000 heactares of irrigated land will bring another 68 residents to the area. Based on 17 full-time equivalents generated per 1,000 hectares of irrigated land, this estimate appears to use a population multiplier of 4.0. A safer figure would be 40–45 new residents per 1,000 hectares of new irrigation based on a multiplier of 3.5 per married person FTE, and allowing for a proportion of new employees who are younger people with no dependants (multiplier of 2.5 in total). These estimates of population change associated with the increased irrigation are shown in Table 27. The figures show the ongoing operational phases of the irrigation scenarios, after the bulk of the capital and construction activity has been completed.

As a change in population these figures are significant for the study region – up to 13% more than the current population additional under the all irrigation scenario. For the ‘regional high impact’ scenario this figure is +38%, which demonstrates the upper limit of potential impacts of irrigation on the study area. Population impacts of this order in small rural communities have the potential to boost demand for struggling services such as small rural schools, health services, sports clubs and other community activities. They will also create a demand for housing.

Some caution should be taken with these figures, because the employment estimates are likely to be overstated due to the limitations of the model, and the estimates of population to employment changes are also rough. Furthermore the ‘high impact’ scenario has no basis in any solid projection, and demonstrates potential rather than actuality. For all that, however, the figures do demonstrate that the ‘with irrigation’ scenario will be markedly different in population terms than the projections without irrigation. The scenarios with larger irrigation areas appear to have the potential to stabilise the population over the longer term, and even the smaller irrigation scenarios have the potential to mitigate some of the population loss in the study area.

Table 27. Irrigation scenarios - hectares and additional direct and indirect employment –2009 year

Scenario	Area to irrigate Hectares	Addit. direct emplmnt (FTEs)	Addit. direct & indirect emplmnt (FTEs)	Addit. Populn.	Addit. as propn of total current Populn.	Pop. 2021 (Stats projection	Pop. 2021 with irrigation	Pop. 2021 with irrigation change from current
Above Tekapo	30,000	516	935	2300	3%	65,900	68,200	-10%
Above Ohau	10,000	55	102	300	0%	65,900	66,200	-13%
Above Benmore	3,750	28	51	100	0%	65,900	66,000	-13%
Below Waitaki	44,500	903	1647	4100	5%	65,900	70,000	-8%
All irrigation > 5% IRR	74,250	1526	2781	7000	9%	65,900	72,900	-4%
All irrigation	124,250	2162	3939	9800	13%	65,900	75,700	0%
High Output	124,250	6644	11556	28900	38%	65,900	94,800	25%

While it is not the intention of the study to undertake a sub-regional breakdown, the impacts from the irrigation will tend to be concentrated on the lowland parts of the region. The higher employment impact for above Tekapo and below Waitaki is because these schemes will have dairying and other high return land uses, compared to use of water in the Mackenzie Basin primarily for sheep and beef pastoralism. There is also the location of the major centres of Timaru and Oamaru to consider, as these tend to represent the major destination of farm working expenses as demonstrated in a survey of expenditure patterns (56% in South Canterbury[13]). However, small rural centres also tend to gain significantly from increases in expenditure, with 36% of farm working expenses occurring in these centres. Capital expenditure tends to be more directed to the large centres of Timaru and Oamaru, and personal expenditure directed more toward the smaller centres.

Because expenditure patterns tend to drive employment, and employment drives population, we expect that based on this information gathered, there will be significant gains in population in the smaller centres as well as in the Timaru and Oamaru areas. In aggregate we would expect this to represent a significant proportion of the community, and for the larger schemes this could reverse regional declines in population over the long term.

While there are no detailed social impact assessments prepared for the specific irrigation schemes, it can be assumed that there will be distinct social impacts at the local level. As noted these impacts will involve some changes in land ownership and newcomers coming to the district. Where dairying takes place on irrigated land this will result in demographic changes as dairy farming families are often in their lower to middle life cycle, share milkers are frequently young couples or couples with young families, and dairy farm workers are often young and single.

5.6 Wealth and consumer surplus social impacts

The results from the cost benefit analysis in Section 4 indicate that within any given net present value, there are some parties who gain and others who lose. In particular, the establishment of irrigation results in a transfer of wealth from the existing energy asset holder to landholders undertaking irrigation. In a CBA sense it is appropriate that we look at the overall distribution, but these transfers have social impacts which should be included in this part of the analysis. In a distributional sense with the current ownership structure, these social impacts accrue largely outside the region to the taxpayer owners of Meridian Energy Ltd.

In addition to the wealth transfer impacts there are consumer surplus changes which also have significant social impacts. The net result of the New Hydro scenario is a reduction in the price of electricity of up to 0.9c/kWh over several years. This results in a significant benefit to consumers of electricity who pay lower prices than they

[13] Agriculture New Zealand, 2001. Report Prepared for MAF Policy

were otherwise prepared to pay. Most of these consumer surpluses have not been included in the national analysis, and it has to be inferred that they were excluded on the basis that they represent transfers from a producer surplus. This transfer represents a significant social impact in itself, which should be taken into account as a factor in decision making on hydro development in the river. Most of these social impacts will be national rather than regional but the local community will still experience a proportionate share in them.

6. Conclusion

This report combines two separate, but complementary, types of economic analysis of the likely consequences of different scenarios of water allocation and use in the Waitaki Catchment. An economic impact analysis traces the effects of new activity (irrigation and/or new hydro development) through a model that provides static snapshots of effects on regional output, value added and employment at different phases in each scenario, to give a sense of the distribution of impacts through the local economy. A cost benefit analysis compares the stream of benefits and costs that are expected to flow over an extended period under each scenario, to arrive at an estimate of net present value derived from each scenario.

Regional impact analysis

The economic impact results indicate significant change in the economy of the study area. Irrigation produces enduring changes felt widely across the regional economy, with a relatively small boom during construction. Hydro development produces large impacts in the short term, but with little in the way of ongoing increase in economic activity outside the energy sector.

In terms of economy-wide impact on value added, the New Hydro-only scenario more than matches the ‘all irrigation’ scenario. However, more than 90% of the New Hydro scenario’s value added increase is a return on capital, which largely accrues to owners outside the region. To the extent that farm businesses are more likely to be owned by local residents, agricultural value added increases are more likely to be spent and re-spent in the local economy.

The economic impact methodology has limitations because of its inability to distinguish real trade creation from trade diversion effects in the region, identify the effects on resource input prices and resource demands on other parts of the economy, and to track dynamic effects over time. However, these limitations are common to all the options considered in this study, so the impact analysis is still informative of the relative outcome across the different scenarios.

Regional cost benefit analysis

The regional cost benefit analysis results show significant concurrence between the national and regional effects in terms of those matters quantified, but significant differences between the national and regional in terms of the unquantified environmental, social, recreational and tourism matters. The key points from the regional analysis are discussed below.

New Hydro shows a large positive outcome in the regional cost benefit analysis under those items quantified, and the positive nature of this outcome appears relatively insensitive to the assumptions used. However New Hydro has a number of negative unquantified outcomes. Of these:

- The environmental outcomes are mostly negative and mostly *national*, with significant regional impacts such as groundwater, flooding and erosion changes.

- The recreational impacts are mixed, but there are a number of negatives which are *disproportionately borne by the regional community*, because of limited substitutes at the regional level.

- The social impacts are significant and mostly negative and are *all borne by the regional community.* There will be benefits from direct and indirect employment generated by hydroelectric development, but the magnitude of those benefits will be reduced at the regional level if a large proportion of the workforce comes from outside the region. Population impacts associated with this employment will also be short term and may cause more complications than benefits for the host communities and their social services, in the absence of mitigation measures to accompany that development.

- The economic impacts are primarily value added through energy, with limited engagement in the regional economy, and very limited employment creation. Economic impacts in the construction phase are significant but not enduring.

The quantified irrigation regional outcomes are largely positive at the lower discount rates in the without-New Hydro scenarios. However when New Hydro is added to the system, the quantified results become largely negative because of the additional costs of losing water to the hydro-generation system. The irrigation takes also produce some unquantified outcomes. Of these:

- The environmental outcomes are mixed, with some positives in terms of soil erosion and groundwater, but negatives in terms of water quality, landscape and potentially some impacts in the braided river ecosystems. These impacts are of *mixed national and regional incidence*.

- The recreational outcomes are largely neutral, and those impacts which do occur are of *mixed regional and national incidence, with some bias toward regional*.

- The social outcomes are significant and positive, although there are some short term impacts as community structure changes and management of change strategies may be required at the regional and local levels. These benefits are *all experienced regionally*.

- The impacts on the regional economy are significant and ongoing. Employment creation is expected to be significant, and the economy is expected to be larger and possibly more diverse post development.

The analysis at the regional level presents a contrast of two types of proposal. The New Hydro scenario is a robust proposal in terms of the monetary CBA outcomes but has significant and negative social, recreational and environmental impacts and limited regional economic impacts. The irrigation proposals are more marginal in terms of monetary CBA outcomes because they are very sensitive to assumptions, and while they may have some environmental impacts there are significant and positive social impacts in the region and significant and on-going regional economic impacts in terms of changes to the regional economy size and structure.

A key point is the fact that the irrigation proposals are viable without New Hydro but not with New Hydro at the lower discount rates. So crucial considerations from a regional perspective are whether New Hydro is likely to proceed in the near future, and what form it will take, as this will determine the size of the net benefit (or cost) of irrigation takes. If New Hydro is *not to proceed* then from a regional point of view allocation to irrigation is desirable in most respects at the lower discount rate used in this study (7.5%). Applying the higher discount rate of 10% irrigation does not appear to be sufficiently worthwhile to outweigh the losses from diverting water from existing generation plant.

If a New Hydro project *were to proceed*, allocation to irrigation becomes less desirable in terms of monetary CBA outcomes apart from those proposals that are integrated with hydro development. However irrigation has such positive regional social and economic impacts decision makers may still wish to include it in the allocation mix.

6.1 Caveats

These conclusions have some significant caveats. The costs for New Hydro have been based on a Project Aqua type development. That Project Aqua did not proceed probably indicates that the costs were higher or the benefits lower than have been projected here. Similarly capital costs for irrigation projects appear to have increased over the last year with changes in fuel and steel prices, and the capital cost assumptions in that regard may be lower than is currently experienced.

The agricultural assumptions have been based on ranges of estimates rather than single figures, and as a general comment tend to be higher than published survey data applicable to the land use types. The actual outcomes in these areas will be determined by a combination of factors such as land use change, discount rate choices by investors, changes in management, and changes in technology which are difficult to predict in an average sense. Furthermore there are other unquantified reasons why landholders undertake irrigation beyond issues such as reduction in risk and stress, maintenance of lifestyle, and amenity which have not been included as benefits despite perhaps being important parts of the decision making process.

This study has revealed limitations in both cost benefit analysis and economic impact analysis in addressing the question of how best, from a regional perspective, to allocate and use water. As these limitations are common to all the options examined here, the results can be considered more indicative of the relative ranking of different options than of the absolute levels that any particular option is likely to realise.

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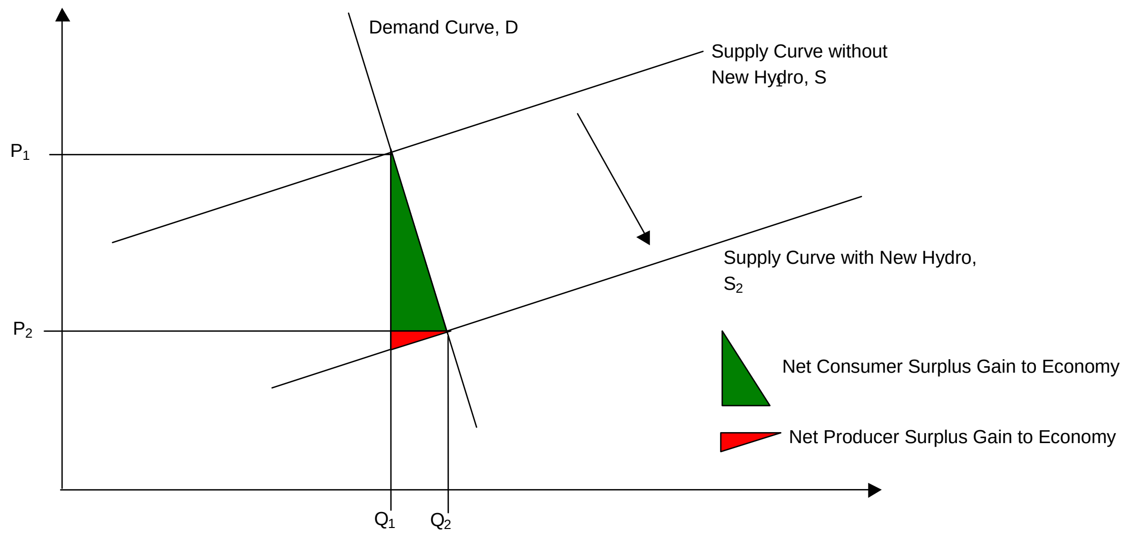
8. List of interviewees and other contacts

David	Allan	Farmer
Tom	Allan	Farmer
Ben	Aubrey	Mackenzie
Allan	Bennet	Fonterra
Alistair	Betts	Farmer and Chairman, PrimePort
Peter	Brown	Farmer
Murray	Cleverly	Aoraki Development Trust
Darron	Cook	SKM
Fiona	Cooper	Fiona Aston Consultancy
John	de Veth	Farmer
Dennis	Fastier	Farmer
Fred	Fields	Fields Horticulture
Stuart	Ford	Agribusiness Group
Neville	Forrest	Farmer
Justin	Ginnivan	SKM
Jason	Gooch	Food Processors Ltd.
Bob	Goslin	Farmer
Owen	Harvey	Innovations and Solutions Ltd.
Mark	Hawkins	Farmer
George	Hennessy	Farmer
David	Henshaw	Chairman, Aoraki Water Trust
Susan	Houston	Waitaki Development Board

Bevan	Hurst	Farmer
David	Martin	Farmer
Andrew	McFarlane	McFarlane Rural Business Ltd.
Steve	McKight	McCains New Zealand Ltd.
Raewyn	Moss	Meridian Energy Ltd.
Robin	Murphy	Morven-Glenavy Irrigation Company Ltd.
Graeme	Ogle	Rezare Systems Ltd.
Ross	Rathgen	Farmer
Gerard	Scott	Farmer
Alistair	Shearer	ECan
Ad	Sintenie	Barkers Fruit Processors
Malcolm	Smith	Farmer
Robert	Smith	Farmer
John	Talbot	ECan
Brian	Tierney	Brian Tierney Management Services
Mark	Urquart	Farmer
Trevor	Webb	Landcare Research
John	Wright	Farmer

Appendix A Technical discussion of the differences between CBA and EIA

The difference between cost benefit analysis and impact analysis is illustrated in the diagram below, which depicts effects on the electricity market, with and without the commissioning of New Hydro (here representing any new large hydro scheme in the lower Waitaki). Without New Hydro the electricity market is described by the supply line S_1 facing demand D, so that Q_1 electricity is supplied at a price of P_1. With New Hydro, the national supply line shifts down to S_2, which enables a lowering of price to P_2 and some increase in consumption to Q_2 .



Adapted from SKM (2004).

Impact analysis is concerned with the increase in activity (Q_2-Q_1), and the distribution of the value of that activity across various input suppliers and recipients of income. This corresponds to the area beneath the supply curve between Q_2 and Q_1, valued at P_1 in the inter-industry input-output models used for such analysis, on the assumption that prices do not change significantly (a reasonable assumption for small projects). It may also include the flow-on effects in other product markets as the impacts of increased output in the electricity market spread through other sectors that supply or use electricity. Economic multiplier coefficients are used to estimate the flows of inputs and outputs between sectors, the leakage of expenditures out of the locality and retention of business activity within the locality as the original injection of expenditure gets used through subsequent rounds of spending.

Cost benefit analysis aims to calculate the economic surpluses generated by the change in activity, allowing for changes in price. These are the triangular areas in the diagram, both a surplus to consumers from lower electricity prices, and a surplus to producers from increased sales at the margin. The costs of achieving these surplus gains (the area between Q_1 and Q_2 and below S_2) are deducted in calculating the net benefit of the proposal. There will also be flow-on effects into other sectors, but to calculate these effects requires a computable general equilibrium model that allows for price changes in all other sectors consequent on the change in electricity price.

This is complex and beyond the scope of the current regional analysis of the Waitaki. However, the diagram still serves to illustrate that impact analysis and cost benefit analysis measure quite different things. This is because cost benefit analysis is specifically interested in the opportunity cost of resources used in a project, it will also encompass a wider range of effects than the expenditures examined by impact analysis. It uses the value of input resources in their best alternative uses as a measure of those inputs' opportunity costs (eg farm production forgone by water diversion to other uses). In principle this includes inferring a monetary value for uses that have no market value (such as in-stream recreation), but in practice such uses are often weighed up in other ways, outside the monetary analysis.

Appendix B Agricultural assumptions used – base case

These figures represent the assumptions used in the calculation of costs and benefits to the primary production sector. These calculations occur both as part of the irrigation scenarios, and as part of the costs of the New Hydro proposal. A number of changes were made to the approach used by SKM, and these are discussed after the assumptions.

Table 28. Gross margin sssumptions ($/ha)

		Dryland		Irrigation						
		Grazing	Arable	Grazing	Dairy	Dairy Support	Deer	Arable	Horticulture	Viticulture
Mackenzie	Low	4.25	0	230	NA	230	NA	600	NA	NA
	Mid	8.5	0	565	NA	565	NA	750	NA	NA
	High	106	0	900	NA	900	NA	900	NA	NA
Elsewhere	Low	180	450	760	1700	650	700	1250	18000	4000
	Mid	270	650	1050	1900	1150	1200	1400	21000	8000
	High	360	1000	1450	2300	1600	1700	2150	24000	15000

Table 29. Water use assumptions (mm/ha/year)

		Dryland		Irrigation						
		Grazing	Arable	Grazing	Dairy	Dairy Support	Deer	Arable	Horticulture	Viticulture
Mackenzie	Low	0	0	500	500	500	600	200	500	300
	Mid	0	0	600	600	600	650	325	550	350
	High	0	0	700	700	700	700	450	600	400
Elsewhere	Low	0	0	600	600	600	600	500	500	300
	Mid	0	0	700	700	700	700	542.5	550	350
	High	0	0	800	800	800	800	585	600	400

Table 30. On-farm capital costs ($/ha)

		Dryland		Irrigation						
		Grazing	**Arable**	**Grazing**	**Dairy**	**Dairy Support**	**Deer**	**Arable**	**Horticulture**	**Viticulture**
On Farm Capital	Low	0	0	1700	2000	1700	1700	2000	2500	2500
	Mid	0	0	1850	2350	2200	1850	2350	3000	3000
	High	0	0	2700	2700	2700	2700	2700	3500	3500
Farm Transition Cost		0	0	1000	12500	500	3500	500	30000	20000

Table 31. Off-varm O&M costs ($/ha/annum

Scheme?	**Low**	**Mid**	**High**
No	200	225	250
New Scheme	100	125	150
Canal	25	37.5	50

Table 32. Off-farm capital estimates ($/ha)

Location/scheme	**Capital Estimate ($/ha)**
Mackenzie Basin / Ruataniwha District	500
Aoraki Water Trust Proposal	1165
Lake Benmore, Lake Aviemore	1500
Other 'Called in' Consents - Above Waitaki Dam	1500
INO Downlands	4000
INO Gravity	5000
Lower Waitaki Irrigation Scheme	1500
Hakataramea Valley	1500
North Bank / Elephant Hill Area	1500
Waihao Downs	1500
'Called in' Consents - Below Waitaki Dam	1500

Table 33. Scheme description and land use assumptions

Demand Description	System Location	Irrigation Area	Current Profile (%) Dryland Grazing	Current Profile (%) Dryland Arable	New Profile (%) Irrigated Grazing	Dairy	Dairy Support	Deer	Arable	Horticulture	Viticulture
Mackenzie Basin / Ruataniwha District	usOhauA	10000	100%	0%	0%	0%	80%	0%	20%	0%	0%
Aoraki Water Trust Proposal	usTekapoA	30000	79%	21%	0%	0%	32%	28%	15%	10%	15%
Lake Benmore, Lake Aviemore	usBenmore	2000	100%	0%	0%	0%	80%	0%	20%	0%	0%
Other 'Called in' Consents - Above Waitaki Dam	usWaitaki	1750	100%	0%	0%	0%	80%	0%	20%	0%	0%
INO Downlands	WaitakiBlkPnt	20000	90%	10%	0%	0%	60%	40%	0%	0%	0%
INO Downlands - New Hydro	usNew Hydro3	20000	90%	10%	0%	0%	60%	40%	0%	0%	0%
INO Gravity	usWaitaki	50000	90%	10%	0%	0%	60%	40%	0%	0%	0%
Lower Waitaki Irrigation Scheme	BlkPntStwrdRd	3000	100%	0%	0%	0%	100%	0%	0%	0%	0%
Lower Waitaki Irrigation Scheme - New Hydro	usNew Hydro6	3000	100%	0%	0%	0%	100%	0%	0%	0%	0%
Hakataramea Valley	usWaitaki	6000	90%	10%	0%	0%	90%	0%	5%	0%	5%
North Bank / Elephant Hill Area	WaitakiBlkPnt	6000	100%	0%	0%	0%	28%	34%	0%	7%	30%
Waihao Downs	WaitakiBlkPnt	14000	100%	0%	0%	0%	28%	34%	0%	7%	30%
'Called in' Consents - Below Waitaki Dam	BlkPntStwrdRd	1500	100%	0%	0%	0%	18%	70%	10%	0%	3%

B.1 Changes to SKM agricultural contribution ($/ha gross margin, EBITDA)

Mackenzie dryland grazing

SKM used 0.4 – 1su/ha. The range has been altered to 0.2 to 3su/ha. The SKM figures used amount to $35/su, but this appears high, with the current average for the Mackenzie closer to $25/su. However the mid point is a low number and the differences at this level will be less than the margins of error.

The 'Mid' scenario is not a mid-point in this set of assumptions as it is for many of the others. There are two reasons for this:

- We have accepted the argument that in the Mackenzie landholders will tend to irrigate the lowest producing land, since this returns the highest net gain to them from the investment.
- While it is true that with development the dryland is capable of returning more than the mid point, the risks of such development appear high and they are unlikely to be undertaken on the subject land without irrigation.

Irrigated arable Mackenzie

The range has been brought in line with stakeholders' assumptions.

Irrigated dairy support

The SKM estimates are substantially higher than the returns from grazing. It is unlikely that dairy support returns would be significantly higher than grazing, and for this reason the returns are set as equivalent to the grazing returns.

Mackenzie irrigated grazing

The range for the high gross margin assumption has been moved to $900/ha to bring it in line with stakeholder assumptions. This is based on a very high pasture production assumption (14,000–15,000kg/ha) and a finishing system which appears very high relative to other pasture production estimates. The mid-point estimate has been moved to $565/ha.

All other changes are for 'Elsewhere' in the region.

Dryland grazing

Change brings low and high estimates in line with stakeholder assumptions.

Dryland arable

Change brings low and high estimates in line with stakeholders' assumptions. SKM's estimate appears reasonable for a mid-point.

Irrigated grazing

The estimate of $300/ha for sheep and beef was too low and no irrigation would proceed at that level.

The issue of inclusion of impacts from dryland associated with irrigated agriculture is difficult. We accept that there is some impact, largely associated with a reduction in transaction costs, improved management decision making, and a reduction in risk associated with operating in two markets (irrigation allows the operator to move out of the store market and be exposed only to the finishing market risk. A store seller experiences the variability in both the store and finishing market).

However it is not accepted that the entire benefit from dryland should be attributed to the irrigated property. This is because:

- Many of the difficulties can be overcome by contractual arrangements.
- There are dryland operators who are developing their properties in the absence of irrigation, so the willingness to accept risk is individual rather than universal.
- There are properties where the dryland and irrigated blocks are operated as essentially two different systems, and synergies are largely not realised.
- The capital costs of dryland development have not been included in the transition costs.

The SKM figures have been adjusted so that the 'high' revision takes into account all the impact from irrigated on dryland, and the mid-point is weighted toward the low and has some but not all of the impact from irrigation on associated dryland management.

Irrigated dairy

Change brings range in line with stakeholders' assumptions. Weighted toward the 'low' side estimates as this is more in line with MAF Farm Monitoring estimates.

Dairy support

Revision brings range in line with stakeholders' assumptions.

Irrigated deer

Revision brings range in line with stakeholders' assumptions.

Irrigated arable

Revision brings range in line with stakeholders' assumptions and includes trading livestock in the autumn which appears more realistic for a typical arable irrigation scenario. High figure includes approximately 10% in process crops. However information from processors in the area indicates that this level is unlikely across the board. The mid-point is therefore weighted toward the 'low' estimate.

B.2 Off-farm capital costs

This comprises costs for establishment of the irrigation infrastructure. In the Mackenzie Basin the SKM estimate is $1,500/ha, which is the standard cost for off-farm infrastructure. The evidence is limited in regard to costs in this area, but there are likely to be a number of options in the Mackenzie Basin for very inexpensive delivery systems associated with the canal system. Ian McIndoe (Aqualinc, pers. comm.) has indicated that a more appropriate average cost for this area would be in the order of the 'mid hundreds', and a figure of $500/ha has accordingly been adopted. It should be noted that this will only be applicable where limited areas are proposed to be irrigated – the cheaper development options. Where very large scale irrigation is proposed (ie beyond the 10,000ha indicated in this report) these costs are likely to increase as more expensive delivery systems are required.

Above Ohau, off-farm capital has been changed to $500/ha based on estimates which have been made by Aqualinc (Ian McIndoe, pers comm.). The 'Above Ohau off-farm O+M' has been changed to the same estimates for the AWT scheme, on the basis that they are similar scheme types ($45/ha/year). Note that these costs are based on relatively small total area within the Mackenzie being irrigated, and the cheaper options such as direct takes from canals being implemented. As more area is assigned to irrigation in the Mackenzie we would expect the costs to increase.

B.3 On-farm capital costs

This comprises costs for establishment of the irrigation system only. The SKM figures were increased to reflect the fact that irrigation development costs appear to have moved up considerably in the last year. For example a typical recent centre pivot development with no additional complications had an actual cost of $2,700/ha.

Potential irrigators in the Mackenzie area have indicated that most irrigation development is likely to be centre pivot. However the assumptions for the main land use type, irrigated grazing, have tended to assume lower cost approaches to irrigation. On this basis the on farm capital costs for the Mackenzie are lower than they should. Unfortunately the model is unable to accommodate changes to on farm capital costs by area, and this remains unresolved in the final results.

B.4 Transition costs

The dairy estimates of transition costs were adjusted to include Fonterra shares. These had been excluded on the basis that they were transfer costs. However investigation revealed that:

- The payout to dairy farmers effectively includes a return to production and a return to the shares from processing and marketing activities. To include the full payout but not the capital charge to achieve the payout is not correct.
- The share purchase does not represent a transfer payment – the capital is used for expansion of processing plant and other capabilities. In a static pool of growers it may represent a transfer if the entrant were matched by a departing operator, but this does not appear to be the case at present.

The transition costs of Dairy Support were altered downward to reflect the small capital requirement without stock and machinery.

The transition costs for arable are low on the basis that they would typically represent a movement from dryland arable to irrigated arable production. However in the case of the Waihao Downs area and North Bank/Elephant schemes the irrigated arable areas are significantly higher than the dryland areas following the changes made below. Unfortunately the model is not able to accommodate different transition costs by scheme, and so this represents an under costing of the costs of transition for those schemes which has not been resolved.

B.5 Land use areas

SKM use a figure of 70% dairying in the Waihao Downs area and North Bank/Elephant Hill. A copy of the *North Waihao Irrigation Scheme Prefeasibility Study* was obtained which indicates that this figure should be closer to 27% as there are drainage constraints on achieving that level of dairying (Stu Ford, pers.comm. 2004). A revised estimate of land use in these areas is shown above in Table 33.

B.6 Water use assumptions

Irrigation demands for arable have been adjusted to increase water use up to 5/6ths of an equivalent dairy support property. It is possible that as production systems become more intensive, that arable demands will equivalent to those of pastoral land uses.

All pasture-based livestock systems have been changed to the same water use requirements based on irrigated grazing estimates. There is no obvious reason why these should be differentiated.

In common with the SKM approach the estimates do not address the issue of net water use. This is potentially significant in catchment, because any water which passes to groundwater or surface run off would potentially re-enter the surface system and pass through at least part of the hydro generation system. It is appropriate to use gross water use for allocation purposes because any increases in efficiency would mean that a net water use approach would lead to over allocation. However in a cost benefit approach, while increases in efficiency would result in less water re-entering the hydro system, they would involve concomitant increases in agricultural production benefits. Assessing net water use in relation to energy losses is a complex issue, but one which deserves at least qualitative consideration by decision makers.

Appendix C Agricultural Assumptions Used – High Regional Development Scenario

The land use scenario chosen was generated based on:

- a reduction in grazing, with the remaining grazing production based on high returning systems. Processing remained at proportionately the same level
- an increase in horticulture. A very high value model crop was chosen with high returns to landholders. Current levels of processing were maintained, with all processing carried out in the region
- viticulture was assumed to reach the size of a Gisborne, or about half the size of Marlborough over the study period (~2000ha). All processing was carried out in the region
- arable cropping with high levels of processed vegetable and seed production, and all soils suitable for arable production were utilised. All processing was carried out in the region.

It should be noted that this scenario is not seen as having a high probability of eventuating. It is possible that some of the land uses will turn out as indicated, but the probability that the entire scenario will come to fruition is low. Furthermore it is not obvious that parts of the scenario are dependent on new allocations of water to scheme irrigation. The very high value horticulture and viticulture operations may be locatable on existing irrigated areas, or may be able to access water through other means. This would particularly be the case if water trading were in operation.

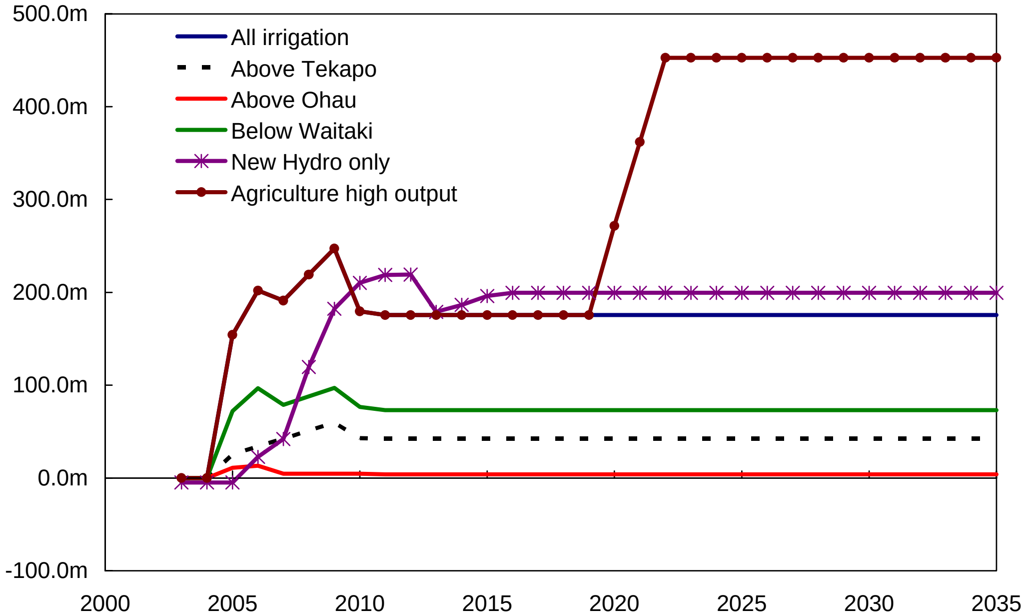
A scheme description of this scenario is given in Table 33, and the results of the impact analysis have been added to a diagram as for Figure 2.

Table 34. Scheme description and land use sssumptions for high regional development scenario

Demand Description	Irrigation Area (ha)	Current Profile (%)		New Profile (%)						
		Dryland		Irrigated						
		Grazing	Arable	Grazing	Dairy	Dairy Support	Deer	Arable	Horticulture	Viticulture
Mackenzie Basin / Ruataniwha District	10000	100%	0%	80%	0%	20%	0%	0%	0%	0%
Aoraki Water Trust Proposal	30000	79%	21%	26%	28%	15%	10%	15%	3%	2%
Lake Benmore, Lake Aviemore	2000	100%	0%	80%	0%	20%	0%	0%	0%	0%
Other 'Called in' Consents - Above Waitaki Dam	1750	100%	0%	80%	0%	20%	0%	0%	0%	0%
INO Downlands	20000	90%	10%	42%	40%	0%	0%	15%	0%	2%
INO Downlands - New Hydro	20000	90%	10%	42%	40%	0%	0%	15%	0%	2%
INO Gravity	50000	90%	10%	42%	40%	0%	0%	15%	0%	2%
Lower Waitaki Irrigation Scheme	3000	100%	0%	85%	0%	0%	0%	15%	0%	0%
Lower Waitaki Irrigation Scheme - New Hydro	3000	100%	0%	85%	0%	0%	0%	15%	0%	0%
Hakataramea Valley	6000	90%	10%	80%	0%	5%	0%	5%	5%	5%
North Bank / Elephant Hill Area	6000	100%	0%	5%	70%	10%	0%	15%	0%	0%
Waihao Downs	14000	100%	0%	5%	70%	10%	0%	15%	0%	0%
'Called in' Consents - Below Waitaki Dam	1500	100%	0%	5%	70%	10%	0%	15%	0%	0%
Total Mackenzie	**16000**	**98%**	**2%**	**80%**	**0%**	**17%**	**0%**	**1%**	**1%**	**1%**
Total Elsewhere	**108250**	**90%**	**10%**	**36%**	**39%**	**5%**	**2%**	**15%**	**1%**	**2%**
Returns ($/ha)		**$180**	**$800**	**$1200**	**$2100**	**$1600**	**$1700**	**$3000**	**$60000**	**$15000**

Figure 6.Total change in value added in regional economy

Dollar millions; New Hydro energy value added included



Source: NZIER

Appendix D Regional economic model results

D.1 New Hydro, no irrigation development

Table 35. Present value of New Hydro under base assumptions (7.5%, 30 Years)

Benefits	*National*		*Regional*		*General Regional Community*	*Primary production sector*	*Energy Sector*
Investment Avoided With New Hydro							
Capital Expenditure	$2063.7m		$0.0m				$0.0m
Operations And Maintenance	$510.2m		$0.0m				$0.0m
Incremental Emissions Benefit	$104.6m		$0.0m				$0.0m
Incremental Fuel Cost Benefit	$237.2m	$2915.6m	$0.0m	$0.0m			$0.0m
Irrigation Sector Expansion							
Increased Agricultural Output	$0.0m	$0.0m	$0.0m	$0.0m		$0.0m	
Net Economy Gain							
Reduced Electricity Charges	$3.7m		$0.1m		$0.1m		
Irrigation Sector Expansion	$0.0m		$0.0m				
Electricity Produced	$0.0m	$3.7m	$1843.5m	$1843.6m			$1843.5m
Total Benefits		$2919.4m		$1843.6m	$0.1m	$0.0m	$1843.5m
Costs							
Investment With New Hydro							
Capital Expenditure	$2099.3m		$794.7m				$794.7m
Operations And Maintenance	$451.4m		$94.1m				$94.1m
Incremental Transmission Costs	$16.8m		$0.0m				$0.0m
Reserve Plant	$0.0m		$0.0m				$0.0m
Agricultural Output Contraction	$46.4m		$46.4m			$46.4m	
On-Farm Infr. - Renew/Mitigate	$1.7m		$1.7m			$1.7m	
O&M- Renew/Mitigate	$2.3m	$2617.7m	$2.3m	$939.2m		$2.3m	
Investment for Irrigation							
Off-Farm Infrastructure	$0.0m		$0.0m			$0.0m	
On-Farm Infrastructure	$0.0m		$0.0m			$0.0m	
On-Farm Transition	$0.0m		$0.0m			$0.0m	
Operations and Maintenance Cost	$0.0m		$0.0m			$0.0m	
Lost Generation Capacity	$0.0m	$0.0m	$0.0m	$0.0m			$0.0m
Total Costs		$2617.7m		$939.2m	$0.0m	$50.4m	$888.8m
Net Present Value 7.5%		**$301.6m**		**$904.4m**	**$0.1m**	**-$50.4m**	**$954.7m**
Net Present Value 10%		**$125.7m**		**$426.5m**	**$0.1m**	**-$41.9m**	**$468.4m**
NPV @ 5%		$667.9m		$2004.2m	$0.1m	-$63.0m	$2067.1m
NPV @ 12.5%		$35.3m		$182.2m	$0.1m	-$36.0m	$218.2m

D.2 Irrigation development, no New Hydro

Table 36. Net present value (7.5%, 30 years) of irrigation, all schemes

Benefits							
	National		*Regional*		*General Regional Community*	*Primary production sector*	*Energy Sector*
Investment Avoided With New Hydro							
Capital Expenditure	$0.0m		$0.0m				$0.0m
Operations And Maintenance	$0.0m		$0.0m				$0.0m
Incremental Emissions Benefit	$0.0m		$0.0m				$0.0m
Incremental Fuel Cost Benefit	$0.0m	$0.0m	$0.0m	$0.0m			$0.0m
Irrigation Sector Expansion							
Increased Agricultural Output	$1189.4m	$1189.4m	$1189.4m	$1189.4m		$1189.4m	
Net Economy Gain							
Reduced Electricity Charges	$0.0m		$0.0m		$0.0m		
Irrigation Sector Expansion	$0.0m		$0.0m				
Electricity Produced	$0.0m	$0.0m	$0.0m	$0.0m			$0.0m
Total Benefits		$1189.4m		$1189.4m	$0.0m	$1189.4m	$0.0m
Costs							
Investment With New Hydro							
Capital Expenditure	$0.0m		$0.0m				$0.0m
Operations And Maintenance	$0.0m		$0.0m				$0.0m
Incremental Transmission Costs	$0.0m		$0.0m				$0.0m
Reserve Plant	$0.0m		$0.0m				$0.0m
Agricultural Output Contraction	$0.0m		$0.0m			$0.0m	
On-Farm Infr. - Renew/Mitigate	$0.0m		$0.0m			$0.0m	
O&M- Renew/Mitigate	$0.0m	$0.0m	$0.0m	$0.0m		$0.0m	
Investment for Irrigation							
Off-Farm Infrastructure	$234.6m		$234.6m			$234.6m	
On-Farm Infrastructure	$193.4m		$193.4m			$193.4m	
On-Farm Transition	$406.8m		$406.8m			$406.8m	
Operations and Maintenance Cost	$107.7m		$107.7m			$107.7m	
Lost Generation Capacity	$135.4m	$1077.9m	$135.4m	$1077.9m			$135.4m
Total Costs		$1077.9m		$1077.9m	$0.0m	$942.4m	$135.4m
Net Present Value 7.5%		**$111.5m**		**$111.5m**	**$0.0m**	**$247.0m**	**-$135.4m**
Net Present Value 10%		**-$55.7m**		**-$55.7m**	**$0.0m**	**$39.1m**	**-$94.8m**
NPV @ 5%		$379.5m		$379.5m	$0.0m	$597.8m	-$218.3m
NPV @ 12.5%		-$157.1m		-$157.1m	$0.0m	-$86.0m	-$71.1m

Table 37. Net present value (7.5%, 30 years) of irrigation schemes if NPV (5%,30yrs) >0

Benefits							
	National		***Regional***		*General Regional Community*	*Primary production sector*	*Energy Sector*
Investment Avoided With New Hydro							
Capital Expenditure	$0.0m		$0.0m				$0.0m
Operations And Maintenance	$0.0m		$0.0m				$0.0m
Incremental Emissions Benefit	$0.0m		$0.0m				$0.0m
Incremental Fuel Cost Benefit	$0.0m	$0.0m	$0.0m	$0.0m			$0.0m
Irrigation Sector Expansion							
Increased Agricultural Output	$799.3m	$799.3m	$799.3m	$799.3m		$799.3m	
Net Economy Gain							
Reduced Electricity Charges	$0.0m		$0.0m		$0.0m		
Irrigation Sector Expansion	$0.0m		$0.0m				
Electricity Produced	$0.0m	$0.0m	$0.0m	$0.0m			$0.0m
Total Benefits		$799.3m		$799.3m	$0.0m	$799.3m	$0.0m
Costs							
Investment With New Hydro							
Capital Expenditure	$0.0m		$0.0m				$0.0m
Operations And Maintenance	$0.0m		$0.0m				$0.0m
Incremental Transmission Costs	$0.0m		$0.0m				$0.0m
Reserve Plant	$0.0m		$0.0m				$0.0m
Agricultural Output Contraction	$0.0m		$0.0m			$0.0m	
On-Farm Infr. - Renew/Mitigate	$0.0m		$0.0m			$0.0m	
O&M- Renew/Mitigate	$0.0m	$0.0m	$0.0m	$0.0m		$0.0m	
Investment for Irrigation							
Off-Farm Infrastructure	$197.7m		$197.7m			$197.7m	
On-Farm Infrastructure	$119.5m		$119.5m			$119.5m	
On-Farm Transition	$298.6m		$298.6m			$298.6m	
Operations and Maintenance Cost	$78.8m		$78.8m			$78.8m	
Lost Generation Capacity	$11.2m	$705.8m	$11.2m	$705.8m			$11.2m
Total Costs		$705.8m		$705.8m	$0.0m	$694.6m	$11.2m
Net Present Value 7.5%		**$93.5m**		**$93.5m**	**$0.0m**	**$104.7m**	**-$11.2m**
Net Present Value 10%		**-$38.7m**		**-$38.7m**	**$0.0m**	**-$30.9m**	**-$7.9m**
NPV @ 5%		$319.0m		$319.0m	$0.0m	$337.1m	-$18.1m
NPV @ 12.5%		-$116.7m		-$116.7m	$0.0m	-$110.8m	-$5.9m

D.3 Irrigation development and New Hydro

Table 38. Net present value (7.5%, 30 years) of irrigation, all schemes

Benefits							
	National		*Regional*		*General Regional Community*	*Primary production sector*	*Energy Sector*
Investment Avoided With New Hydro							
Capital Expenditure	$2063.7m		$0.0m				$0.0m
Operations And Maintenance	$510.2m		$0.0m				$0.0m
Incremental Emissions Benefit	$104.6m		$0.0m				$0.0m
Incremental Fuel Cost Benefit	$237.2m	$2915.6m	$0.0m	$0.0m			$0.0m
Irrigation Sector Expansion							
Increased Agricultural Output	$1189.4m	$1189.4m	$1189.4m	$1189.4m		$1189.4m	
Net Economy Gain							
Reduced Electricity Charges	$3.7m		$0.1m		$0.1m		
Irrigation Sector Expansion	$0.0m		$0.0m				
Electricity Produced	$0.0m	$3.7m	$1843.5m	$1843.6m			$1843.5m
Total Benefits		$4108.8m		$3033.0m	$0.1m	$1189.4m	$1843.5m
Costs							
Investment With New Hydro							
Capital Expenditure	$2099.3m		$794.7m				$794.7m
Operations And Maintenance	$451.4m		$94.1m				$94.1m
Incremental Transmission Costs	$16.8m		$0.0m				$0.0m
Reserve Plant	$0.0m		$0.0m				$0.0m
Agricultural Output Contraction	$46.4m		$46.4m			$46.4m	
On-Farm Infr. - Renew/Mitigate	$1.7m		$1.7m			$1.7m	
O&M- Renew/Mitigate	$2.3m	$2617.7m	$2.3m	$939.2m		$2.3m	
Investment for Irrigation							
Off-Farm Infrastructure	$234.6m		$234.6m			$234.6m	
On-Farm Infrastructure	$193.4m		$193.4m			$193.4m	
On-Farm Transition	$406.8m		$406.8m			$406.8m	
Operations and Maintenance Cost	$107.7m		$107.7m			$107.7m	
Lost Generation Capacity	$320.8m	$1263.2m	$320.8m	$1263.2m			$320.8m
Total Costs		$3881.0m		$2202.4m	$0.0m	$992.8m	$1209.6m
Net Present Value 7.5%		**$227.8m**		**$830.5m**	**$0.1m**	**$196.6m**	**$633.9m**
Net Present Value 10%		**-$50.6m**		**$250.3m**	**$0.1m**	**-$2.8m**	**$253.0m**
NPV @ 5%		$725.1m		$2061.4m	$0.1m	$534.8m	$1526.5m
NPV @ 12.5%		-$205.9m		-$58.9m	$0.1m	-$122.0m	$63.0m

Table 39. Net present value (7.5%, 30 years) of irrigation schemes if NPV (5%,30yrs) > 0

Benefits							
	National		***Regional***		*General Regional Community*	*Primary production sector*	*Energy Sector*
Investment Avoided With New Hydro							
Capital Expenditure	$2063.7m		$0.0m				$0.0m
Operations And Maintenance	$510.2m		$0.0m				$0.0m
Incremental Emissions Benefit	$104.6m		$0.0m				$0.0m
Incremental Fuel Cost Benefit	$237.2m	$2915.6m	$0.0m	$0.0m			$0.0m
Irrigation Sector Expansion							
Increased Agricultural Output	$799.3m	$799.3m	$799.3m	$799.3m		$799.3m	
Net Economy Gain							
Reduced Electricity Charges	$3.7m		$0.1m		$0.1m		
Irrigation Sector Expansion	$0.0m		$0.0m				
Electricity Produced	$0.0m	$3.7m	$1843.5m	$1843.6m			$1843.5m
Total Benefits		$3718.7m		$2642.9m	$0.1m	$799.3m	$1843.5m
Costs							
Investment With New Hydro							
Capital Expenditure	$2099.3m		$794.7m				$794.7m
Operations And Maintenance	$451.4m		$94.1m				$94.1m
Incremental Transmission Costs	$16.8m		$0.0m				$0.0m
Reserve Plant	$0.0m		$0.0m				$0.0m
Agricultural Output Contraction	$46.4m		$46.4m			$46.4m	
On-Farm Infr. - Renew/Mitigate	$1.7m		$1.7m			$1.7m	
O&M- Renew/Mitigate	$2.3m	$2617.7m	$2.3m	$939.2m		$2.3m	
Investment for Irrigation							
Off-Farm Infrastructure	$197.7m		$197.7m			$197.7m	
On-Farm Infrastructure	$119.5m		$119.5m			$119.5m	
On-Farm Transition	$298.6m		$298.6m			$298.6m	
Operations and Maintenance Cost	$78.8m		$78.8m			$78.8m	
Lost Generation Capacity	$136.9m	$831.5m	$136.9m	$831.5m			$136.9m
Total Costs		$3449.3m		$1770.7m	$0.0m	$745.0m	$1025.7m
Net Present Value 7.5%		**$269.4m**		**$872.2m**	**$0.1m**	**$54.3m**	**$817.8m**
Net Present Value 10%		**$4.9m**		**$305.7m**	**$0.1m**	**-$72.8m**	**$378.4m**
NPV @ 5%		$769.4m		$2105.7m	$0.1m	$274.1m	$1831.5m
NPV @ 12.5%		-$138.8m		$8.1m	$0.1m	-$146.8m	$154.8m

D.4 Irrigation development (above Tekapo)

Table 40. Net present value (7.5%, 30 years) of irrigation, no New Hydro installed

Benefits							
	National		*Regional*		*General Regional Community*	*Primary production sector*	*Energy Sector*
Investment Avoided With New Hydro							
Capital Expenditure	$0.0m		$0.0m				$0.0m
Operations And Maintenance	$0.0m		$0.0m				$0.0m
Incremental Emissions Benefit	$0.0m		$0.0m				$0.0m
Incremental Fuel Cost Benefit	$0.0m	$0.0m	$0.0m	$0.0m			$0.0m
Irrigation Sector Expansion							
Increased Agricultural Output	$283.7m	$283.7m	$283.7m	$283.7m		$283.7m	
Net Economy Gain							
Reduced Electricity Charges	$0.0m		$0.0m		$0.0m		
Irrigation Sector Expansion	$0.0m		$0.0m				
Electricity Produced	$0.0m	$0.0m	$0.0m	$0.0m			$0.0m
Total Benefits		$283.7m		$283.7m	$0.0m	$283.7m	$0.0m
Costs							
Investment With New Hydro							
Capital Expenditure	$0.0m		$0.0m				$0.0m
Operations And Maintenance	$0.0m		$0.0m				$0.0m
Incremental Transmission Costs	$0.0m		$0.0m				$0.0m
Reserve Plant	$0.0m		$0.0m				$0.0m
Agricultural Output Contraction	$0.0m		$0.0m			$0.0m	
On-Farm Infr. - Renew/Mitigate	$0.0m		$0.0m			$0.0m	
O&M- Renew/Mitigate	$0.0m	$0.0m	$0.0m	$0.0m		$0.0m	
Investment for Irrigation							
Off-Farm Infrastructure	$23.7m		$23.7m			$23.7m	
On-Farm Infrastructure	$46.6m		$46.6m			$46.6m	
On-Farm Transition	$95.1m		$95.1m			$95.1m	
Operations and Maintenance Cost	$12.5m		$12.5m			$12.5m	
Lost Generation Capacity	$88.4m	$266.4m	$88.4m	$266.4m			$88.4m
Total Costs		$266.4m		$266.4m	$0.0m	$177.9m	$88.4m
Net Present Value 7.5%		**$17.4m**		**$17.4m**	**$0.0m**	**$105.8m**	**-$88.4m**
Net Present Value 10%		**-$10.4m**		**-$10.4m**	**$0.0m**	**$51.1m**	**-$61.5m**
NPV @ 5%		$52.4m		$52.4m	$0.0m	$196.0m	-$143.7m
NPV @ 12.5%		-$28.6m		-$28.6m	$0.0m	$17.1m	-$45.7m

Table 41. Net present value (7.5%, 30 years) of irrigation, New Hydro installed

Benefits							
	National		*Regional*		*General Regional Community*	*Primary production sector*	*Energy Sector*
Investment Avoided With New Hydro							
Capital Expenditure	$2063.7m		$0.0m				$0.0m
Operations And Maintenance	$510.2m		$0.0m				$0.0m
Incremental Emissions Benefit	$104.6m		$0.0m				$0.0m
Incremental Fuel Cost Benefit	$237.2m	$2915.6m	$0.0m	$0.0m			$0.0m
Irrigation Sector Expansion							
Increased Agricultural Output	$283.7m	$283.7m	$283.7m	$283.7m		$283.7m	
Net Economy Gain							
Reduced Electricity Charges	$3.7m		$0.1m		$0.1m		
Irrigation Sector Expansion	$0.0m		$0.0m				
Electricity Produced	$0.0m	$3.7m	$1843.5m	$1843.6m			$1843.5m
Total Benefits		$3203.1m		$2127.3m	$0.1m	$283.7m	$1843.5m
Costs							
Investment With New Hydro							
Capital Expenditure	$2099.3m		$794.7m				$794.7m
Operations And Maintenance	$451.4m		$94.1m				$94.1m
Incremental Transmission Costs	$16.8m		$0.0m				$0.0m
Reserve Plant	$0.0m		$0.0m				$0.0m
Agricultural Output Contraction	$46.4m		$46.4m			$46.4m	
On-Farm Infr. - Renew/Mitigate	$1.7m		$1.7m			$1.7m	
O&M- Renew/Mitigate	$2.3m	$2617.7m	$2.3m	$939.2m		$2.3m	
Investment for Irrigation							
Off-Farm Infrastructure	$23.7m		$23.7m			$23.7m	
On-Farm Infrastructure	$46.6m		$46.6m			$46.6m	
On-Farm Transition	$95.1m		$95.1m			$95.1m	
Operations and Maintenance Cost	$12.5m		$12.5m			$12.5m	
Lost Generation Capacity	$121.8m	$299.7m	$121.8m	$299.7m			$121.8m
Total Costs		$2917.5m		$1238.9m	$0.0m	$228.3m	$1010.6m
Net Present Value 7.5%		**$285.6m**		**$888.4m**	**$0.1m**	**$55.4m**	**$832.9m**
Net Present Value 10%		**$93.9m**		**$394.7m**	**$0.1m**	**$9.2m**	**$385.5m**
NPV @ 5%		$661.5m		$1997.7m	$0.1m	$133.0m	$1864.7m
NPV @ 12.5%		-$8.1m		$138.9m	$0.1m	-$18.9m	$157.7m

D.5 Irrigation development (above Ohau)

Table 42. Net present value (7.5%, 30 years) of irrigation, no New Hydro installed

Benefits							
	National		*Regional*		*General Regional Community*	*Primary production sector*	*Energy Sector*
Investment Avoided With New Hydro							
Capital Expenditure	$0.0m		$0.0m				$0.0m
Operations And Maintenance	$0.0m		$0.0m				$0.0m
Incremental Emissions Benefit	$0.0m		$0.0m				$0.0m
Incremental Fuel Cost Benefit	$0.0m	$0.0m	$0.0m	$0.0m			$0.0m
Irrigation Sector Expansion							
Increased Agricultural Output	$58.1m	$58.1m	$58.1m	$58.1m		$58.1m	
Net Economy Gain							
Reduced Electricity Charges	$0.0m		$0.0m		$0.0m		
Irrigation Sector Expansion	$0.0m		$0.0m				
Electricity Produced	$0.0m	$0.0m	$0.0m	$0.0m			$0.0m
Total Benefits		$58.1m		$58.1m	$0.0m	$58.1m	$0.0m
Costs							
Investment With New Hydro							
Capital Expenditure	$0.0m		$0.0m				$0.0m
Operations And Maintenance	$0.0m		$0.0m				$0.0m
Incremental Transmission Costs	$0.0m		$0.0m				$0.0m
Reserve Plant	$0.0m		$0.0m				$0.0m
Agricultural Output Contraction	$0.0m		$0.0m			$0.0m	
On-Farm Infr. - Renew/Mitigate	$0.0m		$0.0m			$0.0m	
O&M- Renew/Mitigate	$0.0m	$0.0m	$0.0m	$0.0m		$0.0m	
Investment for Irrigation							
Off-Farm Infrastructure	$4.1m		$4.1m			$4.1m	
On-Farm Infrastructure	$15.8m		$15.8m			$15.8m	
On-Farm Transition	$7.4m		$7.4m			$7.4m	
Operations and Maintenance Cost	$4.7m		$4.7m			$4.7m	
Lost Generation Capacity	$31.4m	$63.4m	$31.4m	$63.4m			$31.4m
Total Costs		$63.4m		$63.4m	$0.0m	$32.0m	$31.4m
Net Present Value 7.5%		**-$5.2m**		**-$5.2m**	**$0.0m**	**$26.2m**	**-$31.4m**
Net Present Value 10%		**-$6.9m**		**-$6.9m**	**$0.0m**	**$15.5m**	**-$22.4m**
NPV @ 5%		-$6.6m		-$6.6m	$0.0m	$42.9m	-$49.5m
NPV @ 12.5%		-$8.6m		-$8.6m	$0.0m	$8.5m	-$17.1m

Table 43. Net present value (7.5%, 30 years) of irrigation, New Hydro installed

Benefits							
	National		***Regional***		*General Regional Community*	*Primary production sector*	*Energy Sector*
Investment Avoided With New Hydro							
Capital Expenditure	$2063.7m		$0.0m				$0.0m
Operations And Maintenance	$510.2m		$0.0m				$0.0m
Incremental Emissions Benefit	$104.6m		$0.0m				$0.0m
Incremental Fuel Cost Benefit	$237.2m	$2915.6m	$0.0m	$0.0m			$0.0m
Irrigation Sector Expansion							
Increased Agricultural Output	$58.1m	$58.1m	$58.1m	$58.1m		$58.1m	
Net Economy Gain							
Reduced Electricity Charges	$3.7m		$0.1m		$0.1m		
Irrigation Sector Expansion	$0.0m		$0.0m				
Electricity Produced	$0.0m	$3.7m	$1843.5m	$1843.6m			$1843.5m
Total Benefits		$2977.5m		$1901.7m	$0.1m	$58.1m	$1843.5m
Costs							
Investment With New Hydro							
Capital Expenditure	$2099.3m		$794.7m				$794.7m
Operations And Maintenance	$451.4m		$94.1m				$94.1m
Incremental Transmission Costs	$16.8m		$0.0m				$0.0m
Reserve Plant	$0.0m		$0.0m				$0.0m
Agricultural Output Contraction	$46.4m		$46.4m			$46.4m	
On-Farm Infr. - Renew/Mitigate	$1.7m		$1.7m			$1.7m	
O&M- Renew/Mitigate	$2.3m	$2617.7m	$2.3m	$939.2m		$2.3m	
Investment for Irrigation							
Off-Farm Infrastructure	$4.1m		$4.1m			$4.1m	
On-Farm Infrastructure	$15.8m		$15.8m			$15.8m	
On-Farm Transition	$7.4m		$7.4m			$7.4m	
Operations and Maintenance Cost	$4.7m		$4.7m			$4.7m	
Lost Generation Capacity	$45.6m	$77.6m	$45.6m	$77.6m			$45.6m
Total Costs		$2695.3m		$1016.8m	$0.0m	$82.4m	$934.4m
Net Present Value 7.5%		**$282.2m**		**$884.9m**	**$0.1m**	**-$24.2m**	**$909.1m**
Net Present Value 10%		**$109.6m**		**$410.4m**	**$0.1m**	**-$26.4m**	**$436.8m**
NPV @ 5%		$636.4m		$1972.6m	$0.1m	-$20.1m	$1992.6m
NPV @ 12.5%		$20.3m		$167.2m	$0.1m	-$27.5m	$194.7m

D.6 Irrigation development (above Benmore)

Table 44. Net present value (7.5%, 30 years) of irrigation, no New Hydro installed

Benefits							
	National		*Regional*		*General Regional Community*	*Primary production sector*	*Energy Sector*
Investment Avoided With New Hydro							
Capital Expenditure	$0.0m		$0.0m				$0.0m
Operations And Maintenance	$0.0m		$0.0m				$0.0m
Incremental Emissions Benefit	$0.0m		$0.0m				$0.0m
Incremental Fuel Cost Benefit	$0.0m	$0.0m	$0.0m	$0.0m			$0.0m
Irrigation Sector Expansion							
Increased Agricultural Output	$16.7m	$16.7m	$16.7m	$16.7m		$16.7m	
Net Economy Gain							
Reduced Electricity Charges	$0.0m		$0.0m		$0.0m		
Irrigation Sector Expansion	$0.0m		$0.0m				
Electricity Produced	$0.0m	$0.0m	$0.0m	$0.0m			$0.0m
Total Benefits		$16.7m		$16.7m	$0.0m	$16.7m	$0.0m
Costs							
Investment With New Hydro							
Capital Expenditure	$0.0m		$0.0m				$0.0m
Operations And Maintenance	$0.0m		$0.0m				$0.0m
Incremental Transmission Costs	$0.0m		$0.0m				$0.0m
Reserve Plant	$0.0m		$0.0m				$0.0m
Agricultural Output Contraction	$0.0m		$0.0m			$0.0m	
On-Farm Infr. - Renew/Mitigate	$0.0m		$0.0m			$0.0m	
O&M- Renew/Mitigate	$0.0m	$0.0m	$0.0m	$0.0m		$0.0m	
Investment for Irrigation							
Off-Farm Infrastructure	$2.5m		$2.5m			$2.5m	
On-Farm Infrastructure	$3.2m		$3.2m			$3.2m	
On-Farm Transition	$1.5m		$1.5m			$1.5m	
Operations and Maintenance Cost	$4.7m		$4.7m			$4.7m	
Lost Generation Capacity	$3.5m	$15.3m	$3.5m	$15.3m			$3.5m
Total Costs		$15.3m		$15.3m	$0.0m	$11.8m	$3.5m
Net Present Value 7.5%		**$1.5m**		**$1.5m**	**$0.0m**	**$4.9m**	**-$3.5m**
Net Present Value 10%		**$0.1m**		**$0.1m**	**$0.0m**	**$2.6m**	**-$2.5m**
NPV @ 5%		$3.2m		$3.2m	$0.0m	$8.6m	-$5.5m
NPV @ 12.5%		-$0.8m		-$0.8m	$0.0m	$1.0m	-$1.9m

Table 45. Net present value (7.5%, 30 years) of irrigation, New Hydro installed

	National		*Regional*		*General Regional Community*	*Primary production sector*	*Energy Sector*
Benefits							
Investment Avoided With New Hydro							
Capital Expenditure	$2063.7m		$0.0m				$0.0m
Operations And Maintenance	$510.2m		$0.0m				$0.0m
Incremental Emissions Benefit	$104.6m		$0.0m				$0.0m
Incremental Fuel Cost Benefit	$237.2m	$2915.6m	$0.0m	$0.0m			$0.0m
Irrigation Sector Expansion							
Increased Agricultural Output	$16.7m	$16.7m	$16.7m	$16.7m		$16.7m	
Net Economy Gain							
Reduced Electricity Charges	$3.7m		$0.1m		$0.1m		
Irrigation Sector Expansion	$0.0m		$0.0m				
Electricity Produced	$0.0m	$3.7m	$1843.5m	$1843.6m			$1843.5m
Total Benefits		$2936.1m		$1860.3m	$0.1m	$16.7m	$1843.5m
Costs							
Investment With New Hydro							
Capital Expenditure	$2099.3m		$794.7m				$794.7m
Operations And Maintenance	$451.4m		$94.1m				$94.1m
Incremental Transmission Costs	$16.8m		$0.0m				$0.0m
Reserve Plant	$0.0m		$0.0m				$0.0m
Agricultural Output Contraction	$46.4m		$46.4m			$46.4m	
On-Farm Infr. - Renew/Mitigate	$1.7m		$1.7m			$1.7m	
O&M- Renew/Mitigate	$2.3m	$2617.7m	$2.3m	$939.2m		$2.3m	
Investment for Irrigation							
Off-Farm Infrastructure	$2.5m		$2.5m			$2.5m	
On-Farm Infrastructure	$3.2m		$3.2m			$3.2m	
On-Farm Transition	$1.5m		$1.5m			$1.5m	
Operations and Maintenance Cost	$4.7m		$4.7m			$4.7m	
Lost Generation Capacity	$6.9m	$18.7m	$6.9m	$18.7m			$6.9m
Total Costs		$2636.4m		$957.9m	$0.0m	$62.2m	$895.7m
Net Present Value 7.5%		**$299.7m**		**$902.4m**	**$0.1m**	**-$45.5m**	**$947.8m**
Net Present Value 10%		**$123.6m**		**$424.4m**	**$0.1m**	**-$39.3m**	**$463.7m**
NPV @ 5%		$665.2m		$2001.4m	$0.1m	-$54.4m	$2055.7m
NPV @ 12.5%		$32.9m		$179.8m	$0.1m	-$35.0m	$214.7m

D.7 Irrigation development (below Waitaki Dam)

Table 46. Net present value (7.5%, 30 years) of irrigation, no New Hydro & no integration

Benefits	*National*		*Regional*		*General Regional Community*	*Primary production sector*	*Energy Sector*
Investment Avoided With New Hydro							
Capital Expenditure	$0.0m		$0.0m				$0.0m
Operations And Maintenance	$0.0m		$0.0m				$0.0m
Incremental Emissions Benefit	$0.0m		$0.0m				$0.0m
Incremental Fuel Cost Benefit	$0.0m	$0.0m	$0.0m	$0.0m			$0.0m
Irrigation Sector Expansion							
Increased Agricultural Output	$483.9m	$483.9m	$483.9m	$483.9m		$483.9m	
Net Economy Gain							
Reduced Electricity Charges	$0.0m		$0.0m		$0.0m		
Irrigation Sector Expansion	$0.0m		$0.0m				
Electricity Produced	$0.0m	$0.0m	$0.0m	$0.0m			$0.0m
Total Benefits		$483.9m		$483.9m	$0.0m	$483.9m	$0.0m
Costs							
Investment With New Hydro							
Capital Expenditure	$0.0m		$0.0m				$0.0m
Operations And Maintenance	$0.0m		$0.0m				$0.0m
Incremental Transmission Costs	$0.0m		$0.0m				$0.0m
Reserve Plant	$0.0m		$0.0m				$0.0m
Agricultural Output Contraction	$0.0m		$0.0m			$0.0m	
On-Farm Infr. - Renew/Mitigate	$0.0m		$0.0m			$0.0m	
O&M- Renew/Mitigate	$0.0m	$0.0m	$0.0m	$0.0m		$0.0m	
Investment for Irrigation							
Off-Farm Infrastructure	$80.1m		$80.1m			$80.1m	
On-Farm Infrastructure	$71.7m		$71.7m			$71.7m	
On-Farm Transition	$174.1m		$174.1m			$174.1m	
Operations and Maintenance Cost	$90.9m		$90.9m			$90.9m	
Lost Generation Capacity	$0.0m	$416.7m	$0.0m	$416.7m			$0.0m
Total Costs		$416.7m		$416.7m	$0.0m	$416.7m	$0.0m
Net Present Value 7.5%		**$67.2m**		**$67.2m**	**$0.0m**	**$67.2m**	**$0.0m**
Net Present Value 10%		**-$6.0m**		**-$6.0m**	**$0.0m**	**-$6.0m**	**$0.0m**
NPV @ 5%		$190.7m		$190.7m	$0.0m	$190.7m	$0.0m
NPV @ 12.5%		-$50.0m		-$50.0m	$0.0m	-$50.0m	$0.0m

Table 47. Net present value (7.5%, 30 years) of irrigation, New Hydro & no integration

Benefits							
	National		*Regional*		*General Regional Community*	*Primary production sector*	*Energy Sector*
Investment Avoided With New Hydro							
Capital Expenditure	$2063.7m		$0.0m				$0.0m
Operations And Maintenance	$510.2m		$0.0m				$0.0m
Incremental Emissions Benefit	$104.6m		$0.0m				$0.0m
Incremental Fuel Cost Benefit	$237.2m	$2915.6m	$0.0m	$0.0m			$0.0m
Irrigation Sector Expansion							
Increased Agricultural Output	$483.9m	$483.9m	$483.9m	$483.9m		$483.9m	
Net Economy Gain							
Reduced Electricity Charges	$3.7m		$0.1m		$0.1m		
Irrigation Sector Expansion	$0.0m		$0.0m				
Electricity Produced	$0.0m	$3.7m	$1843.5m	$1843.6m			$1843.5m
Total Benefits		$3403.3m		$2327.5m	$0.1m	$483.9m	$1843.5m
Costs							
Investment With New Hydro							
Capital Expenditure	$2099.3m		$794.7m				$794.7m
Operations And Maintenance	$451.4m		$94.1m				$94.1m
Incremental Transmission Costs	$16.8m		$0.0m				$0.0m
Reserve Plant	$0.0m		$0.0m				$0.0m
Agricultural Output Contraction	$46.4m		$46.4m			$46.4m	
On-Farm Infr. - Renew/Mitigate	$1.7m		$1.7m			$1.7m	
O&M- Renew/Mitigate	$2.3m	$2617.7m	$2.3m	$939.2m		$2.3m	
Investment for Irrigation							
Off-Farm Infrastructure	$80.1m		$80.1m			$80.1m	
On-Farm Infrastructure	$71.7m		$71.7m			$71.7m	
On-Farm Transition	$174.1m		$174.1m			$174.1m	
Operations and Maintenance Cost	$90.9m		$90.9m			$90.9m	
Lost Generation Capacity	$70.7m	$487.4m	$70.7m	$487.4m			$70.7m
Total Costs		$3105.1m		$1426.6m	$0.0m	$467.0m	$959.5m
Net Present Value 7.5%		**$298.1m**		**$900.9m**	**$0.1m**	**$16.9m**	**$884.0m**
Net Present Value 10%		**$73.5m**		**$374.3m**	**$0.1m**	**-$47.9m**	**$422.2m**
NPV @ 5%		$736.3m		$2072.6m	$0.1m	$127.7m	$1944.8m
NPV @ 12.5%		-$47.1m		$99.8m	$0.1m	-$86.0m	$185.8m

Table 48. Net present value (7.5%, 30 years) of irrigation, New Hydro & integration

Benefits							
	National		*Regional*		*General Regional Community*	*Primary production sector*	*Energy Sector*
Investment Avoided With New Hydro							
Capital Expenditure	$2063.7m		$0.0m				$0.0m
Operations And Maintenance	$510.2m		$0.0m				$0.0m
Incremental Emissions Benefit	$104.6m		$0.0m				$0.0m
Incremental Fuel Cost Benefit	$237.2m	$2915.6m	$0.0m	$0.0m			$0.0m
Irrigation Sector Expansion							
Increased Agricultural Output	$483.9m	$483.9m	$483.9m	$483.9m		$483.9m	
Net Economy Gain							
Reduced Electricity Charges	$3.7m		$0.1m		$0.1m		
Irrigation Sector Expansion	$0.0m		$0.0m				
Electricity Produced	$0.0m	$3.7m	$1843.5m	$1843.6m			$1843.5m
Total Benefits		$3403.3m		$2327.5m	$0.1m	$483.9m	$1843.5m
Costs							
Investment With New Hydro							
Capital Expenditure	$2099.3m		$794.7m				$794.7m
Operations And Maintenance	$451.4m		$94.1m				$94.1m
Incremental Transmission Costs	$16.8m		$0.0m				$0.0m
Reserve Plant	$0.0m		$0.0m				$0.0m
Agricultural Output Contraction	$46.4m		$46.4m			$46.4m	
On-Farm Infr. - Renew/Mitigate	$1.7m		$1.7m			$1.7m	
O&M- Renew/Mitigate	$2.3m	$2617.7m	$2.3m	$939.2m		$2.3m	
Investment for Irrigation							
Off-Farm Infrastructure	$80.1m		$80.1m			$80.1m	
On-Farm Infrastructure	$71.7m		$71.7m			$71.7m	
On-Farm Transition	$174.1m		$174.1m			$174.1m	
Operations and Maintenance Cost	$72.4m		$72.4m			$72.4m	
Lost Generation Capacity	$57.1m	$455.2m	$57.1m	$455.2m			$57.1m
Total Costs		$3073.0m		$1394.4m	$0.0m	$448.5m	$945.9m
Net Present Value 7.5%		**$330.3m**		**$933.1m**	**$0.1m**	**$35.4m**	**$897.6m**
Net Present Value 10%		**$96.4m**		**$397.3m**	**$0.1m**	**-$33.8m**	**$431.1m**
NPV @ 5%		$785.3m		$2121.5m	$0.1m	$153.1m	$1968.4m
NPV @ 12.5%		-$30.0m		$117.0m	$0.1m	-$75.1m	$192.0m

Appendix E Economic results sensitivity testing

E.1 New Hydro capital cost sensitivity

Table 49. Net present value (7.5%, 30 years) New Hydro & no irrigation. Capital costs +20%

Benefits							
	National		*Regional*		*General Regional Community*	*Primary production sector*	*Energy Sector*
Investment Avoided With New Hydro							
Capital Expenditure	$2063.7m		$0.0m				$0.0m
Operations And Maintenance	$510.2m		$0.0m				$0.0m
Incremental Emissions Benefit	$104.6m		$0.0m				$0.0m
Incremental Fuel Cost Benefit	$237.2m	$2915.6m	$0.0m	$0.0m			$0.0m
Irrigation Sector Expansion							
Increased Agricultural Output	$0.0m	$0.0m	$0.0m	$0.0m		$0.0m	
Net Economy Gain							
Reduced Electricity Charges	$3.7m		$0.1m		$0.1m		
Irrigation Sector Expansion	$0.0m		$0.0m				
Electricity Produced	$0.0m	$3.7m	$1843.5m	$1843.6m			$1843.5m
Total Benefits		$2919.4m		$1843.6m	$0.1m	$0.0m	$1843.5m
Costs							
Investment With New Hydro							
Capital Expenditure	$2247.9m		$943.4m				$943.4m
Operations And Maintenance	$451.4m		$94.1m				$94.1m
Incremental Transmission Costs	$16.8m		$0.0m				$0.0m
Reserve Plant	$0.0m		$0.0m				$0.0m
Agricultural Output Contraction	$46.4m		$46.4m			$46.4m	
On-Farm Infr. - Renew/Mitigate	$1.7m		$1.7m			$1.7m	
O&M- Renew/Mitigate	$2.3m	$2766.4m	$2.3m	$1087.9m		$2.3m	
Investment for Irrigation							
Off-Farm Infrastructure	$0.0m		$0.0m			$0.0m	
On-Farm Infrastructure	$0.0m		$0.0m			$0.0m	
On-Farm Transition	$0.0m		$0.0m			$0.0m	
Operations and Maintenance Cost	$0.0m		$0.0m			$0.0m	
Lost Generation Capacity	$0.0m	$0.0m	$0.0m	$0.0m			$0.0m
Total Costs		$2766.4m		$1087.9m	$0.0m	$50.4m	$1037.5m
Net Present Value 7.5%		**$152.9m**		**$755.7m**	**$0.1m**	**-$50.4m**	**$806.0m**
Net Present Value 10%		**-$4.1m**		**$296.7m**	**$0.1m**	**-$41.9m**	**$338.5m**
NPV @ 5%		$496.8m		$1833.1m	$0.1m	-$63.0m	$1896.0m
NPV @ 12.5%		-$78.6m		$68.4m	$0.1m	-$36.0m	$104.3m

Table 50. Net present value (7.5%, 30 years) New Hydro & no irrigation. Capital costs +50%

Benefits							
	National		*Regional*		*General Regional Community*	*Primary production sector*	*Energy Sector*
Investment Avoided With New Hydro							
Capital Expenditure	$2063.7m		$0.0m				$0.0m
Operations And Maintenance	$510.2m		$0.0m				$0.0m
Incremental Emissions Benefit	$104.6m		$0.0m				$0.0m
Incremental Fuel Cost Benefit	$237.2m	$2915.6m	$0.0m	$0.0m			$0.0m
Irrigation Sector Expansion							
Increased Agricultural Output	$0.0m	$0.0m	$0.0m	$0.0m		$0.0m	
Net Economy Gain							
Reduced Electricity Charges	$3.7m		$0.1m		$0.1m		
Irrigation Sector Expansion	$0.0m		$0.0m				
Electricity Produced	$0.0m	$3.7m	$1843.5m	$1843.6m			$1843.5m
Total Benefits		$2919.4m		$1843.6m	$0.1m	$0.0m	$1843.5m
Costs							
Investment With New Hydro							
Capital Expenditure	$2471.0m		$1166.4m				$1166.4m
Operations And Maintenance	$451.4m		$94.1m				$94.1m
Incremental Transmission Costs	$16.8m		$0.0m				$0.0m
Reserve Plant	$0.0m		$0.0m				$0.0m
Agricultural Output Contraction	$46.4m		$46.4m			$46.4m	
On-Farm Infr. - Renew/Mitigate	$1.7m		$1.7m			$1.7m	
O&M- Renew/Mitigate	$2.3m	$2989.5m	$2.3m	$1310.9m		$2.3m	
Investment for Irrigation							
Off-Farm Infrastructure	$0.0m		$0.0m			$0.0m	
On-Farm Infrastructure	$0.0m		$0.0m			$0.0m	
On-Farm Transition	$0.0m		$0.0m			$0.0m	
Operations and Maintenance Cost	$0.0m		$0.0m			$0.0m	
Lost Generation Capacity	$0.0m	$0.0m	$0.0m	$0.0m			$0.0m
Total Costs		$2989.5m		$1310.9m	$0.0m	$50.4m	$1260.5m
Net Present Value 7.5%		**-$70.1m**		**$532.7m**	**$0.1m**	**-$50.4m**	**$583.0m**
Net Present Value 10%		**-$198.9m**		**$102.0m**	**$0.1m**	**-$41.9m**	**$143.8m**
NPV @ 5%		$240.2m		$1576.5m	$0.1m	-$63.0m	$1639.4m
NPV @ 12.5%		-$249.3m		-$102.4m	$0.1m	-$36.0m	-$66.4m

Table 51. Net present value (7.5%, 30 years) New Hydro & all irrigation demands. Capital costs +50%

Benefits							
	National		*Regional*		*General Regional Community*	*Primary production sector*	*Energy Sector*
Investment Avoided With New Hydro							
Capital Expenditure	$2063.7m		$0.0m				$0.0m
Operations And Maintenance	$510.2m		$0.0m				$0.0m
Incremental Emissions Benefit	$104.6m		$0.0m				$0.0m
Incremental Fuel Cost Benefit	$237.2m	$2915.6m	$0.0m	$0.0m			$0.0m
Irrigation Sector Expansion							
Increased Agricultural Output	$1189.4m	$1189.4m	$1189.4m	$1189.4m		$1189.4m	
Net Economy Gain							
Reduced Electricity Charges	$3.7m		$0.1m		$0.1m		
Irrigation Sector Expansion	$0.0m		$0.0m				
Electricity Produced	$0.0m	$3.7m	$1843.5m	$1843.6m			$1843.5m
Total Benefits		$4108.8m		$3033.0m	$0.1m	$1189.4m	$1843.5m
Costs							
Investment With New Hydro							
Capital Expenditure	$2471.0m		$1166.4m				$1166.4m
Operations And Maintenance	$451.4m		$94.1m				$94.1m
Incremental Transmission Costs	$16.8m		$0.0m				$0.0m
Reserve Plant	$0.0m		$0.0m				$0.0m
Agricultural Output Contraction	$46.4m		$46.4m			$46.4m	
On-Farm Infr. - Renew/Mitigate	$1.7m		$1.7m			$1.7m	
O&M- Renew/Mitigate	$2.3m	$2989.5m	$2.3m	$1310.9m		$2.3m	
Investment for Irrigation							
Off-Farm Infrastructure	$362.8m		$362.8m			$362.8m	
On-Farm Infrastructure	$292.4m		$292.4m			$292.4m	
On-Farm Transition	$406.8m		$406.8m			$406.8m	
Operations and Maintenance Cost	$107.7m		$107.7m			$107.7m	
Lost Generation Capacity	$320.8m	$1490.3m	$320.8m	$1490.3m			$320.8m
Total Costs		$4479.8m		$2801.2m	$0.0m	$1219.9m	$1581.3m
Net Present Value 7.5%		**-$371.1m**		**$231.7m**	**$0.1m**	**-$30.5m**	**$262.2m**
Net Present Value 10%		**-$584.3m**		**-$283.4m**	**$0.1m**	**-$211.9m**	**-$71.6m**
NPV @ 5%		$50.0m		$1386.3m	$0.1m	$287.5m	$1098.7m
NPV @ 12.5%		-$683.7m		-$536.7m	$0.1m	-$315.2m	-$221.6m

E.2 Irrigation development (above Tekapo) sensitivity test

Table 52. Net present value (7.5%, 30 years) of irrigation, no New Hydro installed, water use set at standard rates (6.3 cumecs)

Benefits	*National*		*Regional*		*General Regional Community*	*Primary production sector*	*Energy Sector*
Investment Avoided With New Hydro							
Capital Expenditure	$0.0m		$0.0m				$0.0m
Operations And Maintenance	$0.0m		$0.0m				$0.0m
Incremental Emissions Benefit	$0.0m		$0.0m				$0.0m
Incremental Fuel Cost Benefit	$0.0m	$0.0m	$0.0m	$0.0m			$0.0m
Irrigation Sector Expansion							
Increased Agricultural Output	$283.7m	$283.7m	$283.7m	$283.7m		$283.7m	
Net Economy Gain							
Reduced Electricity Charges	$0.0m		$0.0m		$0.0m		
Irrigation Sector Expansion	$0.0m		$0.0m				
Electricity Produced	$0.0m	$0.0m	$0.0m	$0.0m			$0.0m
Total Benefits		$283.7m		$283.7m	$0.0m	$283.7m	$0.0m
Costs							
Investment With New Hydro							
Capital Expenditure	$0.0m		$0.0m				$0.0m
Operations And Maintenance	$0.0m		$0.0m				$0.0m
Incremental Transmission Costs	$0.0m		$0.0m				$0.0m
Reserve Plant	$0.0m		$0.0m				$0.0m
Agricultural Output Contraction	$0.0m		$0.0m			$0.0m	
On-Farm Infr. - Renew/Mitigate	$0.0m		$0.0m			$0.0m	
O&M- Renew/Mitigate	$0.0m	$0.0m	$0.0m	$0.0m		$0.0m	
Investment for Irrigation							
Off-Farm Infrastructure	$23.7m		$23.7m			$23.7m	
On-Farm Infrastructure	$46.6m		$46.6m			$46.6m	
On-Farm Transition	$95.1m		$95.1m			$95.1m	
Operations and Maintenance Cost	$12.5m		$12.5m			$12.5m	
Lost Generation Capacity	$144.0m	$321.9m	$144.0m	$321.9m			$144.0m
Total Costs		$321.9m		$321.9m	$0.0m	$177.9m	$144.0m
Net Present Value 7.5%		**-$38.2m**		**-$38.2m**	**$0.0m**	**$105.8m**	**-$144.0m**
Net Present Value 10%		**-$49.0m**		**-$49.0m**	**$0.0m**	**$51.1m**	**-$100.1m**
NPV @ 5%		-$37.9m		-$37.9m	$0.0m	$196.0m	-$233.9m
NPV @ 12.5%		-$57.3m		-$57.3m	$0.0m	$17.1m	-$74.4m

Table 53. Net present value of options, no New Hydro baseline (5% discount rate, 30 year period of analysis) ($million)

Irrigation Demand	Irrigation Area (ha)	Water used (cumecs)	National	Regional	Regional Primary Production outcomes	Regional Energy outcomes
New Hydro (no extra irrigation)	-		$667.9m	$2,004.2m	-$63.0m	$2,067.1m
All Irrigation Demands	124,250	24.1	$379.5m	$379.5m	$597.8m	-$218.3m
All Irrigation Demands >5% IRR[a]	76,250	16.7	$319.0m	$319.0m	$337.1m	$18.1m
Takes above Tekapo	30,000	4.0	$52.4m	$52.4m	$196.0m	-$143.7m
Takes above Ohau	10,000	1.9	-$6.6m	-$6.6m	$42.9m	-$49.5m
Takes above Benmore	2,000	0.4	$3.2m	$3.2m	$8.6m	-$5.5m
Takes Below Waitaki Dam	44,500	9.6	$190.7m	$190.7m	$190.7m	$0.0m

Table 54. Net present value of options, New Hydro baseline (5% discount rate, 30 year period of analysis) ($million)

Irrigation Demand	Irrigation Area (ha)	Water used (cumecs)	National	Regional	Regional Primary Production	Regional Energy
All Irrigation Demands	124,250	24.1	$57.2m	$57.2m	$597.8m	-$540.6m
All Irrigation Demands >5% IRR[a]	76,250	16.7	$101.5m	$101.5m	$337.1m	-$235.6m
Takes above Tekapo	30,000	4.0	-$6.4m	-$6.5m	$196.0m	-$202.4m
Takes above Ohau	10,000	1.9	-$31.5m	-$31.6m	$42.9m	-$74.5m
Takes above Benmore	2,000	0.4	-$2.7m	-$2.8m	$8.6m	-$11.4m
Takes Below Waitaki Dam	44,500	9.6	$68.4m	$68.4m	$190.7m	-$122.3m
Below Waitaki integrated w.New Hydro	44,500	9.6	$117.4m	$117.3m	$216.1m	-$98.7m

Table 55. Net present value of options, no New Hydro baseline (12.5% discount rate, 30 year period of analysis) ($million)

Irrigation Demand	Irrigation Area (ha)	Water used (cumecs)	National	Regional	Regional Primary Production outcomes	Regional Energy outcomes
New Hydro (no extra irrigation)	-		$35.3m	$182.2m	-$36.0m	$218.2m
All Irrigation Demands	124,250	24.1	-$157.1m	-$157.1m	-$86.0m	-$71.1m
All Irrigation Demands >5% IRR[a]	76,250	16.7	-$116.7m	-$116.7m	-$110.8m	-$5.9m
Takes above Tekapo	30,000	4.0	-$28.6m	-$28.6m	$17.1m	-$45.7m
Takes above Ohau	10,000	1.9	-$8.6m	-$8.6m	$8.5m	-$17.1m
Takes above Benmore	2,000	0.4	-$0.8m	-$0.8m	$1.0m	-$1.9m
Takes Below Waitaki Dam	44,500	9.6	-$50.0m	-$50.0m	-$50.0m	$0.0m

Table 56. Net present value of options, New Hydro installed, compared with New Hydro baseline (12.5% discount Rate, 30 year period of analysis) ($million)

Irrigation Demand	Irrigation Area (ha)	Water used (cumecs)	National	Regional	Regional Primary Production	Regional Energy
All Irrigation Demands	124,250	24.1	-$241.2m	-$241.1m	-$86.0m	-$281.2m
All Irrigation Demands >5% IRR[a]	76,250	16.7	-$174.1m	-$174.1m	-$110.8m	-$63.4m
Takes above Tekapo	30,000	4.0	-$43.4m	-$43.3m	$17.1m	-$60.5m
Takes above Ohau	10,000	1.9	-$15.0m	-$15.0m	$10.3m	-$23.5m
Takes above Benmore	2,000	0.4	-$2.4m	-$2.4m	$1.0m	-$3.5m
Takes Below Waitaki Dam	44,500	9.6	-$82.4m	-$82.4m	-$50.0m	-$32.4m
Below Waitaki integrated w.New Hydro	44,500	9.6	-$65.3m	-$65.2m	-$39.1m	-$26.2m

Table 57. Sensitivity test high agricultural GM, low capex, Net present value of options (7.5% discount rate, 30 year period of analysis) ($million)

Scenario (All Agricultural Assumptions upper bound)	National	Regional	Regional Primary Production	Regional Energy
New Hydro only, Low Agricultural Contraction Assumptions	$289.1m	$891.8m	-$62.9m	$954.7m
New Hydro only, Mid Agricultural Contraction Assumptions	$288.7m	$891.5m	-$63.3m	$954.7m
New Hydro only, High Agricultural Contraction Assumptions	$267.1m	$869.9m	-$84.9m	$954.7m
All Irrigation Demands (no New Hydro)	$514.8m	$514.8m	$650.2m	-$135.4m
All Irrigation Demands >5% IRRa(no New Hydro)	$350.3m	$350.3m	$361.5m	-$11.2m
Takes above Tekapo (no New Hydro)	$114.2m	$114.2m	$202.6m	-$88.4m
Takes above Ohau (no New Hydro)	$21.4m	$21.4m	$52.8m	-$31.4m
Takes above Benmore (no New Hydro)	$9.0m	$9.0m	$12.5m	-$3.5m
Takes Below Waitaki Dam (no New Hydro)	$233.5m	$233.5m	$233.5m	$0.0m
Below Waitaki integrated w.New Hydro	$483.6m	$1,086.4m	$188.7m	$897.6m

Table 58. Sensitivity test low agricultural GM, high capex, Net present value of options (7.5% discount rate, 30 year period of analysis) ($million)

Scenario (All Agricultural Assumptions lower bound)	National	Regional	Regional Primary Production	Regional Energy
New Hydro only, Low Agricultural Contraction Assumptions	$310.1m	$912.9m	-$41.8m	$954.7m
New Hydro only, Mid Agricultural Contraction Assumptions	$309.7m	$912.5m	-$42.3m	$954.7m
New Hydro only, High Agricultural Contraction Assumptions	$296.1m	$898.9m	-$55.8m	$954.7m
All Irrigation Demands (no New Hydro)	-$177.2m	-$177.2m	-$41.8m	-$135.5m
All Irrigation Demands >5% IRRa(no New Hydro)	-$60.8m	-$60.8m	-$49.6m	-$11.2m
Takes above Tekapo (no New Hydro)	-$46.4m	-$46.4m	$42.0m	-$88.4m
Takes above Ohau (no New Hydro)	-$46.2m	-$46.2m	-$14.8m	-$31.4m
Takes above Benmore (no New Hydro)	-$5.4m	-$5.4m	-$1.9m	-$3.5m
Takes Below Waitaki Dam (no New Hydro)	-$24.2m	-$24.2m	-$24.2m	$0.0m
Below Waitaki integrated w.New Hydro	$246.9m	$849.7m	-$48.0m	$897.6m

Appendix F Methodology for regional economic impact analysis

At the centre of any input–output analysis is the input–output, or inter-industry transactions table. This quantifies in monetary terms the flows of goods and services between industries and sectors of the economy. The basic layout of such a matrix can be seen in Figure 7.

Figure 7. An input–output transactions table schematic

	Industries 1-50	Final demand categories	Row Totals
Industries 1-50	Quadrant 1 Industry to industry flows Intermediate production and demand	Quadrant 2 Industry to final demand flows	Total output by industry
Primary input categories	Quadrant 3 Primary inputs to production	Quadrant 4 Primary inputs to final demand	Total primary input by category
Column Totals	Total input by industry	Total final demand by category	Total output = Total input

Source: NZIER

There are five basic sectors in an input–output table.

Industries are production sectors, each of which purchases inputs from other sectors. Inputs to an industry are made up of the goods and services purchased from other industries (known as intermediate demand), or primary inputs, which includes everything a firm purchases but which is not classified as an intermediate input (such as wage and salary payments for the purchase of labour, firm profits that accrue to the owners of the firm, and tax payments to the government). Each industry's inputs can be read down the columns of the input output table. Each industry's outputs can be determined by reading along the rows, and the entire output of an industry flows either to one of the other industries, or to one of the final demand categories (see quadrant 2).

Quadrant 2 of the transactions table contains the final demand categories. Regardless of the level of industry aggregation, there are essentially six categories of final demand – residential household consumption, central government, local government, exports, inventories or stocks, and investment (or what economists call capital formation). If the output of an industry is not purchased by another industry, then it is to one of these six categories that industry output will flow. The second broad sector comprises households, who are the individuals and families residing in the economy under study. They appear once in the table as buyers of goods and services; that is, the residential household consumption column of the final demand section. They also show up a second time as sellers of labour in the primary inputs section of the table (ie quadrant 3) where there is a row representing the payments firms make to wage and salary earners. Households are also the owners of capital, receiving part of the firms' profits (gross operating surplus) represented by a row contained in quadrant 3. Some of it accrues to foreign owners of capital while some of it is kept by firms as retained earnings.

The third sector of the economy we consider is the government, which shows up as a final demander of goods and services that it 'purchases' on behalf of the community. It purchases them from the industry called government services. The government also appears in the primary inputs section of the table as the row entity (or rows) to which tax payments are made.

A fourth sector is the outside world, comprising all private economic activity located outside the region under study. This is represented in the transactions table as either imports or exports. Specifically, imports show up as a primary input while exports are a component of final demand.

The final sector in the input–output framework acknowledges is the role of capital. There are two categories of final demand that relate to capital; inventories and investment, which record flows not stocks of capital. The changes in stocks component of final demand may be negative if inventory levels have been allowed to run down during the period covered by the input-output table. Capital also features in the primary inputs section of the transactions matrix, as a row to which payments by firms accrue to the owners of capital (called gross operating surplus); and also in the primary input section by rows that account for depreciation charges (or consumption of fixed capital) and, sometimes, by a row for second-hand asset sales.

We have not yet mentioned quadrant 4. Sometimes primary inputs go straight into final demand without passing through the industry sector of the economy. Two typical examples of such transactions would be tax payments by households directly to the government; for example GST payments, and imports of capital equipment which would appear in the cell denoted by the imports row and the investment column.

F.1 Available input-output tables

Compiling a set of input–output accounts is a major undertaking. Most of the information in the accounts is obtained from surveys. The major inter-industry studies are carried out at a very detailed level – over 200 industry classifications and well over 400 commodities. However, for reasons of confidentiality the results are not published at this level of detail; nor very frequently. The latest inter-industry study published by Statistics New Zealand covers the year ended March 31, 1996.

In addition to the major inter-industry studies, Statistics New Zealand will periodically publish a less detailed set of accounts. While in the past they have done this at intervals of two or three years, in the future this might well be done annually. These 'interim' accounts are more current with respect to the values of industry output, household consumption, tax payments, and the like, but they continue to use information obtained from the major studies to depict input shares and production technologies.

Like its counterparts in other countries, Statistics New Zealand does not produce regional input–output accounts. There is a sizeable literature describing techniques for 'regionalising' a national table. The alternative to employing one of the regionalising techniques is to produce a regional table using survey data. Doing so is very expensive and time-consuming.

F.2 Economic multipliers

Impact analysis is one form of analysis often undertaken within the input–output framework, and requires the calculation of multipliers. A basic tenet of the input–output model is that the various components of final demand (ie. the columns in quadrant II – household consumption, exports, investment, etc) are considered to be exogenous (ie. given, or fixed). Hence, the question one asks when calculating multipliers is: what is the impact on, say, output or value added or employment following an exogenous increase in final demand for the output of the sector of interest? Such an increase might take the form of an increase in export demand, an injection of construction activity or a boost for local production. In other words, given a unit (say, $1 million) increase in final demand for industry j's output, what is the total direct and indirect impact once the economy has responded and settled in a new equilibrium? An output multiplier is simply the figure by which an initial change in output throughout the entire economy should be multiplied to calculate the total change in output resulting from that initial exogenous change (recall that final demand is an element of gross output).

Using the input-output framework, it is easy to see that for an industry to deliver an additional $1 million worth of final demand, that industry is required to directly increase its gross output by $1 million. But that is not the end of the story. To produce an additional $1 million of gross output in one sector, additional inputs to that sector are needed from other industries. And to produce the additional output required in these other industries, additional inputs are needed from yet other industries. And so it continues. This process is sometimes referred to as the *initial* and *subsequent* expenditure rounds. A new equilibrium is attained when the value of a new round of purchases does not change from the current round. The total additional output needed from *all* industries is the amount by which total gross output rises in response to an exogenous $1 million increase in final demand. (The exogenous increase is usually, although not necessarily, associated with a single sector).

While it is possible to compute multipliers for a wide range of economic variables, those of most interest are typically output, value added, employment, and import multipliers. Multipliers are computed on a sectoral basis. The output multiplier for the j^{th} sector is the total change in gross output (or sales) of the entire economy divided by the initial change in output in sector j, where the initial change is nothing more than the exogenous increase in final demand. Income multipliers are defined slightly differently and reflect the total income change in the economy per unit of income generated in the j^{th} sector, where the income change in the j^{th} sector is a direct result of the exogenous increase in final demand of the j^{th} sector.[14] Value added multipliers are similar to those for income, but refer to the increase in value added generated throughout the economy as a result of increased output in the j^{th} sector. Employment multipliers are similarly analogous to the income multipliers except that instead of income, they refer to the number of additional full-time equivalent employees utilised in the economy as a result of increased output in the j^{th} sector.

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[14] Two technical points of clarification are warranted at this juncture. First, the input–output model assumes a linear production technology and thus input requirements increase in proportion to output. Compensation of employees is one such input. Second, we have adjusted the data in the input-output table so that compensation of employees captures payments to the self-employed, proprietors income, and dividend payments, as well as wage and salary payments. It is this adjusted value, net of taxes, that we refer to as household income when we compute income multipliers.

There are two 'types' of each multiplier. Type I multipliers follow the intuition described above. They include the 'direct' effect on output in the industry which experiences an exogenous increase in demand and the 'indirect' effect resulting from the need for all other industries to produce more inputs for that industry. Type II multipliers include an additional effect, the so-called 'induced-income' effect. This arises because as firms produce more output, households receive more income (ie. workers receive wages, investors receive dividends, proprietors receive a return to their management skill, etc), which they in turn spend on food, cars, holidays, TVs and a range of other things. So total output in the industries that produce all these other goods also rises as final demand has increased. Hence, increased output means increased income for households which *induces* yet more consumption and therefore output, which creates additional income. Like the Type I multiplier, the Type II multiplier measures the impact at the point at which a new equilibrium is reached.

Type I multipliers are likely to understate the economic impact, because they exclude the induced-income effect. However, Type II multipliers are likely to overstate the impact, because the way the input-output model is constructed with linear production technology and inputs that increase in proportion to outputs, it understated input constraints and the likelihood that expansion in some sectors will divert trade from other sectors. The technique is unable to distinguish trade diverting from trade creation effects. Nevertheless, Type II multipliers are more informative of the full inter-sectoral consequences than Type I multipliers, so those used in the Waitaki regional analysis are Type II multipliers.

Multipliers have been calculated for output, value added and employment. Each has a similar interpretation: the multiplier is the ratio of the final impact on output, income or employment to the initial impact on output, income, or employment that results from a $1 million increase in demand for output from a particular industry.[15]

So, for example, the employment multiplier for an industry is the total increase in employment in all industries divided by the initial increase in employment in the sector directly affected by a $1 million increase in demand for output. The Type I multiplier includes the 'direct' effect (which is the same as the initial impact) and the 'indirect' effect, which is the flow-on to industries that supply the first industry with inputs. The Type II multiplier includes both these effects plus the 'induced income' effect caused by increased demand for outputs from all industries by households who now have a higher income.

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[15] The employment data comes from Statistics New Zealand's 1996 Census of Populations and Dwellings.

Multipliers are easy to interpret incorrectly. It is tempting, for example, when a particular sector's income multiplier has a value of 4 to interpret this as meaning that a $1 million increase in output in that sector causes a $4 million increase in income. This is incorrect. What an income multiplier of 4 means is that the final impact on income of a $1 million increase in output in that sector is four times the initial impact on income following that increase in output. The initial impact may be quite small and hence a small total impact can give rise to a large multiplier.

Note that the multipliers used in this analysis are presented below.

F.3 Derivation of multipliers

This section explains the use and derivation of IO multipliers. For convenience, the diagram of the structure of the IO table is repeated here.

Figure 8. The input–output table

	Industry inputs (j)				Final demands (f)				Total sales (x)
Industry sales (i)	z_{11}	z_{12}	…	z_{1n}	c_1	i_1	g_1	e_1	x_1
	z_{21}	Z_{22} I	…	z_{2n}	c_2	i_2 II	g_2	e_2	x_2
	⋮	⋮		⋮	⋮	⋮	⋮	⋮	⋮
	z_{n1}	z_{n2}	…	z_{nn}	c_n	i_n	g_n	e_n	x_n
Value added (v)	l_1	l_2 III	…	l_n		IV			l
	k_1	k_2	…	k_n					k
Imports (m)	m_1	M_2	…	m_n		m_f			m
Total outlays (x)	x_1	x_2	…	x_n	c	i	g	e	

F.3.1 Type I and Type II multipliers

As noted above, Type I and Type II multipliers differ in the extent to which they fully capture economy-wide impacts of a sectoral change. Type II multipliers provide a more comprehensive measure of economic change. The derivation of Type II multipliers is essentially an extension of the Type I algebra; hence both Type I and Type II derivations are presented here.

The distinction between Type I and Type II multipliers is as follows:

- *Type I multipliers* measure the direct and indirect effects of a change. In the instance of an output multiplier, the direct effect is the initial rise in output in the industry which is experiencing higher demand. The indirect effects result from the need to produce more inputs for that industry.
- *Type II multipliers* include the direct and indirect effects, as well as the income-induced effect of a change. The initial direct and indirect effects result in higher employment, which in turn boosts household income, which increases demand, which lifts output, which then lifts employment further, and so on.

F.3.2 Derivation of Type I multipliers

Given an *n*-sector economy, the transactions matrix and the vectors of final demands and outputs can be represented as:[16]

$$\mathbf{Z} = \left(\begin{array}{cccc|c} z_{11} & z_{12} & \cdots & z_{1n} & z_{1c} \\ z_{21} & z_{22} & \cdots & z_{2n} & z_{2c} \\ \vdots & \vdots & & \vdots & \vdots \\ z_{n1} & z_{n2} & \cdots & z_{nn} & z_{nc} \\ \hline z_{c1} & z_{c2} & \cdots & z_{cn} & \end{array}\right) \qquad \mathbf{f} = \begin{pmatrix} f_1 \\ f_2 \\ \vdots \\ f_n \end{pmatrix} \qquad \mathbf{x} = \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{pmatrix}$$

where:

z_{ij} = sector *i* sales to sector *j*

f_j = sector *j* sales to final demand

x_j = total sector *j* sales

The *c*-th row represents compensation of employees (i.e. payments for labour), and the *c*-th column is household consumption.

The relationship between the elements of these matrices is:

$$x_i = z_{i1} + z_{i2} + \ldots + z_{in} + f_i \qquad (1)$$

The technical coefficients (or direct input coefficients) of sector *j* are written:

$$a_{ij} = z_{ij} / x_j \qquad (2)$$

which in matrix form is:

[16] In the *Inter-industry Study* 1996, which forms the basis of the multiplier analysis contained in this report, n = 126.

$$\mathbf{A} = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{in} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{pmatrix}$$

Thus a_{ij} is the proportion of sector j's total output (the value of which is equivalent to the value of sector j's total input) and is made up of inputs from other sectors.

Given equation (1), sector i's sales can be rewritten and expressed in terms of technical coefficients as:

$$x_i = a_{i1}x_1 + a_{i2}x_2 + \ldots + a_{in}x_n + f_i \qquad (3)$$

Equations (1) and (3) respectively can be written in matrix form as:

$$\mathbf{x = Zi + f} \qquad (4)$$

$$\mathbf{x = Ax + f} \qquad (5)$$

where **i** is an *n*-element column vector of 1s.

Recall that equations (1) and (3), and hence (4) and (5), are equivalent.

Using an *nxn* identity matrix, **I**, and rearranging equation (5) yields:

$$\mathbf{Ix - Ax = f}$$

$$\Rightarrow \quad \mathbf{(I - A)x = f} \qquad (6)$$

From this we can derive the change in output, $\mathbf{x}^*$, arising from a change in final demand, $\mathbf{f}^*$:

$$\mathbf{x}^* = \mathbf{(I - A)}^{-1}\mathbf{f}^* \qquad (7)$$

$\mathbf{(I - A)}^{-1}$ is the Leontief Inverse, or the total (initial, direct and indirect) requirements matrix. This can be represented by **B** so that:

$$\mathbf{x}^* = \mathbf{Bf}^* \qquad (8)$$

Output multipliers

Re-expressing equation (8) in expanded format gives:

$$\mathbf{x}^* = \begin{pmatrix} b_{11} & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & b_{2n} \\ \vdots & \vdots & & \vdots \\ b_{n1} & b_{n2} & \cdots & b_{nn} \end{pmatrix} \begin{pmatrix} f_1^* \\ f_2^* \\ \vdots \\ f_n^* \end{pmatrix}$$

From this it can be seen that the economy-wide impact of f_j^* is:

$$x_j^* = \sum_{i=1}^{n} b_{ij} f_j^* \qquad (9)$$

For $f_j^* = 1$, x_j^* reduces to:

$$x_j^* = \sum_{i=1}^{n} b_{ij} \tag{10}$$

x_j^* is the (Type I) *output multiplier*: that is, how much does economy-wide output have to increase to meet a $1 increase in final demand for the output of sector *j*.

Value added multipliers

In principle these are calculated in the same way as for output multipliers; the distinction is that changes in sectoral output arising from a change in final demand are scaled by each sector's value added input coefficient (ie the ratio of value added to total inputs).

The value added input coefficients are calculated using the sum of the compensation of employees, the operating surplus and net indirect tax rows of the input-output table. We shall denote this sum as z_{vaj}. In a manner similar to that used to derive the direct input coefficients in equation (2), the value added input coefficients are:

$$a_{vaj} = z_{vaj} / x_j \tag{11}$$

By using this to scale the impact of changes in output we have:

$$v_j^* = \sum_{i=1}^{n} a_{vai} b_{ij} / a_{vaj} \tag{12}$$

This is the (Type I) *value added multiplier*. Its interpretation is: how much will economy-wide value added increase, above the initial increase in sector *j*'s value added payments, given an increase in final demand of sector *j*'s output of $1.

Employment multipliers

These are calculated as for the income multipliers, but rather than use compensation of employees to scale the output effects we have used the ratio of full-time equivalent (FTE) jobs to output by sector. This employment ratio is:

$$e_j = FTE_j / x_j \tag{15}$$

Using this in our multiplier calculation gives:

$$e_j^* = \sum_{i=1}^{n} e_i b_{ij} / e_j \tag{16}$$

F.3.3 Derivation of Type II multipliers

In the calculations above, the matrix elements are restricted to those within the *n*x*n* confines of the transactions matrix of the inter-industry table. However, this effectively excludes the impact of changes in household income arising from additional final demand, since household income and consumption is outside of the *n*x*n* matrix. Type II multipliers address this issue by expanding the *n*x*n* matrix to include household consumption and compensation of employees. Households are effectively treated as another production sector in Type II multiplier analysis, producing labour services and demanding consumption goods and services.

The technical coefficients for the household row and column are:

$$a_{cj} = z_{cj} / x_j \quad (17)$$

$$a_{ic} = z_{ic} / x_c \quad (18)$$

where:

a_{cj} = the labour coefficient for sector *j*

a_{ic} = the 'household consumption' coefficient.

In equation (18), x_C represents household disposable income. For the analysis contained in this report we calculated household disposable income as the sum of:

- compensation of employees (from the input–output tables)
- self-employed earnings (derived from Statistics New Zealand's *Institutional Sector Accounts*)
- dividends (derived from Statistics New Zealand's *Institutional Sector Accounts*)

and then subtracted tax from that sum using an average personal income tax rate derived from the *Institutional Sector Accounts*. Note that both self-employed earnings and dividends are reflected in the operating surplus row of the input-output table.

F.4 Waitaki catchment multipliers

Table 59. Waitaki catchment multipliers

Sector		Emplmnt (FTEs)	Grout ($mil.)	Output	Employment	Value Added
1	Horticulture and fruit growing	480	20.33	2.2364	1.348	1.9209
2	Livestock and cropping farming	3272	272.11	1.6441	1.4029	1.5503
3	Dairy cattle farming	836	70.64	1.9864	1.5638	1.6361
4	Other farming	479	43.14	1.5696	1.3245	1.4278
5	Services to agriculture	563	32.95	2.0093	1.4004	1.9296
6	Other primary production	660	276.35	1.5827	2.3894	1.4661
7	Meat product manufacturing	2372	507.33	1.9811	2.6483	3.1774
8	Dairy product manufacturing	537	312.23	1.6647	4.0473	3.0728
9	Fruit and vegetable processing	294	69.33	1.8764	2.2821	2.4331
10	Other manufacturing	3364	551.17	2.0928	1.998	2.4746
11	Electricity, gas and water supply	229	150.73	1.7256	3.4372	1.2882
12	Construction	1803	233.45	2.2674	1.9983	2.628
13	Wholesale trade	1034	146.36	2.3265	2.1002	2.3438
14	Retail trade	3414	213.44	2.1676	1.4114	2.0659
15	Accommodation, restaurants and	1425	72.16	2.2111	1.3624	2.1497
16	Transport, storage and communic	1283	188.43	2.1949	2.0433	1.9676
17	Finance, insurance, business and	1877	323.64	1.9976	1.9446	1.5965
18	Ownership of owner-occupied dw	0	0	1	0	0
19	Central government administratio	496	48.15	2.5596	1.8764	2.8611
20	Local government administration	283	60.87	2.3293	2.703	2.2468
21	Education, health and community	3286	167.45	2.4585	1.4191	2.241
22	Personal and other community se	814	59.38	2.3346	1.6082	2.5095

Source: NZIER