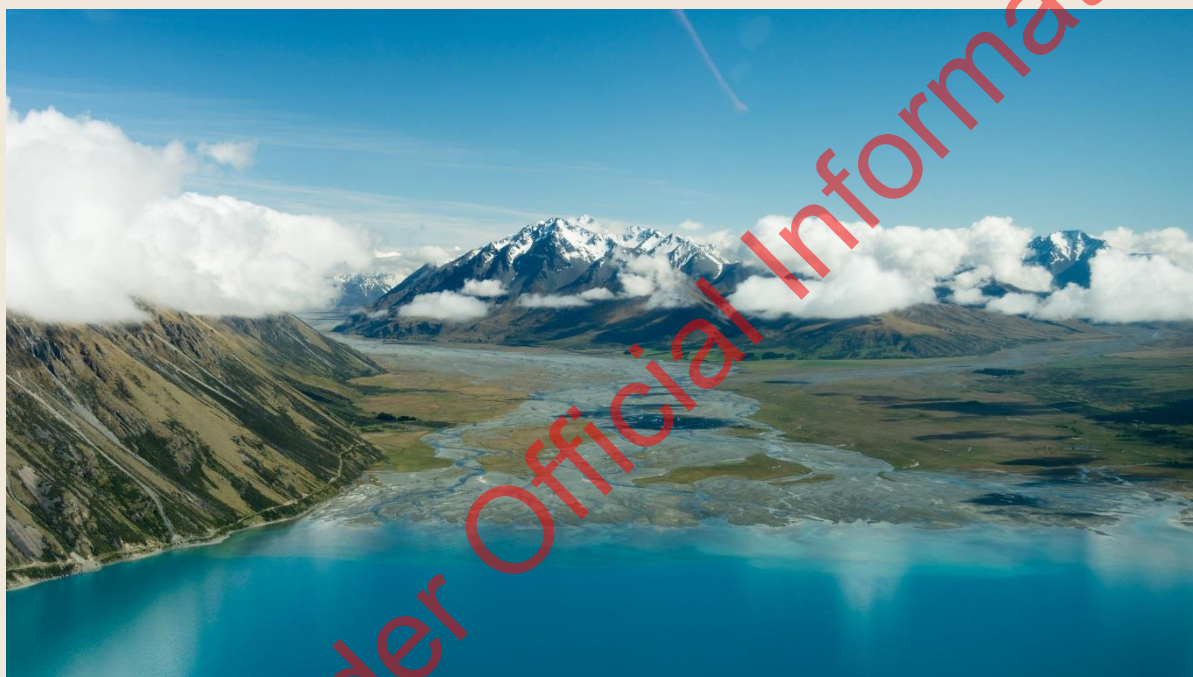


Project River Recovery mitigation work



A costing assessment of potential
mitigation actions for hydro-electric
activity in the Waitaki River catchment

Debbie Lewis and Richard Maloney



Department of
Conservation
Te Papa Atawhai

New Zealand Government

Released under Official Information Act

Cover: Lake Tekapo and Godley River Valley. *Photo: Christoph Strässler*

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1 Context

1.1 Project River Recovery Context

Project River Recovery is funded by Meridian Energy and Genesis Energy under a compensatory agreement that recognises the adverse effects of hydroelectric power development on the upper Waitaki Basin rivers and wetlands (Map 1) (Rebergen and Woolmore, 2015). Project River Recovery began operations in late 1991 after the signing of the agreement in November 1990, amended in May 2011, which is tied to the term of the power providers' consents to take and use water, which expire on 30 April 2025. Project River Recovery's agreed role is to undertake ecological management and research programmes focused on maintaining, restoring and enhancing habitat and ecological communities in the river and wetland ecosystems of the upper Waitaki basin, with further direction and objectives for work set out in seven-year strategic plans. For further details see Rebergen and Woolmore (2015).

1.2 Purpose and Aims

This document is intended to inform decision making and negotiations for Project River Recovery funding by providing detailed costing estimates of work to mitigate the impacts of hydro-electric generation on rivers and wetlands within the Waitaki Basin. Estimates of cost for a range of mitigation actions are provided as well as example scenarios of the potential protection levels achieved for various funding amounts. This document is intended for internal guidance only. It is intended only to provide guidance on funding and not recommendations on mitigation actions.

The aims of this document are:

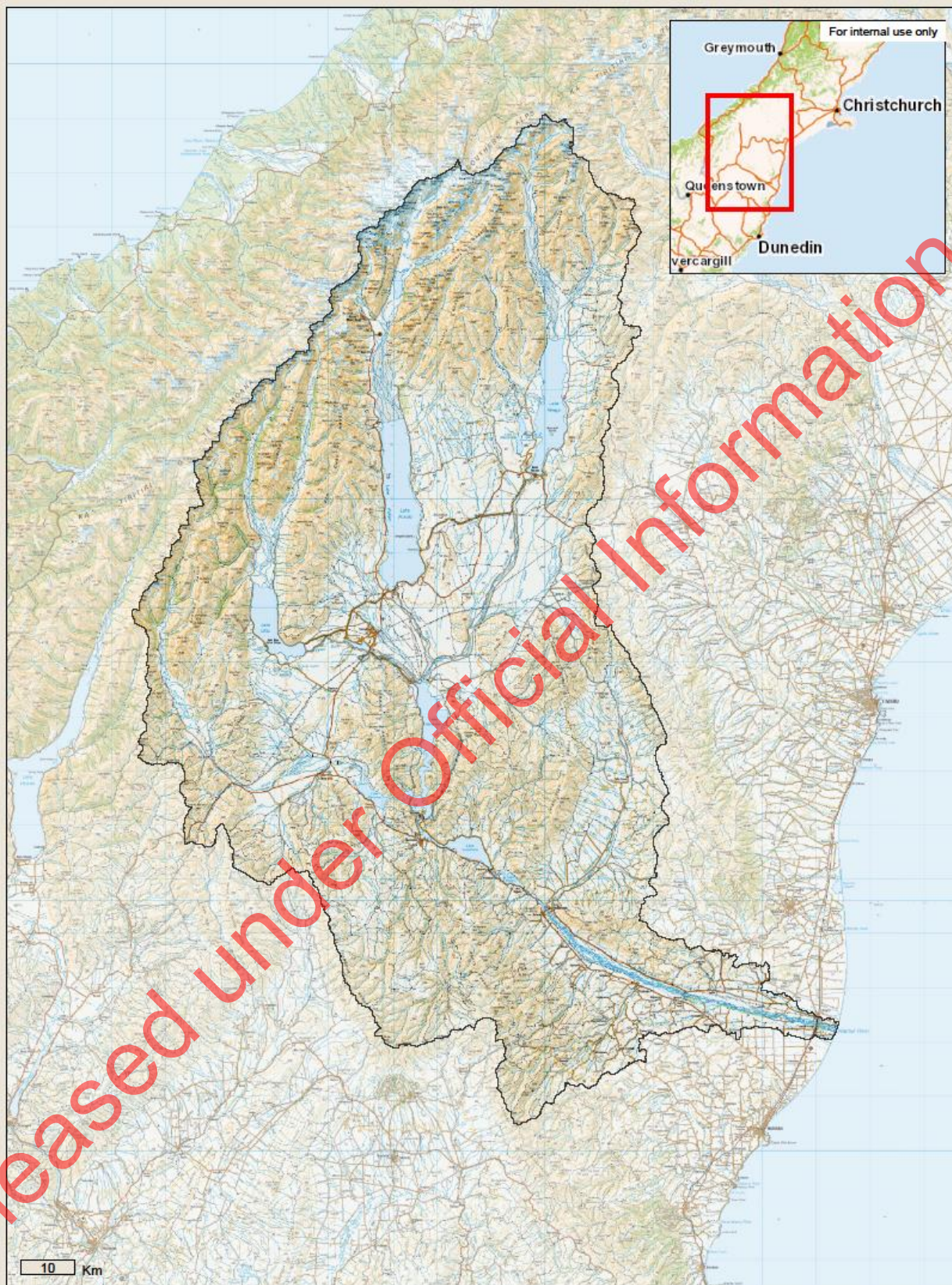
- 1) Identify the potential mitigation actions for hydroelectric power generation activity in the Waitaki River catchment.
- 2) Estimate the cost of the necessary actions
- 3) Provide scenarios with costings based on the potential protection level achieved.

1.3 Current use of funds for Project River Recovery

Project River recovery currently receives approximately \$500,000 per annum to mitigate the impacts of hydro-electric activity in the Waitaki River catchment. In the 2018/2019 financial year Project River Recovery received \$544,000 for mitigation work. Of the funding received, 45% was allocated to weed control and 21% to small mammal pest control (Table 1) which was carried out in a limited area of the Waitaki catchment (see Appendix 1). The remaining funding was allocated to the following projects: southern black backed gull control 2%, skink monitoring 0.5%, predatory fish control 0.3% and restoration work 0.1%. Overheads including salaries, vehicles and office costs are 28% of the total budget. The 2018/2019 budget allowed for minimal restorative work with the majority of the work being control. There has been no recent wetland creation, with only an ongoing management regime (i.e. raising and lowering water levels for plant and bird benefit at the Ruataniwha and Waterwheel wetlands) occurring in the 2018/2019 period. There was no maintenance of predator fences and the project has not carried out any translocations recently. For a detailed breakdown of 2018/2019 mitigation work see Appendix 1.

Table 1 PRR expenditure for the 2018/2019 financial year, rounded to nearest hundred.

Activity	Site	Target species	Amount
Small mammal pest control	Tasman Valley, Upper Ohau - Tern Island	Cats, ferrets, stoats, weasels, rats	\$114,500
Skink monitoring	Upper Ohau - Tern Island, Lake Benmore gullies	Lakes skink	\$2,500
Outcome monitoring	Lower Waitaki Islands	BFT, black-billed gull	\$8,700
SBBG control	Tasman, Murchison, Cass, Godley, Fork	SBBG	\$13,200
Predatory fish control		Trout	\$1,800
Weed Control	Tasman, Fork Stream, Lower Ohau, Goodley, Cass, Macaulay, Upper Ahuriri, Upper Tekapo, Lake Poaka, Waterwheel wetland, and other selected sites as needed	See Appendix 1 for species details	\$247,000
Restoration	Ruataniwha and Waterwheel wetlands		\$500
Overheads and rangers	Vehicle and office costs		\$154,000
Total			\$542,200



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Waitaki River Catchment



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Map 1 Location of the Waitaki River catchment

2 Methodology

This section details the process used to identify the costs of each mitigation project and the scenarios presented in section 3.1.4.

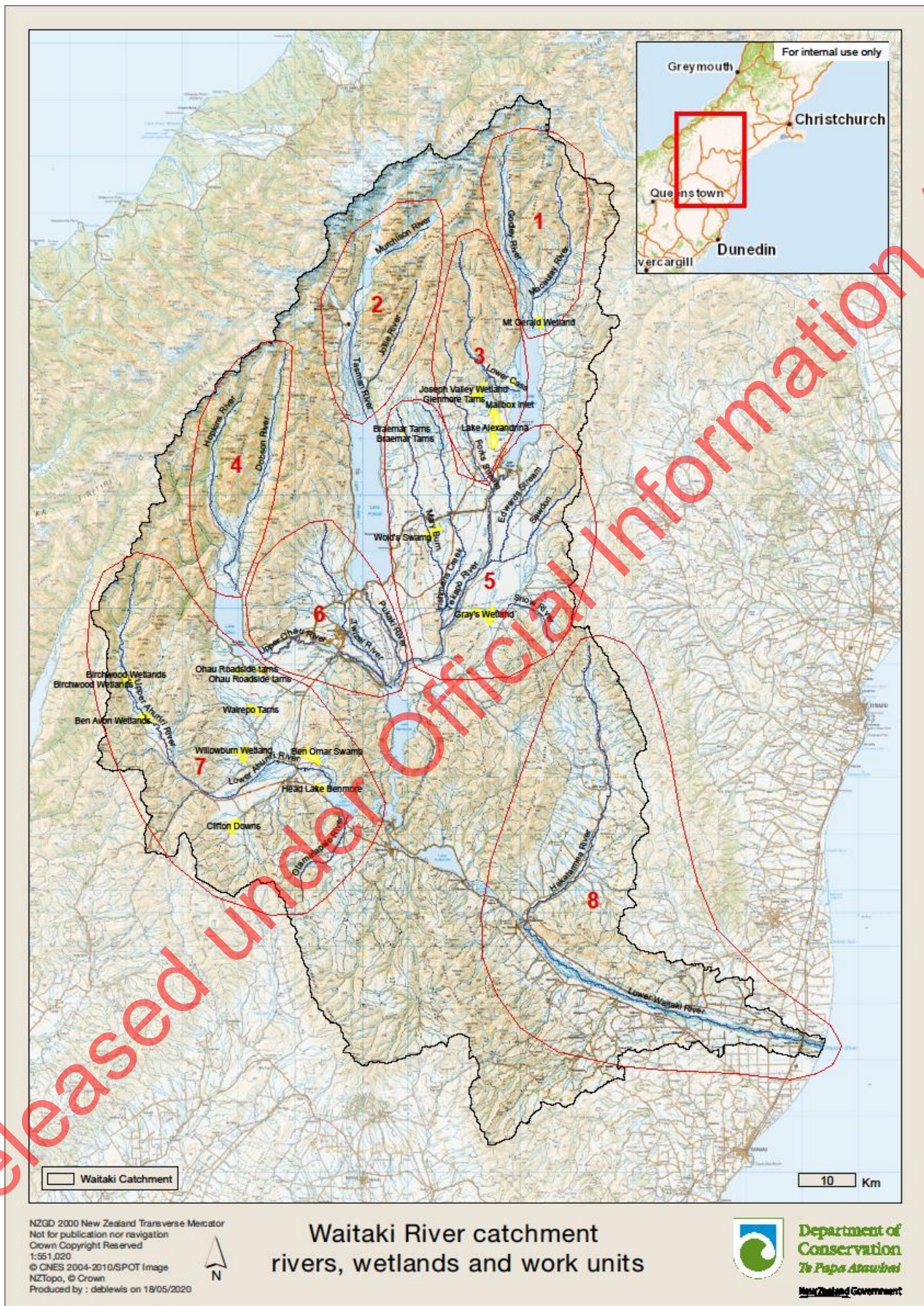
2.1 Identification of work areas

All rivers, major streams and major wetlands were identified within the Waitaki Catchment (Map 2). Rivers that have a geographical feature such as a gorge in their mid-section were split into 'upper' and 'lower'. This is because these features often act as a barrier resulting in varying ecological threats and values in each river section, for example lower sections of rivers often have more anthropogenic disturbance and weeds than upper sections.

The basin was then divided into eight units for work based on geographic area (Table 2, Map 3). This was used because some costs were per river, but others needed to be spread across several rivers. For example, not all tasks required a ranger per river, so a ranger is theoretically assigned to one work unit, and the cost was able to be split between the rivers in that unit.

Table 2. The rivers in each of the eight work units used for dividing and costing some tasks.

Work Unit							
1	2	3	4	5	6	7	8
Godley	Murchison	Forks	Hopkins	Irishman	Pukaki	Otamatapaio	Lower Waitaki
Macaulay	Jollie	Lower Cass	Dobson	Mary Burn	Twizel	Lower Ahuriri	Hakataramea
	Tasman	Upper Cass		Tekapo	Lower Ohau	Upper Ahuriri	
				Edwards	Upper Ohau		
				Sawdon			
				Snow			



Map 2 The rivers and wetlands of the Waitaki River catchment and the eight work units/regions the catchment was divided into for the purposes of this assessment.

2.2 Identified mitigation tasks

This section details the mitigation actions identified for the Waitaki Catchment and the work plans required for each task. Costing estimates and how these were obtained are detailed with each proposed project task. There are some costings that are calculated the same way for several tasks (e.g. depreciation, transport, project management), the method for determining these costs are detailed separately in this section, but they are calculated and presented as part of the total for each task in the results.

2.2.1 Identification of potentially impacted values and necessary mitigation tasks

To identify the tasks required to mitigate the impacts of hydro-electric generation on the upper Waitaki Basin the values requiring protection were first identified. These were identified down to two levels, initially being categorised by 'Value type' then they were further divided into the taxa, or other value type, that required specific action for protection and management more specific 'value' that need protecting or enhancing. The values identified in each category are listed below:

Value type: All, Biodiversity, and Ecosystem Management.

Value: All, Wetland Birds, Braided River Birds, Terrestrial Invertebrates, Vascular Plants, Native Freshwater Fish, Lizards, Wetlands, Braided Rivers, Tarns, Lake-edges, Spring-fed Creeks.

Once the values were identified, the potential threat or restorative work required was identified for each value under the heading of 'Action'. The required work programmes were identified for each 'action' and placed into 'Programme/Target' categories. The following actions (threats) and programmes were identified:

Action: Aquatic weed control, Browsing Mammal Control, Climate Change Adaptation, Disturbance (e.g. vehicles and dogs), Predatory Bird Control, Predatory fish Management, Restorative Action, Small Mammal Predator Control, Stock Management and Weed Control.

Programme/Target: Aquatic Weed Control, Cats and Possums, Clearing Braided River Islands, Clearing Islands and Banks, Ferrets, Lagomorphs, Mice, Minimising Disturbance, Predator Fence Construction, Restoration Planting, southern Black Backed Gulls, Spot Spraying, Stoats, Hedgehogs and Rats, Stock Fencing, Translocation, Trout and Salmon, and Wetland Creation.

The specific costs to complete these programmes were identified and listed as cost 'Items'. They were separated into the following cost 'Type' categories: Set-up, Knockdown, Ongoing. Identified 'Items' include: Contractors, staff time, field equipment, field supplies, building supplies, equipment set-up, monitoring, transport, depreciation, capital charge, Resource Management Act consent applications and quality control. For the full list of costs and which costs were calculated for each action, see the supporting excel document. Table 3 provides an example using cat and possum control. For full costing details see supporting excel document with all costing data: docCM-6302481.

Table 3 Example of categories and grouping used for costings. The example provided is cat and possum control.

Value type	Value	Action	Programme / target	Type	Description	Item
Biodiversity	Braided river birds, terrestrial invertebrates, lizards, wetland birds, vascular plants	Small mammal predator control	Cats and possums	Set-up costs	Equipment set up	Staff hours
					Field equipment	Traps
					Quality control	Staff hours
					Transport	Transport part cost
				Ongoing costs	Checking traps	Staff hours
					Field supplies	All
					Transport	Transport part cost

2.3 Methods used for estimating costs

This section details the methodology used to estimate the costs for each project. To avoid repetition this section is split into two sections. Section 2.3.1 details the costs of items which were common across most projects. Section 2.3.2 then details the additional costs for each specific project or task. For a full list of which costs were included for each project see the supporting excel document docCM-6302481.

2.3.1 Estimating costs of generic 'items'.

This section details the method used to estimate the cost the 'items' that were generic to multiple projects, and were necessary for each work programme. It shows how the number of necessary 'items' was identified. The section is structured by listing the individual 'items' in bold followed by specific details for that item or task.

Contingency: To allow for unforeseen costs (e.g. replacing equipment, additional staff training) and to provide a buffer for the wide range of variables that reduce the accuracy of the costing estimates (e.g. actual river bed size, size of side stream for weir creation), every cost calculated for this assessment has a 20% contingency added. This was calculated by adding 20% to each individual line item in the 35-year total cost. Unless stated, all costs presented within this document include the 20% contingency. The supporting excel spreadsheet docCM-6302481 provides the raw data and costing with and without the contingency included.

Depreciation: Depreciation was calculated per annum for all proposed new structures, including fences and weirs. This was calculated as the total set-up cost of the structure divided by the number of years the structure is expected to be functional e.g. 50 years for predator fences, 20 years for weirs. Functional life of structures was determined using either existing guidelines, calculations consistent with other projects or consultation with specialists.

Capital charges: Capital charges were calculated per annum for all structures, including fences and weirs. This was calculated at 6% of the set-up cost of each structure.

Research and Development: Research and development costs were added to all scenarios and individual projects presented in the results section of this document, because all projects will benefit from the continued development of best practise methods and efficiency gains. Research and development costs were calculated as 5% of the total cost of the work per annum for the first five years of the project.

Outcome Monitoring: Outcome monitoring was calculated as a proportion of 20 FTE 'B band' rangers at a pay rate of \$25 per hour, as per the average hourly wage in the collective agreement. Twenty FTEs was the number of monitoring rangers needed if all the proposed work was funded. The proportions were calculated based on total cost of the proposed work compared with total cost of scenario/project presented.

Overall Project Manager: A project manager was determined to be required regardless of the number of projects selected. Thus, the full cost of a project manager was added to all scenarios or individually costed projects presented in this document. The estimated cost of the project manager is \$100,000 per annum inclusive of salary, office overheads and vehicle.

Project Assistants: The cost of project assistants is calculated as a proportion of eight FTE project assistants per annum. Eight FTEs is the number of assistants needed if all the proposed work was funded. The proportions were calculated based on total cost of the proposed work compared with total cost of each scenario/project presented e.g. if work costing 50% of the total of all proposed work is selected, then four project assistants are budgeted for. Project assistants are each estimated to cost \$80,000 per annum inclusive of office overheads and vehicles.

Ranger Roles: 'B' and 'C' band Ranger roles were costed out based on the estimated hours of work for each project. The per hour cost of each role was based on the Collective Agreement as of March 2020. The mid-level payrate was selected for each role (\$25 per hour 'B' band and \$28 per hour 'C' band).

Field supplies: Estimated field supplies costs are to cover costs such as food allowances. Each project has been assigned an estimated nominal amount based on the type of work involved.

Field Equipment: For projects with known equipment requirements (e.g. weed spray or electric-fishing machine) estimated amounts have been added to each project to cover the initial cost, maintenance, and where necessary, eventual replacement of the equipment. For some projects (e.g. weed spraying) this is a regular annual cost. For other projects (e.g. fish control) this is a high initial cost followed by lower annual maintenance costs. Projects with no specific equipment requirements are identified have been given a nominal amount to cover unexpected equipment costs.

Transport: Fuel use was calculated at \$24 per 100km, estimated for a Toyota Hilux using an online fuel economy calculator. Distance travelled was calculated as a return trip from Twizel to the road end nearest each site. Driving time is based on google maps driving time estimates. Daily vehicle lease costs are based on number of days used x \$73.80 (DOC leases estimated at \$19,000 per annum). These costs are calculated and added to each project.

2.3.2 Tasks and methods used for estimating project specific costs

This section provides the methods used to determine the costs of specific work programmes with the exception of the items listed in section 2.2.2. and identifies how the number of necessary items was determined. This section is structured by listing the work programmes and then detailing the costs for each.

Browsing mammal control, lagomorphs: Rabbit control was calculated as being an initial intensive knockdown using aerial poison in year one, followed by night shooting every two months to maintain low numbers. Lagomorph control costs were based on current and previous DOC projects, aerial poisoning was estimated at \$15 per hectare, and night shooting was calculated for each river at \$600 per night with 3000 hectares being controlled per night. Size of area to be controlled was identified using ArcGIS.

Climate change adaptation: Climate change adaptation management was proposed as wild to wild translocations of species within predator fences. This project has been given a nominal amount of \$10,000 per annum for the first three years to establish populations within predator fenced areas, and a top-up translocation every five years. An additional cost of \$5000 for permissions was also included. This task can only be completed if predator fences are constructed. The cost of fence construction was calculated and presented independently to climate change adaptation project work.

Disturbance: This project includes staff, signage and road barriers. Staff time was calculated as one FTE 'B' band ranger in an educational roll per work unit. Signs were costed based on a sign by Braid as a one-off cost per river of \$7350. A nominal amount was calculated per river for barriers to protect nesting birds or close of tracks/roads when required. Rivers in the upper catchment, or the upper half of a river with a gorge, were given a nominal amount of \$1000 for barriers (chain fences or concrete slabs). Rivers in the lower reaches, and river sections below gorges, were given a nominal amount of \$2000 for barriers. The larger amount for the lower rivers is because of the higher number of vehicle access points to riverbanks in these areas compared with the upper rivers.

Predatory bird control: Southern black-backed gull (SBBG) control is already being carried out along several South Island rivers. The costing of this work involved replicating approximate current contractor costs and methodology for each river with SBBG colonies. Rivers with colonies were identified using the braided river bird database. The Ahuriri, Lower Waitaki and Tekapo SBBG control was estimated at \$30,000 for the first five years (per river per annum), and all other rivers with

SBBG colonies estimated at \$15,000 per river per annum for five years. Quality control was calculated at 16 hours (e.g. two people for one day) per river.

Predatory fish management: Predatory fish management (trout and salmon) requires blocking off sections of side streams with weirs to prevent upstream migration of predatory fish. The area blocked off is then electric fished to remove any predatory fish within the area. Fish control will include a one-off major clearing of the waterway with checks every six months for three years. Following this there will be annual checks of both the weir and the fish populations. Five weirs per river catchment are proposed. Construction dates staggered by river catchment over years four and five but may be further staggered throughout the term of the project. Weirs are estimated to cost an average \$20,000 each, with the expectation of variation in cost between streams. Weirs have an expected functional life of 15 years when they will need to be replaced. Weir construction price was estimated based on the cost of previously established weirs, and consultation with the Freshwater Team. Removal of existing fish from the streams is estimated at six person days per stream. An annual nominal amount of \$300 per river catchment is estimated for purchase and maintenance of equipment. Monitoring of each site is included in the estimated costs at four person days for three years following weir construction per river catchment, and two person days (two people for one day) per year following.

Restorative action

Predator fences: Predator fences costings per m are directly from contractors at \$339 m. Predator fences were costed at one enclosure per 10km of river up to a maximum of four enclosures per river. Enclosures are nominally designed to be 500m of fencing per side (e.g approx. 25,000m depending on shape). Fences require ongoing maintenance, a nominal amount of \$200 per month for equipment and 0.5 days staff time a month per fence to check and repair fences.

Wetland creation: Wetland creation was calculated as one week of digger time and construction of one weir per wetland. The number of wetlands to be created was calculated at one wetland per 20km of river to a maximum of three wetlands per river. Cost of weirs used to regulate flows in created wetlands was as that used for predatory fish control and estimated at \$20,000 each.

Plant translocations: Translocations of plants into predator fence areas were one-off events for each river. The costs were calculated at four 'B' band ranger days for local seed collection per river, a \$5 per plant growing cost for 345 plants per river, four person days of planting and two weeks ranger time per annum for weeding and maintenance per river.

Small mammal predator control

Cats, possums, ferrets, stoats and hedgehogs: The trap requirements for cat, possum, ferret, stoat and hedgehog control were determined and costed by following the trapline layout and current costs of the Te Manahuna Aoraki (TMA) project. Traplines were mapped for each river and wetland using ArcGIS. Traps were then spaced along the line alternating between Timms traps and DOC150/250 traps with a 250 m spacing. Traps were costed at: Timms trap \$40, double DOC150 \$116, DOC250 \$135. Traps were costed as needing to be replaced every 15 years, i.e., twice during the 35-year span of the project (years 16 and 31), with the number of traps required depending on the length of traplines for each river. Quality control of traps was included at \$20 per trap. Checking kill traps was costed at monthly intervals, year-round. Leg-hold traps were opened biannually for 10 days in May and September. Placing and checking traps was costed at \$5 per trap, per check.

Mice: Mouse traps were costed based on recorded costs of traps for the TMA project at \$10 per trap. The cost of trap quality control of mouse traps was estimated at \$4 per trap. Mouse control was planned in consultation with the Department's threats team, as there is currently no SOP for mouse control in these areas. Mouse traps were placed in grids spaced 20 x 20m apart in an area the size of the predator control fences (approx. 500m x 500m). The number of grids per river depended on the overall river length. Trap set-up was costed as an annual trap placement and baiting, followed up by a re-baiting after 1-2 weeks and then monthly checks from August - December.

Stock management: Rivers requiring stock fencing were identified as the Dobson, Hopkins, Cass and Godley Rivers. Only the sections of these river that are bordering farmland require fencing. Accurately determining the extent of existing fencing remotely was not feasible, so estimates were made by using ArcGIS layers to measure how much of each river appeared to be unfenced. Stock fences were costed at \$16 per metre including materials and labour (MPI, 2016). Stock fences were estimated to have a functional life of 50-years.

Weed control: This section includes both island weed control for habitat enhancement, and clearing of banks for weed control. Riverbanks and islands were mapped using ArcGIS for all rivers in the Waitaki catchment. Rivers were then split into categories based on weed density; none, sparse or dense to determine the control method to be used (see Appendix 2). Rivers with dense weeds are proposed to be cleared using either a bulldozer or mechanical tractor, depending on accessibility and infestation level. Rivers with sparse or no weeds are proposed to have spot spraying.

Tractor and bulldozer clearing was costed for two clearing per river per year using the technique best suited to that river. Bulldozer clearing was calculated at \$2000 per hectare and mechanical tractor clearing as calculated at \$250 per hectare for the initial clearing and \$140 per hectare for follow-up treatments. Fluctuations in river level and the dynamic nature of the braided river system mean the area of riverbed visible in aerial imagery is not an accurate representation of the area that is generally exposed and weedy. Calculating the area of riverbed was done by using ArcGIS to make shapefiles of the rivers and riverbeds at the time of the aerial image. Then 10 rivers were selected to have 10 cross-sections measured to determine what percentage is river vs. exposed riverbed. These were then averaged across all rivers to give the average percentage coverage of exposed land within the river bed as 15%. This was then used as the figure to calculate the area requiring weed control in each river polygon (e.g. 15% of the total area of the river polygon). For most rivers, the full length of the riverbed or all islands were calculated. The following rivers were exceptions:

- Waitaki River - control was only calculated for 10 islands and associated riverbanks in the lower Waitaki, this is because the large size of the area would result in prohibitive costs and require multiple bulldozers or tractors operating to cover the area twice per annum.
- Pukaki River - only the lower 1.5km was included in the costings for the Pukaki River, where there is residual water flow.
- Forks River - only the section of river from Braemar Road down was included.
- Otamatapaio River – only the section of river from the Otamatapaio Road end down was included.

Spot spraying: Spot spraying was calculated at a rate of two FTE each covering 5km day. Equipment costs include \$1,000 per annum for chemicals for spraying.

Aquatic weed control: Control of aquatic weeds was costed at a nominal rate of \$5000 per river, per year, for 5 years using mechanical clearance (e.g. bulldozer, digger). Annual follow-up control of \$500 per year is estimated for maintenance (e.g. spot spraying).

2.4 Sources of information

The methods used to estimate the cost of each task or project is identified in the following section. Where possible quotes from contractors or actual costs from other, current, DOC projects were used. If these were not available then the following methods were used, in order of preference: 1) costs from previous DOC projects with estimated increase, 2) estimates based on similar work from other projects in consultation with task specific experts, 3) where estimates are not feasible (e.g. too much unpredictable variation) a nominal amount is presented as the estimated budget.

Estimate method	Task	Source (where applicable)
Costs from contractors	Predator fences SBBG control	Quote per m From current work
Estimates from other projects with consultation	Predator traplines Disturbance signage Weed spraying Weirs Mouse control Trout and salmon control	TMA BRaid PRR Freshwater Group advice TMA trap costings and consultation with the DOC Threats Team. Freshwater Group advice
Estimates from other projects or organisations	Rabbit control Stock fencing Weed control bulldozer Weed control tractor RMA consents Fuel costs	TMA MPI report Based on previous hire Based on field trials in the Ashley River Based on previous applications Estimate from advertised fuel use per km of Hilux petrol vehicle
Estimates from older work	Plants	Estimate
Nominal budget assigned	Plant translocation costs Road barriers for disturbance Aquatic weed control	

2.5 Scenarios

Our aim in this section is to demonstrate how individual projects and costs can be combined to design work programmes that will achieve specific outcomes. This will allow a more informed discussion about the objective of future PRR work, and the likely costs of achieving that objective. Five costing scenarios are presented as well as providing the estimated cost of specific tasks (e.g. predator control). When removing costs between presented scenarios, with the exception of predator fence construction, work was either considered to be carried out fully, or not done at all in each river or unit instead of reducing work intensity. This is to both 1) reduce the number of different scenarios presented and b) acknowledge that work must be carried out to a high standard and reducing the intensity of work from the standard practice will have unknown outcome on efficacy of each work programme.

Five scenarios were costed for this assessment, representing the full range of the intensity of work that could be undertaken. These are not recommendations, rather they are illustrations of how we can use this information to derive anticipated costs of achieving specific outcomes. Note that the scope of this work is limited to the Waitaki catchment. The objectives of each scenario are as follows:

Scenario A: All biodiversity values are fully managed at all places

Scenario B: All values are mostly managed at most places

Scenario C: Most values are mostly managed at some places

Scenario D: Most values are mostly managed at a few places

Scenario E: A few key values are managed at a few key places

The following inclusions and exclusions were applied for each scenario:

Scenario A: Work aims to restore and protect all rivers, wetlands and their biodiversity. All proposed work for rivers and wetlands was included.

Scenario B: Work aims to restore and protect most areas and all biodiversity. Work is reduced to 70-75% of total cost of all work. Lower priority rivers may be excluded for some tasks.

Scenario C: Work aims to restore and protect most biodiversity at most places. Work is reduced to 50-60% of the total cost. Restoration tasks may be excluded from these lower priority rivers: Hakataramea, Upper Ohau, Jollie, Forks, Edwards and Otamatapaio Rivers.

Scenario D: Work aims to restore and protect most biodiversity at key places. Restoration tasks will be excluded for some rivers and the number of sites each work programme occurs at will be further reduced.

Scenario E: Work aims to 'hold the line' and protect only key biodiversity at limited locations with minimal to no restoration work. Work is reduced to 10-15% of total and aims to maintain existing key values in a limited number of key locations. Only the rivers in the upper catchments are included.

3 Results

This section presents the estimated costings in five sub-sections: 1) section 3.1 - total costs, 2) section 3.2 - cost by work plan, 3) section 3.3 - cost by river or wetland, 4) section 3.4 - example costs of two rivers, and 5) section 3.5 - the costs of each scenario presented. Costs presented in tables are rounded to the nearest hundred NZ dollars.

3.1 Total costs

The total annual cost of all proposed hydroelectric generation mitigation work within the Waitaki River catchment is estimated to be \$18.8 million per annum over the 35-year period (Table 3). For river work only, the total cost per annum is \$18.3 million. The total cost per annum of only wetland work is \$590,000. There are some overlapping trapping lines from rivers and wetlands that only get included once in the combined total, but twice in the separate totals which accounts for the higher total cost when separating rivers and wetlands. The full data table for all tasks and costs is in the supporting excel file, docCM-6302481.

Initial set-up costs for most of the projects is estimated to be approximately 4-5 times higher than the ongoing annual costs. This means that there are significantly higher cost estimates for year one of this work compared with the following years. The per annum costs presented in this document are inclusive of the high set-up cost, and are presented as the total cost spread evenly over the 35 years. Although there was some staggering of estimated project start dates for this assessment, it is minimal and if work was to commence as presented in this document, the first year would cost approximately \$59 million, and subsequent years would range from \$10.2 - \$12.5 million per annum.

3.2 Cost by work plan

This section details the cost per annum of each proposed work plan when averaged across the 35 years of a standard resource consent. The total costs provided in this section include the cost of a Programme Manager (\$100,000), regardless of the size of the programme. This is because if an individual project was to be carried out on all rivers or wetlands, the project would still require 1 FTE for oversight. All other costs are proportional to the size of the project.

The largest costs are predator fencing at 43% of the total budget and weed control at 28.5% of the total budget (Table 4). Weed control totals are \$5.5 million per annum, of which 85% (\$4.7 million) is weed control on banks only, whereas clearing of islands is 11% (\$629,000) and spot spraying is 4% (\$194,000) per annum. Predator control work for all predators (mammalian, fish and bird) totals 21.4% of the total budget, or \$4.5 million dollars per annum. Of this cost, mouse control contributes 51% of the cost at \$2.2 million per annum, small mammal predator control for rats, cats, hedgehogs, stoats and ferrets inclusive was 33% (\$1.5 million per annum), predatory fish control 14% at \$600,000 per annum, and SBBG control is 1.8% of the cost at \$177,000 per annum. Climate change translocations, stock fencing and wetland creation each contribute 1-2% of the total cost at an estimated \$196,000 - \$343,000 per annum.

Table 4 Cost of proposed projects. The overall totals column include research and development, monitoring, project manager, and project assistants for the 35-year duration of a standard resource consent period. The proportion of total is the proportion of total costs of "All work" (first row values).

Work plan	Overall Total	Overall Total per annum	Proportion of Total (%)
All work	\$658,559,600	\$18,816,000	100
Rivers only	\$642,139,300	\$18,346,800	97
Wetlands only	\$20,793,200	\$594,100	3
Small mammal predator control	\$52,043,700	\$1,487,000	7
Mouse control	\$78,184,600	\$2,233,900	11
Weed control banks and islands	\$186,601,200	\$5,331,500	28
Weed control: Banks	\$164,820,400	\$4,709,200	25
Weed control: Spot spraying only	\$6,774,600	\$193,600	0.5
Restoration/weed control: Islands	\$22,006,094	\$628,746	3
Disturbance	\$27,349,200	\$781,400	4
Predatory fish	\$21,044,800	\$601,300	3
Predatory birds	\$6,205,500	\$177,300	0.4
Aquatic weeds	\$5,116,300	\$146,200	0.2
Predator fences	\$282,917,200	\$8,083,300	43
Climate change translocations	\$12,034,600	\$343,800	1.8
Wetland creation	\$7,404,400	\$211,500	1
Stock fencing	\$6,884,400	\$196,700	1

3.3 Cost by river or wetland

This section provides the estimated costs per river or wetland if all proposed projects were carried out. The costs in this table do not add to the same amount as the cost of doing all work because overlapping predator control lines were counted individually for each river or wetland. Except for Grays Wetland, there are less projects proposed for wetlands than rivers within this assessment, for example predator fences and SBBG control are only included in the proposed work plans for rivers. This is reflected in the significantly lower cost of wetland work compared with river work.

The average estimated cost of carrying out all proposed work on an individual river is \$785,000 per river per annum, with the lowest cost being the Upper Benmore at \$111,000 and the highest being the Tekapo at \$1.6 million per annum. Seven of the rivers had an estimated cost over \$1 million per annum, Forks, Hakataramea, Lower Ahuriri, Lower Waitaki, Otamatapaio, Pukaki and Tekapo.

The average estimated annual cost for work on individual wetlands is \$118,000 per wetland, with the lowest annual cost being Lake McGregor at \$103,000 per annum and the highest being Lake Alexandra at \$129,000 per annum (Table 5). The percentage of total cost for all work on each

individual wetland was less than 1% per wetland, therefore the proportion of total column for wetlands was excluded from Table 5.

Table 5 Estimated costs per river or wetland for all identified workplans and the percentage of the total costs of all workplans that each river contributes. Grays wetland is included in the rivers as the workplans for this area were planned as a river, not a wetland.

Rivers			Wetlands	
River name	Overall total per annum	Proportion of overall total (%)	Wetland name	Overall total per annum
Dobson River	\$733,500	3	Ben Dhu	\$121,900
Edwards Streaan	\$516,500	2	Ben Omar Swamp	\$119,200
Forks River	\$1,239,600	6	Braemar Tarns	\$124,200
Godley River	\$674,600	3	Glenmore Tarns	\$118,600
Grays Wetland	\$326,600	1	Joseph Swamp	\$121,500
Hakataramea River	\$1,370,900	7	Lake Alexandra	\$129,400
Hopkins River	\$874,400	4	Lake McGregor	\$103,200
Irishmans Creek	\$784,600	4	Mailbox Inlet	\$106,500
Jollie River	\$481,200	2	Mick's Lagoon	\$106,200
Lower Ahuriri River	\$1,234,600	6	Mt Gerald Wetland	\$116,500
Lower Cass River	\$329,600	1	Ohau Roadside Tarns	\$127,400
Lower Ohau River	\$522,300	2	Wairepo Tarns	\$119,900
Lower Waitaki River	\$1,819,200	9	Wold's Swamp	\$116,800
Macaulay River	\$499,000	2		
Mary Burn	\$777,100	4		
Murchison River	\$353,500	1		
Otamatapaio River	\$1,092,000	5		
Pukaki River	\$1,367,200	7		
Sawdon Stream	\$468,400	2		
Snow River	\$336,700	1		
Tasman River	\$503,700	2		
Tekapo River	\$1,600,800	8		
Twizel River	\$828,200	4		
Upper Ahuriri River	\$907,700	4		
Upper Benmore	\$111,100	0		
Upper Cass	\$503,500	2		
Upper Ohau	\$936,000	4		

3.4 Example of estimated costs for two individual rivers

The Tekapo and the Upper Ahuriri Rivers were selected for a detailed description of all estimated costs. These rivers were selected because they are both of a similar length (49km and 47 km respectively), but they have different management requirements. The Tekapo River is a controlled flow river at lower relative altitude, and has high levels of several key species of weeds infesting it, many access points requiring monitoring for disturbance mitigation, and requires SBBG control. The Upper Ahuriri is an upper river, above a gorge, and is relatively weed free, requiring less disturbance management, and does not have SBBG colonies. In both sites, the costs that are calculated based on area only (e.g. trapping lines) are similar.

The annual estimated costs of all proposed work on the Tekapo and Upper Ahuriri Rivers are \$1.2 million and \$623,000 respectively. The largest costs for the Tekapo River are weed control, 43% of the total annual cost (\$508,000 per annum) and predator fence construction which is 31.5% of the total estimated cost (\$365,000 per annum). The Upper Ahuriri has predator fencing as the biggest cost at 61% of the total estimated annual management (\$381,000 per annum), but weed control as less than 1% of the total annual cost at \$5,600 per annum. The next largest cost for the Upper Ahuriri is mice control at 16.5% of the total estimated annual cost. Mice control for both rivers is estimated at \$103,000 per annum, but represents only 8.9% of the costs for the Tekapo River.

Table 6 Breakdown of estimated costs of work to provided full protection and restoration to the Tekapo and upper Ahuriri Rivers

Project	Task	Tekapo River		Upper Ahuriri River	
		Annual cost	% total	Annual cost	% total
Aquatic weed control		\$1,400	0.1	\$1,400	0.2
Browsing mammal control	Lagomorphs	\$3,000	0.3	\$1,500	0.2
Climate change adaptation	Translocation	\$2,200	0.2	\$2,200	0.4
Disturbance	Minimising disturbance	\$11,200	1.0	\$22,700	3.6
Predatory bird control	Southern black-backed gulls	\$9,500	0.8	\$0	0.0
Predatory fish management	Trout and salmon	\$14,800	1.3	\$15,000	2.4
Restorative action	Clearing braided river islands	0	0.0	\$0	0.0
	Predator fence construction	\$364,800	31.5	\$381,400	61.2
	Restoration planting	\$3,600	0.3	\$3,900	0.6
	Translocation	\$7,600	0.7	\$7,600	1.2
	Wetland creation	\$3,300	0.3	\$3,300	0.5
Small mammal predator control	Cats and possums	\$37,900	3.3	\$22,500	3.6
	Ferrets	\$42,900	3.7	\$25,800	4.1
	Mice	\$102,700	8.9	\$102,600	16.5
	Stoats, hedgehogs, rats	\$42,000	3.6	\$25,200	4.1
Stock management	Stock fencing	\$2,500	0.2	\$2,500	0.4
Weed control	Clearing islands and banks	\$508,500	43.9	\$0	0.0
	Spot Spraying	\$0	0.0	\$5,600	0.9
Total		\$1,219,800		\$623,000	

3.5 Estimated costing for each evaluated scenario

This section details the estimated cost of each evaluated scenario (see section 2.5) then identifies what level of protection could be provided, and which values could be managed under each scenario.

The objectives of each scenario are as follows:

Scenario A: All identified values fully managed and protected at all places

Scenario B: All identified values mostly managed at most places

Scenario C: Most identified values mostly managed at some places

Scenario D: Most identified values mostly managed at a few places

Scenario E: Few key values managed at a few key places

Scenario A: All identified values fully managed and protected at all places. Estimated \$18.8 million per annum (Table 7). This scenario would provide protection for all identified values, including the taxonomic groups (terrestrial invertebrates, river birds, wetland birds, freshwater fish, terrestrial plants and lizards), and ecosystems (wetland and braided river) for the entire upper Waitaki Basin. This scenario facilitates a full suite of pest control operations, including browsing and predatory pests (SBBG, possums, cats, stoats, mice, rats, ferrets, and hedgehogs). Restoration work for wetlands and braided river island can be carried out, and proactive steps to assist species in climate change migration are facilitated.

Scenario B: All identified values mostly managed at most places. Estimated \$13.6 million per annum (Table 7). This scenario would provide protection for all identified values, including the taxonomic groups (terrestrial invertebrates, river birds, wetland birds, freshwater fish, terrestrial plants and lizards), and ecosystems (wetland and braided river) in most areas of the upper Waitaki Basin. Work possible in this scenario would be reduced to 73% of total cost of all work, and individual tasks/projects would be carried-out in 96-100% of the rivers included in this assessment. Predator fences and translocations into predator fences would be excluded from the Hakataramea River. Weed control would be significantly reduced, excluding mechanical clearing of banks.

Scenario C: Most identified values mostly managed at some places. Work aims to restore and protect most biodiversity at most places, and cost is 59% of the total of all potential projects. Hakataramea, Lower Ohau, Forks, Edwards and Otamatapaio Rivers were excluded. Mechanical weed control was reduced to islands only, and only for 60% of the rivers. Spot spraying was still included for the upper rivers. Predator fences and restoration planting were reduced to 77% of potential sites. Translocation for climate change migration was excluded for all rivers. All other tasks were reduced to between 76 and 88% of the potential sites.

Scenario D: Most identified values mostly managed at a few places. Work aims to restore and protect most biodiversity at key places only. This scenario cost 31% of the total from scenario 'A'. No projects were removed when compared with scenario 'C', but the number of sites projects were proposed for is reduced to 66% or below, with the focus being on the rivers in the upper catchments. Aquatic weed control, small mammal pest control and spot spraying was reduced to 54-65% of the potential sites. All other projects that were still included were reduced to between 42-46% of the potential sites except for island clearing which is only in 20% of the originally proposed sites.

Scenario E: Few key values managed at a few key places. Work aims to 'hold the line' and protect only key biodiversity at limited locations with minimal to no restoration work. Proposed work for this scenario is reduced to 12% of total in scenario 'A' and primarily includes work that 'holds the line', i.e. with the exception of one wetland (4% of the potential total) and three rivers in the upper catchments, no construction was included (i.e. no dams, stock fences or predator fences), and activities associated with the constructions was excluded (translocations, restoration plantings, trout and salmon control). This excludes 7 of the 17 identified potential work programmes. Only the rivers in the upper catchments were included as these require less resources to maintain. Weed control was reduced to

areas with spot spraying only and reduced to 65% of the potential sites (no change from scenario 'D'). Small mammal predator control is reduced to 54% of the potential sites, except for mice control which is reduced to 26% of the sites.

Table 7. Costing of each scenario showing the total costs over 35 years of each scenario and the per annum cost.

Scenario	Overall Total (inc R&D, monitoring, PM and PA)	Overall Total per annum	Proportion of total (%)
Scenario A:	\$658,559,600	\$18,816,000	100
Scenario B:	\$475,933,500	\$13,598,100	72
Scenario C:	\$383,423,700	\$10,955,000	58
Scenario D:	\$199,225,800	\$5,692,200	30
Scenario E:	\$74,743,100	\$2,135,500	11

Table 8 Work programmes carried out each scenario and the proportion of the total of rivers each work programme was included in for each scenario.

Objective	Programme	Scenario (% of sites)				
		A	B	C	D	E
Aquatic weed control	Aquatic weed control	100	100	77	54	46
Browsing mammal control	Lagomorph	100	100	77	46	46
Climate change adaptation	Translocation	100	100	0	0	0
Disturbance (e.g. vehicles)	Minimising disturbance	100	100	77	46	46
Predatory bird control	Southern black-backed gulls	100	100	76	44	44
Predatory fish management	Trout and salmon	100	100	77	46	0
Restorative action	Clearing braided river islands	-	100	60	20	0
	Predator fence construction	100	96	77	42	0
	Restoration planting	100	100	77	46	0
	Wetland creation	100	100	77	46	4
Small mammal predator control	Cats and possums	100	100	87	56	54
	Ferrets	100	100	87	56	54
	Mice	100	100	85	54	26
	Stoats, hedgehogs, rats	100	100	87	56	54
Stock management	Stock fencing	100	100	77	46	0
Weed control	Clearing islands and banks	100	0	0	0	0
	Spot Spraying	100	100	88	65	65

There was a vast difference in achievable level of management between the five presented scenarios. Figure 1 shows maps comparing the potential level of protection for each river under each evaluated scenario. Scenario A includes full protection and management for 100% of the rivers and their values. Only in scenario A is there full management and protection over any waterway. Scenario B includes most of the projects in all but one river, with that river having over half of the projects still included. In scenario C, most (all but 1-3) of the management tasks included for 81% of the rivers, 4% (one river) only had spot spraying, and 20% of rivers had no protection or management at all. In scenario D, 46% of rivers have most of the management tasks included, but 11% have minimal management or protection with only 1-3 projects included, and 42% of the rivers have no protection or management at all. In Scenario E, the maximum level of protection or management able to be funded in any river was at the level of 'half' or 'some' protection, and approximately half of the projects were excluded leaving

little, or no, restoration or species work. In scenario E, 46% of the rivers retained the 'half' level management, while 4% (1 river) had few (e.g., Jollie River) which retained spot spraying for weeds), and 50% of all rivers had no protection or management.

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Figure 1. Maps showing the level of protection for each river under each proposed scenario. Wetlands were excluded from this figure for the purpose of simplifying the images.

Figure 1 Key:

- Green = Full protection and management of all values.
- Yellow = Most protection and management in place with 1-3 projects not included.
- Orange = Some protection and management in place with approximately half of the identified projects included.
- Pink = Few of the values protected and minimal management in place with only 1-4 of the projects being included.
- Red = No protection or management of this waterway is included.

4 Discussion

4.1 General Discussion

Not all management projects and actions proposed here are specifically mitigating the direct impacts of hydro-electric development. Projects and actions selected were the mix of work that in our opinion will help mitigate direct hydro impacts at a place, or they are actions in another location within the catchment that is acting as an offset for some hydro-electric developments and impacts that are irreversible or not desirable to change.

The total annual cost of all proposed biodiversity work on rivers and wetlands within the Waitaki River catchment is estimated to be \$18.8 million per annum over the 35-year period. For river work only, the total cost per annum is \$18.3 million. The total cost per annum of only wetland work is \$590,000.

Initial set-up costs for most of the projects was approximately 4-5 times higher than the ongoing annual costs. If work was to commence as present in this document, the first year would cost an estimated \$59 million, and subsequent years would range from an estimated \$10.2 - \$12.5 million per annum. This relatively high initial cost can be further spread out by staggering set-up of work plans, either by staggering the start dates of individual project types, by staggering the set-up year by location for each project, or a combination of the two approaches. There was some staggering of work within this assessment (i.e. construction of weirs), however it was not fully explored as it would require an assessment of work priorities that is outside the scope of this document.

The location of the river is the biggest predictor of work costs. The seven rivers that had an estimated cost of over \$1 million per annum for all proposed work (Forks, Hakataramea, Lower Ahuriri, Lower Waitaki, Otamatapaio, Pukaki and Tekapo) are all at relatively lower altitudes, with high weed control and disturbance management costs. The Hakataramea, Lower Ahuriri, Lower Waitaki and Tekapo are also the four longest rivers. However, the Forks, Otamatapaio and Pukaki Rivers are among the shortest length rivers in the catchment. So, although the river length does increase costs, i.e. longer trapping lines and more predator fenced areas, this is not the key driver of the management cost. Rivers with wider riverbeds and large areas of banks or islands (e.g. the Tasman) also have increased costs with some projects, e.g. trapping lines and rabbit control. However, this increased cost is still less than the costs incurred in the lower rivers, with none of the six rivers with the largest area by ha (Tasman, Godley, Irishman's, Hopkins or Macauley) costing over \$1 million per annum.

4.2 Cost by work plan

The approach of reducing costs by reducing work intensity was not used within this assessment, as the reduction in efficacy caused by a reduction in effort are not well understood. For example, reducing the number of traps set has an unknown impact on the efficacy of traplines, but will most likely create disproportionate reduction in the effectiveness compared with the financial savings. It could be possible to reduce the costs by reducing the intensity of some work plans. However, this would only be applicable for some projects and would need to be done cautiously to manage any potential loss of efficacy. For example, predator fencing, weed control and mice control were the highest costing projects identified in this assessment (\$8.1 million \$5.4 million and \$2.2 million per annum respectively). It could be an option to further space predator fences along riverbanks to reduce costs. This will reduce the ability to not only manage predator impact of terrestrial invertebrates and plants, but translocations for climate change.

Mice control was identified as one of the highest costs. This is largely because there is currently no SOP available for mouse control and therefore, estimates in this project were based on using the most intensive example from other successful projects (e.g. traps every 20m instead of every 25m). This cost may be significantly reduced if braided river specific research is able to be carried out to identify the intensity required.

4.3 Scenarios

In order to provide full protection to all areas (scenario A) an estimated \$18.8 million dollars per annum is required, with the minimum estimate which will enable protection of key species at key sites (scenario E) costing an estimated \$2 million per annum. The difference in protection levels between these two estimates has seven of the 17 (41%) identified necessary projects, with clearing weeds from banks or islands, stock fencing, restoration planting, species translocations, predator fencing and pest fish control, excluded entirely. The remaining projects would only be carried out in 4% - 65% (project dependent) of the identified sites, leaving 52% of the catchment's rivers and 41% of wetlands receiving no management or protection work at all.

Scenarios B-E have mechanical clearing of riverbanks excluded from all rivers. Eliminating weed control from riverbanks is not an optimal choice for on-ground work, as weedy riverbeds are known to exacerbate other ecological issues (e.g. predation, river movement). Additionally, without clearing of some areas of riverbeds, several of the other projects presented in this report would not be feasible (e.g. predator fences and mouse control). Since partial completion of tasks was not included in this report, and clearing of all riverbeds was a significant cost that if done in full would consume the majority of the budgets, it was removed and clearing of islands was included. This may potentially represent the clearing of a similar area of riverbed in each catchment, allowing for a weed control budget without the full cost of riverbed clearing.

Although a 'holding the line', or 'management only' approach is presented in this document, it is insufficient to fully mitigate the impacts of hydroelectric activity. This is because holding the line would be assuming that the current state of the rivers and their ecosystems is sufficient to sustain the species within them and act as a functioning ecosystem over the next 35 years. This is unlikely to be the case, especially when inevitable climate change impacts are included.

5 References

Ministry of Primary Industries (MPI), 2016. Ministry for Primary Industries Stock Exclusion Costs Report. MPI Technical Paper No: 2017/11. Wellington, New Zealand.

Rebergen, A.L.; Woolmore, C.B. 2015: Project River Recovery Strategic Plan 2012– 2019. Project River Recovery Report 2015/01, Department of Conservation, Twizel. 28 p.

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6 Appendices

Appendix 1. Budgeted costs for the 2018/2019 Project River Recovery work programme

Activity	Site	Targeted species	Opex	Contractor	Staff	Total
Small mammal pest control	Tasman Valley	Cats, ferrets, stoats, weasels, rats	\$13,000	\$58,000	DOC core budget	\$71,000
	Upper Ohau - Tern Island	Cats, ferrets, stoats, weasels, rats	\$2,000	\$20,000		\$22,000
Outcome monitoring	Tasman Valley	Black-fronted tern, black-billed gull	\$1,500		\$15,000	\$16,500
	Tern Island	Black-fronted tern			\$5,000	\$5,000
Skink monitoring	Tern Island	Lakes skink			\$1,500	\$1,500
	Lake Benmore gullies	Scree skink, lakes skink			\$1,000	\$1,000
Outcome monitoring	Lower Waitaki Islands	BFT, black-billed gull		\$7600	\$1,100	\$8,700
SBBG control	Tasman, Murchison, Cass, Godley, Fork	SBBG	\$10,000	\$2,700	\$500	\$13,200
Predatory fish control		Trout	\$1,500		\$300	\$1,800
Weed Control	Tasman	Mainly Russell lupin, also false tamarisk, broom, willow, gorse		\$27,000	\$500	\$27,500
	Fork Stream	Russell lupin and broom		\$46,000		\$46,000
	Lower Ohau River	Russell lupin, broom, willow, wildings		\$68,000		\$68,000
	Godley/Cass/Macaulay	Lupin, gorse, false tamarisk, willow, broom			Incl. in ranger time	\$0
	Upper Ahuriri	Russell lupin and willow	\$4,500		Incl. in ranger time	\$4,500
	#Upper Tekapo	Russell lupin, broom, willow	\$36,000			\$36,000
	+Lake Poaka, Waterwheel wetland	Alder, willow, silver birch, wildings	\$8,000	\$26,000		\$34,000
	Other selected sites and species	Various e.g. yellow tree lupin, buddleia	\$10,000		\$21,000	\$31,000
Restoration	Ruataniwha and Waterwheel wetlands				\$500	\$500
Overheads	Vehicles and office		\$54,000			\$54,000
Senior Ranger					\$25,000	\$25,000
C band rangers					\$75,000	\$75,000
Total			\$140,500	\$255,300	\$146,400	\$542,200

Appendix 2: The weed cover groupings of each river.

Sparse Weed Cover	Dense Weed Cover
Dobson	Lower Ahuriri
Edwards	Lower Ohau
Godley	Lower Waitaki
Grays Wetland	Pukaki
Hakataramea	Tekapo
Hopkins	Twizel
Irishmans	Upper Ohau
Jollie	
Lower Cass	
Macaulay	
Marybury	
Murchison	
Sawdon	
Snow	
Tasman	
Upper Ahuriri	
Upper Cass	
Forks (lower)	