MANAGEMENT OF RURAL WATER SCHEMES: RESPONDING TO CLIMATE CHANGE

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ABSTRACT

Rural irrigation and water supply schemes are essential to the performance and long term operation of New Zealand's agricultural sector. This paper explains the expected impacts of climate change on rural water schemes, and identifies possible response options to better manage resources and infrastructure in response to climatic changes. It draws on a comprehensive study completed for the Ministry of Agriculture and Forestry to assess climate change impacts on rural water infrastructure, and identify opportunities to implement changes to how rural water schemes are managed to minimise the future impacts of climate change.

The proposed climatic changes in New Zealand will impact on rural water scheme infrastructure by increasing sediment loads on storage facilities, increasing the frequency and severity of floods and droughts, and the significance of water quality and ecological effects. It will also alter the reliability of supply.

The MAF study identified a number of opportunities to better manage rural water schemes to encourage the adaption to and minimisation of the impact of climate change. Some of these changes could be implemented through granting global consents or through regulatory changes to Regional Plans, while others could be addressed through general scheme management works.

KEYWORDS

Climate change, irrigation schemes, rural water supply, planning, adaptation

1 INTRODUCTION

Climate change will impact on both the performance and long term operations of irrigation schemes and rural water supply schemes throughout New Zealand. New Zealand agriculture will face a changing climate in the future including warmer temperatures, increased droughts and more intensive and frequent rainfall events. This will affect both the growing conditions of productive crops and the requirements for water infrastructure.

MWH recently completed a comprehensive study for the Ministry of Agriculture and Forestry (MAF) to assess climate change impacts on rural water infrastructure throughout the country, and identify opportunities to implement changes to how rural water schemes are managed to minimise the future impacts of climate change. A series of case studies throughout New Zealand was used to illustrate the relevant effects and response options. The possible response options and planning changes that can be adopted are expanded in detail for the Manuherikia Irrigation Scheme case study in Central Otago.

2 CLIMATIC CHANGES AND EFFECTS ON RURAL WATER SCHEMES

2.1 PROPOSED CLIMATIC CHANGES

The Ministry for the Environment's guidance manual on Climate Change Effects and Impacts Assessment (2008) was used to identify the likely future climatic changes. This assessment showed:

- A fairly uniform warming across New Zealand is expected, with an average temperature increase of about 0.9°C by 2040 and 2°C by 2090.

- Average annual rainfalls are projected to increase in most areas, other than in the far north of the North Island and the east coast. There are some seasonal changes anticipated, with reduced summer rainfall in the upper catchments of the Southern Alps and reduced spring rainfall in Northland.

- The frequency of extreme rainfall events and droughts is projected to increase in magnitude and/or frequency across the entire country.

- The occurrence of days with temperature in excess of 25°C is projected to increase, with the greatest increase in the north and the least increase in the south.

- The temperature increases will lead to warmer water temperatures, which could lead to increased risk of new invasive organisms in source streams, reservoirs or distribution races.

- Warmer water temperatures and increased carbon dioxide levels could lead to increased aquatic plant productivity in source streams, with increasingly variable pH and dissolved oxygen regimes and increased algae biomass.

2.2 EFFECTS ON RURAL WATER SCHEMES

The proposed climatic changes will impact on rural water scheme infrastructure by increasing sediment loads on storage facilities, increasing the frequency and severity of floods and droughts, and having significant consequential effects on water quality and ecology. It will also alter the reliability of supply. These effects are summarised in the table below:

Table 1: Effects on Rural Water Schemes

Climate Change	Effect
Increase in rainfall	Higher rainfall and average river and stream flows will provide benefits for instream ecology and at times reduce pressure on the water resource.
Decrease in rainfall	Lower stream flows and potentially more rigorous residual flow requirements for source streams. Increased pressure on water resources.
Changing rainfall patterns	Seasonal variations may lead to increased pressure on water resources at times. Less water (or more water) available for storage at different times of the year.
Less snow fall and shorter snow melt season	Lower flows in spring and summer may lead to increased pressure on water resources at times.
Increased risk of drought	Increased frequency and durations of very low river and stream flows may at times increase pressure on water resources and stream ecology. Minimum/environmental flow could be reached more often and abstraction for schemes reduced or halted for periods of time.
Increase in average temperature; Increase in very hot days	Increased temperatures in source rivers and streams with potentially adverse effects on stream ecology. Increased temperatures in storages contributing to higher risk of nuisance algae blooms. Increased risk of weeds, pest fish or other unwanted organisms. May contribute to increased variability on DO and pH regimes. Potentially higher maintenance costs for scheme infrastructure due to clogging of screens and increased corrosion. May also increase the risk of invasion by other unwanted organisms (but possibly reduced risk associated with didymo). Increase in peak demand for stock watering.
Increased frequency of heavy rain events	Increased sediment and nutrient inputs to storages contributing to higher risk of nuisance algae blooms or weeds. Increased sediment yields and erosion in scheme catchments.

Climate Change	Effect
	Potentially increased maintenance costs for scheme infrastructure. An increase in the frequency of large floods may lead to re-evaluation of design parameters for storage lakes. Potential effects on pipeline stability.
Increased summer water deficit for un-irrigated land	Increased water demand for land currently in schemes.
Increased windiness	Coupled with an increase in temperature this could lead to an increase in erosion of topsoil.
Sea level rise	Bores near the coast will have an increased risk of saltwater intrusion.
Decrease in groundwater levels	Increase in pumping head.

Climate change will impact on all New Zealand rural water infrastructure schemes to a greater or lesser extent, affecting capital, operating and maintenance costs. The overall implications of climate change from an infrastructure perspective are expected to be inversely proportional to size: the smaller the scheme, the greater the potential capital, operating and maintenance cost impacts.

Significant one-off capital cost will typically be limited to flood change impacts to storage reservoir spillways. Weed growth due to the increase in water temperature will require infrastructural upgrades and additional operation and maintenance costs. Schemes with screened intakes will likely require increases in capacity and cleaning mechanisms. Support infrastructure including roads and culverts could be disrupted by flooding limiting access to the schemes. The most significant water-related impacts of climate change will arise from the on-farm consequences of altered levels of service and potential disruptions to supplies.

2.3 MANAGING THE IMPACTS OF CLIMATE CHANGE

The MAF study identified a number of opportunities to better manage rural water schemes to encourage the adaptation to and minimization of the impact of climate change. These comprise scheme and on-farm adaptation strategies, and planning responses.

Adaptation strategies include increasing storage within schemes, installing remediation measures to reduce flood damage and identifying secondary flow paths, increasing volumes of water taken, and undertaking various river works to protect scheme assets.

From a planning perspective, involvement of scheme owners and managers in strategic planning in source catchments to help set the rule framework, the seeking of 'global' resource consents for standard scheme works, and incorporating adaptation strategies into collective annual maintenance or asset management plans all offer opportunities to increase the resilience of schemes to the effects of climate change. There is also value in being familiar with the Emergency Works provisions under the RMA, which provide for emergency works to be undertaken following a notification process to the regional council. This allows for the application for retrospective consents, with improvements in management efficiencies during extreme weather events.

3 MANUHERIKIA IRRIGATION SCHEME

3.1 INTRODUCTION

The Manuherikia Irrigation Scheme is located just north of Alexandra and east of Clyde in Central Otago, and comprised one of the case study irrigation schemes for the MAF study. The scheme supplies water to about 285 properties, with an irrigated area of about 2,250 hectares. It was opened in 1922, and was the first scheme in Central Otago that was not founded on the remains of mining enterprise. It is a storage and gravity scheme, which supplies water to land with varying uses including arable farming, horticulture, viticulture and lifestyle properties.

The scheme consists of a main race which draws water from the Manuherikia River and utilizes storage from the Falls Dam located on the upper reaches of the river. The supply is supplemented by the Borough race system which is supplied by a local stream (Chatto Creek).

The scheme has been improved substantially since originally constructed, including substantial benching of races, realignment of leaking sections, the addition of major piping works at the headwaters, and upgrading of structures and race outlets.

Photograph 1: Main race of Manuherikia Irrigation Scheme

3.2 PROJECTED CLIMATIC CHANGES

The mean annual rainfall over the Manuherikia catchment area is projected to increase across all seasons, with up to 20% over the winter months by 2090. Similarly, there will be an increase in the frequency of extreme rainfall events. However annual snow falls at high elevations of the catchment (1600 to 1800 m) are expected to decrease considerably, by 20% in 2040 and 40% in 2090. This will result in a marked change in seasonal river flow in spring and early summer when snowmelt traditionally boosts flows.

Temperatures are projected to increase in line with the national average by 0.9°C above current levels by 2040 and 2.0°C by 2090, coupled with the number of very hot days (over 25°C) increasing and number of frosts decreasing. The number of drought days is projected to increase but not markedly.

The temperature of the river water is projected to increase with rising air temperatures, and water in the Manuherikia main race, which is mostly unshaded, is expected to be susceptible to summer heating.

3.3 IMPACTS ON INFRASTRUCTURE AND POTENTIAL RESPONSE OPTIONS

Projected increases in mean rainfall in the Manuherikia catchment area will provide benefits for instream ecology and reduce pressure on the water resource. However the increase in extreme rain events is likely to lead to increased sediment yields from erosion prone areas, and the requirement for increased sediment cleaning.

The projected small increase in the drought risk in the area is expected to increase the demand for irrigation water, particularly in the dry summer months when the river flow is low. The consequence of the increased water temperatures and CO_2 levels is likely to contribute to the development of nuisance weed and algae growth, which is expected to increase the clogging of screens and requirement for weed cleaning.

The rate of supply of water is constrained by the existing capacity of the race network, and increasing daily supply rates would require a major upgrade of the irrigation reticulation system. The projections indicate an increase in catchment runoff and inflows into the storage dam over winter and spring. Depending on the operational use of the dam storage, and the flexibility of supply from the storage reservoir, this increase in over-season inflows could provide additional seasonal supply to match increased seasonal demand. The following table identifies the climatic effects and potential impacts and response options for the Manuherikia Scheme.

Table 2: Climate Change Effects and Potential Impacts and Response Options

Climate Change	Effect	Impact and Response Options
Average rainfall increased across all seasons	Higher average river flows across all seasons will provide benefits for instream ecology.	At times pressure on the water resource will be reduced.
Increased risk of drought	Increased frequency and durations of very low river flows may at times increase pressure on water resources.	Increased pressure on water resources, particularly in the dry summer months when the river flow is low.
Increase in average temperature; Increase in very hot days	Increased summer temperatures in the Manuherikia River contributing to higher risk of nuisance algae growth and placing stream ecology under increased stress.	Potentially higher maintenance costs for irrigation scheme infrastructure due to clogging of screens and increased corrosion. May also increase the risk of invasion by other unwanted organisms (but possibly reduced risk associated with didymo). Increased removal of weed and cleaning required. Installation of intake screens will help to prevent weed and debris ingestion. Increased operation and maintenance costs on farm due to damage and clogging to service lines and spray heads
Increased frequency of heavy rain events	Increased sediment loads in the Manuherikia River.	Increased maintenance costs related to sediment cleaning in the race. Potential flood damage and increased repairs.
Increased summer water deficit for un-irrigated land	Increased water demand for land currently in Scheme	Increased pressure on water resources.

3.4 PROPOSED FUTURE WORKS

The scheme operators have become increasingly aware that impacts of climate change may have risks to the future operation of the scheme. It is expected that regional pressure will drive the scheme to use water more efficiently and may potentially result in a change of infrastructure to piping.

Land use change to dairy or other intensive uses in the upstream catchments may increase nutrient loadings and potentially weed growth. Weed growth is a primary concern and an increase in weed clearing requirements is already being experienced. Increased sedimentation will require more race cleaning.

Flooding is an area of concern due to the difficulty in accessing the tunnel intake and the risk of damage to the gorge races and piped sections from high waters. Automation of the intake gates, which is programmed into the Scheme's forward works programme, will decrease the risk of damage.

The annual operation and maintenance costs are anticipated to increase by about 40% as a result of climate change.

There is a proposal for a new scheme to irrigate dryland located east of Clyde township using water from Lake Dunstan. The Manuherikia Irrigation Co-operative Society holds a water permit for irrigation water from this

location. The irrigation would allow other more intensive land uses but development of the land into intensive land uses would also be necessary for the scheme to be economic.

Photograph 2: De-silter at the outlet of Tunnel No. 1 of the Manuherikia Irrigation Scheme

3.5 PLANNING RESPONSES

The planning framework for the area where the Manuherikia Scheme is located is the Regional Plan: Water for Otago. The Scheme is located within a catchment that is substantially overallocated as a result of past water allocation decisions, and availability of any extra water to mitigate the increased risk of drought or summer water deficit for unirrigated land is likely to be significantly constrained.

However, the Otago Regional Council has an ongoing programme of plan changes to the Regional Plan: Water. One of the most recent of these plan changes proposed insertion of a new policy for the Council to promote, approve and support water management groups to assist the Council with management of water resources. Some groups are already starting to establish in other catchments in Central Otago, offering an opportunity for scheme owners and managers to be involved in the strategic management of water in source catchments.

With increasing interest in water storage throughout New Zealand it is likely that regional plan provisions will be updated to provide policy and rule guidance for applications to dam and store water. While changes are unlikely to be made to the Regional Plan: Water to alter existing minimum flow requirements for the Manuherikia catchment, further policies may be proposed regarding water storage. Formal plan change processes offer an

opportunity for scheme owners and managers to assist in setting the overall management framework and increasing understanding of opportunities to mitigate the effects of climate change on schemes.

Various maintenance and repair activities on the scheme, such as sediment clearance and flood repairs that will require resource consent to undertake, may be able to be better anticipated. It is becoming more common around New Zealand for 'global' consents to be issued for common activities associated with one consent holder or infrastructural asset with examples in Otago for local authorities and the New Zealand Transport Authority already in place. Recognising the potential for increased maintenance works arising from effects of climate change, global consents could be obtained for common works in the Manuherikia Scheme. This would enable a faster response to necessary works and more efficient management of the Scheme. A challenge that remains to be overcome is developing consent conditions that are sufficiently flexible to provide for works whose size and quantum of environmental effects may not be known at the time application is made. By scheme owners or managers working with council consents and compliance staff it may be possible to define a range of effects, structures or size of works that can be covered by appropriate consent conditions. There may also be the possibility of introducing a provision that allows the conditions of consent to be reassessed every five years to accommodate any changes in circumstances due to climate change. This adaptive management approach may enable the conditions to be adjusted without needing to repeat the process of applying for consent.

This efficiency could be extended by adopting maintenance or asset management plans that apply collectively to several schemes or asset owners. Integrated management of maintenance and assets in this way promotes region-wide consistency, and greater efficiency by avoiding duplication in the administrative process.

4 RECOMMENDATIONS FOR FUTURE ACTION

The study highlighted a range of impacts that arise from a changing climate that affect rural water infrastructure. Climate change will impact on the performance and long term operations of both irrigation schemes and rural water supply schemes, and will impact on all the infrastructure components of rural water schemes.

An outcome of the study was to identify recommendations for future actions that focus on determining how climate change could be factored into water infrastructure management along with potential solutions to minimise climate change impacts on rural water infrastructure. Actions are proposed at a national, scheme and on-farm level and include:

- Arrange awareness and education programmes with all rural water scheme owners and managers to inform them of likely changes to respective scheme performance, to enable them to better plan for the future.

- Provide a forum through which climate change effects on rural water infrastructure can be incorporated into guidance documents and design guidelines that can be used by rural water infrastructure designers and owners.

- Promote research on changes in irrigation water demand under different climate change scenarios.

- Promote regional forums to enable climate change effects and impacts to be discussed and alternative technologies, agricultural practices and overall management options to be presented.

- Develop a "plan of action" to future proof existing schemes against potential physical changes likely to be caused by climate change impacts and effects.

- Adapt farm management practices to take into account climate change related impacts.

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