AQUALINC RESEARCH LIMITED

Manuherikia Catchment Study
Summary Report

Prepared for the Manuherikia Catchment Water Strategy Group

Report C12119/11

January 2012

CENTRAL OTAGO DISTRICT COUNCIL

Ministry for Primary Industries
Manatū Ahu Matua

Otago Regional Council

AQUALINC RESEARCH LIMITED

Disclaimer:

This report has been prepared solely for the benefit of the Manuherikia Catchment Water Strategy Group (MCWSG). No liability is accepted by Aqualinc Research Ltd or any employee or sub-consultant of this Company with respect to its use by any other person.

This disclaimer shall apply notwithstanding that the report may be made available to other persons for an application for permission or approval or to fulfil a legal requirement.

Quality Control			
Client:	Manuherikia Catchment Water Strategy Group		
Report reference:	Title: Manuherikia Catchment Study Summary Report		No: 11
Prepared by:	Peter Brown		
Reviewed by:		Approved for issue by:	
Date issued:	December 2012	Project No:	C12119

Document History							
Version:	0.8	Status:	Working draft	Author:	PB	Reviewer:	
Date:	06-11-12	Doc ID:	Working draft	Typist:		Approver:	
Version:	1.0	Status:	Draft	Author:	PB	Reviewer:	
Date:	06-12-12	Doc ID:	Manuherikia_Summary_Report_Draft	Typist:		Approver:	
Version:	1.1	Status:	Draft	Author:	PB	Reviewer:	IM
Date:	10-12-12	Doc ID:	Manuherikia_Summary_Report_Draft_10Dec	Typist:		Approver:	IM
Version:	1.2	Status:	Final	Author:	PB	Reviewer:	IM
Date:	30-01-13	Doc ID:	Manuherikia_Summary_Report_FINAL	Typist:		Approver:	IM

www.aqualinc.com

CHRISTCHURCH PO Box 20-462, Bishopdale 8543, Christchurch ♦ Phone: (03) 964 6521 ♦ Fax: (03) 964 6520

HAMILTON PO Box 14-041, Enderley 3252, Hamilton ♦ Phone: (07) 858 4851 ♦

TABLE OF CONTENTS

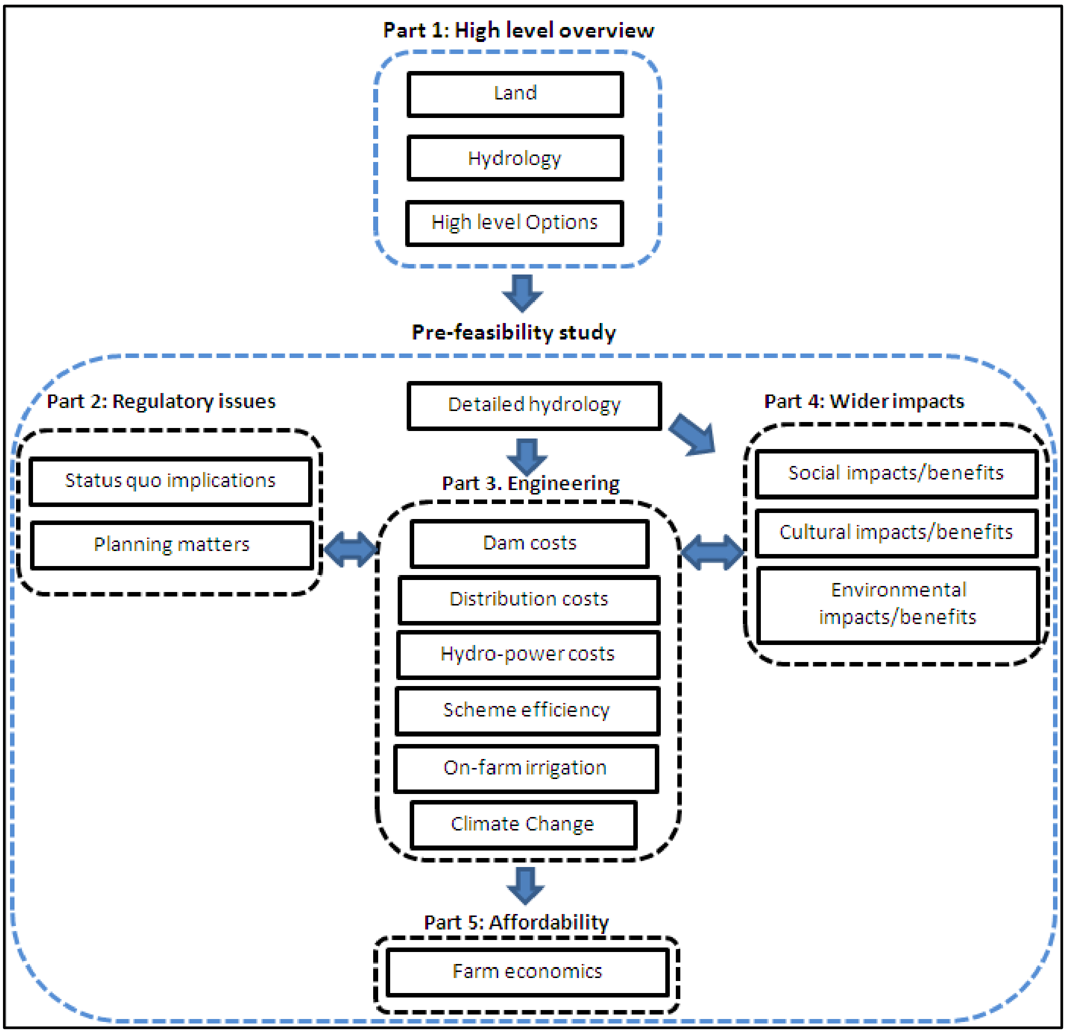
EXECUTIVE SUMMARY

Project Overview

The Manuherikia River system in Central Otago is a unique catchment in terms of climate, topography and water management history. The catchment is semi-arid, with a continental type of climate with larger seasonal temperature variations than is common elsewhere in New Zealand.

The community's long-term goal is to realise the potential growth within the region. The potential growth in the catchment is closely linked to water. It is generally believed that the growth potential is constrained by water availability for irrigation. The Manuherikia Catchment Water Strategy Group (MCWSG) was set up to develop and oversee the implementation of a water strategy for the catchment.

The project can be broadly grouped into four parts. Part 1 provides the initial big-picture information to understand the overall water resources in the catchment. Parts 2-5 looks in more detail at the most promising infrastructure development options. The MCWSG envisages that the project will provide information to help the community make informed decisions, leading to a comprehensive Manuherikia Catchment water strategy. Below is an overview of the study.



Manuherikia Catchment Strategic Water Study

Existing Irrigation

There are six farmer co-operative irrigation companies operating within the Manuherikia Catchment. The irrigation schemes are based on open race infrastructure, some of which was installed for gold mining and dates back to the 1860s. The purpose- built irrigation infrastructure was constructed in the period from 1912 to 1936. In addition to the schemes there are a number of private water permits. Currently, about 25,000 ha of the catchment is irrigated. Of this 25,000 ha, only about 15,000 ha is fully irrigated. The remaining 10,000 ha is only occasionally irrigated with unreliable water, in some cases as little as 2-3 times per year.

Since the last irrigation schemes were installed in the 1930's, there has been little investment in water infrastructure. Investment to maximise productivity per unit of water lags well behind the vast majority of irrigation in New Zealand. After 100 years of irrigating at a "basic" level, a change in mind-set is required to continue to operate irrigation to meet current standards and good practice.

Most of the schemes and private water takes are authorised by mining privileges that collectively expire on 1 October 2021. New water permits will be required. National and Regional policy under the RMA now requires higher standards to be adhered to with respect to freshwater management. These include minimum flows and residual flows in watercourses, allocation limits, greater accountability for the quantity of water taken, water quality limits and limits on discharges back to the environment, and consideration of the proximity of the take to the use location. Significant investment in water infrastructure will be necessary as part of water permit renewals.

Wild flooding and contour irrigation are still the dominate irrigation methods. Traditional irrigation application methods often use large amounts of water for limited production gain. Excess water that is not taken up in the root zone is by-washed to surface water or, by soakage, back into the catchment. These return flows are unlikely to meet the most recent water quality standards. Farmers with reliable water will almost certainly need to upgrade their irrigation systems to utilise modern, efficient irrigation methods. This will require significant on-farm investment – in the order of $3,000 to $5,000 per hectare.

In addition to upgrading systems on-farm, irrigators will need to fund irrigation scheme upgrades. A major cost is remedial work to Falls Dam, to increase the spillway capacity and to raise the dam to improve supply reliability. As a minimum, the dam needs to be raised 5 m, costing about $12 million or an average of $1,700/ha. This cost will need to be funded by Omakau (main race irrigators only), Blackstone, Manuherikia and Galloway Irrigation Schemes. In return these irrigators will receive high supply reliability.

Irrigation scheme distribution systems also need to be upgraded. All water intakes will be required to include measurement of the water taken and many will require provision for fish exclusion or fish passage. Automation and buffer storage ponds will be required to deliver the on-demand flow necessary for spray irrigation. Lining of leaky races will be necessary to comply with current efficiency requirements. Upper Manuherikia Valley distribution upgrades are estimated to cost an average of $700/ha. Part of this cost is associated with replacing aging infrastructure.

Indicative total off-farm upgrade costs are summarised below. For the Manuherikia Irrigation Scheme (MIS) upgrades, we assumed costs could be partially funded by the sale of new water from efficiency savings, reducing costs to existing irrigators. If MIS cannot expand their irrigated area, costs would be higher for existing irrigators.

Off-farm costs for existing Manuherikia Valley irrigators with reliable water

Irrigators	Supply area	Cost/ha
Omakau Irrigation (main race only)	3,400	$2,500
Blackstone Irrigation	600	$1,850
Manuherikia Irrigation (unpressurised)	1,400	$1,000
Manuherikia Irrigation (fully pressurised)	900	$3,500
Galloway Irrigation (fully pressurised)	550	$4,300
Other irrigators	2,500	$700
Total	**9,300**	

Development Options

There are 60,000 ha of irrigable land in the Manuherikia Catchment, of which only 15,000 ha is fully irrigated at present. There are several promising options that would allow the area fully irrigated with reliable water to be increased up to 35,000 ha. Most development potential is associated with raising Falls Dam. Options are summarised below.

Irrigation development potential in the Manuherikia Catchment

Option	New irrigated area	Cost/ha(1)
Raise Falls Dam 27m	14,500	$5,500
Lower Manuherikia efficiency improvements	900	$4,000(2)
Hope Creek Dam (Ida Valley quota increase)	2,500(3)	$1,500(4)
Mt Ida Dam (pressurised supply)	2,200	$11,000
Total	**20,100**	

(1) Cost to supply of unpressurised water under gravity to the farm boundary. ±30%.
(2) Where water is supplied under full pressure this could cost an extra $2,500/ha.
(3) Equivalent area of full irrigation. Cost/ha is however based on water being used to increase the annual quota to the 10,500 ha contract area.
(4) Cost indicative only since dam engineering only assessed to concept level. Cost is to provide a 60% increase in annual quota to the 10,500 ha contract area in the Ida Valley Irrigation Scheme.

Costs estimates have an estimated accuracy of ± 30%. Costs would be refined as part of full feasibility investigations. Land owner issues also need to be worked through before any development could proceed.

Raising Falls Dam would fully provide for the reasonable irrigation requirements of the Upper Manuherikia Valley. The present water allocation to the Lower Manuherikia is sufficient to provide for the reasonable future irrigation needs. Efficiency improvements will however be necessary to realise these benefits.

Hope Creek Dam is a promising option for supplying additional water to the Ida Valley Irrigation Scheme. Land owner concerns need to be worked though. Also the lack of site access means dam engineering is currently only at concept level. No other economical options are available for supplying extra water to the Ida Valley scheme.

Mt Ida Dam is a promising option for supplying extra water to the northern end of Ida Valley. The dam site has a relatively small catchment and is reliant on bringing in extra water from the Manuherikia Catchment using the Mt Ida race. No other economical options are available in the area.

Environmental and social impacts

Irrigation development has the potential to have impacts (positive or negative) on iwi, social, environmental and recreational values. Extensive irrigation has been occurring in the Manuherikia Catchment for over 100 years. All development options are not green-field developments; rather they are an upgrade of existing water infrastructure. Because irrigation is already an integral part of the catchment, effects are generally less than would occur in regions without a history of extensive irrigation.

Raising Falls Dam gives significant flexibility for achieving a flow regime that provides for both irrigation and environmental needs. Raising Falls Dam could allow flows in the Lower River to be increased during the driest months. Higher minimum flows should improve the trout fishery, the aesthetic value, and other recreational opportunities such as swimming and canoeing.

The most challenging environmental issue is probably to provide safe-guards that ensure high water quality is maintained. . To minimise this risk it is important that development is carefully managed, with a particular focus on good riparian management, efficient irrigation, minimising irrigation runoff, good nutrient management, and possibly limits on the proportion of higher risk land uses such as cropping and dairying.

Improvements in irrigation efficiency will reduce groundwater levels in some areas. The area most at risk is the Dunstan Flats. Efficiency improvements on the flats will result in some bore supplies becoming unreliable. New rural water supply schemes on Dunstan Flats and in other areas are a cost effective method of providing an alternative reliable supply of safe water for domestic use and stock.

Bio-diversity, visual, and heritage issues all need to be worked through. With good management we do not expect significant impacts on these values because new irrigation is largely in areas that have been extensively irrigated for over 80 years.

Experience from other irrigation schemes indicates irrigation development creates jobs, increases household income, provides population growth, and promotes investment. An increased proportion of children and young families can be expected, as can a greater proportion of tertiary qualified farmers and professionals. Rural population growth and investment would have a positive flow-on social and economic impact on service towns such as Clyde, Alexandra, Ranfurly and Omakau. New jobs and businesses would be created. Essential social support services such as schools, healthcare facilities, and voluntary organisations would experience growth.

Recommendations

We recommend the following options progress to a full feasibility study. These are the most economically viable development options in the Catchment.

- Raise Falls Dam up to 27 m;
- Lower Manuherikia efficiency improvements;
- Hope Creek Dam; and
- Mt Ida Dam.

A full feasibility study involves investigating each of these options in enough detail to ensure that farmers and investors have sufficient information to decide whether or not to progress to detailed design and construction. Resource consent procurement would be a critical part of the study, to give the necessary confidence around regulatory requirements. We estimate full feasibility investigations would cost in the order of 1-2% of the cost of capital works.

We recommend that some resource consent field work should start as soon as possible, specifically water quality measurements during the driest part of the year. Failure to start gathering additional field data shortly could extend the time it takes to complete investigations by up to a year.

Acknowledgements

This study has been made possible by the generosity of the following who have contributed by way of direct funding or by in-kind contributions. MCWSG are grateful for this support and wish to thank the following:

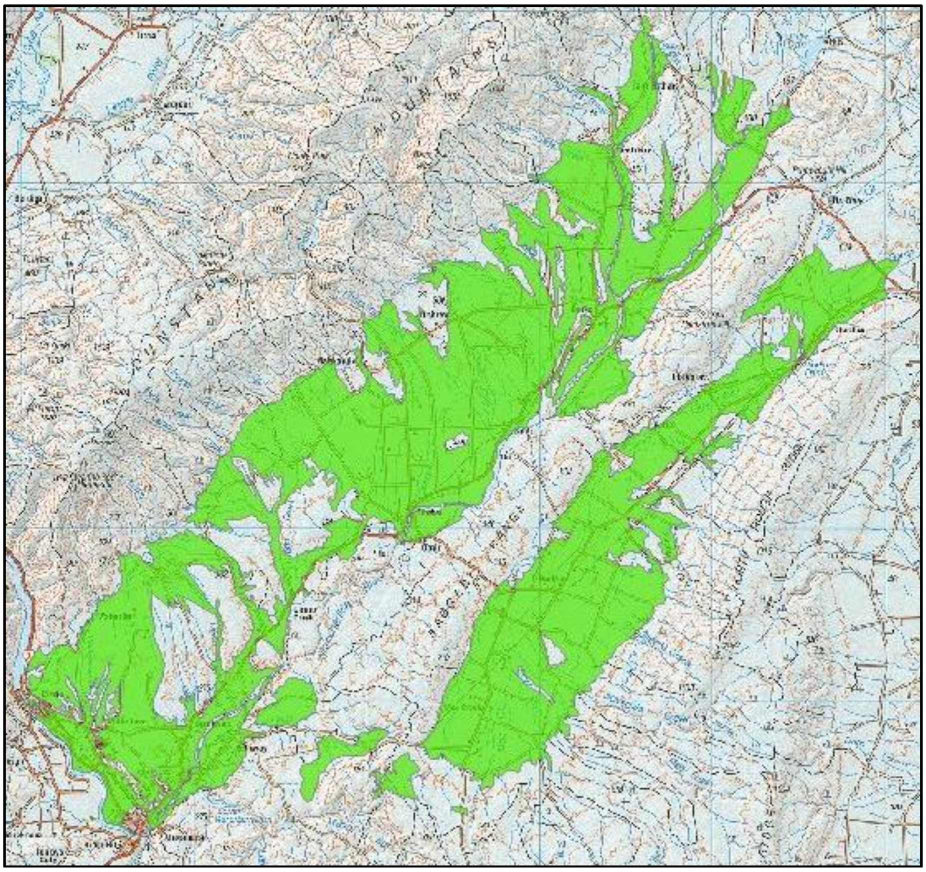
- Ministry of Primary Industries with funding via the Irrigation Acceleration Fund
- The Otago Regional Council
- The Central Otago District Council
- The Manuherikia Catchment irrigation schemes

An independent review of this study was undertaken by Dr Terry Heiler. See "Manuherikia Catchment Water Strategy. Review of Aqualinc Research Limited Pre-Feasibility Study" (Heiler 2012).

1 HIGH LEVEL OVERVIEW

1.1 Land

The Manuherikia catchment is semi-arid, with a continental type of climate with larger seasonal temperature variations than is common elsewhere in New Zealand. Mean annual rainfall for the Manuherikia catchment is about 630 mm/y. Rainfall is higher at the north-eastern end of the catchment, with the Hawkdun Range receiving up to 1,200 mm/y. At the other end of the catchment, Alexandra only receives 350 mm/y on average. The typical rainfall range for irrigable areas is about 350 – 800 mm/y. There are about 60,000 hectares of land in the catchment that are particularly well-suited for irrigation. This is land that is flat to undulating and below an elevation of 550 m. Under efficient spray irrigation, about 550 – 850 mm of water in a dry year is required for full irrigation. Requirements vary depending on the rainfall and soil type. Further details are provided in "Manuherikia Catchment Study: Stage 1 (Land)" (Aqualinc 2012a).



Irrigable land

1 in 10 year annual pasture irrigation demand given 80% efficiency (mm/y)

Soil Plant Available Water	Annual rainfall			
	400 mm	500 mm	600 mm	700 mm
60 mm	840	720	660	620
90 mm	810	690	660	600
120 mm	780	660	620	540

1.2 Hydrology

The Manuherikia River has a mean naturalised flow at the Clutha River confluence of 18.5 m^3/s or 585 Mm^3/y. Irrigation reduces the flow by up to 8 m^3/s, although averaged over a year the reduction is about 2.7 m^3/s or 85 Mm^3/y. In dry years, irrigation abstraction can reduce flows at the confluence to below 1.0 m^3/s. Flows in the Manuherikia River are highest from June to November, and lowest in February and March.

Currently, about 25,000 ha of the Manuherikia catchment is irrigated. Of this 25,000 ha, only about 15,000 ha is fully irrigated. Water scarcity means the remaining 10,000 ha is only occasionally irrigated, in some cases as little as 2-3 times per year. The current area of irrigation is well short of the potential 60,000 ha of irrigable land identified in the Stage 1 study.

The Manuherikia Catchment is water-short in dry years. Water scarcity means it is unlikely the full 60,000 ha of irrigable land could be fully irrigated. Water availability rather than suitable land is the primary constraint on future irrigation development.

Total water allocated within the Manuherikia catchment is over 27 m^3/s and is several times in excess of the water available during low flow periods. Actual water use is closer to 8 m^3/s during periods of peak irrigation demand. Actual water use is much less than the consented allocation, because often the consented flow is unavailable. There is no remaining reliable run-of-river water. Therefore, any new irrigation water will need to come either from efficiency improvements, the Clutha River, or from new storage dams.

Improvements in irrigation efficiency will achieve only a modest increase in the irrigated area. Improvements in efficiency in the lower Manuherikia catchment below Ophir would allow at most an additional 2,000 ha of irrigation. Above Ophir, any improvements in efficiency will not make additional water available for irrigation. The reason is because overall irrigation efficiency above Ophir at a catchment scale is already very high because any losses re-enter the Manuherikia River and are available for downstream use by the Manuherikia and Galloway irrigation schemes. That being said, there are still water quality implications to address.

Existing dams provide about 36 Mm^3 of stored water per year. That is about 7% of the average annual flow of the Manuherikia River at the Manuherikia/Clutha confluence. The majority of usable storage is provided by the Falls, Pool Burn, and Upper Manor Burn dams. Usable storage in Falls Dam is limited by the dam's height. Raising the dam 27 m could create an additional 90 Mm^3/y of usable stored water. Usable storage in the Pool Burn and Upper Manor Burn dams is primarily limited by inflows and raising these dams will not make more water available.

The Ida Valley is more water-short than the Manuherikia Valley. The valley has a couple of promising options. An out of catchment transfer from Hopes Creek could potentially increase the water supply to the Ida Valley Irrigation Scheme by 60%. A mid-sized dam near Mt Ida could potentially supply 2,200 ha of new irrigation.

Further details are provided in "Manuherikia Catchment Study: Stage 2 (Hydrology)" (Aqualinc 2012b).

1.3 High Level Options

In March 2012, two workshops were held, with the community asked to contribute ideas on development options for closing the gap between the irrigation demand and the water supply. We undertook a high level assessment of the 10 most popular options identified at these workshops. Of these 10 options, the 5 most favourable options were explored in more detail to a pre-feasibility level. Two other of the 10 options (Mt Ida dam and Lake Dunstan pumped pipe supply as far as Tiger Hill) have previously been investigated to a pre-feasibility level.

High level options assessment

<table>
<tr><th>Option</th><th>Progress to pre-feasibility?</th></tr>
<tr><td>Raise Falls Dam</td><td rowspan="5">Yes</td></tr>
<tr><td>Hope Creek dam (lower site)</td></tr>
<tr><td>Improve Manuherikia Irrigation Scheme efficiency</td></tr>
<tr><td>Lake Dunstan gravity piped supply</td></tr>
<tr><td>Dam supply to Galloway</td></tr>
<tr><td>Mt Ida dam</td><td rowspan="2">Already assessed</td></tr>
<tr><td>Lake Dunstan pumped pipe supply as far as Tiger Hill</td></tr>
<tr><td>Winter fill on-farm storage</td><td rowspan="3">No</td></tr>
<tr><td>Hope Creek dam (upper site)</td></tr>
<tr><td>Dams on Dunstan Creek</td></tr>
<tr><td>Dairy Creek</td><td>Not assessed.</td></tr>
</table>

Mt Ida Dam is a promising option for supplying extra water to the northern end of Ida Valley. The dam site has a relatively small catchment and is reliant on bringing in extra water from the Manuherikia Catchment using the Mt Ida race. A pre-feasibility study has already been completed for this option (see Hamilton (2006, 2010), PCL (2005) and RainEffects (2006)).

Lake Dunstan pumped pipe supply as far as Tiger Hill was previously investigated in detail by Opus (2010). The study found this option was quite expensive.

The three less favourable options (winter fill on-farm storage, Hope Creek dam (upper site), and dams on Dunstan Creek) were all considered to be too expensive to be worthwhile investigating further. A dam on Dunstan Creek had added complications of complex geology and a high environmental impact. The Dairy Creek proposal was not assessed because this proposal is well advanced and does not impact on other options.

Further details are provided in "Manuherikia Catchment Study: Stage 3a (High Level Options)" (Aqualinc 2012c).

2 REGULATORY ISSUES

2.1 Status Quo implications

There are six farmer co-operative irrigation companies operating within the Manuherikia Catchment. The irrigation schemes are based on open race infrastructure, some of which was installed for gold mining and dates back to the 1860s. The purpose- built irrigation infrastructure was constructed in the period from 1912 to 1936. The schemes were a Crown-owned initiative to introduce irrigation to the low-rainfall Central Otago area. In 1988, the Government made a decision to pass the management and ownership of Crown irrigation schemes to the irrigators.

In addition to the schemes, there are a number of individual irrigators within the catchment who hold private water permits. Some of these private permits are used to supplement scheme water.

There have been many reviews of the operation of the Manuherikia Catchment schemes carried out by the government. Investigations have been carried out into a number of scheme options ranging from “status quo” through to whole of valley schemes. Most of these reports identified risks associated with continued “status quo” or “do minimum” operation of the schemes.

An element of the Manuherikia Catchment Strategic Water Study is to consider the implications of the “do minimum” option. The “do minimum” option consists of carrying out minimum maintenance and continuing to operate the irrigation schemes and private water takes at the same rates and locations as at present.

The risks associated with the continued operation of the schemes under a “do minimum” scenario relate to the physical condition of scheme structures and to the regulatory environment, which is demanding higher water quantity and water quality standards. Risks include:

- Ageing infrastructure with limited life expectancy due to deferred maintenance.
- High distribution losses.
- Low reliability of water supply and level of service.
- Limited opportunities for increased production.
- Traditional scheme operation provides no incentives to upgrade on-farm irrigation methods.
- The Resource Management Act has provided opportunities to significantly alter the regulatory requirements for taking and using water from those that existed when the schemes were implemented.

All scenarios require expenditure to ensure on-going operation of irrigations schemes. These factors will apply to private irrigation also but on a smaller scale.

An analysis of the risk factors leads to the conclusion that many of these are necessitated by regulatory changes either directly or indirectly.

All water intakes will be required to include measurement of the water taken and many will require provision for fish exclusion or fish passage.

Many of the structures used for taking, storing and transporting water do not comply with modern safety standards; or require replacement or expensive on-going maintenance.

Traditional irrigation application methods often use excessive amounts of water for limited production gain. Excess water that is not taken up in the root zone is by-washed to surface water or, by soakage, back into the catchment. These return flows are unlikely to meet the most recent water quality standards.

The lack of reliability of water supply from surface water resources has limited land use opportunities and levels of production.

Replacement of the existing consents to take and use water with water permits under the current regulatory requirements may limit any future opportunities to redevelop the schemes and extend the areas irrigated.

Most of the schemes and private water takes are authorised by mining privileges that collectively expire on 1 October 2021. New water permits will be required and these will be considered under the Resource Management Act 1991 (RMA) instruments that are current at the time that applications are made. National and Regional policy under the RMA now requires higher standards to be adhered to with respect to freshwater management. These include minimum flows and residual flows in watercourses, allocation limits, greater accountability for the quantity of water taken, water quality limits and limits on discharges back to the environment, and consideration of the proximity of the take to the use location.

The Regional Plan Water for Otago (RPW) promotes the establishment of Water Management Groups to assume local management of the water resource for the benefit of users and to ensure compliance with regulatory requirements. Water Management Groups require approval from ORC and can operate independently provided certain criteria are met.

For the irrigation schemes and private irrigation to continue to operate within the Manuherikia catchment, the "status quo" or "do minimum" approach will require authorisations to be obtained and upgrading works to be undertaken to meet safety and regulatory requirements.

After 100 years of irrigating at a "basic" level, a change in approach is required to continue to operate irrigation to meet current standards and good practice.

Further details are provided in "Manuherikia Catchment Study: Stage 3. Implications of a 'Do Minimum' Option" (Opus 2012a).

2.2 Planning issues

Statutory approvals are required for the proposal to construct new works, to upgrade existing infrastructure and to continue to operate and maintain the physical infrastructure of the irrigation schemes.

The proposal to construct additional water storage dams will require a full analysis of the effects of the additional storage and the changed downstream flow management to demonstrate that the regime will provide reliability for irrigators while providing opportunities for enhanced environmental flow considerations. At the same time, the raised water levels above the dam must be shown to be able to be managed to minimise the effects on the lake margins and on upstream ecosystems. The significant changes proposed will need to be discussed openly with river interest groups and stakeholders.

An aspect of the proposals that needs to be further considered is the likelihood of the Otago Regional Council imposing a "sinking lid" approach to the allocation status of the catchment. This approach may limit the allocation of water for irrigation in order to lower the total primary allocation to the rate that is closer to the Schedule 2A Primary Allocation. Such an approach could limit the total area able to be irrigated and the maximum volume of water able to be stored during higher flows.

Proposed Plan Change 6A to the Regional Plan: Water has introduced some uncertainty around the future management of rural water quality and the obligations or limitations that will be placed on rural land users. Because the proposed plan change is still within the submission phase, changes to the proposed rules and limits are possible. Once the outcome of the hearings process is known, the consent requirements of discharges associated with irrigated land will be clearer.

Other consents and approvals will be required from Otago Regional Council and from Central Otago District Council. These approvals will be better defined when the scheme proposals reach the feasibility stage.

Further details are provided in "Manuherikia Catchment Study Stage 3: Planning Issues" (Opus 2012b).

2.3 Regulatory uncertainty

Defining the "do minimum" option is a significant aspect of the current decision making process for irrigators.

There are three key questions that have major implications on what the "do minimum" option is. These are:

1. Is it necessary to provide an auxiliary spillway for Falls Dam to comply with Dam Safety legislation, and in the event of dam failure, if an auxiliary spillway is not provided, is Falls Dam Company liable?
2. Will it be necessary to replace wild flooding and contour irrigation with more efficient systems when mining permits are replaced with RMA consents?
3. Will allocation be reduced below current usage and by how much (i.e. what level of efficiency will be required) when mining permits are replaced with RMA consents?

In our report we have taken a simplistic view. We have assumed Falls Dam spillway needs to be upgraded, wild flooding and contour irrigation will mostly need to convert to spray irrigation, and distribution improvements will need to be made to achieve "reasonable" efficiency. In our view, this is a prudent approach to manage medium to long term regulatory and water security risks.

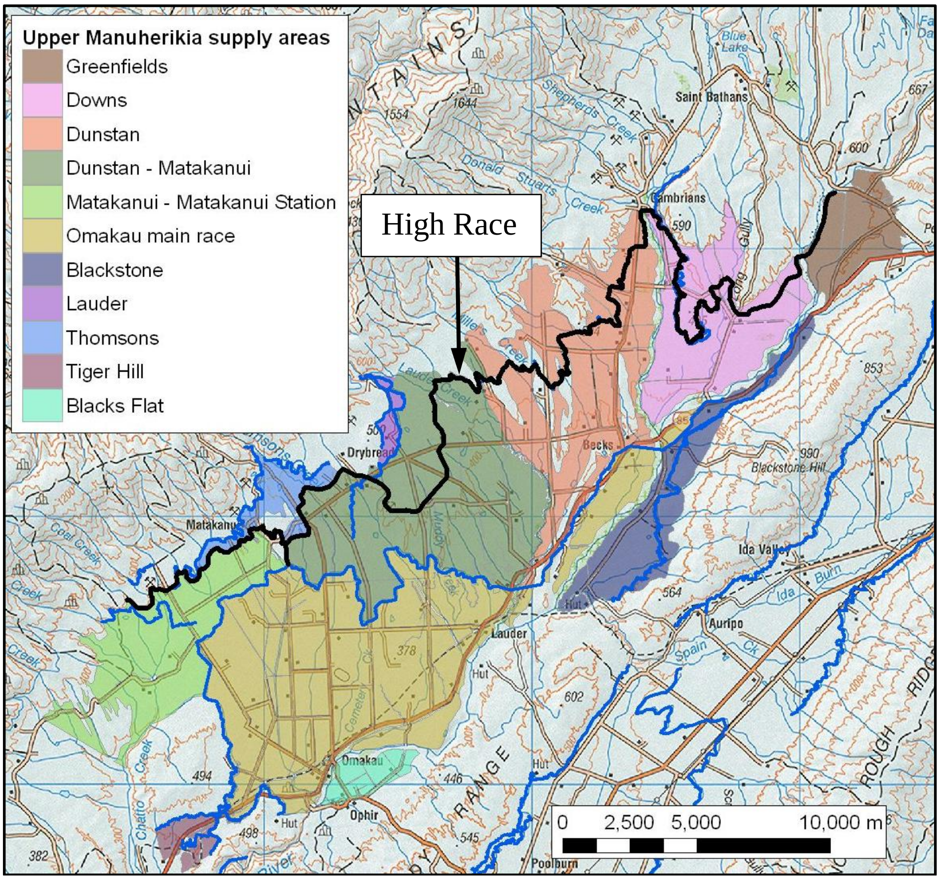
In reality, there is not a black and white, yes or no, answer to any of these three questions, because of the present lack of clarity in the relevant regulatory documents. It is *possible* that the answer to (1)-(3) could be no for the short to medium term. If that was the case, the short term "do minimum" cost would be more like $200/ha, rather than the $700 - $2,500 per hectare plus on-farm conversion costs we have advocated. In our view, there are significant water security and land use option risks for irrigators if a passive or "do almost nothing" approach in response to national regulatory changes is adopted. At present there is an opportunity for in-catchment stake-holders to collaboratively develop a catchment wide solution to water security and water quality issues. However, a passive approach on the part of irrigators may lead to more stringent and impractical conditions being imposed externally.

3 ENGINEERING

3.1 Raise Falls Dam

3.1.1 Description

Falls is the best dam site in the Manuherikia Catchment, with good inflows, a small valley opening to a wide basin, a strategic location for the downstream supply of irrigation, and favourable geology. The existing Falls Dam utilizes only a fraction of the potential storage capacity at the site. The full scale development option involves raising Falls Dam 27m, which would give a lake water level of 588 m AMSL when the Dam is full. Conveyance would be via a new 70 km long high race. In total, 21,000 ha could be fully irrigated in the Upper Manuherikia Valley, an increase of 14,500 ha from the 6,500 ha currently fully irrigated. The idea has been investigated a number of times in the past: first in the 1920's, and later by MWD in the 1970's and 1980's.



Falls Dam +27m command area.

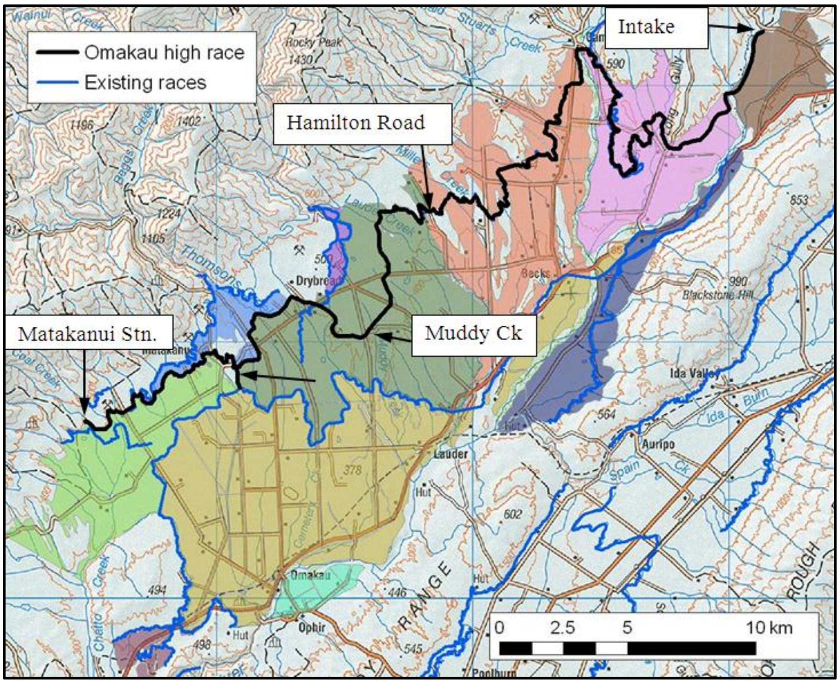
We estimate there is currently 4.0 m^3/s of reliable water available in the Upper Manuherikia Valley. Distribution losses (in the order of 20%) means only about 3.2 m^3/s of this water is available on-farm. In most areas, about 4.3 mm per day is necessary for full production. This means only about 6,500 ha can be fully irrigated with current distribution infrastructure. In addition to this reliable water, there is a significant amount of water that is generally only available in spring and early summer, that is used for partial irrigation. We estimate an additional 4,000 – 6,000 ha in the Upper Manuherikia Valley may be partially irrigated with unreliable water.

The Falls Dam Company have indicated Falls Dam needs to be modified; to address the risk that the dam may not be able to pass an extreme flood. As part of these works, the dam would also be raised 5 m to provide higher supply reliability. We have assumed raising Falls Dam 5 m will be part of the "do minimum" option. Under this "do minimum" option, it is likely that there would be little or no new irrigation in the Upper Manuherikia Valley, because the increase in storage will largely be required to counter the impacts of improved on-farm irrigation efficiency and higher minimum flows, and because higher reliability is required to best utilise spray irrigation. Furthermore, existing distribution cannot accommodate any significant additional capacity [necessary to expand the irrigated area], without significant capital expenditure.

A total of 25,000 ha of irrigable land in the Upper Manuherikia Valley could be serviced with reliable irrigation water if a new high race was constructed. Of this 25,000 ha, the actual area that could be supplied will depend on how high Falls Dam is raised, and how far the High Race extends. We considered four development scenarios as summarised below. Scenario 1 is the "do minimum" option. Development options 2-4 assume 85% uptake (i.e. only 85% of the potential irrigated area is supplied with scheme water). For Scenario 4 this means the actual area fully irrigated is 21,000, rather than 25,000 ha.

Development scenarios

Scenario	High Race		Falls Dam height	Area fully irrigated (ha)	
	Termination point	Length (km)		From High Race	Upper Valley Total
1	No High Race	0	+5m	0	6,500
2	Hamilton Road	33	+15m	5,500	12,000
3	Muddy Creek	41	+23m	11,500	18,000
4	Matakanui Station	68	+27m	14,500	21,000



Possible High Race termination points

3.1.2 Dam engineering

The potential to raise Falls Dam to allow for increased storage has long been recognised. The original dam construction method was specifically chosen to make it easier to raise the dam in the future.

Opus have completed a pre-feasibility engineering cost estimates for raising Falls Dam between 5 and 27 m. Opus recommends one of two construction methods: Concrete Face Rock Dam (CFRD) or Roller Compacted Concrete (RCC). CFRD is the same method that was used to construct the original Falls Dam. Using this method the current dam would be retained, but the crest of the dam would be raised. If RCC dam construction were used, a completely new dam would be built just downstream of the existing dam. Estimated construction costs for the two options are given below.

Capital cost of raising Falls Dam

Option	Spillway level (m amsl)	Additional storage	CFRD		RCC	
			$	$/m^3	$	$/m^3
+5m	566.5	8Mm^3	$11.5M	$1.39	-	
+15m	577.0	40Mm^3	$35.5M	$0.91	$42.9M	$1.10
+27m	588.0	90Mm^3	$54.1M	$0.57	$68.0M	$0.71

Raising Falls Dam 5 m needs to be budgeted into 'do minimum' costings. Falls Dam flood spillway capacity does not comply with current dam legislation. This means at some stage major remediation works will be required. Opus have estimated that it will cost about $11.5M to cut an auxiliary spillway and raise the dam 5 m. While it is not essential to raise the dam 5 m to comply with dam legislation, the additional cost to raise the dam 5 m at the same time as the spillway is cut is not high. Raising the dam will improve irrigation reliability to existing dam users.

Further details are provided in "Manuherikia Catchment Water Strategy Study Stage 3. Falls Dam Redevelopment Engineering Prefeasibility Study" (Opus 2012c).

3.1.3 Distribution engineering

We expect the "do minimum" off-farm distribution upgrades necessary to obtain resource consents will cost existing Upper Manuherikia Valley irrigators about $700 per hectare. Upgrades include automatic gates on intakes, lining of leaky races to comply with current efficiency requirements, and replacing critical aging infrastructure.

We expect distribution costs for new irrigation will be about $2,200 - $2,500 per hectare. Costs are lower if the High Race terminates at Muddy Creek, since beyond this point high race construction becomes more difficult. This cost includes the construction cost of providing unpressurised water to farm boundaries, but excludes land purchase costs. By 'new' irrigation we mean land that currently does not have access to reliable water; some of this land will however have access to unreliable spring water. Costs are summarised below.

Capital cost of Upper Valley distribution upgrades

Scenario	Total	Cost		Cost/ha[2]	
		Total	Marginal[1]	Existing	New
1	6,500	$4.4M	$0.0	$700	N/A
2	12,000	$18.2M	$13.8M	$700	$2,500
3	18,000	$30.1M	$25.7M	$700	$2,200
4	21,000	$41.1M	$36.7M	$700	$2,500

(1) Total cost minus "do minimum cost" (Scenario 1)
(2) Estimated accuracy ±30%. Exclude land purchase costs and GST.

We assumed 80-85% uptake of the irrigable area. Distribution costs for new irrigators will be higher if uptake is lower than 80%. For scenarios 2 to 4, 60-70% of the costs are associated with constructing the High Race. The remaining 30-40% of cost is associated with secondary distribution and upgrades to existing races. Secondary distribution construction could largely be staged, if required. Whether there are opportunities to stage High Race construction and upgrades to existing races will depend on where the initial farmer uptake interest lies.

Long term, the degree of pumping largely determines the cost of operating an irrigation scheme. While inflation eventually minimises capital expenditure costs, pumping costs continue indefinitely; increasing at a rate greater than inflation. 80% of the supply area can be supplied under gravity. 20% of the supply area is located above the race, and farmers would need to pump direct from the race. We envisage that pumping would be an individual irrigator responsibility rather than an irrigation scheme responsibility. Because no scheme pumping is necessary, annual operation charges, excluding debt servicing, should be minimal ($30-$50/ha).

Secondary distribution below the High Race could largely be PVC pipes. Piped secondary distribution has a number of advantages over open races, including negligible distribution losses; a continuous on-demand supply; and in some cases a pressurised supply. The extensive network of existing races, used at present to distribute largely unreliable water, is another option for secondary distribution.

Further details are provided in "Upper Manuherikia Valley distribution" (Aqualinc 2012g).

3.1.4 Hydropower

Raising Falls Dam will result in only modest increases in generation revenue; consequently the cost of raising the dam would need to be borne primarily by irrigators. Increases in power revenue should be sufficient to fund necessary power infrastructure upgrade costs, however it is unlikely power generation could contribute any significant amount to dam construction costs. In general, the value of water for power generation is an order of magnitude less than the value of water for irrigation.

Power Generation Potential

Option	Average annual revenue	Increase in revenue
Status quo. 4 m^3/s turbine capacity	$690,000	N/A
Raise Falls Dam 5 m & no new irrigation. 4 m^3/s turbine capacity. (Scenario 1).	$830,000	$120,000
Raise Falls Dam 15 m & 6,000 ha of new irrigation. 6 m^3/s turbine capacity. (Scenario 2).	$1,300,000	$610,000
Raise Falls Dam 27 m & 15,000 ha of new irrigation. 6 m^3/s turbine capacity. (Scenario 4).	$1,360,000	$670,000

Further details are provided in "Manuherikia Valley Detailed Hydrology" (Aqualinc 2012e).

3.1.5 Cost sharing options

Per hectare costs to individual irrigators will depend on how scheme upgrade costs are apportioned. The apportioning approach below is only one possible method. MCSWG may adopt an alternative approach.

Existing irrigators

The major cost for existing irrigators is remedial work to Falls Dam, to increase the spillway capacity and to raise the dam to improve supply reliability. As a minimum, the dam needs to be raised 5 m, costing $11.5 million or an average of $1,700/ha. This cost will need to be largely or completely funded by Omakau (main race irrigators only), Blackstone, Manuherikia and Galloway Irrigation Schemes. In return, these irrigators will receive high supply reliability. The cost to these irrigators is a much cheaper option than constructing on-farm storage to improve reliability, which would cost three times as much.

Contribution from existing irrigators to Falls Dam "do minimum" upgrades"

Scheme	Contribution (1)	Cost	Supply area	Cost/ha
Omakau (Main Race)	53%	$6.1M	3,400ha (2)	$1,790
MIS	35%	$4.0M	2,300ha	$1,740
Blackstone	6%	$0.7M	600ha (2)	$1,150
Galloway	6%	$0.7M	520ha	$1,320
Total	**100%**	**$11.5M**	**6,820ha**	**$1,700**

(1) Falls Dam Company shareholding

(2) Based on a supply rate of 4.3 mm/d. For Omakau, only irrigators supplied from the Main Race are included, since only these irrigators will benefit from reliability improvements. If irrigators spread their water further, or Omakau Irrigation spread dam upgrade costs over all shareholders, the per hectare costs will be lower.

On top of a contribution to Falls Dam upgrades, existing irrigators with reliable water will need to contribute an average of $700 per hectare to intake and distribution upgrades necessary to obtain resource consent.

New irrigators (which will include some farms that currently have unreliable water) will need to pay the marginal cost of development; that is the total scheme upgrade costs minus the "do minimum" cost that that existing irrigators would fund. For scenarios 3 and 4 this 'marginal' cost accounts for over 80% of the total scheme upgrade costs, therefore new irrigators would be funding the vast bulk of the works. Average costs are given below.

Average costs for new irrigators supplied from Falls Dam

Scenario	Dam height increase	Marginal costs[1]			New irrigation	
		Falls Dam	Distribution	Total	Area (ha)	Cost/ha
1	5 m	N/A			0	N/A
2	15 m	$24.0M	$13.8M	$37.8M	5,500	$6,870
3	23 m	$36.5M	$25.7M	$62.2M	11,500	$5,410
4	27 m	$42.6M	$36.7M	$79.3M	14,500	$5,470

(1) Scheme construction costs only (GST excl). Estimated accuracy ±30%. Excludes land purchase costs and baseline $15.9M 'do minimum' costs ($11.5M for dam and $4.4M for distribution upgrades) that existing irrigators will need to pay for.

Because of the topography of the basin above Falls Dam, the potential new area that can be supplied increases exponentially with increasing dam height. As a result the cost per hectare of irrigation *decreases* as the dam height and irrigated area increase. The optimum dam height is 584-588m AMSL, or an increase of 23 to 27 m. This results in the lowest per hectare irrigation costs. Raising Falls Dam more than 5 m but less than 23 m is unattractive because of the high per hectare cost. There is also no advantage in raising the dam above 588 m, because little additional area could be supplied since the dam would not fill every winter.

Some areas of "new" irrigation already have access to unreliable water. A possible charging regime would be to charge these irrigators 10-30% less, depending on their existing water reliability. In return for a cost reduction, existing partial irrigators would need to surrender their water rights to the Irrigation Company. Providing a discount to areas currently partially irrigated would increase costs to other farmers who currently have no water by about 5%. Costs are summarised below.

Costs for new irrigators given 20% discount for partially irrigated land

Scenario	"New" irrigation (ha)			Cost/ha		Total cost
	No water	Unreliable water	Total	No water	Unreliable water	
3	8,500	3,000	11,500	$5,700	$4,560	$63M
4	11,000	3,500	14,500	$5,750	$4,600	$79M

3.2 Hope Creek Dam

The possibility of damming Hope Creek and transferring the water to the Ida Valley Bonanza Race has been considered for many decades. The idea pre-dates the construction of the Upper Manor Burn and Pool Burn reservoirs. The natural dam site is at a stream bed elevation of about 615 m. A 10 km race and short section of pipe would connect this dam to Bonanza Race. The diversion would allow for a 60% increase in the seasonal allocation for existing Ida Valley irrigators.

3.2.1 Hydrology

Hope Creek dam has a potential annual average yield of 15 Mm^3. This is 75% of the potential yield of the Upper Manor Burn dam. Fifteen years of near continuous flow data is available for the Hope Creek, near the proposed dam site. This data means we have considerable confidence in the potential catchment yields.

Hope Creek dam could potentially supply an average of 13 Mm^3 per year to Ida Valley. In all but the driest of years, at least 10 Mm^3 per year would be able to be supplied. In wet years, when the Upper Manor Burn dam was spilling, Hope Creek water would not be used. The limited storage in the Hope Creek dam means Hope Creek, Upper Manor Burn and Pool Burn dams would need to be managed together. Hope Creek water would be used first, with the dam being drawn down to the minimum level most years. The Upper Manor Burn and Pool Burn dams store water for several seasons, and in dry years, a greater proportion of water would come from these dams. This additional water would allow an additional 2,500-3,000 ha to be fully irrigated in the Ida Valley.

15 Mm^3 of usable storage would ensure the majority (on average 13 Mm^3) of Hope Creek dam yields are able to be ultilised. A dam water level operating range of about 632 – 644 m amsl would provide 15 Mm^3 of storage. This would require about a 32 m high dam. A 13 to 15 m pumping lift would be necessary to lift water from the minimum lake operating level, to the height of the conveyance race. Raising the dam an additional 2 m, would reduce the pumping lift by about 4 m.

There is some uncertainty in the Hope Creek Dam stage – storage relationship because of the shape of Stone Hut Flat and availability of only 20 m contours. To improve the stage – storage relationship we recommend a high resolution aerial photogrametry, LIDAR, or GPS topographic survey be undertaken prior to finalising any design. A 1 in 500 year flood at Hope Creek would have a 60 m^3/s peak flow. However flood storage in the reservoir means the peak spillway flow would only be 10-15 m^3/s. While we do not expect reservoir leakage to be significant, this would require investigation prior to finalising designs.

Further details are provided in "Manor Burn Catchment Detailed Hydrology" (Aqualinc 2012f).

3.2.2 Dam engineering

Pre-feasibility dam cost estimates have not been made since to date it has not been possible to get access to the dam site due to land owner concerns. The dam would be approximately 32 m high and 170 m wide at the crest. The suitability of the dam site cannot be confirmed until a dam engineer has been able to visit the site.

Indicatively, for an earth dam, approximately 140,000 m^3 of fill would be required, and would cost between $4M and $10M.

3.2.3 Distribution

Conveyance from Hope Creek Dam to the Bonanza Race was based on pumping a 1 m^3/s flow up to a maximum pump lift of 15 m and utilising a 9.9 km long diversion race inclusive of pipe structures. The race would be substantially constructed through schist rock, similar to the Upper Bonanza Race country.

The estimated capital cost of construction with associated engineering and consenting costs is $4.7M. When the present value of electricity 'Use of System' and power charges are added, the Present Value of the proposed diversion system is $6.3M. The concept of utilising wind-power with an associated buffer storage pond is another option that warrants further investigation.

There would be no requirement to upgrade the capacity of either the Bonanza Race or the Ida Valley distribution system. Ida Valley Irrigation Scheme's primary constraint is the annual water supply, not peak distribution capacity.

Further details are provided in "Hope Creek - Ida Valley Distribution" (Hamilton 2012).

3.3 Lower Manuherikia Valley efficiency improvements

Given that the Manuherikia Valley is not fundamentally water short, it is less important than originally thought to find alternative water sources in the Lower Manuherikia, such as Clutha River water or a dam in the Manor Burn catchment. The existing supply from the Manuherikia River is the cheapest and most energy efficient option. The present water allocation to the Lower Manuherikia is sufficient to provide for the reasonable future irrigation needs. Efficiency improvements will however be necessary to realise these benefits.

For the Lower Manuherikia Valley, there is no clear distinction between "do minimum" costs, and development costs. Efficiency improvements will be required as part of obtaining resource consents. However, if the irrigation schemes are to retain their present allocation rates, efficiency improvements will need to go hand in hand with an expansion in the irrigated area. Much of the upgrade works necessary for resource consent purposes, such as the installation of flow recorders and automatic gates, are also of considerable operational value to the schemes.

Upgrade works will likely include:

1. Flow recorders on all takes in excess of 5 l/s;
2. Automatic gates on the MIS and Chatto Creek intakes (largely completed);
3. Automation of some secondary races;
4. Buffer storage ponds and flow automation system to reduce bywash;
5. Lining sections of leaky races;
6. Replacing some races with piped supplies; and
7. Replacement of the aging Chinky Gully Aqueduct.

In many areas, gravity pipe supplies, fed from the Manuherikia Irrigation Scheme Main Race, are an attractive option. Below the race there is good fall, allowing pressures to build up over a short section of pipe. About half of the supply area, including Dunstan Flats and Galloway, could be supplied with a fully pressurised gravity pipe supply. Pressurised pipe supplies have a number of advantages including:

- No need for on-farm pumping or storage ponds;
- A continuous, on-demand supply;
- Negligible distribution losses;
- Minimal operation and maintenance costs; and
- A very simple system [for life style blocks in-particular] to operate on-farm.

Distribution upgrades are expected to cost $6.6M, given conservative expansion in the irrigated area, or $7.7M given optimistic expansion. In addition, the Manuherikia Irrigation Scheme (MIS) and Galloway Irrigation Scheme would need to contribute $4.7 M to Falls Dam "do minimum" upgrade costs. The Lower Manuherikia differs from the Upper Manuherikia. No new water is required; therefore where there is an expansion in the irrigated area, this will reduce the cost to existing irrigators. Another difference is 50% of the area can be supplied with fully pressurised water. Fully pressurised water, compared with no pressure, is worth about $2,500/ha equivalent capital expenditure to spray irrigators. We do not expect all irrigators would be charged a flat rate, with rates varying depending on whether they are an existing or new irrigator, and the level of pressure delivered. Distribution upgrades are well suited to being staged. Costs are summarised below. Per hectare costs to individual irrigators depends on how scheme upgrade costs are apportioned. The apportioning approach below is only one possible method. MCSWG may adopt an alternative approach. Per hectare costs are cheaper under the optimistic expansion scenario, since upgrade costs are spread over a greater area.

Lower Valley Distribution Upgrade costs (conservative expansion)

Irrigators	Supply area (ha)		Cost/ha		Total
	Existing	New	Existing	New	
Dunstan Flats (fully pressurised)	300	200	$3,500	$6,500	$2.4M
MIS other (unpressurised)	1,300	450	$1,000	$4,000	$3.1M
MIS other (fully pressurised)	600	200	$3,500	$6,500	$3.4M
Galloway (fully pressurised)	520	30	$4,300	6,500	$2.4M
Total	**2,720**	**880**			**$11.3M**

Lower Valley Distribution Upgrade costs (optimistic expansion)

Irrigators	Supply area (ha)		Cost/ha		Total
	Existing	New	Existing	New	
Dunstan Flats (fully pressurised)	300	400	$2,900	$6,000	$3.3M
MIS other (unpressurised)	1,300	650	$400	$3,500	$2.8M
MIS other (fully pressurised)	600	350	$2,900	$6,000	$3.8M
Galloway (fully pressurised)	520	80	$3,900	$6,000	$2.5M
Total	**2,720**	**1,480**			**$12.4M**

Upgrade costs would provide for a significantly improved level of service to irrigators compared to the status quo. Improvements include the provision of on-demand supply, fully pressurised supplies to 50% of the supply area, increased security of supply through asset upgrades, decreased operating costs, and in some locations frost fighting capacity. On-farm spray conversion costs would be significantly higher without this investment in scheme infrastructure. Upgrade costs should not therefore be viewed as simply a resource consent compliance cost.

Further details are provided in "Lower Manuherikia Valley distribution" (Aqualinc 2012h).

3.4 Galloway Dam Supply

In the High Level Options report, a new dam in the Manor Burn catchment was proposed as an alternative supply for Galloway Irrigation Scheme. Two possible dam sites with sufficient capacity to fully supply Galloway were identified: one 300 m upstream of the existing Lower Manor Burn dam and one on Little Valley Creek West Branch. Water from Manor Burn would be conveyed via the Galloway High Race. The High Race would need to be reconstructed to flow back in the opposite direction. A pump station would be required to lift water about 30 m from the Lower Manor Burn dam to the High Race.

Pre-feasibility investigations indicated this option is likely to be considerably more expensive that the alternatives of upgrading the existing races or a piped supply from Manuherikia Irrigation Scheme. Optimistically, we estimate this option has a capital cost of $5.5M or $10,000/ha. There is considerable uncertainty in dam costs and costs could be significantly higher. If the Present Value (PV) of pumping costs are added, the total PV cost of a pressurised water supply would be in the order of $14,000/ha.

Other difficulties are the lower dam site would have a significant negative impact on recreational and environmental values. The Lower Manor Burn dam is one of the most popular places for ice skating in New Zealand. A new dam 300 m upstream of the existing dam would have a negative impact on ice skating opportunities because of the increase in water depth and dam operating range. In addition to having recreational values, the Lower Manor Burn dam also has environmental values. Amongst other values, the margins of the dam are classified as a Regionally Significant Wetland under the Otago Water Plan. A new dam would probably have a negative impact on these values because of the increased lake operating range.

The Little Valley Creek West Branch dam site would not have the same recreational and environmental impact. However, the dam would flood a significant area of land, potentially resulting in land-owner issues.

In favour of this option is that it frees up some Manuherikia River water. However, whether or not this is actually beneficial will depend on other factors such as whether the scheme is economically viable, and what happens to any Manuherikia River water savings. If any Manuherikia water savings were transferred to the Upper Manuherikia Valley, this would have a negative environmental impact because of the loss in conveyance flows. Another complication is water rights; it would be difficult to reduce Galloway's Manuherikia River allocation if they upgrade existing distribution to achieve reasonable efficiency.

Further details are provided in "Lower Manuherikia Valley distribution" (Aqualinc 2012h).

3.5 On-farm irrigation

The cost of installing or upgrading irrigation is very site-specific. However, some systems tend to be more expensive than others. The following table gives indicative costs of some systems, based on recent costs of installed systems. The higher costs are for more complex layouts. The lower costs are for simple layouts.

Component	Irrigation System Costs	
	Capital ($)	**Annual energy costs ($/y)**
New centre-pivot system, open race delivery to top of property	$3500 - $4500	$200-$250
New centre-pivot system, open race delivery to middle of hilly property	$4500 - $6000	$400 - $450
New centre-pivot system, piped delivery under pressure, simple layout	$2500 - $3500	$0
New centre-pivot system, open race delivery to bottom of hilly property, high lifts	$6000 - $7500	$450 - $800
New K Line, open race delivery to top of property, light- med soils	$3000 - $4000	$150-200
New K Line, delivery under pressure, light-med soils	$2000 - $3000	$0
New rotary boom, delivery under pressure, light- med soils	$3000 - $4000	$0
New border-strip, open race delivery to top of property	$2500 - $3500	$0
Upgrade border-strip, open race delivery to top of property	$2000 - $3000	$0
Long-lateral, delivery under pressure, light-med soils	$3000 - $4000	$0
Hard-hose gun, open race delivery to top of property	$3000 - $4000	$300 - $400
Solid set delivery under pressure (medium)	$6000 - $8000	$0
Solid set open race delivery to top of property, medium pressure	$7500 - $9500	$250 - $300
Solid set open race delivery to top of property (high pressure guns)	$7500 - $10000	$400 - $750

When assessing the difference in costs between various options, it is critical to include all of the annual operating costs. They include debt servicing, operating (labour) costs, maintenance costs, and water charges.

Some systems, because of their lower efficiency, will need to be operated for longer each year than systems with high efficiency to maintain similar production. That will impact on energy costs and water costs as well as labour and maintenance.

Systems such as solid-set appear expensive, but because they can be automated require little or no labour, and can be programmed to apply specific depths of water to specific areas to increase efficiency, may work out to be cost-effective overall compared to other systems.

Further details are provided in "Manuherikia Catchment Study: On-farm Irrigation Development" (Aqualinc 2012k).

3.6 Climate Change

The weather within the Manuherikia catchment is variable and it will continue to experience natural climate variations between seasons. However, due to greenhouse effects (primarily increased concentrations in atmospheric CO_2) and global warming, the frequency of extreme weather events, both droughts and floods, could increase.

Impact of any climate change on agriculture could have both positive and negative aspects. Warmer weather would probably lengthen growing seasons. However if drought frequency increases this would increase pressure on the water resources.

NIWA's climate change predictions for the Manuherikia Catchment are:

- The mean annual temperature could increase by 0.9 and 2°C relative to 1990 (i.e., the average of 1980-1999) by 2040 and 2090, respectively.
- The mean annual precipitation could increase by up to 5% and 10% relative to 1990 by 2040 and 2090, respectively. However, most of the precipitation increase may occur in winter and the average summer rainfall could reduce. Low summer rainfall would increase the crop-water deficit, increasing irrigation requirements.
- Occurrence of extreme climate events such as floods, severe droughts, and warmer days could increase. The current 1-in-20 year droughts could occur approximately three times more frequently by 2090.

A reduction in summer rainfall and increased irrigation requirements means if Falls Dam is not raised, reliability to existing Manuherikia irrigators will reduce. Without additional storage, any additional winter rainfall cannot be ultilised. In contrast, if Falls Dam is raised the full 27 m, additional winter rainfall would be able to be captured and used in summer.

An increase in drought frequency would significantly impact on dryland production. An increase in the water available for irrigation would be necessary to off-set this reduction in dryland production, if current production levels are to be maintained.

Raising Falls Dam 27 m will provide security of reliable irrigation water, which will be critical to realising the economic benefits from agriculture and horticulture. The well-designed and future-proofed irrigation schemes will make the district more resilient to climate change.

Further details are provided in "Impact of Climate Change on the Manuherikia Irrigation Scheme" (Aqualinc 2012l).

4 WIDER IMPACTS

4.1 Social impacts

The Manuherikia catchment is a farming district where the local economy is based on agriculture. Extensive irrigation has been occurring in the Manuherikia Catchment for over 100 years.

Experience from other irrigation schemes indicates irrigation development creates jobs, increases household income, provides population growth, and promotes investment. An increased proportion of children and young families can be expected, as can a greater proportion of tertiary qualified farmers and professionals.

Rural population growth and investment would have a positive flow-on social and economic impact on service towns such as Clyde, Alexandra, Ranfurly and Omakau. New jobs and businesses would be created. Essential social support services such as schools, healthcare facilities, and voluntary organisations would experience growth.

Land use intensification and diversification can be expected. A shift away from sheep and beef farming to a more diverse and intense range of farming enterprises generally occurs. Social changes can occur as old families move away from the area in favour of the younger generation with their youth, enthusiasm and knowledge to change land use and to manage more intensive systems. The social cohesion of the community may be affected as ownership changes occur in the short term. In the long term, it will be the attitudes of the community towards change that will determine whether or not development proves to be a social success.

Because irrigation is already an integral part of the catchment, social effects would be less than would occur in regions without a history of extensive irrigation.

Further details are provided in "Manuherikia Catchment Study: Social Impacts" (Aqualinc 2012d).

4.2 Environmental impacts

Extensive irrigation has been occurring in the Manuherikia Catchment for over 100 years. The area contains some of the oldest schemes in the country. Irrigation and associated infrastructure is an integral part of the natural environment. Under the RMA, because of the long-history, irrigation and associated infrastructure form part of the base-line natural environment, not the pre-European state of the catchment.

We have identified a number of infrastructure upgrade options that would allow up to an additional 20,000 ha to be fully irrigated (a third of which is already partially irrigated). All development options are not green-field developments; rather they are an upgrade of existing water infrastructure. Almost all irrigation would be within current irrigation scheme command areas or areas irrigated with private water rights. Upgrading water infrastructure will simply allow these areas that are already irrigated to be more completely and reliability irrigated.

Irrigation development has the potential to have impacts (positive or negative) on iwi, environmental and recreational values. Because irrigation is already an integral part of the catchment, effects are generally less than would occur in regions without a history of extensive irrigation.

We have developed options that can provide for both water security for agriculture and environmental needs. Options which may have had a significant environmental impact (such as damming Dunstan Creek) were excluded early on in investigations.

The most significant upgrade option is raising Falls Dam 27 m, which would allow an additional 15,000 ha to be fully irrigated in the Upper Manuherikia Valley. This option will impact on the flow regime in the Manuherikia Main Stem, and may impact (positively or negatively) on water quality.

Raising Falls Dam gives significant flexibility for achieving a flow regime that provides for both irrigation and environmental needs. Raising Falls Dam 27 m would allow flows in the Lower River to be increased three-fold above current levels during the driest months. Higher minimum flows should improve the trout fishery, the aesthetic value, and other recreational opportunities such as swimming and canoeing.

Safe-guards that ensure high water quality is maintained is probably the most challenging environmental issue that needs to be worked through as part of feasibility investigations. To minimise this risk it is important that development is carefully managed, with a particular focus on good riparian management, efficient irrigation, minimising irrigation runoff, good nutrient management, and possibly limits on the proportion of higher risk land uses such as cropping and dairying.

Minimising risks to native fish will probably primarily involve good riparian management. Native fish primarily occur in smaller tributary streams where irrigation has depleted flows. Predatory trout pose the greatest risk to native fish, so in general it is important to maintain the low flows in these tributaries to discourage trout habitat.

A formal assessment of visual impacts will be required as part of feasibility investigations. We expect impacts should be limited given that almost all new irrigation would occur on the Manuherikia and Ida Valley floor, in areas that have been irrigated and farmed to a moderate intensity for at least 80 years. No irrigation of hill country or high country is proposed.

There are a large number of archaeological and heritage sites in the Manuherikia area. A formal assessment will be required as part of feasibility investigations. We do not expect the proposals to impact on these sites because irrigation infrastructure development is largely a retrofit of existing schemes and existing races are largely retained.

Improvements in irrigation efficiency will reduce groundwater levels in some areas. The area most at risk is the Dunstan Flats. Efficiency improvements on the flats will result in some bore supplies becoming unreliable. New rural water supply schemes, on Dunstan Flats and in other areas, are a cost effective method of providing an alternative reliable supply of safe water for domestic use and stock.

A significant amount of further work is required to assess the proposals to a level that would be appropriate for a resource consent hearing. Early indications are that investment in existing water infrastructure has the potential to provide for both economic and environmental sustainability. To achieve this good management of environmental risks associated with land use diversification will be necessary.

Further details are provided in "Manuherikia Catchment Study: Environmental Impacts" (Aqualinc 2012j).

4.3 Manuherikia Flow Regime and Water Quality impacts

4.3.1 Manuherikia main stem flows

Raising Falls Dam gives significant flexibility for achieving a flow regime that provides for both irrigation and environmental needs. We have made a 'first cut' at what we see as a possible dam management regime that would provide both security of supply for irrigators and an enhanced flow regime from an environmental perspective. Other flow regimes are possible, and it would be up to the community to come up with a solution that works for both farmers and other stake holders. The final outcome should pool on the knowledge from different groups and should include factors such as iwi values, trout habitat, minimising algae build-up, and swimming conditions.

Low flows are the most important aspect of the flow regime for protecting in-stream values. Long periods of low flows in summer and autumn are a natural occurrence due to the semi-arid climate, although the low flow level is significantly below natural levels in the Lower Manuherikia River due to irrigation abstraction. Increasing Falls Dam storage allows excess winter and spring water to be released in summer. Given the 60 m high dam and 15,000 ha of new Upper Valley irrigation (Scenario 4), flows in the Lower River could be increased 3-4 fold above current levels.

Flow variability, and in particular flood flows and freshes, help to clear out water ways. The Manuherikia River naturally has long periods (up to 11 months) between fresh flows. Raising Falls Dam and increasing the irrigated area has the potential to further reduce the period between fresh flows. One possible mitigation approach is to allow for additional disturbance or rejuvenating flows to be provided from storage. Further work is required to understand the role high flows have in removing algae, and to determine the amount of flow that is necessary to effectively disturb the river.

4.3.2 Manuherikia tributary flows

Raising Falls Dam and increasing the irrigated area would not have a direct impact on tributary flows. For most of the Dunstan Range tributaries (other than Dunstan Creek) virtually all the head-water flow is diverted into irrigation races near the base of the ranges. Irrigation drainage water re-enters these streams but is generally abstracted further down at other irrigation intakes. Ultimately only a residual flow reaches the Manuherikia River during the irrigation season. The amount of water in these streams is ultimately determined by the residual flow left below irrigation intakes, which is a separate consenting issue independent of any increase in irrigated area. ORC have set residual flows to protect native fish habitat, and to minimise the risk to native fish of predatory trout.

Dunstan Creek differs from other tributaries since this creek provides a significant proportion of the flow to the Manuherikia River year round. Raising Falls Dam would not require any more water be taken from Dunstan Creek.

4.3.3 Water quality

Water quality in the Manuherikia Catchment is generally good. This is partly due to the low agricultural intensity and partly due to the catchment's natural hydrology and geology.

Land use intensification can pose a risk to water quality. The most important risks are EColi, sediment, and ammonia contamination. These point source contaminates can be minimised through good effluent and riparian management, and preventing irrigation run-off. Converting surface irrigation to spray irrigation will help to reduce EColi and sediment contamination. Current water quality is compromised by irrigation runoff water entering streams.

Another concern with land use intensification is more algae growth as a result of increased nitrogen and phosphorus. Managing these diffuse source contaminates can be more challenging. There is however some factors that mean the Manuherikia River is at less risk of nutrient problems compared with some other catchments in Otago. These factors include the dry climate, the lack of groundwater, the irrigation command area being relatively flat, and the free draining soils. Furthermore, we expect converting existing surface irrigation to spray irrigation will reduce both phosphorus and nitrogen losses during the irrigation season. Other factors that mitigate the nutrient risk are higher minimum flows and potentially artificial fresh flows.

The dry climate and lack of groundwater means with efficient irrigation most nitrogen losses from land will enter water ways during periods of high river flows, at a time when nutrients do not cause any problems. In the Manuherikia, efficient irrigation is probably the single most important factor in minimising nutrient losses during the critical summer and early autumn period. Nitrogen is only lost when soil water drainage occurs, so if drainage is well controlled during the irrigation season losses will be low. With good irrigation management irrigation can even reduce nitrogen losses, by increasing plant uptake.

We recommend further monitoring and data analysis be done to understand periphyton (i.e. algae) growth and removal dynamics. Until this work is done it is not possible to say for sure how periphyton cover may be affected by land use intensification and/or land use change.

Early indications are that it will be possible to fully irrigate the Manuherikia Valley and to farm effectively, while at the same time maintaining good water quality, provided land use remains predominately sheep farming. Good irrigation management and farming practices will be necessary. What is less clear is whether the catchment could also accommodate a large scale shift in land use to higher risk activities such as cropping and dairying, without compromising water quality.

We expect Plan Change 6a nutrient limits will be significantly revised before the plan is finalised. Until the final version of the plan is known, we cannot say how well irrigation development scenarios align with the plan.

4.3.4 Monitoring

A critical limitation in current data is the lack of periphyton cover measurements. To better understand the periphyton growth and removal dynamics we recommend periphyton cover estimates be made as part of regular water quality sampling at Ophir and Galloway. We recommend that the sampling frequency be increased to monthly, up from two monthly, for a period of 12 months.

We recommend a macro-invertebrate survey in late summer, following a long period of low flows. This information will help with understanding periphyton removal dynamics, and would complement the survey undertaken in the wet summer of 2010/11.

We recommend monthly water quality sampling in Falls Dam, Upper Manor Burn and Pool Burn reservoirs, for a period of 12 months. This data is needed to assess whether or not more storage at Falls Dam will increase nitrogen concentrations below the dam in summer.

Further details are provided in "Manuherikia Flow Regime and Water Quality impacts" (Aqualinc 2012i).

4.4 Cultural impacts

Kai Tahu ki Otago has undertaken a preliminary cultural assessment of the irrigation proposals. Most of the key issues and expectations of Iwi in relation to the proposals are consistent with the requirements of other stakeholders, the irrigators and community: For example the designer flow regime is supportive of healthy ecosystems, water quality needs to be maintained, and native fish need to be protected.

Further details are provided in "Cultural scoping study: Manuherikia Catchment strategic water study" (KTKO 2012).

5 Economics

Preliminary on-farm economic analysis has been undertaken for irrigation development in the Manuherikia Valley. Five case study farming operations were evaluated: (1) mixed sheep, deer and dairy support; (2) sheep and beef breeding and finishing and dairy support; (3) hill country sheep and beef breeding and finishing; (4) dairying or dairy support; and (5) dryland conversion to irrigated sheep and beef. Key conclusions from the study were:

- The size and state of the existing irrigation capability has a big impact on returns as only marginal returns are gained from the full conversion of existing reasonably efficient irrigation.
- Continuing irrigation development based on some current land uses, particularly with low performing breeding stock, does not appear to give enough extra returns to justify the investment.
- Returns from higher producing land uses are significantly more than are presently being achieved and provide an attractive return from development.
- The higher the value of irrigated land uses the greater return from the investment.
- The pre-feasibility study indicates that it would be financially viable to proceed to the next stage of scheme development.

Further details are given in "Affordability and Regional Economics for the Manuherikia Catchment Study" (TAG 2012).

6 References

Manuherikia Catchment Study Reports

Aqualinc (2012a). "Manuherikia Catchment Study: Stage 1 (Land)". Report prepared by Aqualinc Research Ltd for the Manuherikia Catchment Water Strategy Group. Report C12040/1. March 2012.

Aqualinc (2012b). "Manuherikia Catchment Study: Stage 2 (Hydrology)". Report prepared by Aqualinc Research Ltd for the Manuherikia Catchment Water Strategy Group. Report C12040/2. April 2012.

Aqualinc (2012c). "Manuherikia Catchment Study: Stage 3a (High Level Options)". Report prepared by Aqualinc Research Ltd for the Manuherikia Catchment Water Strategy Group. Report C12040/3. June 2012.

Aqualinc (2012d). "Manuherikia Catchment Study: Social Impacts". Report prepared by Aqualinc Research Ltd for the Manuherikia Catchment Water Strategy Group. Report C12119/2. July 2012.

Aqualinc (2012e). "Manuherikia Valley Detailed Hydrology". Report prepared by Aqualinc Research Ltd for the Manuherikia Catchment Water Strategy Group. Report C12119/3. July 2012.

Aqualinc (2012f). "Manor Burn Catchment Detailed Hydrology". Report prepared by Aqualinc Research Ltd for the Manuherikia Catchment Water Strategy Group. Report C12119/4. July 2012.

Aqualinc (2012g). "Upper Manuherikia Valley distribution". Report prepared by Aqualinc Research Ltd for the Manuherikia Catchment Water Strategy Group. Report C12119/5. October 2012.

Aqualinc (2012h). "Lower Manuherikia Valley distribution". Report prepared by Aqualinc Research Ltd for the Manuherikia Catchment Water Strategy Group. Report C12119/6. October 2012.

Aqualinc (2012i). "Manuherikia Flow Regime and Water Quality impacts". Report prepared by Aqualinc Research Ltd for the Manuherikia Catchment Water Strategy Group. Report C12119/7. December 2012.

Aqualinc (2012j). "Manuherikia Catchment Study: Environmental Impacts". Report prepared by Aqualinc Research Ltd for the Manuherikia Catchment Water Strategy Group. Report C12119/8. December 2012.

Aqualinc (2012k). "Manuherikia Catchment Study: On-farm Irrigation Development". Report prepared by Aqualinc Research Ltd for the Manuherikia Catchment Water Strategy Group. Report C12119/9. December 2012.

Aqualinc (2012l). "Impact of Climate Change on the Manuherikia Irrigation Scheme". Report prepared by Aqualinc Research Ltd for the Manuherikia Catchment Water Strategy Group. Report C12119/10. December 2012.

Hamilton, D. (2012). “Hope Creek - Ida Valley Distribution”. Report prepared by David Hamilton and Associated for the Manuherikia Catchment Water Strategy Group. November 2012.

Heiler (2012). “Manuherikia Catchment Water Strategy. Review of Aqualinc Research Limited Pre-Feasibility Study”. Report prepared by Heiler Consulting. October 2012.

KTKO (2012). “Cultural scoping study: Manuherikia Catchment strategic water study”. Report prepared by Kai Tahu ki Otago Ltd. November 2012.

Opus (2012a). “Manuherikia Catchment Study: Stage 3. Implications of a ‘Do Minimum’ Option”. Report prepared by Opus International Consultants Ltd 2012 for the Manuherikia Catchment Water Strategy Group. September 2012.

Opus (2012b). “Manuherikia Catchment Study Stage 3: Planning Issues”. Report prepared by Opus International Consultants Ltd 2012 for the Manuherikia Catchment Water Strategy Group. November 2012.

Opus (2012c). “Manuherikia Catchment Water Strategy Study Stage 3. Falls Dam Redevelopment Engineering Prefeasibility Study”. Report prepared by Opus International Consultants Ltd 2012 for the Manuherikia Catchment Water Strategy Group. November 2012.

TAG (2012). “Affordability and Regional Economics for the Manuherikia Catchment Study”. Report prepared by The AgriBusiness Group for the Manuherikia Catchment Water Strategy Group. October 2012.

Other reports

Hamilton, D. (2006). “Mt Ida Dam investigation feasibility study report including simulation for water storage and piped irrigation reticulation.” Report prepared for Hawkdun Ida Burn Irrigation Co. Ltd. by David Hamilton & Associates Ltd. June 2006.

Hamilton, D. (2010). “Mt Ida Dam Project”. Newsletter prepared for Hawkdun Ida Burn Irrigation Co. Ltd. by David Hamilton & Associates Ltd. June 2010.

PCL (2005). “Feasibility study: Proposed Upper Idaburn Dam. Report prepared for Hawkdun Ida Burn Irrigation Co. Ltd. by Pickens Consulting Ltd. February 2005.

RainEffects (2006). “Upper Ida Burn Irrigation Dam: Feasibility study hydrology report”. Report prepared for David Hamilton and Associated Ltd by RainEffects Ltd. June 2006.

OPUS (2010). “Lower Manuherikia Valley Water Resources Study: Summary document for discussion brief.” Report prepared for the Manuherikia Irrigation Co-operative Society Ltd by Opus International Consultants Ltd. August 2010.