

Investigation
into the
Merits of Integrating
Hydro-Electric Generation
With
Irrigation Proposals
For
North Otago

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Prepared by: Ken Mitchell
Whitston Consultants

Table of Contents

Executive Summary	6
1 Introduction	10
1.1 Background	10
1.2 Scope of Study	12
2 Primary Water Supply Options.....	14
2.1 Background	14
2.2 Main Water Supply System Options	15
2.3 Distribution Systems	16
2.4 Supply System Capacity Versus Hydro Potential	16
2.5 Concept 1: Lake Aviemore Intake.....	18
2.5.1 Description	18
2.5.2 Concept Variations	21
2.6 Concept 2: Lake Waitaki Intake	22
2.6.1 Description	22
2.6.2 Concept Variations	24
2.7 Concept 3: Kurow Intake	25
2.7.1 Description	25
2.7.2 Concept Variations	27
2.8 Concept 4: Black Point Pumped Intake	28
2.8.1 Description	28
2.8.2 Concept Variations	31
3 Strategic Issues	33
3.1 Concept 1: Lake Aviemore intake - Strengths and Weaknesses	33
3.2 Concept 2: Lake Waitaki Intake - Strengths and Weaknesses	34

3.3	Concept 3: Kurow Intake – Strengths and Weaknesses.....	35
3.4	Concept 4: Black Point Intake - Strengths and Weaknesses.....	36
4	Hydro Electricity Generation	40
4.1	Lake Aviemore Intake Option	40
4.1.1	Generation Opportunity	40
4.1.2	Network Integration	41
4.1.3	Generation Value	42
4.2	Lake Waitaki Intake Option.....	44
4.2.1	Generation Opportunity	44
4.2.2	Network Integration	44
4.2.3	Generation Value	45
4.3	Kurow Intake Option	46
4.3.1	Generation Opportunity and Network Integation	46
4.3.2	Generation Value	48
4.4	Black Point Intake Option	48
4.4.1	Generation Opportunity	48
5	Assessment of Energy Issues.....	49
5.1	Implications of Load Increase for NWL.....	49
5.2	Electricity Charges.....	49
5.2.1	Connection Charges.....	50
5.2.2	NWL Network Development Costs	54
5.2.3	Line Charges	55
5.2.4	Energy Charges	58
5.3	Summary of Electricity Supply Cost Comparisons.....	60
5.4	Energy Price Path.....	61

6	Other Value Adding Possibilities.....	63
6.1	Carbon Credits	63
6.2	Water Storage	64
6.3	Potable Water Supply	64
6.4	Irrigating Hakataramea	65
6.5	Benefit of Higher Supply Intake	65
6.6	Amenity and Stream Augmentation	65
7	Economic Viability Issues	66
7.1	Cost Hurdle.....	66
7.2	Sensitivity to Uptake	67
7.3	Change of Landuse	68
7.4	Land Value	70
7.5	Time Delay Verses Scheme Size	70
7.6	Borrowing Risk	72
7.7	Unit Rate for Water Supply.....	72
8	Conclusions	74
8.1	Alternative Scheme Concepts	74
8.2	Storage and Supply Rate.....	74
8.3	Generation Option	75
8.4	Preferred Option	76
8.5	Optimization.....	76
8.6	Community Costs and Benefits	77
8.7	Viability and Development	78
8.8	Consents and Legal Issues	79
9	Recommendations.....	80

Appendix A: Small Scale Low Head Hydro Generation82

Executive Summary

Ken Mitchell, of Whitston Consultants, has been engaged by an independent community group interested in the potential to maximize the benefits of water utilization by linking irrigation with distributed hydro-electric generation, potable water supply, and environmental enhancement. In particular this study aims to provide an assessment of:

- The opportunities for developing hydro generation in association with irrigation.
- The strategic and economic benefits that generation might deliver to Network Waitaki Ltd (NWL) as the provider of a key infrastructure.
- A comparison of the electricity supply issues that irrigation proposals present to NWL, which have not been considered in investigations to date.

This assessment starts from a neutral position regarding preference for either gravity or pumped irrigation. The primary focus is delivery of maximum benefit to the community and the local economy.

This study finds that there is strong potential for considerable economic and strategic benefit to be delivered from developing hydro generation on the back of irrigation. By virtue of the fact the hydro generation operates on a gravity and/or flow principle, a predominantly gravity fed supply from the Waitaki River to the Kakanui Valley, delivered at elevation would provide the most reliable and sustainable basis for both electricity generation and extensive irrigation development in North Otago.

The major hurdle is finding an economic method of channeling the required volumes of water from the Waitaki catchment, over complex geology and undulating terrain.

There have been numerous attempts, but all have been based on the premise of providing sufficient capacity to meet peak summer water requirements. The result is a primary canal capacity that is fully utilized for only a short period of each season and not at all, for much of the year.

Incorporating storage into irrigation design can minimize canal over-capacity, as the canal can operate more continuously, at a lower flow rate and still deliver the same total volume of irrigation water annually. The extent to which the canal can be downsized (above a certain minimum) is inversely proportional to the storage volume available.

There are hydro generation opportunities, both to use the surplus supply capacity en route and to capture energy when water is released from large storage reservoirs.

This study shows that there is potential scope to improve economics, reduce risk, and exploit management advantages by employing different levels of storage in a Waitaki River-based scheme and the supplementary benefits of integrating dedicated generation into this type of scheme. In this context, intake level is a fundamental parameter that directly affects generation and storage possibilities. It also recognizes that distributed generation opportunity in such a wide-reaching scheme adds value while minimizing burden on existing electricity networks.

This study finds that these crucial areas of opportunity have not been methodically examined at all in any of the investigations representing the current preferred irrigation options. Given the level of investment required for a community scheme and the direction and the impact that the choice will have on all in the District, it is strongly recommended, in the interest of sustainable water use and financial prudence, that these omissions be addressed.

Based on a preliminary assessment, this study finds that there may well be considerable economic and strategic benefit delivered to NWL, its consumers, irrigators, and the wider North Otago community/economy from developing hydro generation.

Several conceptual approaches are examined and these provide a framework for a more thorough investigation.

Further, these schemes enhance compliance with the following vision recorded in the Irrigation North Otago, INO, Strategic Plan 2002 – 2005. This document provides the most recent, community representative, strategy for meeting North Otago's irrigation requirements. Any irrigation proposals should be consistent with the Strategic Plan.

Achieving timely, affordable and sustainable irrigation opportunities for wider North Otago.

In light of the themes expressed in the derivation of this vision, we recommend that "sustainability" be interpreted as:

Optimum resource use, efficient use of electricity, and minimum exposure to risk.

This study shows that schemes incorporating hydro generation, increase the area able to be serviced, have a value creation impact on affordability, reduce the long run risk position, and provide for sharing of the benefits/risks across the community. As current proposals include significant contribution from the public

sector it is reasonable that the best outcomes for the wider community receive financial consideration.

Concern is expressed that effort to salvage what can be recovered from the promises of Project Aqua is sacrificing an appropriate level of re-evaluation with regard to irrigation, particularly considering the level of public expenditure and level of risk involved. The absence of Project Aqua has eliminated some of conflicts over resource use, resulting in a greater number of possibilities for irrigation. It is timely that the departure from Irrigation North Otago's Strategic Plan, that occurred when Meridian Energy became involved (to protect their interests), be reassessed.

From an electricity supply perspective, the local economy is facing significant electricity price increases driven largely by factors external to North Otago and the Waitaki District's control. Owning generation will provide some shelter from the economic impacts of this issue.

With regard to irrigation, future electricity price increases (including the very recently announced 18% increase) present a disproportionately large risk for proposals that are energy intensive. Energy intensive proposals will require NWL to invest more heavily in network upgrade, a cost which will be shared by all consumers. Risks associated with irrigation are, therefore, amplified in network investment.

Having a Regional Energy Strategy would be an appropriate framework against which energy intensive proposals can be assessed. The same might be said for having a Water Management Strategy.

This study has identified areas where economic analysis can be improved as well as associated opportunities for better concept development and optimization. This issue is one of maximizing economic value from a broader community/local economy perspective, rather than delivering an improvement in viability for individual farming operations per se. In particular the impact on electricity infrastructure needs careful consideration. The lines network underpins the local economy. Inappropriate infrastructure development results in an unnecessary cost burden on the economy, which can contract the economy rather than support its expansion.

Other value-adding possibilities have been briefly highlighted. There is the potential for accessing carbon credits. If the proposed joint irrigation hydro generation scheme qualifies, then securing carbon credits would provide a real advantage for the Waitaki District economy as it is deriving a tradable commodity from external sources. This is one way of indirectly accessing Government support for irrigation.

Having a well prepared and argued case for water allocation coordinated with a water management strategy and environmental plan is a key strategic issue for the Waitaki District.

Securing water resource access is the single largest strategic issue that needs urgent, focused and concerted effort by the District's leadership. The new water allocation legislation provides an opportunity for accessing valuable resources into the future. Recent investigations, into the economic value of using water for irrigation as a priority over generation, provide an indication that there is likely to be a significant shift in balance between local and national interests with regard to future water allocation.

The coming water allocation framework will set constraints on North Otago's economic development.

A developed set of conclusions and recommendations is provided at the end of this report.

1 Introduction

1.1 Background

There have been many years of investigation into various proposals for irrigating North Otago. To date the major viability hurdle has been the cost of getting water over the ridge lines and into the river valleys south of the Waitaki River.

Changing landuse is increasing the level of economic gain realizable from irrigation and bringing overall economic viability to irrigation. With the view to economies of scale, there is still however a need to minimize costs and a desire to service as large an area as possible.

Network Waitaki (NWL) is considering the role it might play in contributing to viability of irrigation. To do this it must consider what actions it can initiate that minimize costs to its consumers, add most value to the various proposals put forward, and assess each proposal from the perspective of its own business best interests.

This report is intended to assist NWL with:

- Selection of a preferred option should the company wish to pursue any of the irrigation/hydro proposals identified.
- Providing grounds for investment decisions.
- Determining what terms and conditions are necessary to protect the company's interests.

This report is not a full technical review of irrigation proposals. It relies heavily on technical detail, costings, etc., detailed in the following irrigation reports:

- Waitaki Electric Power Board, Report on Hydro Investigation, R.A. Pickworth, December 1992.
- Waitaki Electric Power Board, Waiareka/Kakanui Water Resources and Irrigation Options Study, Irricon, September 1992.
- North Otago Gravity Irrigation, Scoping Study, Irricon/MWH, February 2002.
- Project Aqua, Irrigation – Summary of Technical and Economic Analysis, February 2002.

- Irrigation North Otago, Normalisation Study, Riley Consultants Ltd., April 2002.
- Irrigation North Otago, Assimilation Study, BECA/Irricon/MWH, July 2002.
- Irrigation North Otago, Strategic Plan, Waitaki Development Board, November 2002.
- Network Waitaki, Network Development Plan, Whitston Consultants, November 2003.
- North Otago Gravity Irrigation, Scoping Study Panel Review, Pickens Consulting, December 2003.
- Network Waitaki, Line Pricing Methodology Review, Energylink, December 2003
- North Otago Irrigation Implementation, Post Downlands Development, Pickens Consulting, February 2004
- North Otago Irrigation Company, North Otago Irrigation Scheme Stage 1 Secondary Works Contract, BECA Carter Hollings and Ferner, March 2004
- Irrigation North Otago, Post Downlands with Storage, April 2004
- North Otago Irrigation Company, Transmission Proposal to Network Waitaki, 2004.
- North Otago Irrigation Company, Wealth from Water, Macfarlane Rural Business, May 2004.

Based on existing information this report:

- Updates previous understandings to reflect the current proposals.
- Includes the possibility of hydro generation.
- Considers the opportunity for further optimization of the main scheme concepts as discovered during this investigation.
- Adds the impact of irrigation on NWL's network in terms of costs, risks, and benefits derived from NWL's own planning.
- Reinterprets economic viability for more integrated schemes utilizing the studies completed to date.

Being a local electricity consumer owned company, and a key player in the provision of infrastructure in the Waitaki District, it would be appropriate for Network Waitaki to consider how it could help to achieve the vision of developing:

*A community-based irrigation scheme
for Greater North Otago that
optimizes resource uses, maximizes affordability
and minimizes exposure to risk.*

1.2 Scope of Study

A number of options involving the development of irrigation schemes combined with secondary hydro-electricity generation options have been proposed as an alternative to pumped schemes for irrigating the Waiareka and Kakanui valleys.

It is proposed to undertake a preliminary assessment of these options and compare them with the pumping alternative as means of assessing the merits for Network Waitaki Ltd.'s further consideration.

The purpose of the study is therefore to identify economic viability and preferred options for enhancing irrigation and electricity infrastructure through the addition of generation.

For each option the following data will be determined and analysed:

- Quantification of basic parameters; water use, area irrigated, etc.
- A schedule of the strategic advantages and disadvantages which impact on cost and risk.
- A limited assessment of costs.
- An assessment of potential energy value, price paths, etc.
- An assessment of the electricity networks ability to utilize generation at each location.
- An assessment of Transmission Cost Avoidance and the value of avoided and/or deferred network expenditure.

- Investigation of other potential “value adding” contributions such as carbon credits.
- Identification of sizing issues with regard to storage options.
- Sensitivity analysis with regard to risk variables such as cost, water, head, energy prices, etc.

Comments will be provided comparing the above with the pumped scheme benchmark.

General comments regarding viability issues and the relationship between rate of take-up and capital efficiency will be made.

2 Primary Water Supply Options

2.1 Background

The concept of a combined irrigation/hydro generation scheme using the Waitaki River to serve the Kakanui valley and associated Downlands has been a reoccurring theme, but the irrigation component has often been secondary to hydro when considering the value proposition. Where irrigation schemes have been the primary focus, hydro has been considered rather as a retro-fit, once the fundamental irrigation parameters have been set, with the aim of improving the economics of the overall scheme proposal. To date, there has been no serious study aimed specifically at optimizing both irrigation and generation in a fully integrated fashion to explore cost/benefit advantages. In essence, this is what this preliminary study sets out to do.

A second important point is that there has not, in recent times, been a formal scoping exercise on the technical options for the primary supply component of a gravity-based scheme. As hydro-electric generation essentially operates on a gravity and/or flow principle it is very necessary this requirement is addressed.

The Gravity Irrigation Ltd study was fundamentally a re-costing of the Ministry of Works and Development proposal of the early 1980's but with some significant modifications to the secondary water distribution system. The study itself was largely initiated to provide a cost estimate for a gravity-based alternative to the pumping scheme being promoted at the time. The study did not include formal process to rank alternative methods of delivery and methodically arrive at a preferred option. A more recent study undertaken under the auspices of Irrigation North Otago has recommended further evaluation of the role that gravity may play in an integrated and staged scheme for wider North Otago (INO, Assimilation Study, 2002).

Meridian Energy's efforts to strategically position itself for realising Project Aqua, resulted in the generation company supporting a pumped scheme starting as far downstream as possible and avoiding infrastructure/resource conflicts that a gravity scheme would have presented.

With the demise of Project Aqua and Meridian's reduction in support/strategic interest for irrigation, water and irrigation resources are now more available to the North Otago community to apply to its economic benefit. The way is now clear for this exercise to be completed, including an examination of the benefits of the joint Irrigation/Hydro approach.

2.2 Main Water Supply System Options

In order to examine the general scope for a conjunctive Irrigation/Hydro scheme development, we have chosen four scheme proposals that illustrate different approaches. The four scheme proposals are most simply distinguished by their point of intake from the Waitaki River. Essential parameters for each proposal are summarized in Table 2.1. Each one is then discussed in order from upstream to downstream in the following sections.

Table 2.1: Summary of supply system options considered in this Study.

Option	Intake Point	Intake elevation	Method of delivery	Length of primary supply line	Kakanui Catchmnt delivery level	Intake capacity adopted in example	Attractive features
		(m)		(m)	(m)	(m ³ /s)	
1	Lake Aviemore	265	Canal and siphon	93,695 (54km if piped)	233	9 - 15	No tunnel required, accesses new viticultural areas, maximizes head for scheme generation
2	Lake Waitaki (Gravity Irrigation Ltd Proposal)	229	Canal and siphon	46,900	196	25 INO consent application	Baseline cost example, avoids pumping in primary canal
3	Kurow bridge	200	Canal and siphon	22,750	200	29 intake, 15 delivered	Hybrid in-scheme generation provides energy for lift, no mitigation issue with Meridian
4	Black Point (Downlands Water Co. Proposal)	100	Pipeline and canal	?	235	16	Access issues minimised, geotechnical issues minimised, quicker to construct

While this report focuses on these four options, it is important to remember that further work will be required to optimize and confirm the feasibility of any one as a joint irrigation/hydro scheme. Optimization is complex because there are many interrelated variables. For example:

- Intake location and elevation, environmental and social impacts, the geology that must be traversed and generation potential/delivery pressure
- River verses lake intake, effects on fish screening, silt load and mitigation concerning lost or transfer of generation capacity

- Unit rate of supply for irrigation and its effects on scheme reliability and cost
- Area and location of land to be irrigated which affects minimum flow and delivery elevation requirements
- The inter-relation between storage capacity and peak rate of supply
- Opportunity to augment Waitaki supply with water harvesting in the Kakanui catchment
- Choice of conveyance method – canal, natural water course or pipeline, impacts on land requirements, access issues and costs
- Gradient of supply line which affects cross sectional area of the delivery conduit and generation potential/delivery pressure
- Flow allowance for generation scheme capacity and load factor
- Relationship between head, method of generation, location, proximity of electricity network, and capital costs.
- Tunnel verses higher elevation of intake

None of these factors have been optimized for the concept examples discussed.

2.3 *Distribution Systems*

Confining this study to the configurations, costs and hydro opportunities associated with the primary supply system would simplify matters appreciably. But for this to be acceptable the secondary distribution method and costs would need to be the same for all four supply options being considered. Such an assumption would lead to serious inaccuracies because for each, the point of intake, elevation, route, the method and rate of water delivery inevitably influence the most practical and cost effective method of distribution. The same variables also potentially affect the location and total area of economically irrigable land. The method of distribution within the Kakanui Valley is also dependent on whether hydro generation is incorporated into the distribution network or if the head is retained in pipe networks for pressurized delivery to each property.

2.4 *Supply System Capacity Versus Hydro Potential*

There are effectively four types of generation opportunity within each scheme:

- i) Use of discharge from major storage facilities or inline flow within the distribution system for energy recovery,
- ii) Use of all season flow within the primary system supplying storage facilities.
- iii) Use of out-of-season irrigation flow within the primary system (most likely within the Waitaki catchment).
- iv) Use of out-of-season irrigation flow within the primary system plus a dedicated generation increment (most likely within the Waitaki catchment).

A level of energy recovery is theoretically possible irrespective of the capacity of the primary system provided there is sufficient regulation over the flow to make it practical. However, any energy preserved in a pipeline distribution network is not available for recovery without sacrifice of either volume or pressure.

The volume of out of season irrigation water that could be used for generation is directly dependent on the capacity of the primary system. If more storage is available then reduced capacity is required because the same volume of irrigation water can be delivered over a longer period. The inverse relationship between storage availability and the irrigation surplus is illustrated in Table 2.2 for different peak capacities.

However, when generation is using the flow into storage facilities it is not dependent on irrigation draw-off. The trade-off is less head being available for feeding the secondary distribution system. Clearly optimization will be very dependent on the opportunities dictated by geography and geology.

Preliminary survey indicates that it is probable viable conditions exist. It will make little difference to sizing capacity if the available storage is contained in one or two very large facilities or many small on farm facilities. A survey of possible storage sites, their capacities and elevations located within the command of each concept, would be a rational starting point for an optimization study.

Table 2.2: Relationship between the capacity of the primary supply, storage volume required and the surplus irrigation water available for off season generation

Capacity of primary delivery system (Canal or Pipeline)	Storage volume required to meet full irrigation requirement with this delivery rate	Off-season irrigation water available for generation in primary delivery system	Average period over which generation water is available
(M3/s)	(Mm3)	(Mm3)	(mths)
9	110	2.3	1
12	70	94	4
15	38	188	7
18	11	283	8

Notes

- 1 Water requirement is based on a gross average irrigation demand of 5,067m³ at 75% on-farm irrigation efficiency.
- 2 An additional allowance of approximately 12% of the stored flow has been made for evaporation and seepage
- 3 The primary delivery system could be pipeline, canal or some combination
- 4 Figures exclude potential for energy recovery within the distribution system
- 5 The actual generation potential associated with each supply option depends on the elevation of supply

2.5 Concept 1: Lake Aviemore Intake

2.5.1 Description

For this option it is proposed to siphon or divert up to 15m³/s water out of Lake Aviemore at 265m AOD to supply a primary canal that traverses hill land down the margins of the valley. The concept is illustrated schematically in Figure 2.1.

The higher route maintained with this option has the advantage of making water directly accessible to new vineyard country on the north facing slopes and river flats immediately south of the Waitaki River. The Lake Aviemore take-point also maximises head available for generation and storage.

Figure 2.1 Concept 1: Lake Aviemore Intake/Otekaieke Generation

Siphons are used to shorten the canal, avoid very steep faces and difficult geology. Major siphons would be required to circumnavigate the Kurow Hill, possibly some of the steeper faces between Kurow and Otiake, the Maerwhenua and Awamoko Rivers.

The primary canal would extend as far as the Catchment divide between the Awamoko and Bobbing Creek catchments before connecting to the distribution system and feeding storage facilities.

For the purposes of this example, a 15m³/s delivery rate has been used. This flow has been adopted because the study has identified a storage facility of 40Mm³ capacity.

If an average grade of 1:3,000 (combination of headloss in the canal and siphons) can be achieved, then water could be delivered on top of the divide and on to this reservoir. The length of the canal and the undulations in some of the country that would need to be traversed, provides incentive to further reduce the canal capacity below 15m³/s if further storage is economic, be it on or off-farm.

Developing storage in the many small streams and valleys that are crossed will allow the quantity of water and cost of infrastructure to be optimized thus providing maximum utilization/efficiency of the investment.

Economic pipe sizing for the siphons may also be a factor in determining the delivery rate adopted.

Table 2.3 shows for example the approximate rate of delivery and the delivery level that could be expected at the main divide with different size pipelines. Note that higher unit head losses occur with small diameter pipes. Accordingly, while two or more smaller pipes combined to supply the same discharge as a single large pipe may be more economic, that option introduces more head loss.

Table 2.3: Approximate delivery rates and levels to the main divide with a single continuous pipeline from Lake Aviemore

Pipe Diameter	Head loss	Delivery rate	Delivery level at divide
(m)	(m/km)	(m ³ /s)	(m asl)
1.2	2.4	2.8	137
1.5	1.82	4.4	168
1.8	1.44	6.3	188
2	1.27	7.8	197
2.4	1.02	11.3	210
2.8	0.84	15.4	220

Notes

- 1 Calculations based on a velocity of 2.5m/s for smooth pipe
- 2 Pipeline length is 53 Km

The fact that the route identified for this option can traverse more elevated dryland much of the way down from Aviemore, through Otiake, Otekaieke, Earthquakes onto the shoulder of the Smillies Rd ridge (at about 240m asl) and cuts through to the Awamoko river catchment near Brookstead Rd, makes irrigation from it a more attractive proposition in these more elevated areas. Servicing into the Island Cliff, Tokarahi and Tapui areas (about 280m asl) and the upper plateau areas near Grandview, Rocklands, and Conlan Rd (about 300 – 320m) by pump becomes practical and so maximizes command area.

If the supply system is of sufficient capacity, generation could be incorporated (See Figure 2.1). There would be sites for generation into tributaries traversed en route but the maximum head (about 88m) with the shortest penstock is off Black Hill just south of the Otekaieke River with discharge directly back to the Waitaki River. Electricity supplied by such a generation unit could be used for boost pumping in the primary supply network if sufficient flow for year-round generation was provided. An alternative would be to look at cross crediting pumping power requirements from off-season generation.

2.5.2 Concept Variations

The option of having a single continuous pipeline supply between Aviemore and Awamoko has been examined, is feasible and also shortens the length of the primary supply system from about 94 to 53km. Pipes preserve water pressure and therefore are able deviate with land contour. However, the unit rate of head loss in pipes is much higher than in canals so a single continuous pipeline can not deliver to the same elevation at the divide as a canal.

Greater delivery elevation has a number of major advantages:

- simplifies the divide traverse by shortening and/or avoiding the need for a tunnel,
- simplifies fish screening issues,
- provides maximum flexibility in distribution options,
- brings more distant and elevated lands into contention for irrigation,
- maximizes storage options
- maximises the scope for domestic and stock water supply, including supply to Oamaru Reservoir,
- enhances the option for domestic water supply to Dunedin City, and
- maximises the scope for in-scheme hydro generation and/or pressurized delivery.

Some combination of canal and pipeline is therefore likely to be the best overall solution.

A supply system from Aviemore that incorporates a significant length of pipeline should not be discounted without thorough examination, as there are many real, if less obvious, advantages.

Factors that are potentially very significant include avoiding land access/ownership issues, consenting, simplifying design, installation, operation and maintenance; minimizing risk and preserving high water quality output. Pipelines are also largely modular, so with appropriate planning at the outset, the supply system from Aviemore could accommodate an optimum solution delivering incremental capacity in stages by adding delivery pipelines.

Another variant in canal design, flagged for more detailed investigation, is the option of increasing canal volume which allows a shallower canal gradient. The same flow rate can essentially be retained via the utilization of the potential

energy associated with a higher volume of stored water in the canal. This allows retention of height (to overcome crossing the Rakis Table divide) and permits the use of alternative shorter routes. The disadvantage is a larger canal holding more water at higher elevations. Preliminary investigations suggest that geology conditions may actually be favourable for this approach.

The Aviemore Intake Option is new, has not been investigated like the others and comments are therefore necessarily general. Clearly, a fundamental aspect affecting the viability of this concept is access to water at Aviemore, which would reduce output generation systems owned by Meridian Energy. But overall, the combined generation from the same volume of water could be increased via new generation plant integrated into the irrigation scheme.

A further consideration is that this option, with its higher take-point, could be used to improve the economics of supply to the Hakataramea Valley. The total lift to pump over the ridge opposite the Awakino confluence with the Waitaki is about 153m and this could be reduced to around 100m with supply from Lake Aviemore. A canal running back up into the Hakataramea from this point at about the 360 contour could command a vast area of several thousand hectares up to 25km from its confluence with the Waitaki on both banks.

2.6 Concept 2: Lake Waitaki Intake

2.6.1 Description

This is essentially the original Gravity Irrigation Ltd proposal as described in the Irricon/MWH Scoping Study of February 2002. The concept is illustrated schematically in Figure 2.2. A more detailed description of scheme parameters and costs can be obtained from the scoping study.

The concept is a gravity fed canal with an intake from Lake Waitaki. The canal runs into the hills between Ngapara and Georgetown at about RL 195 m above sea level. From this point, water would be carried by gravity through a tunnel into the Waiareka/Kakanui catchment and on to supply balancing reservoirs at elevation. Each balancing reservoir acts as a “header tank” for autonomous pipe networks. The proposal would provide water under sufficient pressure to obviate the need for on-farm pumping within the Waiareka and Kakanui valleys. To irrigate the more elevated valley margins, and ground above the main supply canal, pumping is required (see delivery levels illustrated on Concept diagrams).

Figure 2.2 Concept 2: Lake Waitaki Intake/Black Point Generation

A traditional off-season hydro generation opportunity is an added opportunity that is considered by this report. The proposal is to generate off the scarp opposite Bortons about 1km east of Taylors Road into a tailrace canal that would lead back to the Waitaki River upstream of the Lower Waitaki Irrigation Scheme intake pond.

While Irricon/MWH identified considerable generation potential (installed capacity of 23MW) it was concluded that it would be more efficient to manage the scheme in such a way that this water was directed through the Project Aqua turbines than install independent generation capacity.

The opportunity is large scale in comparison to NWL's network and essentially targets competition solely in the energy market. Twenty three MW of generation capacity, is well beyond the existing networks capability to distribute and consume the energy. Consequently significant network upgrade and injection back into the national grid would be required. Such network upgrades are an additional cost to the proposal negating the savings that a lower capacity scheme would be able to realize. The generation therefore has to compete in the wholesale electricity market on the cost of its energy which carries a transmission overhead that established generators have not been required to pay.

There have been two main peer reviews of the cost estimation for the Gravity Irrigation Ltd proposal. One considered that the estimate may be found

conservative on further investigation (Riley Consultants Ltd, April 2002) and the second considered the scheme costs may be well above initial estimates (Pickens Consulting, December 2003). In the light of this conflict, we have accepted the original estimate for the purposes of this study.

The initial estimated cost is \$238M (including \$30M contingency but excluding any provision for hydro development) for the primary and secondary infrastructure (Irricon/MWH, February 2002). If the 47,188ha assessed as irrigable were realized, this equates to an average off-farm capital cost of \$5,051/ha.

Based on the 2002 figures, the operating cost was estimated at about \$65/ha. After consideration of the electricity costs alone, as investigated in this study, we have revised the operating cost to \$105/ha. These costs could be considered as setting the benchmark for further enhancement and/or optimization of this proposal.

While initial capital cost estimate is high, and actual costs could be higher still, it is considered premature to dismiss this proposal on the basis of cost without further work on generation opportunities and benefits this may bring to all parties involved.

2.6.2 Concept Variations

The main opportunity for the optimisation of the Lake Waitaki option concerns the proposed capacity of the canal and generation potential.

The generation option briefly mentioned in the initial scoping study considered only out-of-season irrigation flow. An alternative is to increase the capacity of the canal to provide for year round generation. In the longer term, another possibility would be to feed water discharged from a generation facility tail-race directly into the Lower Waitaki Irrigation canal at Bortons rather than discharging into the Waitaki River, resulting in more efficient use of water. However, larger canals in this topography and geology present increasing engineering challenges that may not provide the required marginal cost/benefit.

If sufficient storage is identified and delivery rates can be lowered accordingly, it may also be feasible to preserve the head in Lake Waitaki by piping water around Kurow Hill and possibly as far as Otiake Rd. This could translate into delivery at the catchment divide at about 213m asl and provide additional command and storage opportunity. All such options are dependent on finding a reliable engineering solution to meet the target elevation. This requires more detailed study.

Alternatively, the opportunity to divert only the required intake flow after it has passed through the power station into a slightly elevated stilling basin could be

explored. The stilling basin would be set at the minimum level required to circumnavigate the base of Kurow Hill (possibly in a pipeline). In the off season the box would not be used. This arrangement would mean the opportunity cost of lost generation to Meridian would be small.

2.7 Concept 3: Kurow Intake

2.7.1 Description

This concept has been proposed as an innovative alternative to attempt to address some of the outstanding issues associated with the Gravity Irrigation Ltd proposal (Concept 2). The concept is illustrated schematically in Figure 2.3.

Figure 2.3 Concept 3: Kurow Bridge Intake/Otekaieke Generation

Important modifications include:

- Relocating the intake from Lake Waitaki to just downstream of the Kurow Bridge. The main advantages include avoiding the steep and constrained fairway available between the town and the foot of Kurow Hill, and avoiding or minimizing disruption to the town. However, the down side is that it sacrifices 7m of head and this means that the canal would not

exactly coincide with the existing Upper Waitaki Irrigation scheme race. Accordingly, infrastructural and easement complications can be expected.

- By including storage within the scheme, the capacity of the supply canal and/or pipelines and associated structures, such as linings, etc., can be minimized. Use of storage ponds has the additional advantage of reducing risk associated with an open canal at elevation.
- The installation of a generation facility primarily to provide energy to lift water to a higher elevation. The generation/pumping arrangement can be configured to more than compensate for the lower intake level at Kurow to improve access to irrigation water and alignment further down the valley.

In order to provide generation flow for the lift, additional water must be taken into the canal at Kurow. Just how much additional water would be required depends on the irrigation flow and elevation to which irrigation water is to be delivered. There are many possible configurations.

Table 2.4 below shows the installed capacity, the generation flow and the total intake requirement for two rates of irrigation delivery from an intake at Kurow.

Table 2.4: Preliminary estimate of the generation, lift and flow configuration with intake at Kurow bridge and generation plant at Otekaieke (Black Hill) to deliver to the Ngapara Tunnel

Irrigation delivery rate	Installed pump lift capacity	Required Generation flow	Total intake needed at Kurow
(m ³ /s)	(MW)	(m ³ /s)	(m ³ /s)
8	2	7	15
15	3.7	14	29

Notes:

1. Pumping lift = 18m (i.e. lift from 192 to 210m a.s.l.)
2. Generation head available at Otekaieke = 36m

A major advantage with this arrangement, is that from the lift point at Black Hill the canal would need to be half the capacity required from Kurow to Otekaieke (Black Hill).

From Black Hill the downsized supply canal would follow a route south of the Kokoamo Hill and Settlement Rd, to Camp Hill and thence to a 1.4km long tunnel through to the Waiareka Catchment as with Concept 2.

In the example on Figure 2.3, the main difference is that the delivery elevation can be slightly higher, giving it sufficient elevation for water to flow as far as Herbert provided the geological conditions can be navigated at acceptable cost.

In winter the full intake flow could be applied to generation subject to a viable utilization of the excess asset involved. Irrigation North Otago has lodged an application prepared by Gravity Irrigation Ltd for a consent to abstract 25 cumec from Kurow Bridge. This could be used to deliver perhaps 12 – 13 cumec for irrigation without revision of the application with this intake arrangement.

As with other proposals, the amount of water needed for irrigation may be able to be reduced when realizable land area is considered or the volume reduced via storage if an annual average requirement is applied.

These issues impact on the amount of water available and on the duration volumes are available for generation.

A preliminary check has been made to confirm that 15cumecs combined with 40M m3 of storage will service the area proposed in the Gravity Irrigation Scoping study. Further, a storage site of sufficient volume, and apparently suitable geology, has been identified although its usefulness depends on certain minimum delivery levels. Other volume/storage scenarios have also been considered.

2.7.2 Concept Variations

Two variations have been examined associated with this concept.

The first was to move the intake upstream to nearer the toe of the Waitaki Dam. Abstraction closer to the dam would gain about 7m of head. Comparison of Tables 2.4 and 2.5 indicates that this variation makes quite a marked difference. In the one move, it both reduces the lift and increases the generation head.

Table 2.5: Rough estimate of generation, lift and flow configuration with intake just below the Waitaki Dam and generation plant at Otekaieke (Black Hill) to deliver to the Ngapara Tunnel

Irrigation delivery rate (m3/s)	Installed pump lift capacity (MW)	Required Generation flow (m3/s)	Total intake needed at the Waitaki Dam (m3/s)
8	1.2	4	12
15	2.3	8	23

Notes:

1. Pumping lift = 11m (i.e. lift from 199 to 210m a.s.l.)
2. Generation head available at Otekaieke = 43m

The question as to whether it is possible to take water through to the Kakanui Valley in the vicinity of the Tokorahi/Tapui Rd., as an alternative to the Camp Hill/Ngapara Tunnel route, has also been considered.

The main attraction of this route is that it avoids the need to traverse most of the technically more difficult limestone, siltstone and mudstone geology. The main disadvantage is that the saddle near Island Cliff requires that water be delivered to the south side of the Maerewhenua at about 282m a.s.l. This elevation is even higher than Lake Aviemore (265m) so straight gravity options do not appear practicable.

Table 2.6 below looks at the configuration that would be required to use the same generation/pumped lift concept to lift directly into this area from a canal commencing at Black Hill.

Although it is theoretically possible to recapture some lift energy on delivery down into the Kakanui valley, the very large diversion requirements suggest that, unless more generating head can be secured, supplying water via Tokorahi/Tapui with this configuration is not feasible. This approach would have the negative energy balance associated with pumping dominated schemes. Nevertheless this does not imply that such an approach is uneconomic. Instead, the appropriate conclusion could be that it is not energy efficient.

Table 2.6: Estimate of generation, lift and flow configuration with intake just below the Waitaki Dam and generation plant at Otekaieke (Black Hill) to supply via the Tokoraha/Tapui area

Irrigation delivery rate (m ³ /s)	Installed pump lift capacity (MW)	Required Generation flow (m ³ /s)	Total intake needed at the Waitaki Dam (m ³ /s)
8	9.7	30	38
15	18.2	56	71

Notes:

1. Pumping lift = 88.6m (i.e. lift from 199 to 288m a.s.l.)
2. Generation head available at Otekaieke = 43m

2.8 Concept 4: Black Point Pumped Intake

2.8.1 Description

This scenario is the original Downlands Water Company Ltd. proposal now being promoted under the new name North Otago Irrigation Company Ltd. (NOIC).

The proposal is to develop primary infrastructure consisting of multiple pumping stages, starting at Black Point, capable of lifting 8cumecs, up to approximately 140m, into a holding pond above Ngapara, on the Millar's property on the Georgetown-Ngapara Road.

This primary infrastructure would be capable of servicing approximately 20,000ha above and in the Waiareka catchment.

Figure 2.4 Concept 4: Black Point Intake/Pumped Lift

The main pipe from the main pumping station at Bortons to the holding pond on Millars property will be sized for the full 20,000ha scheme but the primary and boosting pumps initially installed will only lift sufficient water for the 10,000ha targeted by Stage 1. Pumping is provided by multiple pumps at each site so finer resolution with regard to pump installation is feasible. The main backbone of the initial piped distribution system is also to be sized for 10,000ha. Prior to Meridian's retrenchment this was also proposed to be upsized for the 20,000ha.

The primary system for Stage 1 requires approximately 11MW of capacity from NWL's network available at Black Point. Stage 2 adds another 9MW. Dedicated network assets are required for this and there is still some uncertainty about the adequacy of design and firmness of costs in this regard.

Budget costs, contained in the NOIC Transmission Proposal presented to NWL, show that the primary and secondary infrastructure for Stage 1 will be in the vicinity of \$59M and Stage 2 will cost a further \$28M. The secondary infrastructure for Stage 2 essentially duplicates some Stage 1 piping and extends

it towards Whitstone and Airedale. Actual design for Stage 2 will depend on where the demand for water is strongest.

The above costings exclude the \$7.7M needed to develop the power supply to the main pumps which NWL and Meridian have been asked to fund. It is questioned whether or not the supply to the Duntroon, Tilverstowe and Glenn Settlement spurline boost pumps is able to be achieved within this estimate.

The off-farm capital cost benchmark (ignoring the uncertainties), if all 20,000ha are realized, is therefore \$4,800/ha.

NOIC's current plan is to provide these indicative off-farm costs to farmers and let farmer demand for irrigation water determine the final distribution system design for Stages 1 and 2.

Consequently there is a risk that Stage 2 in particular may "cherry pick" areas in the Kakanui catchment to the detriment of a more comprehensive scheme feeding into the top of the valley.

It should be noted that the land proposed to be irrigated in the Duntroon, Tilverstowe and Glenn Settlement districts are not serviced from the secondary pipeline running down into the Waiareka Valley but by additional, pump assisted, pipeline spurs. The NOIC contract documents for the installation of this secondary infrastructure indicate that irrigation supply for 4,376ha is assumed for Stage 1. This part of the irrigation water distribution system will be upgraded during Stage 2 to service a total irrigated land area of 6,623ha outside the Waiareka Valley which is independently serviced by the main secondary pipeline.

In percentage terms 45% of Stage 1 irrigated land area is therefore on the divide and has a high probability of needing some pumped assistance whatever proposals are developed. Consequently a pumped scheme designed for 10,000ha will not suffer a total loss value if it was assimilated into a wider gravity orientated scheme at a later date.

The secondary distribution network into the Waiareka Valley is proposed to be fully piped preserving the very high pressures developed and minimizing the need for on farm pumping. This system is not likely to be markedly different in nature or cost to gravity orientated schemes.

However, the probable design for Stage 2 is not clear at this time, nor is the certainty as to whether the 20,000ha will be realized without extension into the Kakanui Valley. The NOIC proposal (reference Contract Drawing 3851303/C004 prepared by Beca) has only identified 17,831ha of land potentially likely to take up irrigation after development of Stage 2. This is 11% below the targeted 20,000ha being adopted for price leveling. The shortfall in total area to be

irrigated compared with the cost leveling assumptions and the volume of water consented is listed as “spare capacity” to be discharged into the Waiareka Creek.

The land area to be serviced by the Waiareka Valley distribution system is forecast at 4,376ha for Stage 1 increasing to 8,358ha for Stage 2. Consequently the design indicates that only 48% of the 17,831ha the land identified as irrigable will be serviced from the Waiareka Valley distribution system.

The increase in pipeline capacity needed for Stage 2 largely results from a doubling of piping on the Burnside spur, to allow infill of land blocks not irrigated, and more than doubling the Windsor Park spur. No increase in Stage 2 is attributed to the Five Forks spur which is almost completely taken up in Stage 1. Therefore extension towards Whitstone and Airedale only amounts to 2,850ha (15%) and some boost pumping which has not been identified at this stage is likely to be required to operate the irrigation guns suitable for crop farming in this area.

Annual operating costs compared to those associated with Concept 2 are substantially higher and have more sensitivity to risk factors, such as the price path of electricity, as has been highlighted by Riley Consultants in their normalization review. Costs for NWL, both capital development costs and operating costs are identified and discussed in Section 5 of this report.

2.8.2 Concept Variations

This pumped scheme proposal has been thoroughly investigated over the past two years and has been through many evolutions.

One difficulty has been developing a scheme that would integrate with Project Aqua. However, the greatest challenge has been securing firm commitments from a sufficiently large and geographically consolidated nucleus of landowners to warrant proceeding.

If properties are interspersed with dryland areas, the reticulation distances increase. Cost per unit area likewise increases. Opportunity for variation therefore now largely concerns total irrigation area and the total extent of the command area of Stage 1. NOIC is about to issue a prospectus for Stage 1 of the scheme that may well determine if the scheme will proceed.

There is however, a possible variation to the pumped concept that would provide a way of hedging against future power price hikes that could place a pumped scheme at risk.

Comparing Figures 2.2 and 2.3 with Figure 2.4 shows an interesting opportunity for integration between either irrigation concept proposals 2, and 4 or irrigation concepts 3 and 4.

Concepts 2 and 3 deliver water to the divide at about 200m. Lift 1 of Concept 4 delivers water to a canal at about this level.

If Stage 1 of the NOIC pumped scheme goes ahead, there is the opportunity to link into this scheme with concept 2 or 3 at this level at a later date. It is acknowledged that integrating the NOIC distribution systems with supply from either concept 2 or 3 would render the lift 1 pumping equipment redundant. But the pumps could perhaps be relocated to lift water into the Tokorahi/Tapui area.

Options would include a lift directly to suitable storage sites which have already been identified for local abstraction or to pressurize a pipe network directly.

However, it is important to note that the downside of finding a positive use for any pumps installed at Bortons would be far outweighed by the significant advantage gained by integrating the NOIC scheme with either concept 2 or 3. Integration would reduce the required lift from the floor of the Waitaki Valley at Bortons by 100m to all pumping areas. This type of integration planning was envisaged in the Assimilation Study Report (Irrigation North Otago, July2002). So far, it has not been explored in any depth.

3 Strategic Issues

3.1 Concept 1: Lake Aviemore intake - Strengths and Weaknesses

- i) Although more circuitous, the canal alignment from Lake Aviemore, does provide an opportunity along its length for irrigation into areas not covered by concepts 2, 3, or 4. There would also be opportunity for staged irrigation development into these areas which is a significant economic advantage.
- ii) A major cost disadvantage is that the primary canal, at 94km, is substantially longer than options that take a route that commences on the floodplain. The final length does however depend on the proportion of pipe used in the route and can be reduced to 53km if the primary canal was totally piped.
- iii) The high intake level allows extension to the greatest command area. This could include the Hakataramea, Tokorahi/Tapui and any area up to about the 360m AOD level of Aviemore Dam with the aid of auxiliary pumping.
- iv) In conjunction with storage, the supply system can be developed in a staged manner, allowing an efficient capital expenditure program.
- v) The generation potential is distributed, allowing the maximum amount of benefit to be gained from an electricity distribution network perspective.
- vi) The scheme will be relatively balanced from a generation/energy use perspective providing shelter from external electricity price path issues.
- vii) In the long run, after capital servicing costs have been reduced, this proposal will deliver a strengthening economic position.
- viii) There are more opportunities for other value adding initiatives, such as stock and potable water supply, with this scheme.
- ix) Hydro discharge into the Waiareka, Kakanui, Maheno, Waianakarua, etc. catchments has the potential to improve water quality in these rivers by dilution, counteracting the impacts of more intensive farming. However there will be discharge consent issues with the noxious weed *Lagarosiphora* major now infecting the hydro lakes in the Waitaki catchment.
- x) Fish screening, when water is taken from a hydro lake rather than the lower river, is more straight forward and less expensive.

- xi) The existing water currently flows through Meridian Energy Ltd.'s Aviemore and Waitaki Power Stations. Meridian is therefore likely to oppose water consent applications and/or require mitigation on the basis of lost revenue.

Meridian does not, and cannot, use all of the Waitaki River flow all of the time. The actual impact can be minimized with a balanced sharing of water rights and coordination of operating regimes, especially if significant storage is incorporated in the scheme. Recent events suggest Meridian will be concerned about the potential impacts on their existing water rights if they are seen to aggressively oppose irrigation development indefinitely. More pertinently, the draft Waitaki Catchment Bill has proposed that the Allocation Board will have the authority to review current consents. North Otago needs a strong economic case for capturing access to a greater share of the water resource.

- xii) As the water is carried to locations where more head for hydro generation is able to be realized than that currently available through the Aviemore and Waitaki Dams, then there is more economic value achievable by directing water through the proposed irrigation/hydro scheme. Similarly, the amount of spill at Meridian's dams will be reduced, as there is essentially more installed generating capacity in the generation system. A mitigation proposal could be developed around such a proposal.
- xiii) Post Project Aqua, Meridian have stated publicly that they remain interested in the generation potential of the lower Waitaki River. Therefore, any distributed generation proposal is likely to be viewed as an opportunity cost by Meridian. The larger and the more elevated the intake for a conjunctive hydro/irrigation scheme, the greater will be Meridian's potential economic loss.

Their preferred option has been to subsidize pumped irrigation further downstream and it seems improbable that Meridian would change this strategy. This could very well be a lever to securing a greater contribution from Meridian towards Concept 4.

3.2 Concept 2: Lake Waitaki Intake - Strengths and Weaknesses

- i) This concept has all the advantages of a gravity-based scheme, but compared to Concept 1 is less attractive from an area perspective. Changing the location of previously considered hydro opportunities strengthens the case for this option.

- ii) Investigations into the distribution system are substantially more advanced than other options. Similarly, costs and risks have been identified at a preliminary stage.
- iii) Getting the primary canal through Kurow and through some other areas of difficult geology is a significant hurdle . These issues have however been identified and included in costings and risk assessment.
- iv) The water intake at least partially bypasses the Waitaki Dam turbines. Accordingly, it can be expected that Meridian will be opposed to the granting of a water right.

3.3 Concept 3: Kurow Intake – Strengths and Weaknesses

- i) This option is an innovative hybrid of hydro development, gravity, and pumped irrigation which is intended to overcome some of the geological and social issues around the Kurow area while retaining good delivery elevation at the catchment divide for irrigation to the wider North Otago area.
- ii) Being at the same location, as the intake for Project Aqua, concept 3 has the potential to exploit some of the investigation work undertaken by Meridian with regard to the intake and start of the canal.
- iii) The primary canal is shorter and significantly reduces in capacity approximately at its mid point due to the proposed location of hydro generation. The portion requiring full water capacity, for both irrigation and generation, is 22km long.
- iv) The hydro opportunity is significant in scale (estimated in the example considered at 6 MW for 14cumecs all year less the 3.7MW needed seasonally to lift the 15cumec peak flow for irrigation) This is close to the maximum level NWL is able to cope with from the perspective of deriving the non-energy benefits that distributed generation can offer. More generation for example would require sub-transmission support.
- v) Additional generation is available from May to Oct when the full 15 cumecs of water is not needed for recharging irrigation storage reservoirs. Because this generation will only be utilized during outside the irrigation season it may be more economic to trade off-peak capacity for a higher load factor. The scale issue with regard to NWL's network capacity at Waikaura can be overcome by developing this generation at another location such as at a major storage reservoir.

- vi) Depending on the final arrangements of storage, delivery, design of the secondary distribution network, level of pressure to be retained in the delivery pipes, etc. there is further small-scale, widely-distributed generation opportunity (such as the low-head helical turbine) that could be developed. This is equally true for other gravity options.
- vii) Without the need for mitigation to Meridian for lost generation at Aviemore and/or Waitaki, this hydro opportunity has the most to offer in terms of revenue to off-set irrigation delivery cost.
- viii) Reactivation of Project Aqua would eliminate the hydro plant. However, the irrigation scheme would remain compatible with an alternative future Aqua
- ix) It can generate more energy than will be used by the remainder of the scheme and therefore offers shelter to NWL consumers against electricity price rises. Similarly, its value will grow in the face of such price rises.
- x) It could provide the energy needed to pump water into the Hakataramea and the north side of the Waitaki River but this would require additional water as the demand would also be in summer. 6MW is approximately the amount of energy needed to lift 3cumecs 153m from the toe of the Waitaki Dam over the saddle.
- xi) It can reach the same feed points as Concept 2 and therefore in theory can service at least the same area. If the delivery elevation is higher than Concept 2 then it will improve scope to distribute water to the extremities of the command area.
- xii) With potential to increase delivery elevation with the in-line generation at Otekaieke any areas requiring pumping further down the line will benefit by an equivalent head gain and reduced local pumping cost compared with Concept 2 .

3.4 Concept 4: Black Point Intake - Strengths and Weaknesses

- i) Investigations were underway into the feasibility of a major pumping proposal at the time Project Aqua was proposed by Meridian in 2001. This led to the need to adapt the irrigation proposal to conform with Meridian's generation plans.

Meridian was prepared to support a pumped irrigation proposal provided it conformed to certain criteria. These criteria included staging issues, location of take and abstraction rates as well as proposing an overall "mitigation

package” that would require commitments from other existing schemes as well.

With the demise of Project Aqua the restrictions and promises have greatly reduced.

- ii) It is suggested that the current drive for this pumping option which would salvage something from the progress made with Meridian, may be preventing a more rational reappraisal of the outcome released compared to the vision of providing irrigation to wider North Otago. Where there is an element of “the few” benefiting at the expense of “the many”, there is the risk that decisions may not be made in the best long-term interest of the wider community.
- iii) This option is the most advanced in terms of design and cost detail and tendering for the primary infrastructure.
- iv) The water right exists, so some of the major resource consent issues are well advanced. However other consent issues such as discharging water from one catchment to another, easements, etc. still have some hurdles to overcome. It is understood there is a right to discharge up to 1m³/s to the Waiareka Creek but not to the Kakanui.
- v) The scheme is preferred by Meridian should Project Aqua in a new guise ever be reactivated.
- vi) It is proposed that both Meridian and NWL fund the power supply arrangement saving \$7.7M of capital costs for irrigators and allowing Meridian and irrigators to capture the benefit of transmission savings. There is concern over whether these savings will remain accessible and whether the load will develop quickly enough to capture adequate transmission savings. Note that NWL is obligated to pass transmission savings through to consumers. NWL’s pricing structure does not include a recovery to fund new capital expenditure. Consequently it does not experience significant windfall revenue from load growth.
- vii) A 5 year line charge 50% discount from NWL is proposed by NOIC.
- viii) Meridian has agreed to underwrite 2,500ha of Stage 1 lowering the strike level to 7,500ha.
- ix) The WDC is also proposing to provide financial support for Stage 2 in the form of over-sizing primary supply facilities. This is focused on up-sizing the primary supply system pipe for a capacity of 20,000ha. However it does not include provision for a sufficiently large backbone in the secondary distribution system. It is questioned whether this is not a better place for

investing in excess capacity as it will still be useable if the NOIC proposal is integrated into a wider area scheme at some later date.

- x) The primary power supply from the Waitaki Dam to Bortons is incompatible with NWL use because of the voltage quality issues created by the pumping design.
- xi) The scheme is very costly from an electricity perspective and fully exposed to the forecast rising electricity price path. This issue threatens viability in the long run.
- xii) A 3 year fixed-price energy agreement has been negotiated with Meridian for the primary pumping. It would be unusual for such agreements to cover any high spot price events for which irrigation is particularly exposed as its highest demand is during dry years. There is also an issue of electricity rates shock at contract renewal time.
- xiii) This scheme won't be affordable during high spot price events. Large, low-margin loads, with a high requirement for firmness, are least attractive to electricity retailers. This will be reflected in contract prices eventually.
- xiv) Expansion is difficult without increasing the disadvantages of pumping.
- xv) Compared with the other concept options this proposal places the most pressure on NWL to invest in network upgrade which is unlikely to result in a more efficient asset investment.
- xvi) NWL's consumers will carry a large burden in terms of funding capital investment, increased operating costs and the risk of non-uptake of Stage 2.
- xvii) Hydro opportunity is limited to energy waste recovery from the spill into the Waiareka Creek, which may be difficult to manage without storage.
- xviii) The scheme will deliver irrigation faster to the group of farmers expressing the most urgency for irrigation, some of whom have already made investment decisions based on the promise of water.
- xix) Stage 1 has the advantage of a good concentration of dairy farming. The rate of uptake and area that is realizable for Stage 2 is potentially overly optimistic with the consequence that economics are not being accurately represented.
- xx) If the engineering components of the pumping scheme were optimized to an accurate assessment of its economic development potential, the overall cost may be reduced.

- xxi) Pumping eliminates the economic rationale for developing other value adding opportunities that increase water demand, for example, generation, supply for potable water, supply for stock water, etc.
- xxii) If the scheme was optimized to the minimum required to service the farmers in the Waiaireka Valley wanting irrigation now it would not significantly impact the economics of the wider area concepts 1, 2, and 3.
- xxiii) An economic and/or resource efficiency issue is that all water distributed has already been lifted to the top of the divide (a pumping head of approximately 140m).
- xxiv) This scheme satisfies the community irrigation vision least on all accounts.

4 Hydro Electricity Generation

A large proportion of irrigation development in NZ has utilized power generation as a means of adding value and overcoming economic hurdles. In the long run, hydro electricity will always prove economic because its operational costs are very low relative to the rising value of the energy it provides. The issue is therefore what the capital investors servicing requirements are.

Irrigation lowers the cost hurdle for generation where it provides the impounding infrastructure needed to deliver an adequate and consistent volume of water at a suitable head. This cost typically accounts for 30 – 40% of an independent hydro opportunity.

Hydro generation can operate from stored water schemes, where it is able to obtain maximum value by operating in a peaking role, or it can generate on a “run of the river basis”.

The bulk of NZ’s large scale hydro generation is “run of river” because of the very large construction costs that would be required to build sufficient storage. Hydro is not seen around the world as a “cheap” form of generation. Lack of storage, combined with heavy reliance on hydro generation for base load supply, underlies the country’s energy issues; our base load generation is not firm and is dependent on water flows.

Irrigation and/or hydro proposals for North Otago can be designed to exploit water accessed on a firm draw-off basis. Rather than being limited to generating through irrigation off-season, generation can be arranged to occur year around.

Generation can utilize potential energy wherever head is developed or it can generate from water flow and therefore is very adaptable to the wide range of local opportunity available to North Otago.

4.1 Lake Aviemore Intake Option

4.1.1 Generation Opportunity

Along the main supply route, there are a number of opportunities for multiple hydraulic drops in the order of 60 to 100m. The size of the plant and its operating regime is dependent on the design of the irrigation scheme with regard to delivery capacity, storage, distribution, and pipeline pressure requirements. For example:

- If irrigation storage was located at the bottom of the head, then the generation would be able to operate year round, sized to the flow required to recharge the reservoir. This, however, means less head available for pressurizing the irrigation distribution system.
- There is a potential trade-off with regard to using head for generation and then replacing it with booster pumping. There are losses associated with generation and pumping. However, if the head is more than the minimum needed to meet hydrant pressures under peak demand, then the potential energy is not being fully harnessed. This would be the case if water was delivered to the top of the catchment divide or into storage facilities without employing inline generation.
- At times when the primary supply system is delivering more water than is needed for storage, additional plant could be installed to capture generation from spill. Spill could be permitted anywhere enroute and therefore generation could exploit maximum head opportunities.
- This option could minimise consenting issues with regard to mixing water from different catchments or spilt water could be used to flush and improve the water quality of the Kakanui river, for example.
- If generation is located at the storage outlet, generation characteristics are dependent on the operating regime of the irrigation plus any seasonal surplus.
- If pipeline pressure cannot be sacrificed for generation, then the scheme can only generate from the surplus water during the off season in the main supply system.

4.1.2 Network Integration

This scenario not only preserves the head associated with the Aviemore and Waitaki Dams but develops greater head by shifting the generation point further downstream.

Consequently, an argument that water is still being used for generation can be made. Furthermore, it would be possible to demonstrate that more generation is being derived from the same water. With more total installed generation capacity, spillage can be reduced at Aviemore and Waitaki and better overall use is made of the water resource.

In addition, low head, low capacity generation can be developed on every drop structure.

Compared to many other countries, NZ has been slow at exploiting distributed generation opportunities such as these. Distributed generation is particularly suited to operators of distribution infrastructure such as irrigation companies and electricity lines companies. These businesses are locally owned and deliver local economic benefit.

Distributed generation has much to offer lines companies.

Large-scale generation needs costly dedicated line capacity to distribute its output. Securing the supply when the generation is not available becomes a costly issue. In contrast, the diversity of many small schemes overcomes security issues and can, in some circumstances, be used as an alternative to capital intensive line upgrade.

In short, distributed generation not only creates value by generating electricity but also improves service levels in a more cost effective manner by avoiding transmission cost and avoiding distribution upgrade costs.

Ownership of these assets provides the local community with a hedge against strategic issues, such as the increasing energy price path that is beyond its control.

If community interest and economic well-being are an objective, development of distributed generation has a significant strategic contribution to offer. Passing the water through the turbines at Aviemore and Waitaki doesn't deliver the same or as many economic advantages at a District level.

4.1.3 Generation Value

Without sufficient detail to be specific, it is expected that within the \$1,000/kW to \$4,000/kW range typical of hydro generation, this scheme will deliver opportunities in the mid cost range. The generation is likely to be competitive with the delivered cost of energy from the national grid and will be increasingly profitable as the price path inevitably escalates.

Generation is, therefore, able to support some of the cost of the irrigation scheme but also would contribute indirectly in a wide range of ways. For example, off-setting or avoiding network development costs that would otherwise be subsidised by other consumers, and capturing value from Meridian's hydro spill, etc.

However, in the first instance, it is advised that the primary canal infrastructure be optimized for irrigation capacity requirements. Given the length of the canal, significantly more investigation is needed to prove that it is worthwhile increasing capacity for generation. The W.E.P.B. Pickworth study suggested the larger canal was the most economic with Concept 2, that is, the Lake Waitaki intake.

Much of the energy benefit accruing from supplementary generation associated with the Lake Aviemore intake option may be lost to Meridian as mitigation for accessing the water. Whether mitigation would be required depends on decisions by the new water allocation board and the status of Meridian's "ownership" claim over all water west of the Waitaki Dam. However, there are probably sufficient other benefits to this generation that will enable a sound case to be made for access, particularly if canals are sized for irrigation supply and as there are no other generation alternatives downstream of the Waitaki Dam.

Benefits include:

- Avoidance of Meridian spill.
- Avoidance of Transpower's transmission charges.
- Avoidance of Transpower transmission upgrade costs.
- Reduced exposure to national price path for transmission costs.
- Development of more head providing more energy from the same water volume.
- Avoidance of the need to upgrade the sub-transmission distribution network.
- Lower transmission and distribution losses.
- Very high certainty over firmness of generation output.
- Spreading risks over multiple sites.
- Improved security of supply.
- Carbon credits.
- Ability to capture benefit from the rising national price electricity path
- More self-sufficient and sustainable community.

It is estimated that there is in the order of \$8 -10M p.a. of value to be gained from pursuing these benefits with the Lake Aviemore intake option.

4.2 Lake Waitaki Intake Option

4.2.1 Generation Opportunity

This option does not affect the water passing through the Meridian's existing Aviemore hydro station but it currently does propose to by-pass their Waitaki Station. The first section of the main canal to Otiake would become obsolete should Project Aqua ever be reactivated. Getting a sufficiently large canal around the back of Kurow below the scree slopes would be particularly challenging. Hence, water taken from Lake Waitaki may need to be piped to east of Kurow.

Again, the flow rate for irrigation depends on the volume of storage developed in the command area. If 9m³/s plus storage is adequate to meet irrigation requirements then the canal would be roughly half the size of the Lower Waitaki main canal.

In this investigation 24cumec and 32cumec options have been considered. The extra 8cumec option arises from the possibility of feeding the Lower Waitaki Irrigation Scheme water through the generation facility integrated with the Lake Waitaki intake option rather than Lower Waitaki Irrigation Company abstracting their total take from Borton's Pond. The additional 8cumecs would deliver approximately an extra 8.5MW. However, the extra earnings are off-set against the cost of up-sizing the 47km canal, the generation plant, etc. Given that peak capacity will not be available all year round the pay back period will be long. However, this generation is not dissimilar to some of the irrigation proposals.

The most suitable point for generation would be at Bortons. At this point there is sufficient head (approximately 90m). The fall is steep, minimizing penstock length and the river is close enough at this point to limit the cost of developing a tail race. Ironically, this proposal would take water down pipes in the same location as the Black Point intake option proposes to pump it up hill.

4.2.2 Network Integration

From the Waitaki Dam intake the water would be gravity fed to the edge of the scarp east of Bortons. From there it could either pass on to the tunnel and be spilt into the Waiareka Valley, etc. or be put through the generators.

There are several disadvantages affecting the viability of this concept at the higher flows considered:

- The scale of the generation would require significant new transmission and distribution investment to connect electricity output with load as the existing electricity lines network in the Bortons area has insufficient capacity.

- There is a seasonal availability issue as generation and new irrigation would compete for the water resource. This results in both the network assets and generation facility being used less efficiently because the irrigation and generation assets would be sized to match peak capacity and peak demand. This is the same for any concept that generates with water dedicated to irrigation during the irrigation season. However the larger size of the infrastructure implies a greater level of inefficiency in this case.
- For a secure supply, generation of this scale would need to be backed up via supply from the national grid whenever the generation is not available. With smaller scale generation it is more likely that NWL would be able to manage security via demand side responses within its own network.
- Because of its scale, the generation has similar economic characteristics to standard, centralized, grid connected, generation. Meridian were not able to achieve viability for Project Aqua which essentially used the same resource in the same fashion. The same technical and cost issues will exist for this option.
- Engineering safe passage of large flows across some of the geology may prove challenging.

4.2.3 Generation Value

The Waitaki Electric Power Board priced a similar option in 1992 at a cost of \$41M (approximately \$4,000/kW) equating to construction costs of 7.23c/kWh. The market value of energy was approximately 4c/kWh at that time. The marginal cost for increasing the canal size specifically for generation flows i.e. from 5 to 15m³/s, was included in the above figure. The cost of the facilities to deliver the basic 5m³/s irrigation flow had already been included in the irrigation scheme costs. Even at these historical values, competitiveness within the existing energy market is some years off.

The Lake Waitaki Intake option represents the traditional commercial application of generation. The value of energy output from the generation is derived from its competitiveness in the energy market without the non energy value adding benefits that distributed generation can deliver if it is niched to the scale of NWL's network. Its lack of competitiveness in the energy market results from the fact that it cannot utilize its capacity on a full time basis and has no other value streams other than energy production.

4.3 Kurow Intake Option

4.3.1 Generation Opportunity and Network Integration

This option utilizes a hybrid solution of gravity fed supply system and pumped lifting, with hydro generation providing the energy for the pumping.

The economic advantage of this option is that a canal large enough for both the irrigation requirements and the generation requirements, is relatively short and direct (22km). Therefore construction costs will be lower. It has been determined that about 29 cumecs would meet full time generation and irrigation needs, if sufficient storage can be confirmed. However, benefits here are offset by a reduced head.

With optimization of the primary canal, storage and distribution more viable opportunities exist for this scheme compared with the Lake Waitaki intake scheme. It is proposed to target 15cumecs with 40M m3 of storage to service the same area targeted by Concept 2 i.e. Lake Waitaki intake option.

There are three main generating opportunities:

- A full time 6MW opportunity at Waikaura of which 3.7MW could be used to lift 15cumecs of water for irrigation 18m. Fifteen cumecs is sufficient for the average seasonal demand. Irrigation water would not be required for an off season of approximately 5 months duration.
- The net surplus generation of 2.2MW operating full time has a value of approximately \$1.15M p.a. The additional 3.7MW not needed for pumping during the off-season has a value of approximately \$800,000 p.a. This revenue will readily pay back in 5 to 7 years the estimated \$8-12M cost of generation and pumping plant, leaving a surplus to contribute towards the primary supply canal costs, etc.
- NWL's existing 11kV distribution network will probably cope with distributing the 2.2MW surplus energy without upgrade. If capacity is distributed in both directions, there probably is sufficient base load to utilize all the energy during NWL off-peak times.
- However, to utilize 6MW would require 11kV upgrade and injection into the 33kV sub-transmission system at Kurow. The development of more load, such as pumped irrigation into the Hakataramea Valley, would help resolve the supply and demand imbalance.
- 11kV and/or 33kV upgrade would add in the order of \$1 – 2M cost. At this order of additional cost, the proposal would remain viable.

- To fully use the additional 6MW of generation available from the irrigation off-season water surplus, would require double the generation plant which would be greatly under-utilised for most of the year.
- Sub-transmission would certainly be required, possibly to both Kurow and Ngapara. Injection back into the grid at Lake Waitaki may be necessary during minimum load periods.
- An additional benefit that can be derived from not needing to utilize the 15cumecs irrigation capacity all year round because of storage but having some surplus generating capability is to target maximum generation during the daily/weekly periods of energy market premium. Premiums in the order of 20% of average spot market value can be realized in this way. Similarly the irrigation pumping load can be utilized to hedge the generation revenue during periods of low spot price.
- An alternative to utilizing the off-season surplus at Waikaura, would be to continue pumping (at that cost penalty) and generate at another point along the canal where more benefit can be captured from distributed delivery of energy through the avoidance of line upgrades. This strategy potentially allows realization of other benefits, such as the development of more head which would overcome the pumping efficiency issue.
- Generation on the end of the Ngapara tunnel is a possibility with the advantage that the sub-transmission system is already established (and constrained) at that location.
- As for the Lake Aviemore option, there are a range of possibilities as to how head in the vicinity of the storage reservoirs might be utilized for generation. However, the opportunities with regard to the size of the head and suitability of site are likely to be reduced.
- As for all schemes with a gravity element, there is opportunity for small scale, low head/flow orientated widely distributed generation. This is able to support localized pumping requirements and minimize network upgrade issues.
- No attempt has been made to quantify the size of this opportunity or the niche benefits it might deliver as substantial detail on the secondary infrastructure is needed for such an assessment.

4.3.2 Generation Value

It is estimated that there is in the order of \$5 -7M p.a. of value to gained from pursuing these benefits.

4.4 *Black Point Intake Option*

4.4.1 Generation Opportunity

It appears that the distribution network into the Waiareka Valley is now likely to return to the original concept of using pipes instead of canals in order to preserve as much pressure as possible in the distribution system. Pressure developed within the pipe distribution system will require pressure reducing valves for any spilling into the Waiareka Creek.

There is a small generating opportunity associated with spilling and/or excess pipe pressure.

The economics of primary pumping will always limit the availability of water for hydro generation Only the waste water and pressure will be available which is likely to be managed to minimum levels.

Given that Stage 2 of the Black Point Intake Scheme option will require extra secondary pumping to reach parts of the extended network it is assumed that no water or pressure will be sacrificed to generation.

5 Assessment of Energy Issues

5.1 Implications of Load Increase for NWL

There is a misconception that NWL stands to benefit greatly from load growth associated with irrigation.

Irrigation typically changes and intensifies land-use. The existing network, in rural areas, was designed to service a predominance of dry land sheep farming. Intensified farming operations not only create higher demand, but also require higher quality service delivery, such as security of supply.

Significant upgrade will be required to address changing land-use. Depending on the amount of tertiary on-farm pumping required with the various irrigation options, a significant amount of capacity upgrade may be needed.

One way or another, this will cost electricity consumers. Depending on pricing policy, irrigators may or may not bear the total burden.

If NWL adopts an average pricing methodology then existing consumers will see significant price increases. The average pricing policy will also expose NWL to regulatory pricing controls.

If NWL adopts a user pays approach then a significant economic hurdle may be presented to irrigation development.

NWL is owned by a Consumer Trust, which has a more specific set of beneficiaries than a community trust. Consequently, NWL must consider how an investment might benefit its 11,400 electricity consumers rather than a small subset of consumers such as irrigators. It is not able to justify increasing prices to all consumers solely to support irrigation. There needs to be an additional means of adding value for consumers.

NWL therefore needs to factor in the relative impacts of network upgrade implications for each scenario to identify economic viability at a higher level.

5.2 Electricity Charges

NWL's tariff structure currently targets a revenue recovery that is intended to cover its operational costs, including depreciation provisions, and a very low rate of return, reflecting its debt free position.

NWL's cost recovery options fall into two categories:

- Connection Charges - a form of capital contribution paid on a one off basis by new consumers or existing consumers who apply to have their peak load requirement increased. The aim is for new or increased load users to partially meet the capital cost of providing capacity for a new or upgraded connection.
- Line Charges – These form NWL’s normal operating revenue stream and are a combination of fixed and variable charges.

Revenue recovered as a fixed charge sees no increase associated with growth, unless the number of network connections increases. Variable charges may not be sufficient to cover the increase in operations during a development phase. Some costs, such as those relating to transmission, security, etc. are driven by demand which irrigation growth will place pressure on because it has a different load profile.

Existing pricing cannot be sustained if significant debt servicing is introduced to NWL’s cost structure. Therefore, to address capital requirements for network upgrades, a contribution is required from the user in the form of a “connection charge”. Currently this charge is \$280/kW.

This charge alone, while vital from a funding perspective for NWL, places more of the true economic cost of proposals onto irrigators. Although a capital contribution for new and upgraded connections is a justifiable, economically efficient, pricing approach, it does impact more heavily on irrigation proposals needing more intensive infrastructure support.

5.2.1 Connection Charges

Schemes that require pumping, inherently have a higher long term economic cost than those that can utilize gravity to feed water because running costs inevitably overtake any initial savings in capital investment.

i) Primary Pumping

Primary pumping options could be incorporated in any one of the basic intake options. However, for all but the Black Point intake option (NOIC pumping scheme proposal) these are likely to be self-contained, generation/pump arrangements that do not require specific upgrades for supply of electricity. Depending on the size of the generation component with such an arrangement, it is possible that network upgrade will be required to transmit power from the site during off-season generation.

To provide electricity for both the main and primary boost pumps required for the Black Point intake proposal there are two main delivery options:

- Transpower Point of Supply (also known as a Grid Exit Point or GXP)
- Meridian Point of Supply

The Transpower option would be to feed from a new GXP developed under the 110kV Waitaki Oamaru (WTK-OAM) tower line on the opposite of the river at Black Point. This arrangement would incur standard Transpower New Investment charges and ongoing annual charges per their pricing methodology.

The Meridian option involves a direct link to Lake Waitaki Power Station and is a special arrangement proposed to bypass transmission charges. .

To provide the electricity supply for the proposed primary pumping associated with Black Point Intake scheme via the Meridian Point of Supply option requires an investment of \$6.254M by Network Waitaki and \$1.455M from Meridian Energy.

The Meridian electricity supply option is not the least cost nor does it provide lowest risk for NWL. The option has been considered by irrigators because it permits them to obtain an Avoided Transmission Benefit.

We question the estimate of the area that will be irrigated by the NOIC scheme and the amount of water that will ultimately need to be pumped. We also question the rate at which load will develop. If analysis is reworked, it is possible that the Avoidance Benefit will not cover the extra cost of connecting via a "Meridian Point of Supply". Clearly a different, lower-cost, electrical supply arrangement is possible if the irrigated area is below 10,000ha.

NWL has no options for alternative use of a dedicated line from Lake Waitaki to Bortons. So the line will not deliver any benefit to NWL's broader consumer base. In fact, it can be argued that restrictions on future upgrades of NWL's network, created by occupation of line route by infrastructure dedicated to supply irrigation pumps, and the need for a non-standard voltage, etc., will add cost to other NWL consumers.

It would be possible to lower costs to NWL's broader consumer base if NWL were to be permitted to connect its existing load for the Upper Waitaki and Hakataramea consumers at Meridian's Lake Waitaki Point of Supply. If NWL required the Black Point pumps to comply with its Connection Standards it could not only share the line, deriving some benefit, but the extra pump costs (for soft starters) would be offset by a lower cost line.

The Waitaki District Council also has the ability to reduce the cost of the line by addressing the undergrounding issue through the townships of Kurow and Duntroon.

From NWL's perspective, the Meridian supply proposal is a little one sided. It is difficult to demonstrate that it is in the best interests of NWL's business and its shareholders.

NWL must also keep in mind regulatory constraints with regard to pricing equity. It is required to offer the same terms to all consumers.

There is a concern that irrigation infrastructure will be put in place prior to full consideration being given to optimization issues. To date, proposals have focused on servicing as much area as is technically possible rather than econometrically probable. In particular, the supply costs of pumped schemes are particularly sensitive to the amount of water being pumped. If the peak load at Black Point was to be lower than predicted on paper then NWL would be recommending a completely different solution.

ii) Secondary and Tertiary Pumping

Faced with the prospect of major irrigation scheme development, NWL has investigated options for meeting future demand (refer to NWL's Network Development Plan, 2003)

The Network Development Plan has applied the following assumptions with regard to pumping load.

- Load associated with secondary pumping needed to supplement pipeline pressure or lift water adds 0.12kW/ha of demand.
- Load associated with tertiary on-farm spray irrigating when delivery pressure is insufficient adds 0.33kW/ha of demand. This assumes predominantly "K-Line" method.
- However it should be noted that currently a significant quantity of land targeted by the Black Point scheme is used for cropping and consequently will need sufficient pressure to operate traveling and/or "gun" type irrigation.

The secondary pumping requirements alone for the 6,600ha associated with the Duntroon, Tilverstowe, and Glenn Settlement pipelines average out at 0.77kW/ha.

Consequently, the connection charges that will be faced by the irrigation company and individual farmers will be:

- Zero for 100% gravity fed farms.
- \$92/ha for farms just requiring tertiary pumping.
- \$126/ha for farms needing secondary and tertiary boosting.

To date, significant effort has been made by the NOIC to present farmers with an average costed irrigation proposal in an effort to overcome differences in staged construction costs. This means that all farmers in stage one will pay the same scheme capital and operating costs.

On farm costs however will depend on the farmers irrigation method preferences and will therefore lie where they fall. However, average on farm costs can be used as benchmarks for economic comparisons.

The Gravity Irrigation Ltd., Scoping Study (Irricon/MWH, 2003) concluded that for a gravity-based scheme:

- 52% irrigable area can be totally gravity fed.
- 22% requires secondary and tertiary pumping.
- 26% requires tertiary pumping only.

This gives an average of \$52/ha for connection charges.

The NOIC proposal is further developed and gives more specific information on the water distribution network, land area, and land-use proposed for the Black Point scheme. Current proposals include a large component of secondary pumping and include very large primary pumping stations.

Approximately 45% of the land to be irrigated requires secondary pumping at an average of 0.77kW/ha. It is assumed that this level of pumping will be sufficient to provide operating pressure for “K-lines” but will require tertiary boosting for approximately 50% of the land area being cropped and needing other methods of spreading water. The above average 0.33kW/ha of tertiary pumping will be assumed.

On the basis that 45% requires both secondary and tertiary pumping and that, consistent with other fully piped secondary distribution systems, 26% requires only tertiary pumping, there would be an average connection charge of \$163/ha.

Excluded from these costs are the 100% user pays costs the farmers will face for the installation and/or upgrade of any electricity assets that they own or that are dedicated to their use. These tend to be a more significant component of the cost of connecting for a consumer but costs can only be determined on a case by case basis. Typically the cost of establishing a new rural connection ranges between \$10,000 and \$50,000.

5.2.2 NWL Network Development Costs

i) The NOIC Pumped Scheme

The above section indicates that in comparison with a pumped option, approximately one third of the growth in load is likely to develop under a gravity scenario. Lower load growth is preferable from NWL's perspective, as significant load growth in low-density, low capacity, rural networks is difficult to service economically.

It is more likely that for smaller loads there is already sufficient capacity in the rural network to meet higher demand, without the need for expensive sub-transmission support. This would give an improved economic outcome because existing assets can be utilized more efficiently.

While optimum utilization of the network needs load to be higher and more concentrated, the existing distribution voltage has limitations with regard to its ability to support large loads at long distance. Pumped scheme loads will be sufficiently large enough to trigger network upgrades.

In situations where development increases the ratio of sub-transmission investment to distribution investment the \$280/kW connection charge is likely to prove inadequate to recover capital costs. In this scenario NWL's line charges will be driven upwards across its entire consumer base.

It is worth noting that the 5MW of secondary pumping proposed for the Black Point scheme will only deliver \$1.4M of connection charges. This is less than half of the upgrade costs that NWL will face.

It is a fact of life for network companies that economics is driven by asset utilization. To improve economics the existing investment has to be used more effectively. New investment only improves economics where loads are concentrated and close to the core. Unfortunately the bulk of secondary pumping required for the Black Point scheme is remote from NWL's load centre and will require substantial reinforcement and possibly extension of the sub-transmission system.

After considering the load projections in NWL's Network Development Plan, there will be approximately \$4M of network development in the Duntroon, and Ngapara

areas, triggered by Stage 1 of the NOIC Scheme, followed by another \$2M in the Enfield, and Totara areas within 10 years if Stage 2 proceeds. Depending on impact into the Kakanui Valley upgrade of the Maheno substation and interconnecting lines may also be necessary.

Depending on the actual land area irrigated, connection charges can only be expected to contribute 20% - 30% of the funding requirement. NWL therefore needs to consider what additional benefit, if any, network development required for the NOIC Scheme can deliver to its other customers as they will be bearing the bulk of the cost burden.

ii) Gravity Scheme Proposals

NWL is more likely to recover 30% to 40% of the lower development costs associated with a gravity alternative via connection charges. We estimate development costs would be around \$3M. In terms of the annual line costs on every consumers power bill pumped irrigation will incur a \$23 p.a. higher cost in comparison to a gravity option assuming costs are annualized over a 10 year period.

Gravity irrigation also has the potential to deliver viable hydro generation in locations that off-set the need for line upgrade, provided generation can operate co-extensively, at the time irrigation demand exists.

Whether this can occur depends on the type of generation, the elevation of supply, available storage and distribution method. While retaining pressure head in delivery networks reduces opportunity for generation, it also neatly avoids increasing network load. Moreover, net energy use is significantly lower because inefficiencies of generation, transmission and pumping are avoided. Hence, if one is looking for the lowest cost scheme to the community and country, the implications of the water network and electricity reticulation need to be considered together.

Such an integrated analysis has been missing to date. Yet it is particularly important if the wider community is being asked to help fund a particular option. It is noted that a recently released Ministry of Economic Development investigation into water use (in preparation for Project Aqua water allocation) has concluded that irrigation delivers more economic benefit than generation.

5.2.3 Line Charges

The Network Waitaki Line Pricing Methodology Review (Energylink, December 2003) provides the following information:

- For the 2002/03 year, NWL delivered 193 GWh of electricity to consumers.
- Line charges delivered \$6.126M of distribution cost recovery, that is 72%. This covers the operating and maintenance costs of running the distribution network.
- Line charges delivered \$2.340M of transmission cost recovery, that is 28%. This covers all Transpower's charges to NWL for access to and use of the national grid.
- Total revenue was \$8.466M. This gives an average yield of 4.4 cents per kWh.

Further NWL Line Charge Disclosures indicate that approximately 42% is recovered via fixed charges and 58% via variable or use dependent charges.

NWL's costs, including consumer discounts, are such that its operating surplus represents a post tax return of 2.3%.

If NWL's standard tariffs are charged to irrigators then cost recovery is averaged over a greater level of consumption and charges can be lowered to all consumers. No breach of price path regulations would result.

If a special tariff was negotiated with irrigators that effectively gave them a discount related to volume, the weighted average price may be distorted and breach pricing controls.

In short, the benefits of increased load need to be able to demonstrate that they have been fairly distributed across all consumer groups.

The NOIC Black Point Transmission proposal would not appear to achieve this.

i) Primary Pumping Line Charges

As described Concept 2, the gravity scheme with a Waitaki intake, had a lift of about 5m built into the branch line that was proposed to deliver water to the southern or Herbert end of the command area. It is anticipated that with further work the need for this lift can be avoided. As already indicated, pumping lifts in Concept 3 with a Kurow intake, are self sustaining.

Therefore, only the Concept 4 Black Point proposal is totally dependent on major external energy import to drive primary pumping lift. Special connection arrangements with Meridian Energy would allow avoidance of associated transmission charges. An individual 100% fixed line charge is under consideration by NWL to minimize cost and deliver certainty for investors.

A five year 50% discount has been requested by the NOIC to address the differential between average cost for Stage 1 and 2. This has been conditionally agreed to in principle by NWL and the Waitaki Power Trust Board.

As the assumptions with regard to the amount of land that will be irrigated and the rate at which uptake will be achieved remain uncertain, it would be inadvisable to enter into a fixed term contract which has no provisions to amend charges if the forecasts in the irrigator's prospectus don't eventuate. NWL is currently being offered no guarantees on this aspect.

It is unlikely that Stage 2 will start within the 5 year line charge discount period. Therefore irrigators will not only experience the rate shock created by the removal of the discount but will be subject to an increase resulting from the smaller area of uptake over which costs are averaged when charges are reviewed.

The risk also remains that the irrigation company may fail, leaving NWL with \$6M of stranded assets in the form of a 66kV line from Lake Waitaki to Black Point it can't readily redeploy. However, it is assumed that post failure, irrigation would be continued by another operator. Hence, the low risk factors that are traditionally applied in line company weighted average cost of capital, WACC, calculations.

A legal technicality that needs to be investigated is that NWL has a legal obligation to connect any consumer who requests a connection to network asset it owns. New pumped irrigation of areas like the Hakataramea Valley, upper Otiake, Otekaieke, or Elephant Hill and Tapui, etc. might result in such an outcome. Issues around reapportionment of costs and opposition from Meridian Energy Ltd to increasing supply at Lake Waitaki should be pre-empted in any agreements.

The charges proposed for the Lake Waitaki 66kV line by the NOIC are well below the consultancy, KPMG, recommended investment hurdle for NWL, KPMG have recommended an after tax return of 10.77% on the basis of NWL's current WACC of 7.4%. Investments that don't meet this hurdle rate lower dynamic efficiency of NWL's capital structure resulting in higher costs for subsequent investments.

A significant inconsistency in the NOIC proposal, intended to deliver a lower rate of return, is that other customers pay a connection charge in addition to their line charges. If NWL is obligated to offer the same terms to all its customers, funding development will become even more dependent on price rises to all consumers.

ii) Line Charges for Secondary and Tertiary Pumping

For the purpose of establishing a benchmark for the comparison of different options the following analysis relating to line charges is based on two assumptions: that the irrigation season equates to 2,100 hours of pumping p.a. (refer Figure 8.1 of the Irricon/MWH, Scoping Study, 2002) and that NWL average yield rate of 4.4 cents/kWh is maintained.

On this basis we predict:

- Secondary pumping costs will be \$11.09/ha on average for gravity based schemes
- For the Black Point scheme secondary pumping costs will be around \$71.15/ha if averaged only across land needing secondary pumping or \$32.01/ha if averaged across 20,000ha.
- Tertiary pumping will cost approximately \$30.49/ha.

Applying the same pumping scheme demand profiles as in Section 5.2.1 (ii), the average line costs for each scheme across their entire area are as follows:

- NOIC Black Point scheme \$36/ha which reflects higher percentage of pumping compared to wider area proposals.
- Gravity schemes in general averaged line costs will range around \$17/ha

5.2.4 Energy Charges

Energy costs are charged by the electricity retailer in addition to the NWL line charges. Retailers also charge additional costs relating to meter reading, billing, administration, and so on, via a combination of fixed and variable charges.

When load profiles are predictable, have attractive seasonal variations relative to the retailer's generation portfolio, and have high volume, then competitive contracts for supply may be offered by the retailer.

Pumped schemes have more scope for achieving lower energy tariffs but require substantially more energy in the first instance.

The following estimates of energy charge by the retailer have been made:

- Primary pumping – 6.6c/kWh per the price negotiated with Meridian by NOIC. The NOIC May 2004 Newsletter indicated that the negotiated energy charge is to be fixed for three years.

- Secondary and tertiary pumping – 7.9c/kWh. This figure is based on Ministry of Economic Development’s comparisons of electricity unit rates for average domestic consumers scaled to Network Waitaki’s average yield to adjust for different consumption levels and fixed charge components.

Primary pumping has been assessed by NOIC to use 51GWh p.a. However it is not clear how much land this is expected to irrigate and how much water is being supplied. Assuming an irrigation area of 20,000ha, requiring 8cumecs of water to be pumped, an expected energy cost of \$168/ha p.a. can be derived.

Secondary pumping is therefore expected to cost \$127.74/ha p.a. for the NOIC Black Point scheme averaged across 20,000ha.

Secondary pumping for less energy intensive gravity dominated schemes is expected to cost around \$19.91/ha p.a. averaged across all irrigators.

Tertiary pumping is assumed to be the same for all schemes with a fully piped distribution network and is therefore expected to cost \$54.75/ha p.a.

Averages for non-primary pumping, that is all secondary off farm and tertiary on farm pumping, are correspondingly:

- \$96/ha p.a. for the Black Point pumped based scheme
- \$31/ha p.a. for a gravity based scheme

5.3 Summary of Electricity Supply Cost Comparisons

Table 5.1: Electricity supply related costs as a function of cost per hectare for gravity and pumped irrigation development as at May 2004

Cost Item	Costs for Gravity based option (Concept 2 example) \$/ha	Cost for Pumped based option (Concept 4 example) \$/ha
A Capital Cost (NWL and MEL)		
Primary Supply	\$0	\$385
Network Development	\$75	\$300
Total Capital Cost (\$/ha)	\$75	\$685
B Capital Cost (Irrigators)		
Connection Charge		
- Primary pumping	\$0	\$0
- Secondary and Tertiary pumping	\$52	\$163
Total Capital Cost (\$/ha)	\$52	\$163
C Annual Costs		
Line Charge (NWL)		
- Primary pumping	\$0	\$26 (4)
- Secondary and Tertiary pumping	\$17	\$36
Energy Charge (Retailer)		
- Primary pumping	\$0	\$168
- Secondary and Tertiary pumping	\$31	\$96
Total Annual Cost (\$/ha)	\$48	\$326

Notes:

1. Per ha figures assume full uptake of 40,000ha for Gravity and 20,000ha for Pumping.
2. Primary supply capital costs include Meridian Energy Ltd contributions.
3. No primary pumping requirement assumed for the gravity option. Other options will fall between these two benchmarks.
4. Concessional rate applicable for first 5 years.
5. No cost of capital components included.

5.4 Energy Price Path

With continued depletion of national excess electricity system capacity and the associated increase in sensitivity to dry year risk, it is clear that electricity is on an upwards pricing trend. In these circumstances, no retailer will provide a fixed price long term contract that does not permit them to raise prices in the event of extreme excursions on the wholesale market that might arise from an energy crisis for example.

Irrigators in particular are exposed to dry year risk because their demand is greatest in dry conditions. In the recent crisis, this equated to wholesale electricity costs rising from approximately 4c/kWh to 80 cents/kWh. These costs were passed through to major users wherever possible.

With each energy crisis that has occurred over the past few years, the minimum spot price rolling average has not reset back to a value equal to its position prior to the crisis. Rather, the spot market has reset to one substantially higher. It is important to note that wholesale increase in average price has approached 30% p.a. for the last 2 years.

Again, it is worth noting that there has not actually been a lack of supply during these events. The issue is pricing risk and its impact on the major users who underpin our economy. Prices will rise in order to stabilize this risk. But increased energy costs may reach a level that some businesses can't sustain. The prices North Otago will pay will be dictated by external issues.

More specifically, there are three main factors that are seen as driving the price of electricity upward:

- Investment in reserve generation to cover dry year hydro shortfall. The proposed industry emergency provisions will still only aim to manage a 5 year dry risk and constrain spot price to 20c/kWh. It is suggested that elimination of this risk via a fully hedged position would require a 30% energy price rise.
- The Minister of Energy has forecast that the depletion of Maui gas (which generates 30% of our electricity) will result in an 8% increase in prices.
- The Climate Change Office predicts a carbon tax will add 1.5 cents per unit or approximately 19% to the cost of electricity.

These three issues give rise to industry commentators predicting a 60% price rise in electricity over the next 5 – 10 years. Compared to the recent price rises without these additional cost drivers, this doesn't appear to be an extreme prediction.

Before committing to investment, NWL needs to be aware of the hedging arrangements by any irrigation company whose scheme is heavily dependent on pumping.

In the absence of a long term flat or indexed electricity supply contract between the irrigators and the retailer, sensitivity analysis using figures ranging from 8.5c to 15c kWh should be available to demonstrate the viability of the scheme in the face of an upward price path. No such analysis has been presented to investors to date.

6 Other Value Adding Possibilities

This section looks at other opportunities to add value to a joint irrigation/hydro scheme that could extend benefit or reduce costs to NWL consumers and the community at large.

6.1 Carbon Credits

The carbon tax will not come into force until sufficient countries have signed the agreement. Consequently, there exists uncertainty as to what impact the tax will have on new investment proposals.

However, there is a global market for carbon credits and to establish that market in NZ the Government has been approving the value of carbon credits for certain projects. The tender process involved favours projects that can demonstrate they will lower NZ's carbon production by either generating electricity from a non-carbon producing source, or by delivering a more energy efficient solution.

Gravity irrigation per se is likely to qualify on the basis that electricity consumption for Concepts 1, 2, and 3 are less than a half of that of the concept 4 pumped alternative. In addition, if hydro-generation can be integrated to irrigation, then an even more attractive proposal can be presented.

While carbon tax adds cost and risk to pumping proposals, these costs are offset by value-adding carbon credits for gravity/hydro proposals. From this perspective the potential benefits for a gravity/hydro scheme are in effect, two fold over a stand alone pumping scheme.

This is a significant issue that would be worthy of more detailed investigation in order to reduce investment risks associated with pumped supply for irrigation. In the earlier example given for the Black Point proposal, the primary pumping alone is expected to require 51GWh of electricity p.a. If a carbon tax adds 1.5c/kWh to the cost of electricity then this equates to \$765,000 extra cost p.a. or \$38/ha p.a.

Alternatively, this would justify the expenditure of approximately \$7M (at NWL's investment hurdle rate of 10.77%) on a proposal that didn't have this risk.

Carbon credits and hydro generation offer wider scope for central government support for irrigation proposals provided the requisite criteria are met.

6.2 Water Storage

In the proposals developed to date, there has been little investigation into the benefits of storage to reduce the size of the infrastructure from that needed for peak demand.

We predict that more thorough investigations into the area of land that is likely to be irrigated will reveal that intended capacities are well beyond optimum. Developing sufficient storage capacity may not be as onerous as first thought particularly where there are multiple sites and a wide area to choose suitable sites and levels.

Average irrigation season demand is only about 66% of peak flow.

The annual average demand is only about 33% of peak flow.

If the primary delivery system needed to supply peak demand is 25 cumecs, with sufficient storage, a constant delivery of about 8 – 9 cumecs would be sufficient to supply the same annual volume. Effectively the cost of the delivery infrastructure would be reduced, provided economical storage can be developed.

6.3 Potable Water Supply

Using gravity to run water from Lakes Aviemore, Waitaki or from Kurow develops sufficient head to deliver water to the numerous district water schemes without the need for primary pumping. This includes Oamaru Town supply. Water supply could also be as far reaching as Palmerston and into the future, Dunedin City.

Water for domestic and stock use is under increasing pressure with regard to availability, water quality, capacity to service growth, and operating costs. Most local schemes are reliant on pumping and therefore face the same price path issues with regard to electricity charges as pumped irrigation does.

The use of a gravity irrigation scheme as the point of supply for these schemes introduces the possibility of further economies.

There is more scope to integrate with water schemes if the distribution network is at least partially piped. Any investigation into the feasibility of extensive irrigation should include an examination on how it might best contribute to the existing water supply infrastructure. Information on water schemes, including the Oamaru Water Scheme requirements, fed in at an early stage, may justify altering the scheme design, especially if servicing potable water supply contributes to the funding of the scheme.

6.4 Irrigating Hakataramea

The Aviemore Intake option has the potential to reduce by about 50m the pumping head required to service the lower Hakataramea Valley and possibly more elevated parts of the North side of the Waitaki River. This would maximise the command area of such a scheme.

Theoretically, the 6MW generation plant built into the Kurow Intake option would be sized approximately to provide sufficient electricity to lift 3cumecs water into the Hakataramea. But in principle, the lift required at Black Hill has a priority claim over this generation. However, the off-season generating potential could be developed to off-set electricity costs.

Neither NWL's distribution network or the Lake Waitaki Transpower point of supply currently have the capacity to service this pumping. Major asset upgrades would be required.

Hakataramea Valley and Station Peak are part of NWL's franchise, to be included in the assessment of benefit to its customer base. But they are not part of the Waitaki District. Integrating hydro generation with irrigation would lead to a broader sharing of water and energy resources.

6.5 Benefit of Higher Supply Intake

The 265m AOD of the Aviemore proposal has an additional benefit in that pumped irrigation from the main supply canal has the potential to economically reach land areas as high as 350m. This increases the total potential command area. It would improve direct access to delivery systems and reduce pumping costs.

6.6 Amenity and Stream Augmentation

The opportunity to discharge to the lower reaches of tributaries of the Waitaki River from potential hydro generation sites can also augment low flows in, for example, the Oteaieke, Otekaieke, and Maerewhenua Rivers. This could improve fish habitat and water quality.

Considering the negative impacts that irrigation and intensive farming practices can have on already stressed river systems, this could be a positive mitigating factor for the consenting application. The extent to which augmentation of tributaries is possible will however depend on the siting of generation stations.

7 Economic Viability Issues

Economics is not an exact science. Forecasts and assumptions are fundamental to the outcome of an analysis. Assumptions in particular, need to be made explicit. They also need to be very carefully considered. This section provides preliminary comment on some of the more critical parameters needing examination if the most economic scheme is to be identified. .

7.1 Cost Hurdle

Several investigations have been made into the costs that can be sustained to fund irrigation by various forms of North Otago farming operations in terms of the increased revenue that irrigating could realise:

- Initial figures produced by the North Otago Gravity Irrigation Scheme Scoping Study February 2002 predict that for intensive sheep and beef farming medium term annual water charges of \$322 per hectare could be sustained.
- The Meridian Energy Irrigation – Summary of Technical and Economic Analysis February 2002 indicates that for irrigation linked with Project Aqua \$375/ha can be sustained.

Viability is considerably higher for dairy farming. Essentially irrigation doubles grass growth and cows are more efficient converters of grass into income.

Accurate forecasting of what landuse changes are probable for each area and the rate at which change will occur is necessary in the absence of taking a conservative position during analysis. Reports currently available, for example, are relatively silent on the viability of viticulture on irrigated land.

For the purposes of our analysis it is assumed that costs above \$350/ha will result in a highly elastic demand and will exclude uptake by farms not suitable for changing landuse.

Preliminary information provided to farmers on the NOIC Black Point proposal indicates that the annualized share cost will be about \$150/ha, operating costs (including capital servicing) in the order of \$550/ha, and annualized on-farm development cost of about \$150/ha. This gives a benchmark of approximately \$850/ha before tertiary pumping electricity costs and on-farm operating costs are added.

This benchmark figure assumes dryland farms have already been re-grassed and/or re-fenced, as required to get maximum benefit from irrigation. Adding

costs for re-grassing and re-fencing would make the benchmark significantly higher.

Viability is highly sensitive to both productivity and commodity prices. The Wealth from Water, Macfarlane Rural Business paper, indicates that farmer cash surpluses can be eliminated by a 5% drop in product prices or production output. Normal levels of annual variation in productivity and pricing can be expected to exceed a 5% threshold relatively frequently.

To support the higher costs necessarily requires higher productivity and reasonably stable gross margins, interest rates, etc. With increasing globalization farmers are now price takers with regard to the commodity prices that dictate their incomes. A downturn in dairy company payout, for example, also can potentially eliminate viability of irrigation.

The impact of other sensitivities, such as electricity prices, and the potential accumulated impact of several years of a negative outcome need to be considered in risk analysis.

7.2 Sensitivity to Uptake

The recent development of the Horse Gully Rd Scheme provides one local example of the relationship between demand elasticity and cost hurdle. It is believed that this scheme has an annualized off-farm operating cost in the order of \$450/ha. The actual uptake achieved was approximately 50% of the area originally designed for, which in turn, was lower than area considered irrigable.

If this figure alone is used, the sensitivity of uptake to cost is a 1.75% drop in demand for every 1% cost increase above the \$350/ha hurdle.

At \$550/ha the NOIC Black Point scheme represents a 57% increase in cost compared with Horse Gully. Therefore NOIC costs/ha would be expected to cause a 100% drop in demand in the absence of simultaneous change to a higher earning, more intensive landuse. Expressed in an alternative way, no farmers are likely to sign up for a scheme at this level unless they have already changed to a suitable landuse or have taken a decision that they will change immediately.

If the relation between irrigation costs/ha and uptake can be refined sufficiently, it will be helpful in predicting the likely response to irrigation water supply and the rate of development that can be reasonably expected for all irrigation schemes, cost scenarios, and existing landuses.

7.3 Change of Landuse

The rate at which landuse will change is not driven by purely rational commercial behavior. It is related to the circumstances of individual farming operations and the preferences of the farmers managing them.

Consider the demographics of the farming community in the Downslands and Waiareka and Kakanui Valleys of North Otago:

The majority of farms are well established, dry land livestock operations. Farmers age distribution gives expectation that a significant majority are at a stage in life where they are unlikely to take on a large amount of debt or learn a new farming skill set. It therefore appears likely that conversion of their farms will be driven by the rate at which they retire or sell up. Increasing land values may encourage an early sell up.

Farmers entering the industry have a need for higher returns than traditional landuse is delivering, due to the hurdle of purchasing and developing a farm. For dairy operations the cost hurdle of obtaining dairy company shares is becoming a major limiting factor.

Where debt levels are high, farmers are likely to opt for an intermediate step, such as supporting dairying with grass growing and winter grazing. But there is also saturation emerging in this mode of farming in North Otago. Table 7 of Meridian's Irrigation Technical and Economic Analysis indicates that dairy support will only represent 6% of production in the long run. If the profit margin is not increased, irrigation delivers no progress for them. The forecast productivity gains assumed in other studies have not allowed for the higher cost structures of some existing farms and the reduced potential for profit growth.

The high capital costs of establishing dairy farms results in a significant component of dairy units being owned via investment groups. So long as the returns are adequate, these groups will fund irrigation and develop existing properties over a relatively short period.

Outside of these investment groups it is suggested that the cycle of changing landuse away from traditional dry landuse may be as long as 20 years. This is based on the rate at which existing farmers will retire and the age at which new farmers enter farm ownership.

Just because it is possible to irrigate land doesn't mean that it will be irrigated. When costs are being averaged on a per hectare basis, it is more appropriate to use the realizable area as the base for averaging and not the irrigable area. The gap between realizable area and irrigable area is related in part to the sensitivity to cost outlined above.

From Table 7 of Meridians Irrigation Technical and Economic Analysis the following indicative conclusions can be drawn.

In order to make these assessments it is necessary to derive a basis for identifying how much production increase results from irrigation and how much is related to an increase in specific types of landuse. We have also assumed that some types of landuse will not support irrigation. Therefore, the changes in production figures relate to change in land use and some minor overall efficiency gains. The decrease in land use in uneconomic operations is assumed to be proportional to the increase in the landuse for economic operations (i.e. same total area) providing a crude distinction for allocation production gain:

- Given that for a \$350/ha increase in costs, a 100% increase in productivity is required to break even, it is evident that existing arable, horticulture, and sheep farming are unlikely to achieve viability
- Existing landuses will still represent around 20% of total production after irrigation development. The areas to be irrigated therefore should be reduced by at least this amount.
- Dairy, process cropping, beef, deer, and dairy support operations are strongly viable in terms of productivity gain. They appear to be able to support costs at a level well above the \$350/ha hurdle.
- For these landuses the cost sensitivity to uptake could be applied to a higher hurdle of \$700/ha.
- The difference in viability for different landuses is the driver for the predicted increase in these landuses. In production terms irrigation would result in a 44% increase.

If we therefore take the percentage of land considered irrigable within each command area, exclude the area expected to take up immediately, and consider that 44% of the remainder will have irrigation realized over a 20 year period we can derive an expected annual growth in demand for irrigation.

Consider the following worked example:

For an irrigable 40,000ha scheme with an initial take up of 7,000ha we could expect irrigation to be realized for 14,520ha with an average development rate over 20 years of 726 ha per annum.

This is approximately 3.4% growth per annum in area irrigated which is not dissimilar to what would be considered strong economic growth.

It should be noted that this is only valid on a District wide average basis. Specific areas will have a higher density of land area suitable for economic irrigation development and will be in different states of development. It would not be reasonable to apply the analysis to specific, more focused, irrigation proposals. While more robust analysis is clearly necessary, it would appear that these conclusions are consistent with current experience.

7.4 Land Value

There is a relationship between productivity and land use. Land value is not only linked to productivity but also linked to growth external to North Otago as its cost is attractive to different farming methods. Increasing land value lowers the profit margins for new entrants and therefore land value/landuse will reach an equilibrium.

In a perfectly rational market the equilibrium will be related to the most economically sustainable mix of landuses under the prevailing set of resources and cost structure. The likely new landuse mix with irrigation isn't known with certainty but must be forecast as accurately as possible if scheme design and economics are to be accurate.

A marginal irrigation proposal has the potential to reduce the districts economy and therefore conservative risk margins should be included in economic analysis.

Investing in irrigation purely on the basis of capturing a capital gain in land value is risky. Irrigation still needs to demonstrate improved profit to justify the investment. If it actually decreases return, land value may actually drop. The critical factor is the need for growth in profitability not revenue.

7.5 Time Delay Verses Scheme Size

Should the uptake of irrigation be slower than that needed to support the revenue requirement to fund the investment, either the irrigation company faces insolvency or connected farmers will be subjected to increasing water charges and carry the burden of under-utilised capacity.

Given the sensitivity to costs, this outcome would create an unrecoverable downwards spiral. Even though a scheme may be viable for one farm, the failures of others will place it at risk.

Staged developments have a risk that the hurdle for subsequent stages may not be overcome if economics are too marginal for the initial stages.

Achieving an optimum level of excess capacity is important from an economic perspective.

As an infrastructure company NWL would typically install 30% excess capacity when upgrading its network. This provides for 10 to 15 years of growth at rates of 2 to 3% per annum.

Less than 10 years provision and there is an increasing risk that the investment won't achieve payback before the need to upgrade. Longer than 15 years and it tends to be more efficient to add capacity via a new set of completely independent assets.

The gap between 15 years and the 20-year landuse change cycle is less of an issue when it is considered that practicably there will be a construction period of approximately 5 years.

For the example given above, 3.4% growth equates to excess capacity requirement of 34 - 51% depending on whether the a 10 or 15 year provision is desired. More than this and the costs of the overbuild are likely to higher than optimum resulting in negative impacts. Design needs to be optimized to the new target and then costs averaged across the new area.

Optimizing size can be achieved by:

- Scaling the size of a scheme to reflect the current demand at a given scheme cost and the rate at which landuse is expected to change (as above), or
- Selecting schemes that are able to be developed in a building block or staged fashion and only initiating expansion when demand is sufficient and concentrated.

When development is to be staged, economic analysis should ideally demonstrate that viability remains if development is halted at any point.

If viability is dependent on a certain level of uptake across the entire scheme, then that sets a higher investment strike rate in terms of the farmer commitment required before any development should be considered. This is a particular issue when costs lie disproportionately in the primary infrastructure.

There is a concern that the NOIC's pumped option (proposed to be developed in 2 stages) will not reach the trigger for Stage 2 within the next 15 years, given the higher portion of dairy landuse in the Stage 1 area and the conversion rate likely for other areas.

7.6 *Borrowing Risk*

It is unlikely that borrowings will be attainable on fixed terms for longer than 5 years and the longer the terms, the higher the risk premium likely to be required.

Borrowings at this level will require a mixed portfolio of loans to diversify risk, a range of financial management instruments, and an appropriate treasury management policy.

The sensitivity of funding cost should be included in economic assessment including a suitable risk premium. Because of the size of the capital investment required, apparently small differences in the cost of capital impact directly on scheme viability. For example, for a 20,000ha scheme costing \$100M, a 1% variation in interest rates equates to \$50/ha p.a.

The Wealth from Water paper by Macfarlane Rural Business states that farmer cash surplus can be completely eliminated by an interest rate rise of 1.1%. Increases in interest rates during the current period of firming up scheme costs for the investment prospectus are reaching this level.

7.7 *Unit Rate for Water Supply*

In the face of high and permanent water rights application for Project Aqua, there has been a somewhat uncivilized scramble to secure access to sufficient irrigation water to meet all possible future regional needs.

For the purposes of consents, the unit water requirement estimates have been based on pasture, which has high water demand for peak production. However, the final unit supply rate is ultimately an economic decision which balances risk of water shortage against cost of supply. With factors such as climate change and the diversification of farming in North Otago it would be appropriate to review supply rates in some localities before the scheme capacity is finalised.

Such analysis would support any applications to be made to the proposed Water Allocation Board as it would demonstrate a considered, sustainable position.

7.8 *Costs and Benefits*

This report has provided estimates and indicative figures for the extra costs and the value of benefits identified with various development examples.

In comparison to the benchmark cost of the original gravity proposal (intake option 2), hydro generation has the potential to add in order of an additional 25%

value to some irrigation proposals. Viability is therefore greatly enhanced in the long term.

In addition, questions have been raised with respect to some of the key assumptions applied in economic analysis to date. A particular issue identified is the actual area of irrigation that will be realized at the estimated cost. A realistic assessment may allow greater optimization and maximization of economic value.

There is insufficient cost reduction potential to expect viability of irrigation to shift significantly in terms of land area that will realize irrigation for landuses not currently economic. However for landuses that are economic the exercise of maximizing the economic benefit through optimal design is likely to be worth the effort and a limited amount of further delay to ensure the optimum is achieved.

In the absence of more detailed technical investigation to pin point development preferences and optimize design, a more comprehensive cost benefit analysis is not possible for this report

However, there is sufficient detail in this report to determine that there are alternative concepts that are worthy of more robust investigation.

8 Conclusions

8.1 *Alternative Scheme Concepts*

This study has looked at the hydro generation possibilities with four main irrigation scheme concepts.

Two of these are based on existing irrigation proposals. The other two are new concepts which seek to address high capital and/or high running costs associated with the current scheme concepts.

The primary factors that set the engineering parameter requirements for the other options include:

- Level of intake/supply
- Realizable irrigation area
- Rate of delivery
- Volume of storage
- Generation systems and locations

8.2 *Storage and Supply Rate*

Sufficient cost effective storage appears to be a key to developing a viable irrigation scheme for North Otago because it enables downsizing the rate of delivery by up to two-thirds peak flow. The advantages of this include:

- Long supply lines become economically viable and are perceived as less risky.
- Lining canals with smaller cross-sections in difficult geology becomes simpler.
- The use of pipelines for significant distances becomes more economically feasible.
- Installation of pipelines and other structures in riverbeds, on steep faces, etc., becomes less complex.

- Faster progress can be expected which reduces periods of disruption to current farming operations and shortens the time for return on capital investment.
- Smaller or buried conduits are more socially acceptable and are less likely to draw criticism during consent application.
- Water stored within the irrigation command at the start of each season is, in effect, an insurance against failure in the supply line during the season, so it reduces risk.
- Any generation from storage during the irrigation season balances any off-season generation that is available from the main delivery system improving security of electricity supply.

Including storage as an integral part of the scheme also provides a natural means of staging development. The water supply for the first stages of irrigation development can be entirely met by the primary delivery system. As demand grows, more storage can be added. Storage probably improves viability of gravity-based supply but may also allow downsizing benefits for a pumping scheme.

8.3 Generation Option

At a very preliminary level it appears that hydro generation is likely to prove viable and deliver other value adding benefits to three of the irrigation scheme Concepts examined. Ultimately, generation may be able to contribute up to 25% of the value created by these irrigation proposals.

Substantial wealth creation can be delivered to the North Otago economy through pursuit of an irrigation strategy that includes electricity generation. This is likely to deliver significant strategic advantages to the local economy and, in particular, to NWL and its consumer owners.

There are a number of other advantages from including hydro generation within an irrigation scheme.

First, is that it is generating value from water delivered for the period when landowners are developing irrigation on their properties. This is a particular advantage with a gravity proposal where the initial capital investment is high, the potential command is large and the lead time to full development will be many years.

Secondly, it mitigates for irrigation uptake constrained by the rate of landuse change.

Thirdly, there is generation technology available internationally which enables the same water to be used for both irrigation and generation. Such an outcome is highly significant to the sustainable use of natural resources.

8.4 Preferred Option

The contribution from generation makes the two new concepts the most economic of the four options considered.

Until such time as the engineering components are quantified and costs are developed, it is not possible to identify just which concept and configuration will deliver the strongest business case. .

While there is currently insufficient detail on these preliminary irrigation proposals to confirm that they will deliver water at a lower irrigation cost than the current benchmarks, this appears probable. We are confident that these two alternative Concepts and their variations appear to have the potential to reduce risk and operating costs associated with the two more fully investigated existing proposals.

When operating cost is included in the comparison, the pumped option is the more expensive.

This is largely due to it being an energy intensive application which is subject to a very alarming price path. It also has greater risks and services a smaller command area. Consequently, it conforms least to the vision to provide affordable, timely, sustainable irrigation to wider North Otago.

8.5 Optimization

The need for further cost minimization has arisen from a concern over the accuracy of forecasts regarding landuse change and irrigation uptake.

Under current cost profiles expectations appear optimistic. Slower rate of uptake would result in a higher probability that infrastructure will be significantly overbuilt or that the scheme will fail to meet investment criteria. While this places Stage 1 of the NOIC Black Point proposal at risk, it is also a real issue for those providing financial support for the development of later stages.

It is a major concern that inability to reach the uptake trigger for Stage 2 of the NOIC proposal may place pressure on “cherry picking” the best opportunities in the Kakanui Valley with the result of diminishing the viability of achieving economic irrigation to a wider area.

It may also prove to be effective, if infrastructure was optimized on the basis of average annual water delivery needs through the adoption of enhanced storage.

There is a significant potential to develop new storage, with all the options particularly in the case of Concept 1 (Lake Aviemore intake) which delivers water at a higher elevation by gravity alone. Concepts 1 and 3 could deliver at the highest elevations so are likely to best meet the community vision to provide irrigation opportunity to the largest area.

8.6 Community Costs and Benefits

From the community's perspective, previous economic analysis has been too narrow in not including the electricity infrastructure issues which will impact on the local economy one way or another.

The more intensive nature of pumped schemes presents considerable disadvantage to NWL specifically with regard to cost burden that will be transferred to existing consumers. Given NWL's monopolistic position which enables the company to transfer investment risk to its captive electricity customers, this issue has the potential to attract Commerce Commission scrutiny. Hence caution should be exercised.

Hydro generation development adds significant strength to irrigation proposals. This includes providing shelter from external pressure on electricity price path and dry year generation shortfall risk.

The hydro generation is particularly attractive to NWL when it is distributed in nature and therefore better positioned to deliver a wide range of non-energy benefits to NWL's network. Development of generation concepts should include this consideration.

The potential for accessing carbon credits is a real advantage for North Otago as it is deriving value from external sources and could significantly improve the financial performance of an integrated hydro irrigation scheme.

Having a Regional Energy Strategy would be an appropriate driver against which proposals could be assessed.

Concern is expressed that effort to salvage something from the promises of Project Aqua is sacrificing an appropriate level of re-evaluation with regard to the irrigation vision, particularly considering the level of expenditure and level of risk involved. The absence of Project Aqua has eliminated some of conflicts over resource use, resulting in a greater number of possibilities for irrigation.

The departure from Irrigation North Otago's Strategic Plan that occurred when Meridian Energy became involved, needs now to be corrected and reassessed.

8.7 Viability and Development

From a cost hurdle perspective, this study finds that the economic issues are quite polarized and heavily dependent on the type of farming operation being serviced.

For certain landuses where irrigation is economic there is a significant cost margin before irrigation becomes uneconomic. This raises the issue of, on what basis public funding support is justified?

Making some early progress for these farms with a pumping scheme may be a rational response in the current climate, provided an assimilation path is retained for wider irrigation development. Specifically the strategic positioning resulting from commitment to Stage 2 of the NOIC proposal risks reducing the efficiency with which this scheme can be integrated into the other concepts.

Also of consideration is that it is likely that the larger, stronger concepts can be developed before NOIC Stage 2 reaches its investment trigger.

Loss of the land area associated with Stage 1 of the Black Point proposal to a larger proposal is not likely to impact too severely on economic benefit of irrigation. Approximately 6,600ha are located at the top of divide, which needs pumping support, and the remainder is serviced from a distribution network that would be of similar design under all concepts.

However the farmers who commit to the more expensive option could be locked into a less competitive position with the consequent impact on their business value.

Farms where irrigation is uneconomic at the \$550/ha level of current proposals will remain uneconomic even if very large savings can be realized. It is suggested that this would be an unrealistic expectation.

It is also considered unrealistic to expect landuse to change and farmers to take up irrigation just because they can. Economic analysis may have been optimistic in this area. Minimizing the cost hurdle for this group will have the greatest influence on their ultimate uptake.

A hydro/gravity based scheme is most likely deliver viability for this group.

8.8 Consents and Legal Issues

Consenting and securing strategic development opportunity still needs to be addressed.

The NOIC Black Point proposal is well advanced in this regard. North Otago needs to focus on making progress with this issue or risk missing out as a wider community.

Having a well prepared and argued case for water allocation coordinated with a water management strategy and environmental plan is a key strategic issue for the Waitaki District.

Securing water resource access is the single largest strategic issue that needs urgent, focused and concerted effort by the District's leaders.

The new water allocation legislation provides an opportunity for securing access to valuable resources.

Recent investigations into the economic value of using water for irrigation as a priority over generation provides a possibility that there will be a significant shift in balance between local and national interests with regard to allocation.

The coming water allocation process will create opportunities or set constraints on the District's economic development into the future.

9 Recommendations

1. Minimise and optimize design of the primary infrastructure for the current NOIC Black Point proposal to service only Stage 1. In particular, avoid Stage 2 extension of the secondary infrastructure into the Kakanui Valley. We recommend that the secondary infrastructure design targets 14,000ha of irrigated land in its fully developed final state.
2. Redesign electricity supply arrangements for the NOIC Black Point proposal based on principles of least cost to NWL's consumers and NWL's wider development objectives. In particular, ensure the design allows for integration with other electricity load growth drivers as forecast in NWL's Network Development Plan.
3. Adhere to NWL's standard pricing terms for new connections as NWL is legally obligated to offer the same terms to all potential consumers. No justification is found for NWL to treat irrigation proposals any differently to other new developments.
4. Inform farmers of the full costs of establishing and operating electricity supply for irrigation and forecasts of electricity price path. This will avoid potential farmer disappointment when expectations are not realized. Optimistic sales presentations from the promoters of irrigation proposals has the potential to generate public relations issues for NWL.
5. Undertake detailed investigations into the areas of land that will realize irrigation development. Focusing on realistic forecasts of landuse change rather than land that can technically be irrigated viably. Including the Hakataramea and other areas able to be reached by Concepts 1 and 3.
6. Post Project Aqua re-assess INO's Irrigation Strategic Plan and apply as the basis for moving forward. Adherence to a plan will eliminate capture by specific interest groups.
7. Develop a Regional Energy Strategy as an appropriate driver and decision framework against which proposals can be assessed.
8. Detail the integrated hydro generation/gravity irrigation options (Concepts 1 and 3) sufficiently to get investment decision quality costings and technical feasibility on an optimized area basis. Particular attention should be given to:
 - Water storage opportunities
 - Engineering water conveyance options (for example, fully piped systems)

- Integration with domestic and stock water supplies
 - Maximising potential to capture external benefits such as carbon credits
 - Ability to extend services to a wider area
9. Create an implementation plan for staged extension of the water distribution infrastructure.
 10. Rework NWL Network Development Plan to adjust to new requirements.
 11. Confirm economic analysis, timing assumptions, contractual agreements, etc., are consistent with uptake forecasts, etc.
 12. Develop an implementation plan for best option.
 13. Develop a strategy for representing the District's interests with regard to water allocation and secure water rights.
 14. Support water applications by establishing a Waitaki District Water Management Plan coordinated with an Agenda 21 compliant Environmental Plan.

Appendix A: Small Scale Low Head Hydro Generation

There exists an opportunity for Network Waitaki Ltd. to be a market leader in the application of small scale (5 to 500kW) generation powered by the head in drop structures and the flow in the canal/pipe systems of irrigation schemes. A significant potential to incorporate small scale low head hydro generation with irrigation exists, not only in the design of new schemes but as a retro fit option for existing schemes.

Recent changes encapsulated in the Electricity and Gas Industries legislation, Government Policy Statements, and industry rules for the connection of distributed generation, are enabling this type of development.

A number of new generating possibilities have been discovered during investigations. Appendix A is intended as a file for this information so that it is preserved for future reference.

Note: This information has been excluded from the public release version of this document.