Ministry for Primary Industries
Manatū Ahu Matua

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Economic Evaluation of Stock Water Reticulation on Hill Country

A report prepared for the Ministry for Primary Industries and Beef + Lamb New Zealand

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AGFIRST

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1.0 EXECUTIVE SUMMARY

Note: This report outlines the economics of reticulating stock water on hill country. It does not investigate or report on the technical/engineering aspects of stock water supply.

Water is a requirement for life, and its availability has a major impact on farming productivity. The purpose of this study was to investigate the economic returns, in an investment sense, on eleven case study farms where they had essentially changed from a natural water source for stock water; usually a combination of creeks/streams and (mostly) dams with variable water quality and reliability, to a reticulated system of good quality, reliable water.

The methodology involved two interviews with the farmer; the first to collect information on the water scheme and pre- and post- scheme stock numbers and performance, and the second to talk through the draft results of the analysis and clarify any further information requirements.

The farms themselves were spread around the country; 2 in Northland, 1 on the East Coast, 5 in Horizons, 1 in the Wairarapa, and 2 in North Canterbury.

The analysis was based on calculating the NPV (Net Present Value) and IRR (Internal Rate of Return) over a 20-year period, using a discount rate of 8% real. The cash flow considered the capital costs involved, including subdivision fencing (a crucial component of achieving the lift in productivity) and any increase (or decrease) in capital stock numbers, changes in farm operating costs, and benefits from increased stock numbers and stock productivity. The general sequence of events leading up to the improved stock numbers/performance was:

- Installation of the water reticulation scheme, followed by
- Increased subdivision, followed by
- Better grazing management, followed by
- Improved pasture utilisation, and/or better pasture production, followed by
- Improved stock numbers and/or performance

A key driver of the productivity gains was the subdivisional fencing, which allowed for better grazing management. But the subdivision was not possible until water was provided for in each paddock.

The result of the analysis shows a significant return on the investment:

Farm	NPV ($000)	IRR	Effective ha	Stock Units
Horizons 1	$1,057	47%	610	6,358
Horizons 2	$465	22%	590	5,287
Horizons 3	$282	14%	761	8,258
Horizons 4	$817	52%	1,112	9,455
Horizons 5	$809	23%	850	6,556
Northland 1	$506	80%	366	3,348
Northland 2	$1,525	40%	485	5,004
East Coast 1	$1,821	36%	1,850	21,614
Wairarapa 1	$1,358	76%	680	6,755
Canterbury 1	$4,759	85%	5,000	34,431
Canterbury 2	$519	23%	2,100	9,454
Weighted Average*		53%		
Raw Average		45%	1,309	10,593
Median		40%	761	6,755

*Weighted on effective area of the farm

The payback period was also relatively short;

	Payback Years
Horizons 1	2.75
Horizons 2	4.5
Horizons 3	7.5
Horizons 4	2.25
Horizons 5	4.25
Northland 1	1.75
Northland 2	4.0
East Coast 1	3.5
Wairarapa 1	1.5
Canterbury 1	1.5
Canterbury 2	4.75
Weighted Average	3.0

Across the case study farms, stocking rate had increased by 0.5 SU/ha, and lambing percent by 12%, post the installation of the water reticulation scheme. Most farms had also significantly increased the proportion of animals sold prime versus store, as well as increasing the weight of animals finished.

For the farmers, reasons given for installing a water reticulation scheme varied:

- Many stated their main reason was because the current stock water system was inadequate and limiting production;

- Many cited problems with dams; water quality was poor, they often dried up in dry periods, and rescuing stock stuck in the dams was a constant job;
- All of the farmers noted issues with the impact of drought, often resulting in areas of the farm which were un-grazable due to no water, and saw providing a reliable water supply as a means of combating this;
- Many wanted to better graze hill country areas, and saw better water supply and subdivision as a necessity to achieve this; and
- Some wanted to finish more animals and recognised the need for good water to achieve this.

While none of the farmers had directly analysed the financial returns from the investment in the stock water system, they had observed the benefits via better grazing management, better stock performance, increased stock numbers, and improved animal welfare. They also noted that with the provision of reliable water and good subdivision, other options were opening up with respect to cropping and pasture renewal.

All the farmers noted the "peace of mind" that the water scheme gave them (and their staff); many noted that in a drought they only had to worry about feed, not water, and all commented that they were very pleased they didn't have to spend time dragging stock out of almost empty dams.

Most of the farmers had environmental plans, and noted that the stock water reticulation and subdivision made implementing the plan easier, especially with fencing off waterways.

When asked what the main advice they would give to other farmers contemplating installing a stock water reticulation scheme would be, the overwhelming comment was; "Just do it".

2.0 INTRODUCTION

2.1 Background

The main purpose behind this study was to analyse the economic benefits of reticulating stock water on hill country, particularly as no such study had previously been carried out on this topic. A secondary purpose was to understand the motivations for putting the system in, explore observed costs and benefits and seek any advice and recommendations to other farmers looking at investing in water reticulation systems.

2.2 Why do livestock need water?

This question may seem strange given the axiomatic; in the absence of water, life would be somewhat limited.

Adams and Sharpe (1995, cited in MPI 2004) claim that livestock need a plentiful supply of good, clean water for normal rumen fermentation and metabolism, proper flow of feed through the digestive tract, good nutrient absorption, normal blood volume and tissue requirements. Notably, however, a broad consensus based on scientific evidence for this statement is lacking. For example, the water component of the diet may be adequate to support normal animal production in many situations. Growing pasture has a high water content (82 - 85%), while dried grains and concentrates have very low water contents (around 15%). Additional water is only needed to supplement the water that animals consume in their diet, although this in itself is misleading. Livestock species differ widely in their ability to conserve water. Key to this is the animal's ability to recover water by producing concentrated urine in the kidneys. If an animal is given *ad libitum* access to water, it may well drink in excess of its ‘requirements’ and thereby reduce the amount of water recovered from urine by the kidneys (MPI 2004).

As an example, Merino sheep, which evolved in hot dry environments, can conserve water by producing highly concentrated urine to a much greater degree than sheep breeds which evolved in cooler North European climates (McFarlane 1968, cited in MPI 2004). Deer, on the other hand, do not have the ability to produce highly concentrated urine, having evolved in the cooler, moister areas of the world (Harrington 1985, cited in MPI 2004).

Despite the importance of water to livestock, there is limited research that has examined the water requirements of livestock, the variability of water composition, the effect of contamination and the overall impact on animal performance.

Canadian trials (Willms et al, 2002) showed that calves with cows drinking clean fresh water gained 9% more weight than those with access to pond water, although cow weight was unaffected. Yearling heifers with access to clean freshwater gained 23% more weight than those with access to pond water. Lardner (et al 2005) indicated that access to fresh clean water improved weight gain by 9% - 10% over a 90-day grazing period.

Within New Zealand, the Animal Welfare Act (1999) requires managers of livestock to provide *“proper and sufficient food and water”*. What “sufficient water” means can be highly related to the context, as water intake is closely related to feed intake and thus animal productivity (Schutz, 2012), as well as the climate and the type of feed being consumed. Guidelines on water requirements is given by ANZECC (2000) as indicated below (also governed by codes of welfare under the Animal Welfare Act 1999).

Table 1: Estimates of water requirements for livestock (ANZECC 2000)

Type of Livestock		Average daily consumption (litres/head)	Peak daily consumption (litres/head)
Sheep			
	Lactating ewes on dry feed	9	11.5
	Mature sheep on dry pasture	7	8.5
	Mature sheep on green pasture	3.5	4.5
	Fattening lambs on dry pasture	2.2	3
	Fattening lambs on green pasture	1.1	
Dairy Cattle			
	Dairy cows in milk	70	85
	Dairy cows, dry	45	60
	Calves	22-25	30
Beef Cattle*			
	Breeding Cow	30	45
	Yearlings	20	30
	Calves	10	20
Deer*			
	Mature Hind	5.7	11
	Hind 15-27 months	5.4	11
	Mature stag	6.6	13
	Stag 15-27 months	6.3	13
	Yearling	10	15
Horses			
	Working	55	70
	Grazing	35	45

*Aqualinc (2004a,b)

There is a clear relationship between water intake and feed intake in cattle. MPI (2004) cites several studies where dry matter intake was highly correlated with water consumption. In addition, other factors that increased water intake included; water and ambient air temperature, increasing milk production, and animal live weight.

Brew et al (2011) found in their trial to measure water intake in growing 7 to 9-month old beef cattle that there was no difference between bulls, steers or heifers in either gross water intake or water intake per kilogramme of metabolic body weight. They found that cattle of Brahman and Romosinuano breeding consumed less water than British or Continental breeds at the same metabolic body weight.

2.3 Water Quality

Water quality is another important issue, with Codes of Welfare requiring "palatable" water which is not harmful to stock health. There is very limited information available on the impact of water quality on ruminant livestock productivity. As a result, water quality factors affecting livestock productivity have not been well defined, although several factors have been raised, including:

(i) Organoleptic (odour and taste);

(ii) Physiochemical properties (pH, total dissolved solids, total dissolved oxygen, hardness);

(iii) Toxic compounds (heavy metals, toxic minerals, organophosphates, hydrocarbons);

(iv) Excess minerals or compounds (nitrates, sodium sulphates, iron); and

(v) Bacteria and algae.

(MPI 2004)

The most extensive studies of water quality and its impact on animal productivity have been carried out in Canada (Willms *et al*. 1996, 2000, 2002). They investigated water quality in dams and measured a vast array of water components. However, they were not able to identify any individual components of water that had a particular influence except that, in specific experiments, they showed that faecal contamination influenced the palatability of water for stock and hence water consumption and live weight gains (MPI 2004).

Studies in New Zealand (MPI, 2008) showed:

(i) A trial where dairy cows were given water contaminated with faecal material resulted in a reduction in water intake directly proportional to the level of contamination, over the first four days of the trial. After four days, water intakes resumed to the same level as the control (uncontaminated water) group. Within the group there was a large variation between individual cows.

(ii) Another study resulted in a 4% difference in milk production over a dairy herd when the cows were given two weeks on one water source and then switched for two weeks on another source with differing water quality.

(iii) Within water troughs, sediment at the bottom of the trough often held significant levels of bacteria which can infect the water within the trough. Conditions promoting bacterial growth are greatest in the spring, declining through the summer, presumably as UV levels increase. Trough cleaning, including removal of the sediment layer, can greatly improve water quality.

(iv) Surveys of trough water in late summer found cyanobacteria in the majority of troughs, which have the potential to adversely affect animal health.

3.0 METHODOLOGY

This project was designed as a series of case studies where each farm chosen had installed a stock water reticulation scheme over the last 3 - 5 years. Each farm was visited twice to collect the required pre- and post-water scheme information, reasons for installing the scheme, and how their farming system had changed as a result.

A case study approach was used because it allowed the study to be based on real, empirical data, which was verifiable and able to be checked by farmers. The analysis is an investment cost-benefit approach based on calculating the NPV and IRR over a 20-year cash flow, using a base discount rate of 8% real.

Observations made by the farmers were also captured and are summarised in the report.

3.1 Farm Selection

The farms selected for analysis were spread throughout the country, although mostly in the North Island; two in Northland, one on the East Coast, five in Horizons, one in the Wairarapa, and two in North Canterbury. This is illustrated below.

Figure 1: Case Study Farm Locations

A number of other farms in different regions were approached, but they had either installed stock water schemes a decade or two beforehand, or were just in the process of installing a scheme. In either case obtaining good pre- and post-information was not possible.

3.2 Farm Visits

Each farm was visited twice. The first visit was to collect a range of information on the farm both pre- and post- the stock water scheme, such as:

- Reasons for installing the scheme;

- Physical parameters on the farm; farm size, topography, level of subdivision, etc.;
- Livestock numbers and performance pre- and post- the scheme;
- Fertilisers applied and amounts of supplementary feed made on-farm and purchased in both pre- and post-scheme;
- Description of the water scheme;
- Stock grazing management and any changes as a result of the scheme and especially during droughts;
- Any impacts on animal health, animal welfare;
- Any environmental impacts; and
- The capital and operating costs involved with the scheme.

The questionnaire developed and used for all farms is shown in Appendix 1.

The second visit was to show the farmers the draft analysis, check that the figures used were accurate, and to sort through any additional questions or information required.

4.0 FINANCIAL INVESTMENT APPROACH

The investment analysis was conducted using a discounted cash flow approach over a 20-year period. This involved consideration of the capital costs of the stock water scheme, plus the marginal costs and benefits associated with the scheme, for example increased stock numbers and/or performance offset by any increased operating costs. These costs and benefits are described in more detail below.

The base discount rate used was 8% real (deflated for inflation and tax). This is the Treasury Guideline Rate, based on the "government opportunity cost of capital" (Treasury, 2008) which is generally used as the default discount rate in New Zealand. Sensitivity around this rate is discussed in a later section. (The calculation of the 8% is shown in Appendix 1).

The main indices calculated to test the financial returns (net benefits) relative to the investment costs were Net Present Value (NPV) and Internal Rate of Return (IRR).

The Net Present Value (NPV) figure is the value of the cash flow over the period in question (in this case 20 years), in today's dollars. In essence, it discounts the value of future costs and benefits back to the present day.

A positive NPV indicates the project can more than meet its cost of capital (the discount rate), while conversely, a negative NPV says the project fails to meet its cost of capital. The magnitude of a positive NPV is also important. A bigger NPV means that the project meets its cost of capital by a greater margin within the assumptions used in the calculation.

The Internal Rate of Return (IRR) indicates the return the project provides as an investment. It is similar to an interest rate provided by a bank when money is deposited with the bank. The IRR also indicates the cost of capital at which the NPV is zero.

A project that shows a negative NPV but a positive IRR, means that the project is profitable, but only up to the level indicated by the IRR; it is failing to meet the prescribed cost of capital. As noted above, the analysis is based on the marginal costs and benefits associated with the stock water scheme, i.e. any increased or decreased costs and benefits relative to the farm system prior to the scheme.

4.1 Capital Costs

As expected, the main capital costs were around the installation of the reticulation scheme, which covered a range of costs:

- Pump(s)
- Electricity supply (where applicable)
- Storage tanks
- Pressure relief tanks
- Pipe
- Troughs and fittings
- Earthworks
- Contract labour
- Fencing (e.g. around water storage tanks)
- Other (e.g. development of weirs, dams)
- Machinery costs (e.g. burying of pipes)

In addition, all farmers had invested their own time in assisting with the installation of the scheme. This time was costed into the scheme, as an opportunity cost, at $50/hour. Similarly, many had also used their own machinery (tractor/digger/bulldozer). This again was costed against the scheme at the equivalent contract rate.

Virtually all the farms had increased the level of subdivision fencing as a result of the water scheme[1], in order to take advantage of the water and improve their grazing management. The cost of this fencing was also included as a capital cost. Note, this applied only to the increased subdivision fencing. In a number of instances farmers had used the opportunity to repair/rejuvenate existing fences. The cost of this was not included, on the basis that this is something that would have occurred at some stage anyway.

All the case study farmers had altered stock numbers and/or stock type as a result of the water reticulation, and increased subdivision. A number had purchased in stock directly, with this cost incorporated as part of the capital cost of the water scheme. Many farmers though had increased/altered stock numbers by breeding up (i.e. increasing their retained replacement numbers). In this instance a capital cost of the increase/change in stock was calculated using a 5-year average (2012-2016) of the IRD Herd Scheme values.

4.1.1 Salvage Values

A salvage value was calculated as the residual value of the scheme at the end of the 20-year period. The inclusion of a salvage value was based on the idea that much of the reticulation scheme would still be in existence in 20 years, and still have a value. The value was based on depreciating all capital items (water scheme and fencing) at 5% diminishing value[2] through to the twentieth year.

Similarly, the capital stock cost incurred or calculated, was included as a salvage value at the same initial value, given that the equivalent stock was still on the farm.

4.2 Operating Costs

There were a range of operating costs taken into account:

(i) Repairs and maintenance. Most of the schemes were relatively new and as such R&M costs were relatively low, with most relating to either pump costs and/or trough fittings. An assumption was made to include R&M costs at 1.5% of capital costs, excluding labour, capital stock, and machinery costs. In addition, on the basis that R&M costs could be expected to increase as time progressed, the costs were inflated at 1% per year across the 20 years.

(ii) Electricity or fuel costs for the pumps. This varied throughout the year, generally higher in summer, lower in winter (as expected). An annual average cost was used in the analysis.

(iii) Insurance. Some farmers had specific insurance on the scheme, in which case this cost was included. For many, insurance was included in their general farm insurance plan, in which case no additional cost was included.

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[1] For a number of farms this included fencing off streams as part of the subdivisional fencing, but capital costs exclude any riparian planting.

[2] IRD Income Tax Act 2007 Schedule 20. http://www.legislation.govt.nz/act/public/2007/0097/latest/DLM1523373.html
Construction of…..or other improvements for the purpose of conveying water for the use on land.

(iv) Farmer time. All the case study farmers reported spending some time "overseeing" the scheme and carrying out minor repairs (the cost of which is captured above).
This varied from around 0.5 - 2 hours per week on average, with again more time spent in the summer versus the winter. This time was not costed, on the grounds that this is something of "normal farming requirement" i.e. that is what the farmer is there for.

(v) Additional fertiliser. A number of farms are applying additional fertiliser as a result of the water scheme/increased subdivision/increased stock numbers. This cost was included as an additional operating cost.

(vi) Additional supplementary feed. Similarly, a number of the farms had either increased the amount of supplement made on-farm, or purchased in, as a result of the increased livestock, or different livestock being run. Again, this additional cost was included as an operating cost.

4.3 Financial Benefits

4.3.1 Valuation of Benefits

The benefits as outlined below were valued on the basis of a five year average of Beef + Lamb New Zealand Economic Service data, depending on the latest dataset available.

The North Island hill country figures were based on a weighted average across North Island Class 3[3] and Class 4[4] hill country, while the South Island figures were based on South Island Class 2[5] hill country data.

(i) The Gross Margins were based on the five year average 2012/13 – 2016/17.

(ii) Store and prime prices were based on the five year average 2012/13 – 2016/17. These were gross values less animal health costs.

(iii) Sheep and cattle schedules were based on the five year average 2010/11 – 2014/15.

(iv) Deer values/schedules were based on the All Class NZ average data over the period 2012/13 - 2014/15.

(v) As noted the capital value of the livestock were valued at the five year average of the IRD Herd Scheme values.

Details on these figures are shown in Appendix 2.

The purpose in using these standardised figures were to eliminate any distortions from differing schedules and years, ensuring that the benefits calculated were just due to changes in stock numbers and/or performance.

4.3.2 Benefits

There were several areas where benefits arose.

(i) Change in stock numbers. Any increase or decrease in stock numbers was calculated, and a standardised gross margin applied to these changes. In many instances, farmers had decreased sheep and increased cattle numbers, although this was not universal.

(ii) Changes in lambing and/or calving percentages, and changes in numbers sold prime versus store. In many instances, farmers had improved their lambing and or calving percentages post the water scheme (due to better feeding) and were selling a greater proportion of animals prime rather than store. This was calculated through, with the net benefit accruing to the scheme.

(iii) Increased slaughter weights. In many instances, farmers were finishing stock to greater weights than pre-scheme. In these instances, the additional weight was valued via the average schedule and multiplied by the number of stock involved.

(iv) Opportunistic stock finishing. On a few farms the new water supply coupled with the additional subdivision has opened up the opportunity to trade or finish additional stock depending on pasture supplies. This was accounted for as a benefit on those farms where it had occurred, on a one in three year (or more) basis.

(v) Saved costs. Pre- the reticulated scheme, a number of the farms had relied on dams as a major source of water. These were maintained/cleaned out on a regular basis either

[3] Steep hill country or low fertility soils with most farms carrying six to 10 stock units per hectare. While some stock are finished a significant proportion are sold in store condition.

[4] Easier hill country or higher fertility soils than Class 3. Mostly carrying between seven and 13 stock units per hectare. A high proportion of sale stock sold is in forward store or prime condition.

[5] Hill farms with mainly mid-micron wool sheep mostly carrying between two and seven stock units per hectare. Three quarters of the stock units wintered are sheep and one quarter beef cattle.

annually or through to five yearly. With the advent of the reticulated scheme, many of these dams were destroyed, and in all instances the maintenance on them was ceased. The cost of this now ceased maintenance was included as a saved cost.

(vi) Lessened the impact of drought. All of the farmers noted that the installation of the stock water scheme had materially benefited the farm during periods of drought, in the sense of either being able to carry stock for longer, and/or continue to graze most of the farm whereas in the absence of the water scheme often large portions of the farm were not grazable, especially for cattle. This benefit was incorporated into the analysis via two proxy benefits:

(a) An assumption of a "dry" period every fifth year, where the benefit was equivalent to 10% of the five-year average net farm profit for either North or South Island hill country (B+LNZ data); and

(b) A more severe drought every tenth year, where the benefit was equivalent to 20% of the five-year average net farm profit for either North or South Island hill country.

These drought "periods" (i.e. every 5/10 years) is a standardised proxy only. Droughts occur at irregular intervals, and several of the case study farms had experienced droughts of varying intensity over the last 10 years. Similarly, the impact of droughts would vary between the case study farms – again the "benefits" indicated are standardised proxies to reflect the benefit reticulated water provides.

This "benefit" is not in the sense of increased income in those years, rather it is in the form of a saved cost.

(vii) Gradual introduction of the benefits. The installation of the stock water scheme and extra subdivision does not necessarily translate into instant benefits. Often some time elapses before the benefits of the better grazing manifests itself. This is difficult to readily model, so again a proxy was used in this analysis, whereby:

- In year one, 50% of the overall reported benefit was gained
- In year two, 70%
- In year three, 90%
- In year four and thereafter, 100%

5.0 RESULTS

5.1 Financial

A summary of the results is shown below in table 2. This shows strongly positive IRR's for all farms, well above the discount rate, and are therefore also showing a strongly positive NPV. The table also illustrates that every farm was different with key influences being the capital cost relative to the size of increases in livestock carried and resultant improvements in stock performance.

Table 2: NPV and IRR results

Farm	NPV ($000)	IRR	Effective ha	Stock Units
Horizons 1	$1,057	47%	610	6,358
Horizons 2	$465	22%	590	5,287
Horizons 3	$282	14%	761	8,258
Horizons 4	$817	52%	1,112	9,455
Horizons 5	$809	23%	850	6,556
Northland 1	$506	80%	366	3,348
Northland 2	$1,525	40%	485	5,004
East Coast 1	$1,821	36%	1,850	21,614
Wairarapa 1	$1,358	76%	680	6,755
Canterbury 1	$4,759	85%	5,000	34,431
Canterbury 2	$519	23%	2,100	9,454
Weighted Average*		53%		
Raw Average		45%	1,309	10,593
Median		40%	761	6,755

*Weighted on effective area of the farm

This shows that all the reticulation schemes have been strongly positive as an investment. The farm with the lowest rate of return (Horizons 3) sells the vast bulk of its stock as store (95% of lambs, 100% of cattle), whereas the other case study farms sell most stock as prime, and an increasing percentage prime following the advent of the reticulated water scheme. Canterbury 2, who has reduced stock numbers (mostly sheep) largely due to drought, is showing a positive return due to improved stock performance.

Capital costs per hectare and per stock unit are shown below, where Total Capital = capital involved in the water reticulation scheme + subdivisional fencing + increased/changed stock numbers, and Water Only Capital = just the capital involved in the reticulation scheme.

Table 3: Capital costs per hectare and per stock unit

	Total Capital Cost/ha	Total Capital Cost/SU	Water Only Capital Cost/ha	Water Only Capital Cost/SU
Horizons 1	$342	$33	$98	$9
Horizons 2	$507	$57	$245	$27
Horizons 3	$601	$55	$280	$26
Horizons 4	$132	$16	$132	$16
Horizons 5	$509	$66	$125	$16
Northland 1	$134	$15	$130	$14
Northland 2	$811	$79	$246	$24
East Coast 1	$293	$25	$200	$17
Wairarapa 1	$206	$21	$108	$11
Canterbury 1*	$303	$13	$134	$6
Canterbury 2	$142	$32	$126	$28
Weighted Average	$311	$29	$154	$15
Raw Average	$362	$37	$166	$18
Median	$303	$32	$132	$16

*Based on the area serviced by the water scheme (1,500ha), not the effective area of the farm.

The variation in capital involved between the case study farms is illustrated below.

Figure 2: Capital costs/ha

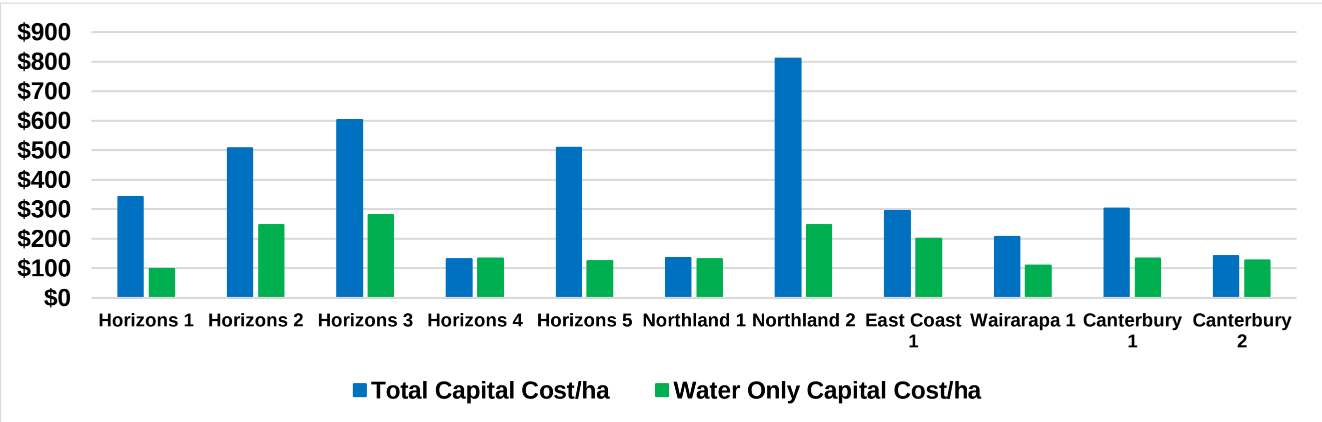
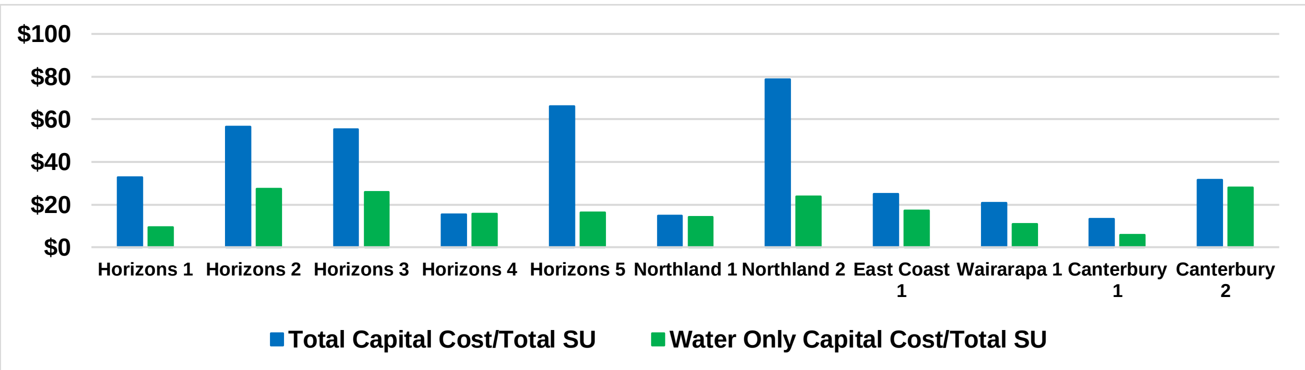


Figure 3: Capital costs/SU



The ratio of expenditure on subdivisional fencing and changes in capital stock relative to the capital cost of the water scheme itself, are shown below.

Table 4: Cost of subdivisional fencing and changes in capital stock relative to the water scheme cost.

	Water Cost	Fencing Cost	Capital Stock Cost
Horizons 1	$1.00	$1.43	$1.08
Horizons 2	$1.00	$0.59	$0.48
Horizons 3	$1.00	$0.49	$0.65
Horizons 4	$1.00	$0.04	-$0.04
Horizons 5	$1.00	$1.50	$1.56
Northland 1	$1.00	$0.00	$0.03
Northland 2	$1.00	$0.91	$1.40
East Coast 1	$1.00	$0.09	$0.38
Wairarapa 1	$1.00	$0.36	$0.55
Canterbury 1	$1.00	$0.60	$0.66
Canterbury 2	$1.00	$0.46	-$0.47
Weighted Average		$0.54	$0.47
Raw Average		$0.59	$0.57
Median		$0.49	$0.55

This table shows the expenditure on subdivisional fencing and increases/changes in capital stock, relative to the expenditure on the water reticulation scheme. For example, for every $1 spent by Horizons 1 on water, they spent $1.43 on fencing, and $1.08 on increases/changes in capital stock.

The per stock unit figures shown in Table 3 and Figure 3 relate to the total stock units on the property. If capital and operating costs are distributed only across the marginal increase in stock units; i.e. post-stock units less pre-stock units, the results are:

Table 5: Capital and operating costs per marginal stock unit

	Total Capital Cost/Marginal SU	**Water Only Capital Cost/Marginal SU**	**Operating Costs/Marginal SU**
Horizons 1	$462	$132	$7.91
Horizons 2	$1,012	$490	$12.97
Horizons 3	$350	$163	$3.97
Horizons 4	$8,867	$8,461	$211.15
Horizons 5	$623	$165	$5.93
Northland 1	$1,178	$1,143	$37.78
Northland 2	$848	$257	$13.14
East Coast 1	$529	$360	$20.36
Wairarapa 1	$170	$89	$3.20
Canterbury 1	$544	$225	$7.01
Canterbury 2*	n/a	n/a	n/a

*Had decreased stock units

A comparison of operating costs is shown below. These include repairs and maintenance, insurance (if involved), plus electricity and/or fuel costs.

Table 6: Operating costs per hectare and per total stock unit

	Operating cost/ha		Operating cost/SU
Horizons 1	$5.86		$0.56
Horizons 2	$6.50		$0.73
Horizons 3	$6.83		$0.63
Horizons 4	$3.13		$0.37
Horizons 5	$4.84		$0.63
Northland 1	$4.30		$0.47
Northland 2	$12.56		$1.22
East Coast 1	$11.29		$0.97
Wairarapa 1	$3.90		$0.39
Canterbury 1	$3.90		$0.17
Canterbury 2	$5.47		$1.22
Weighted Average	$4.77		$0.59

The return on the investment is a combination of a range of factors; capital, operating costs, and benefits. Analysis indicates that each of these in isolation only has a moderate (at best) relationship with the final rate of return, as illustrated by the R^2 values below.

Figure 4: Total capital cost vs IRR

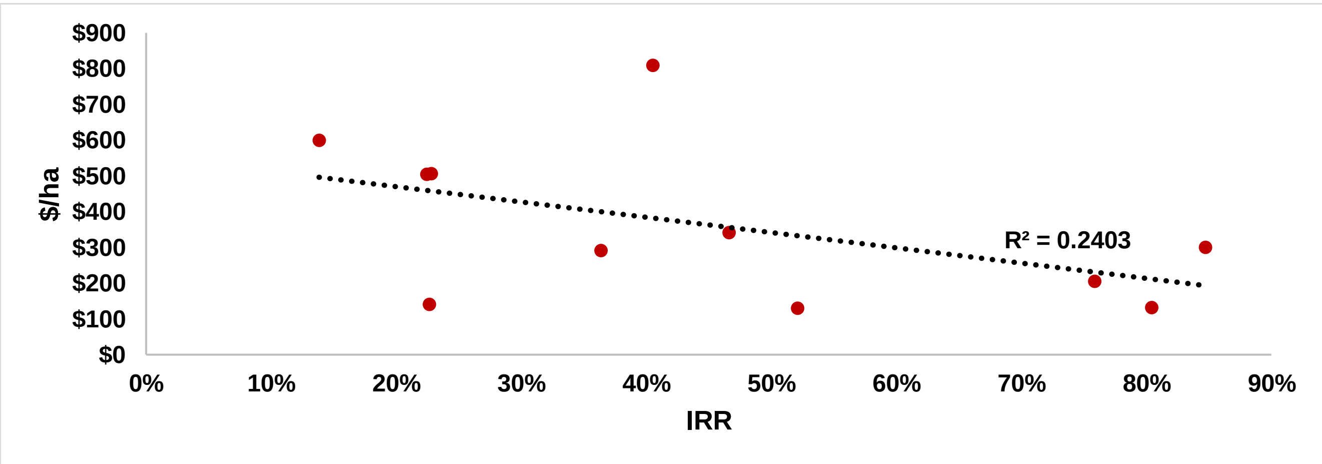


Figure 5: Water only capital cost vs IRR

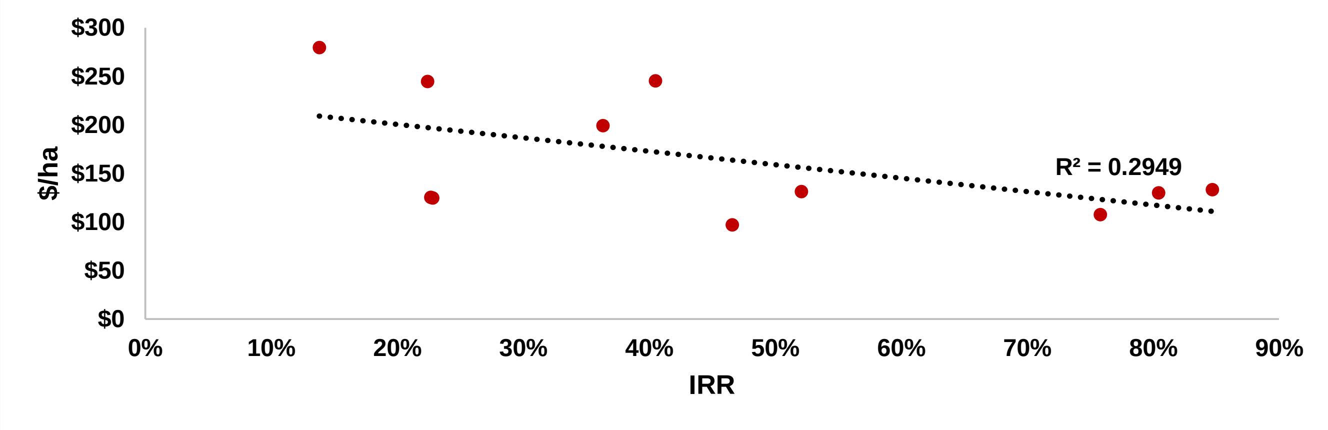
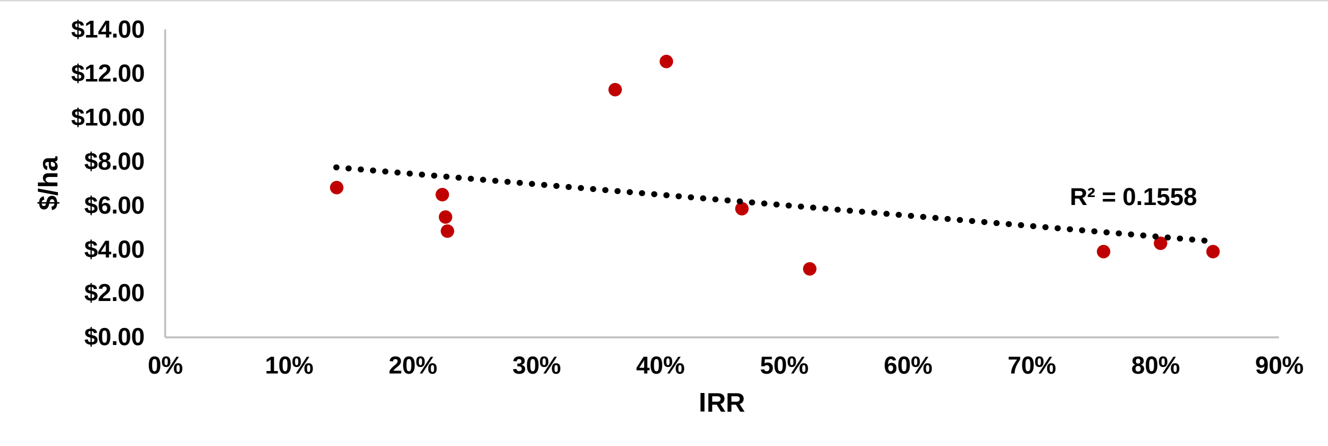


Figure 6: Operating costs vs IRR



These all reinforce the concept that each farm has its own unique issues and characteristics which influences the return on the investment. [A perfect relationship is where R^2 =1.0]

5.1.1 Payback Period

The payback period is the length of time required to recover the cost of an investment and is an important determinant of whether to undertake the investment, as longer payback periods are typically not desirable for investment positions.

This factor was calculated for the case study farms, as illustrated below.

Table 7: Payback periods (rounded to nearest 0.25 years)

	Years
Horizons 1	2.75
Horizons 2	4.5
Horizons 3	7.5
Horizons 4	2.25
Horizons 5	4.25
Northland 1	1.75
Northland 2	4.0
East Coast 1	3.5
Wairarapa 1	1.5
Canterbury 1	1.5
Canterbury 2	4.75
Weighted Average	3.0

5.2 Physical

As outlined in Section 5, the case study farms had all altered aspects of the physical characteristics of their farms.

5.2.1 Subdivision

All but one of the farmers had increased their level of subdivision, which was a key component in improving the productivity of the farm.

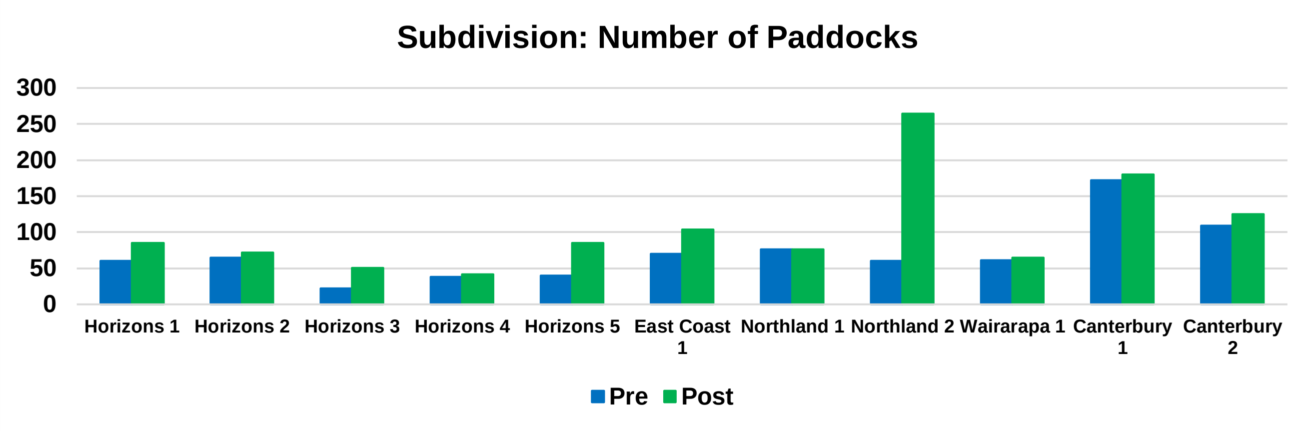
Table 8: Number of paddocks

	Pre Scheme	Post Scheme
Horizons 1	60	85
Horizons 2	65	72
Horizons 3	22	51
Horizons 4	38	42
Horizons 5	40	85*
East Coast 1	70	104
Northland 1	76	76
Northland 2	60	264*
Wairarapa 1	61	65
Canterbury 1	172	180
Canterbury 2	109	125
Average	70	104

*Include techno beef systems[6]

[6] A techno beef system involves intensive subdivision into small paddocks, through which mobs of cattle are constantly rotated.

Figure 7: Number of paddocks



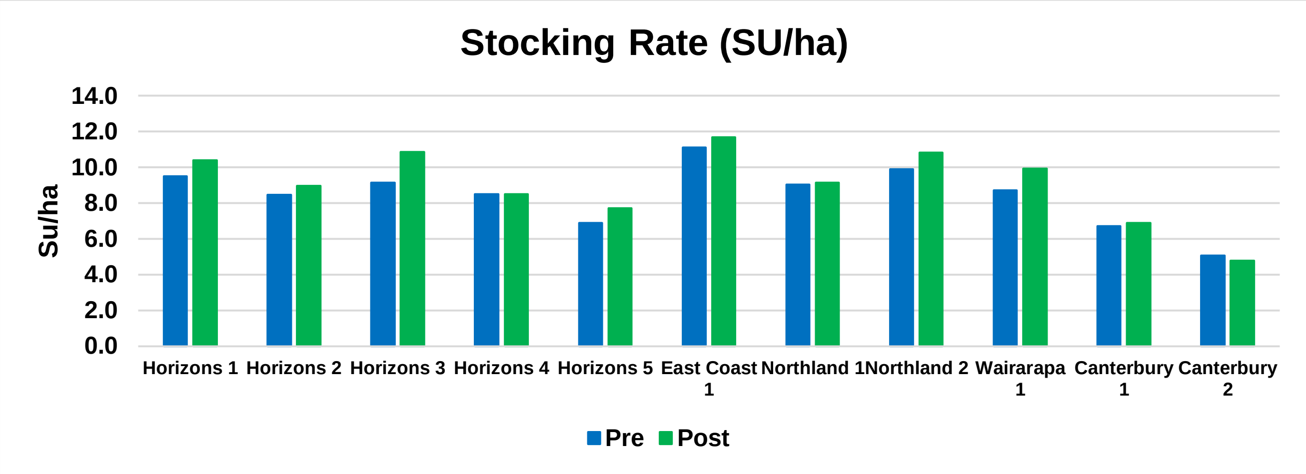
5.2.2 *Stocking Rate*

A key response as a result of the water scheme/subdivision on most of the farms was an increase in stocking rate, with an average increase of 0.5 SU/ha.

Table 9: Pre and post water scheme stocking rate (SU/ha)

	Pre	Post
Horizons 1	9.5	10.4
Horizons 2	8.5	9.0
Horizons 3	9.1	10.9
Horizons 4	8.5	8.5
Horizons 5	6.9	7.7
East Coast 1	11.1	11.7
Northland 1	9.0	9.1
Northland 2	9.9	10.8
Wairarapa 1	8.7	9.9
Canterbury 1	6.7	6.9
Canterbury 2	5.1	4.5
Average	8.5	9.0

Figure 8: Pre and post water scheme stocking rate (SU/ha)



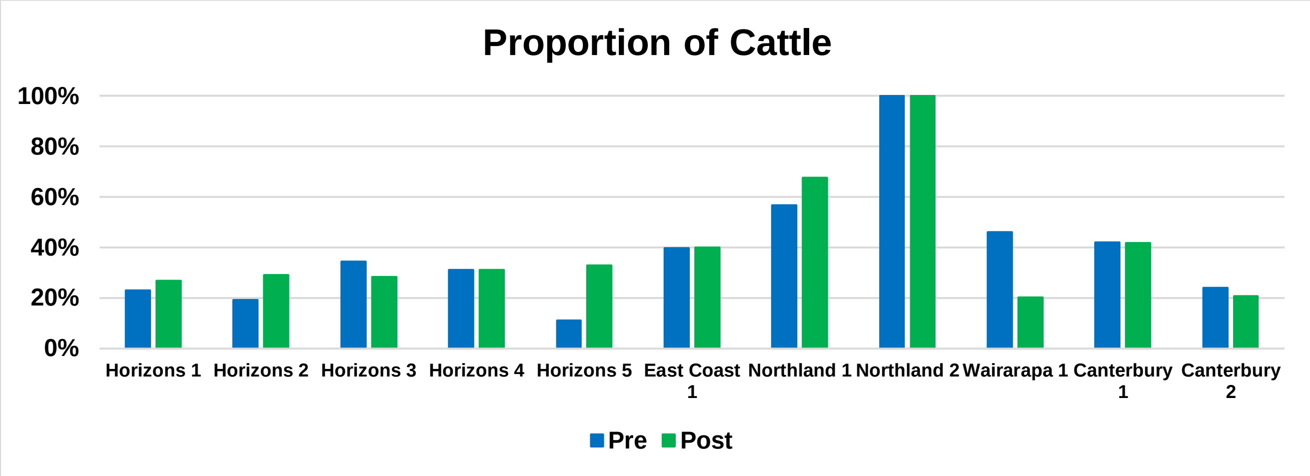
5.2.3 *Proportion of Cattle*

On some of the farms the response to the improved water supply was an increase in cattle numbers, with two of the farms developing techno beef units as a direct result. On average though the increase in the proportion of cattle was only 1%; of the case study farms, 4 increased cattle numbers, 4 made no change, and 3 decreased cattle numbers.

Table 10: Proportion of cattle stock units pre- and post-water scheme

	Pre	Post
Horizons 1	23%	27%
Horizons 2	19%	29%
Horizons 3	34%	28%
Horizons 4	31%	31%
Horizons 5	11%	33%
East Coast 1	40%	40%
Northland 1	57%	68%
Northland 2	100%	100%
Wairarapa 1	46%	20%
Canterbury 1	42%	42%
Canterbury 2	24%	22%
Average	39%	40%

Figure 9: Proportion of cattle stock units pre- and post-water scheme



5.2.4 Lambing Percentage

Lambing percentage improved on all the farms, with the exception of Northland 2, which is 100% bull beef. On average the increase was 12%, which is based on the average lambing percent post-the water scheme, less the average lambing percent pre-the water scheme. This is a direct result of the better feeding levels for replacement hoggets and breeding ewes; as discussed in Section 9, this is a direct flow-on effect from the water reticulation system, e.g. Install water reticulation scheme ⟹ increase subdivision ⟹ better grazing management ⟹ better pasture utilisation/improved pasture growth ⟹ improved animal performance.

It is not possible to give a direct comparison with farms with no water reticulation system, but an indicative comparison can be made with performance figures from the Beef + Lamb New Zealand Economic Service survey (realising that (i) these figures include farms with and without water schemes, and (ii) the periods noted below don't line up exactly with the case study farms):

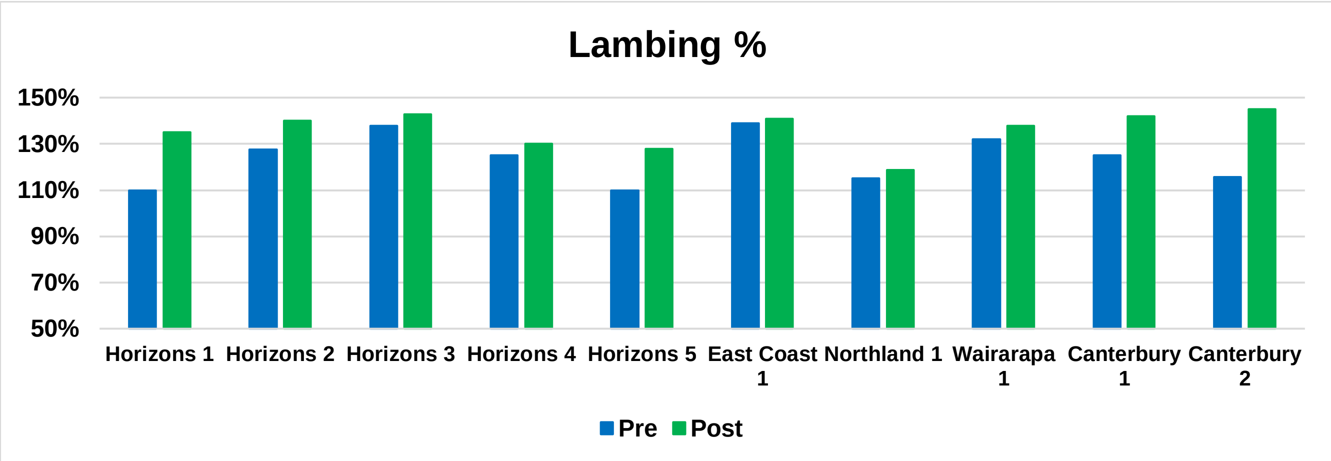
Table 11: Comparative lambing %

	5-year average to 2011/12	5-year average to 2016/17	Difference
North Island Hill Country	118%	125%	7%
South Island Hill Country	117%	123%	6%

Table 12: Lambing percentage pre and post water scheme

	Pre	Post
Horizons 1	110%	135%
Horizons 2	128%	140%
Horizons 3	138%	143%
Horizons 4	125%	130%
Horizons 5	110%	128%
East Coast 1	139%	141%
Northland 1	115%	119%
Wairarapa 1	132%	138%
Canterbury 1	125%	142%
Canterbury 2	116%	143%
Average	124%	136%

Figure 10: Lambing percentage pre and post water scheme



Prime stock finishing weights had also increased, with post-scheme lamb carcass weights increasing by an average of 1.1 kg, and cattle weights by 20 - 30 kg.

5.3 Sensitivity Analysis

5.3.1 Rate of Improvement

As discussed in Section 3.3.2, a base assumption around the rate of improvement in the benefits gained was made. Most of the case study farmers felt this was realistic, although a few felt their gains were either faster or slower. A sensitivity analysis was carried out as outlined below.

Table 13: Sensitivity rate of gain in benefits

	Base	Faster	Slower
Benefit in year 1	50%	60%	30%
Benefit in year 2	70%	80%	50%
Benefit in year 3	90%	90%	70%
Benefit in year 4	100%	100%	90%
Benefit in year 5+	100%	100%	100%

The results are as follows.

Table 14: NPV and IRR results from varying the rate of benefit gain

	Base		Faster		Slower	
	NPV ($000)	IRR	NPV ($000)	IRR	NPV ($000)	IRR
Horizons 1	$1,057	47%	$1,088	50%	$955	38%
Horizons 2	$465	22%	$481	23%	$413	20%
Horizons 3	$282	14%	$305	14%	$206	12%
Horizons 4	$817	52%	$836	56%	$755	44%
Horizons 5	$809	23%	$844	24%	$697	19%
Northland 1	$506	80%	$518	88%	$468	63%
Northland 2	$1,525	40%	$1,563	43%	$1,401	35%
East Coast 1	$1,821	36%	$1,869	38%	$1,662	31%
Wairarapa 1	$1,358	76%	$1,392	84%	$1,246	59%
Canterbury 1	$4,759	85%	$4,860	92%	$4,423	68%
Canterbury 2	$519	23%	$546	24%	$429	19%
Weighted Average		53%		58%		43%

This indicates a very good return, even at the slower rate of gain.

5.3.2 Drought Impact

Section 3.3.2 also outlines the assumptions made around incorporating a “drought effect” into the analysis. Again, the farmers felt this was realistic, although several felt that the benefits assumed should be higher, especially given they had suffered droughts of various intensity over several of the last three to five years.

A sensitivity analysis was carried out as follows.

Table 15: Drought impact sensitivity parameters

	Base	No drought	More severe drought
Every 5 years	10%	0%	20%
Every 10 years	20%	0%	40%

Where the percentage gain is the percent of net farm profit “saved”. The impact of this is as illustrated below.

Table 16: NPV and IRR results from varying the drought impact parameters

	Base		No drought		More severe drought	
	NPV ($000)	IRR	NPV ($000)	IRR	NPV ($000)	IRR
Horizons 1	$1,057	47%	$1,029	46%	$1,085	47%
Horizons 2	$465	22%	$465	22%	$465	22%
Horizons 3	$282	14%	$247	13%	$317	14%
Horizons 4	$817	52%	$766	51%	$868	53%
Horizons 5	$809	23%	$771	22%	$848	23%
Northland 1	$506	80%	$482	80%	$531	81%
Northland 2	$1,525	40%	$1,493	40%	$1,558	41%
East Coast 1	$1,821	36%	$1,737	36%	$1,905	37%
Wairarapa 1	$1,358	76%	$1,327	75%	$1,388	76%
Canterbury 1	$4,759	85%	$4,674	84%	$4,843	85%
Canterbury 2	$519	23%	$483	22%	$554	23%
Weighted Average		53.3%		52.9%		53.8%

This shows that the "drought effect" has had a relatively marginal impact on the results, with the weighted average IRR only shifting by around half a percentage point. This is mainly due to the assumptions made within the analysis; in the event of a drought, actual benefits could be much higher. The main drought benefit is very much in the "peace of mind" arena.

5.3.3 Repairs and Maintenance

Section 4.2 outlines the base assumptions around R&M costs; 1.5% of capital costs initially, inflating at 1% per year. If these figures are doubled to 3% initially, inflating at 2% annually, the impact is as follows.

Table 17: R&M sensitivity

	Base	Doubled
Weighted Av IRR	53%	52%
Av IRR	45%	44%
Median IRR	40%	40%

6.0 PHYSICAL CHARACTERISTICS OF THE CASE STUDY FARMS

The following table summarises the case study farms, showing pre- and post-water scheme stock numbers and performance. Note a blank space = information not applicable.

Table 18: Summary of Case Study Farm Physical Characteristics

Horizons 1				**Horizons 2**				**Horizons 3**		
Total Area (ha)	650			Total Area (ha)	660			Total Area (ha)	876	
Effective Area (ha)	610			Effective Area (ha)	590			Effective Area (ha)	761	
Flat area (%)	3%			Flat area (%)	8%			Flat area (%)	9%	
Rolling - cropable (%)	3%			Rolling - cropable (%)	10%			Rolling - cropable (%)	4%	
Rolling – non cropable (%)	51%			Rolling – non cropable (%)	22%			Rolling – non cropable (%)	67%	
Steep (%)	43%			Steep (%)	59%			Steep (%)	21%	
	Pre:	Post:			Pre:	Post:			Pre:	Post:
Number of paddocks	60	85		Number of paddocks	65	72		Number of paddocks	22	51
Sheep SU's	4,548	4,648		Sheep SU's	4,029	3,754		Sheep SU's	4,558	5,921
Cattle SU's	1,358	1,710		Cattle SU's	962	1,533		Cattle SU's	2,392	2,337
Stocking Rate (SU/eff ha)	9.5	10.4		Stocking Rate (SU/eff ha)	8.5	9.0		Stocking Rate (SU/eff ha)	9.1	10.9
Lambing % (lambs docked/ewes mated)	110%	135%		Lambing % (lambs docked/ewes mated)	128%	140%		Lambing % (lambs docked/ewes mated)	138%	143%
% lambs sold store	90%	10%		% lambs sold store	50%	20%		% lambs sold store	96%	95%
Lamb kill weights (kg)	15.3	17.0		Lamb kill weights (kg)	16.0	18.5		Lamb kill weights (kg)	17.0	18.0
Calving % (calves weaned/cows mated)	90%	95%		Calving % (calves weaned/cows mated)	88%	88%		Calving % (calves weaned/cows mated)	86%	93%
Cattle kill weights (kg)	290	310		Cattle kill weights (kg)				Cattle kill weights (kg)		

Horizons 4				**Horizons 5**				**East Coast 1**		
Total Area (ha)	1,276			Total Area (ha)	1,058			Total Area (ha)	2,050	
Effective Area (ha)	1,112			Effective Area (ha)	850			Effective Area (ha)	1,850	
Flat area (%)	18%			Flat area (%)	8%			Flat area (%)	12%	
Rolling - cropable (%)	0%			Rolling - cropable (%)	10%			Rolling - cropable (%)	39%	
Rolling – non cropable (%)	41%			Rolling – non cropable (%)	67%			Rolling – non cropable (%)	49%	
Steep (%)	41%			Steep (%)	15%			Steep (%)	0%	
	Pre:	Post:			Pre:	Post:			Pre:	Post:
Number of paddocks	38	42		Number of paddocks	40	85		Number of paddocks	70	104
Sheep SU's	6,506	6,506		Sheep SU's	5,206	4,396		Sheep SU's	12,409	12,974
Cattle SU's	2,932	2,949		Cattle SU's	656	2,160		Cattle SU's	8,180	8,640
Stocking Rate (SU/eff ha)	8.5	8.5		Stocking Rate (SU/eff ha)	6.9	7.7		Stocking Rate (SU/eff ha)	11.1	11.7
Lambing % (lambs docked/ewes mated)	125%	130%		Lambing % (lambs docked/ewes mated)	110%	128%		Lambing % (lambs docked/ewes mated)	139%	141%
% lambs sold store	50%	17%		% lambs sold store	90%	80%		% lambs sold store	40%	25%
Lamb kill weights (kg)	16.5	17.8		Lamb kill weights (kg)	16.0	17.5		Lamb kill weights (kg)	15.8	16.2
Calving % (calves weaned/cows mated)	88%	91%		Calving % (calves weaned/cows mated)	95%	95%		Calving % (calves weaned/cows mated)	90%	92%
Cattle kill weights (kg)				Cattle kill weights (kg)		+40		% cattle sold store	20%	5%

Northland 1				**Northland 2**				**Wairarapa 1**		
Total Area (ha)	407			Total Area (ha)	729			Total Area (ha)	732	
Effective Area (ha)	366			Effective Area (ha)	485			Effective Area (ha)	680	
Flat area (%)	13%			Flat area (%)	0%			Flat area (%)	5%	
Rolling - cropable (%)	19%			Rolling - cropable (%)	44%			Rolling - cropable (%)	10%	
Rolling – non cropable (%)	28%			Rolling – non cropable (%)	16%			Rolling – non cropable (%)	60%	
Steep (%)	41%			Steep (%)	40%			Steep (%)	25%	
	Pre:	Post:			Pre:	Post:			Pre:	Post:
Number of paddocks	76	76		Number of paddocks	60	264		Number of paddocks	61	65
Sheep SU's	1,435	1,087		Sheep SU's	0	0		Sheep SU's	3,200	5,396
Cattle SU's	1,872	2,261		Cattle SU's	4,795	5,258		Cattle SU's	2,728	1,359
Stocking Rate (SU/eff ha)	9.0	9.1		Stocking Rate (SU/eff ha)	9.9	10.8		Stocking Rate (SU/eff ha)	8.7	9.9
Lambing % (lambs docked/ewes mated)	115%	119%		Lambing % (lambs docked/ewes mated)				Lambing % (lambs docked/ewes mated)	132%	138%
% lambs sold store	0	0		% lambs sold store				% lambs sold store	30%	60%
Lamb kill weights (kg)				Lamb kill weights (kg)				Lamb kill weights (kg)	16.5	16.5
Calving % (calves weaned/cows mated)				Calving % (calves weaned/cows mated)				Calving % (calves weaned/cows mated)	82%	86%
Cattle kill weights (kg)				Cattle kill weights (kg)	245	296		Cattle kill weights (kg)		

Canterbury 1				**Canterbury 2**		
Total Area (ha)	6,240			Total Area (ha)	2,288	
Effective Area (ha)	5,000			Effective Area (ha)	2,100	
Flat area (%)	3%			Flat area (%)	2%	
Rolling - cropable (%)	22%			Rolling - cropable (%)	33%	
Rolling – non cropable (%)	0%			Rolling – non cropable (%)	0%	
Steep (%)	75%			Steep (%)	65%	
	Pre:	**Post:**			**Pre:**	**Post:**
Number of paddocks	172	180		Number of paddocks	109	125
Sheep SU's	16,407	16,407		Sheep SU's	7,078	5,957
Cattle SU's	14,129	14,404		Cattle SU's	2,555	2,123
Deer SU's	3,060	3,620		Deer SU's	1,001	1,374
Stocking Rate (SU/eff ha)	6.7	6.9		Stocking Rate (SU/eff ha)	5.1	4.5
Lambing % (lambs docked/ewes mated)	125%	142%		Lambing % (lambs docked/ewes mated)	116%	143%
% lambs sold store	60%	0%		% lambs sold store	54%	37%
Lamb kill weights (kg)	17.0	17.6		Lamb weaning weights (kg)	28.1	32.5
Calving % (calves weaned/cows mated)	82%	89%		Calving % (calves weaned/cows mated)	90%	91%
Fawning %	93%	95%		Cattle kill weights (kg)	213	233
Cattle kill weights (kg)		+10-20kg		Fawning %	93.2%	92.7%
				R1 deer kill weights (kg)	51.5	55.0

6.1 Description of Water Reticulation Systems

6.1.1 Horizons 1

Water source is a creek, with a small electric pump lifting the water 10m head to a 25,000 litre tank, from which another larger (electric) pump lifts the water 150m head to 2 x 25,000 litre tanks, with the water then gravity fed to troughs over the farm.

6.1.2 Horizons 2

Water source is a high altitude dam (900m) fed by run-off and spring water. Water is pumped via electric pump 18m head to 1 x 25,000 litre and 1 x 30,000 litre storage tanks and then gravity fed to 3 other storage tanks (2 x 25,000 litre and 1 x 30,000 litre) at lower altitude in different parts of the farm. There are also four pressure break tanks (1 x 500 litre, 3 x 1,000 litre) in the system. Lateral pipes gravity feed off to troughs.

6.1.3 Horizons 3

Water source is a stream, with the water collected into a gallery which feeds into a sump/well. From there a submersible pump lifts 20m of head to 2 x 30,000 litre storage tanks. A diesel generator pump then lifts the water 160m head (4.5 km distance in 63 mm pipe) to 4 x 30,000 litre tanks at high points on the farm. Water is then distributed via gravity to 90% of the farm including one 30,000 litre, pressure break tank. Every paddock has a trough, with a number to eventually have two troughs.

6.1.4 Horizons 4

Water source is a small stream with a consistent flow. The water is pumped via an electric powered Roto-Flow pump over 3 km and 150m altitude to storage tanks. Water is then gravity fed to the farm, including a second storage tank 1.5 km away at 105m altitude. Total storage capacity is 110,000 litres. Most paddocks have at least two troughs.

6.1.5 Horizons 5

Water source is a spring located at 480m altitude. The water syphons into a 25,000 litre storage tank and then gravity feeds through the rest of the farm, including an additional two 25,000 litre storage tanks on different parts of the farm, and the farm house (at 160m altitude). Pressure relief tanks and troughs help break the pressure at regular intervals.

6.1.6 Northland 1

Water source is a creek, with consistent flow. The water is pumped via electric pump (mains power) 130m head in 50mm line to storage tanks, and then gravity fed in 32mm pipe around most of the farm.

6.1.7 Northland 2

Water source is a variety of streams or springs, and a neighbours’ dam, with five sources used in different parts of the farm. Water is pumped via four electric pumps and one petrol driven pump to storage tanks and then gravity fed around the farm. One of the water sources directly feeds the farm house.

6.1.8 Wairarapa 1

Water is sourced from a bore at the back of the farm at an altitude of 350m, then pumped from an electrically powered pump to the main tank at an altitude of 400m. From this tank, it is gravity fed from two main lines which have a series of break tanks to various troughs.

6.1.9 East Coast 1

Water source is a river. A pontoon on the river has two electric pumps which pump the water to settling tanks. From there it is pumped to storage tanks at a high point on the farm and gravity fed to 50% of the farm, including the woolshed. From the woolshed it is pumped to storage tanks at another high point and then gravity fed to the rest of the farm. No pressure break tanks are used.

6.1.10 Canterbury 1

Water source is a stream, with a 4-cylinder diesel powered pump lifting the water 180m head over 1.2 km in 65mm pipe to 4 x 33,000 litre storage tanks. The water is then gravity fed over 1,500 ha of the farm in 75mm line, with pressure-break tanks at various distances on every gravity line.

6.1.11 Canterbury 2

Water source is from 2 springs in adjacent gullies at about 436m altitude. The water is collected in tanks just below the springs, which then feed down 120m into a turbine. The turbine is powered by water from a weir which flows through 200mm pipe over a 4m drop. The turbine (+ gravity) pushes the water to storage tanks at 463m altitude and then gravity feeds to the rest of the farm. When the creek the weir is situated on gets too low, a diesel pump is used to lift the water to the storage tanks. In a normal year, this usually occurs for 2-3 months over the summer. The creek can also be used as a back-up water source if the springs dry up.

7.0 FARMER COMMENTARY

In addition to the quantitative data collected from farmers, a range of questions were asked to establish a qualitative viewpoint on a range of factors which have previously been anecdotally reported as benefits or costs of stock water reticulation. Summaries of these views are outlined below.

7.1 Motivation for installing stock water system

A broad range of reasons for installing the stock water system were given. Many of these factors were shared by multiple farmers. Most of the farmers stated their main reason for installing water was that the current supply was inadequate and was limiting their production. Many of the farmers also reported challenges with dams, including that stock were getting stuck in dams, the quality of the water within the dams was poor and/or they dried up during dry periods, and that the cost of maintaining dams was high. Similarly, most of the farmers interviewed wanted to minimise the impact of drought on their farm and providing a secure supply of water was one way of doing this.

Further subdivision and development of the properties was a strong motivating factor and the ability to graze hills better (with animals spending most of their time near the water source (usually near the bottom) rather than grazing whole hillsides). Some farmers wanted to finish more animals and recognised the need for good water to do this.

Other reasons included previous experience with water reticulation systems and observing the benefits, that the farm was 'no longer summer-safe', wanting to avoid having stock in waterways for both environmental and stock safety reasons, and to be able to secure high-value grazing contracts.

The farmers did not require a consent for the schemes, as stock water is a priority under the RMA, and the water takes were all within the relevant Regional Council limits.

7.2 Analysis and assumptions made

There was a surprisingly limited amount of formal analysis done before installing the system. Two of the farmers interviewed used an independent company to complete the full analysis. This may in part be due to a lack of readily available, independent data. Analysis was mostly done by the farmers themselves in conjunction with suppliers and contractors and with other critical farming partners such as board directors, farm owners, family and local consultant. A critical factor was to assess the water source over a period (often over a year) to ensure it was reliable.

Analysis that was done included costs, current and potential pasture production, subdivision plans, peak water demand, measuring contours and heights, looking at what other farmers had done with their systems, and analysing options for trough and tank sites.

A range of assumptions were made around the benefits of the stock water system. Many farmers assumed that there would be better quality and utilisation of feed, and they would be able to graze their property better, some also reported that they would be able to increase their stocking rates and use crops. Additional assumed benefits included being able to graze cattle all year around, better animal performance, being able to get rid of dams, that stock would do better with cleaner water and therefore that health and welfare of animals would improve, and that repairs and maintenance costs would decrease.

7.3 Unexpected factors and costs during installation

Most of the farmers interviewed reported no unexpected costs or other factors during the installation of their water systems. The unexpected factors reported included a minor issue with joining high pressure pipe initially, and a water quality issue which caused troughs to leak which required a filter to fix.

Unexpected costs reported by the farmers included going slightly over budget due to factors such as siting troughs, going for higher specification pipe and trough fittings than budgeted, high pressure water which has increased repairs and maintenance costs, and higher costs of pump maintenance and flushing. One farmer needed to purchase an additional pump to operate as a back-up to the system.

7.4 Observed benefits from the stock water system

None of the farmers interviewed had done a financial analysis of the benefits from putting their system in and were all quite surprised by the positive results shown in the financial analysis. All reported significant observed benefits of their system and were confident in their investment decision on this alone.

Most of the farmers reported better grazing management, utilisation of feed grown and less weeds. Many of the farmers also reported that they could subdivide and develop their 'better' land to use it more effectively, including with the use of crops which had not previously been an option. Most reported better animal health, stock performance including weaning weights, lactation and weights at slaughter with farmers being able to increase the amount of finishing done on-farm as opposed to store.

In particular, the farmers reported 'peace of mind' and less stress on staff and stock as a significant benefit for their business.

Other observed benefits included reduced stock deaths from being able to fence off gorges and gullies, being able to access all paddocks on the farm throughout the year, reduced maintenance costs for dams, smaller paddocks (from subdivision) are easier to muster, greater flexibility of the farm system, particularly in summer, and less bulls required because cows aren't spread over such big areas.

7.5 Advice and hindsight

Having installed the water systems, observed the benefits, and having the positive economic benefits highlighted on their farms, the farmers interviewed are all now strong advocates for stock water reticulation. The farmers were asked to offer advice to other farmers putting in systems and what they would do differently with the benefit of hindsight.

Consistently, farmers' advice to other farmers was: "Just do it!"

Additional practical advice and changes made with the benefit of hindsight is outlined below.

7.5.1 Analysis and planning

- Plan well and get good advice; work with people you like.
- Speak to a farmer who has already put in a system.
- Work out peak water requirements for your stock and allow for increased stocking rate because of water and additional subdivision. Ensure your infrastructure has the specifications to meet this demand and go over specifications if you can to allow for extension of the system or greater stocking rates than anticipated.
- Spend time understanding altitude, distances for pipe and animals to travel, and stock grazing patterns. This will help design the best system for your farm.
- Talk to the pipe suppliers, they have a lot of experience and expertise with different farm systems and different water systems.
- Make sure you understand the requirements for different pressure ratings on pipes, whether pressure-break tanks are needed, what fittings are needed to handle the pressure, and what the water source will need to supply.
- Put in the entire system in one go rather than staging (if finance allows).

7.5.2 Water source

- Ensure the water source is clean and reliable (plentiful all year around, including in drought conditions).
- Having the water source near the power source is valuable for maintenance.
- If buying hill country, look at the water supply and allow a budget for a water system if needed.

7.5.3 Infrastructure

- Put in more troughs than you think you will need (particularly where sheep and cattle will be drinking from same trough). It is easier to put them in during installation than later, but at least allow for more to be put in.
- Burying the pipe reduces the risks to the whole system.
- Invest in a good pump.
- If you need to pump vertically, try and reduce the lift if you can. This might require two pumps.
- Use backflow preventers in the system.
- Don’t use a trough as a pressure-breaker because if it is infected with animal faeces this will affect troughs further down the line.
- Invest in repeater/telemetry to monitor tanks remotely.
- Consider adding in house supply with the system, and include a firehose/hydrant for filling spray machines.
- Put plenty of taps on feeder lines to enable isolation for fixing leaks.

7.5.4 Grazing management

- Use trough location to improve grazing management by locating troughs in areas that are currently poorly grazed.
- If finishing cattle or lambs, good quality, plentiful water is a necessity.
- Fence off gullies and waterways during installation, rather than afterwards (while the fencer is on the property).

7.6 Specific benefits and other uses of the system

As well as the general questions that farmers were asked, specific areas of pre- and post-benefits or otherwise were also targeted. These included changes in grazing and drought management, observed changes in animal health and welfare, environmental outcomes, and plans for further development of the system or the farm.

7.6.1 Grazing management

While one of the farmers reported no change in grazing management, the remainder all reported significant shifts since the stock water system was installed. Commonly, pre-scheme grazing management was complicated, extensive, grazed to where the natural water was, limited by climate (months where areas couldn't be grazed), variable utilisation of grass grown, and reliant on unreliable dams.

Conversely, once the system was installed, and in most cases, additional subdivision completed, grazing management improved dramatically. Farmers reported improved pasture quality and utilisation, the ability to rotationally graze all through summer and save up feed for mating, opportunity to over-sow or use crops, increase stocking rate, greater use of cattle as a management tool as well as a productive animal, the ability to single-sire mate, ability to invest in a techno beef system, and the ability to undertake further subdivision.

7.6.2 Drought management

A significant benefit was observed by all farmers in terms of their drought management. Nearly all of them had experienced at least one severe drought in recent years. Many reported droughts being less stressful as they only have to worry about feed, not water as well. As a consequence, management for most during a drought had much greater flexibility and utilisation with the whole farm being able to be grazed and rotations maintained. Farmers reported still being able to finish lambs, even in a drought, and were not having to 'take their chances anymore'. Not having to check dams and pull stock out of them on a daily basis provided significant peace of mind to farmers. On one North Canterbury property, which has experienced severe drought for the past 2 years, ewes were able to be maintained by feeding supplement on the paddock rather than sending off for grazing, or slaughter.

7.6.3 Animal health and welfare

None of the farmers used their water system for the provision of animal health treatments or preventatives (e.g. zinc for facial eczema management). However, a number of them have considered it as a possibility or are planning to use it for this at some stage. Possible treatments include zinc, copper, iodine, trace elements, and treatments to manage bloat. Some reported a reduction in liver fluke since the system has been in place, while some still report challenges from liver fluke. None of the farmers needed to treat their water although limescale was an issue on some of the properties. Some farmers managed flooding by turning off the water supply when water levels were high or water is dirty.

Farmers reported general improvement in animal health since putting the system in place and that animal movements around the farm were much easier with water more readily available to stock.

Farmers also reported significant improvement in animal welfare with nearly all of the farmers stating they no longer need to drag animals out of muddy dams, that stock are less stressed as they don't have to walk long distances to get water, that animals can access water quickly and easily, and that animals are fed better due to better grazing management. Other improvements in animal welfare included less misadventure, farmers stressing less about the welfare of their animals, and being able to keep cattle on-farm most years rather than selling store.

With the advent of the water reticulation system, stock spend much more time around the troughs. As a result, additional shade and shelter provision is planned on most of the properties. This includes the use of regeneration of scrub/bush, shelter belts for shelter and shade, and pole planting for erosion control, shade and drought fodder.

7.6.4 Environmental

Environmental gains were also reported by most of the farmers. Most of the farmers had an environmental plan and reported that the stock water reticulation and subdivision made implementing the plan easier. Environmental benefits reported include fencing of waterways to protect the water source, and enhance the water quality, providing culverts or bridges for all stock crossings on waterways, fencing off dams and wetlands, fencing off bush, considering QEII covenants of bush, riparian planting and riparian regeneration, planting and fencing old dams, and regular pole planting for erosion control.

Farmers reported no longer seeing stock tracks down to rivers, even with access, stock preferring to drink from troughs rather than natural waterways, and now having the confidence to fence dams and waterways.

There was a range of distances of stock exclusion planned and completed, with some farmers having full stock exclusion, others aiming for this, and some working towards stock exclusion where practical. Several kilometres per year of stock exclusion are planned across the farmers interviewed who have not completed full stock exclusion yet.

7.6.5 Further development

Some farmers are planning further subdivision fencing on their property now that the water system is in place. Highlighting the value of the schemes to the farmers, most are looking at some form of extension of their water scheme or installing additional schemes on their properties to cover greater areas. Two of the properties are investigating small-scale irrigation. Of the farmers interviewed, plans are in place for over 2,500 hectares of additional area to be covered by individual extension of schemes.

8.0 IMPACT ON CAPITAL VALUE OF THE FARM

The installation of a stock water reticulation scheme is also very likely to have a positive impact on the capital value of the farm. Discussion with farm valuers indicated that, relative to a similar farm with only natural water supply, a stock water system that provided reliable, good quality water in every paddock could (a) add 1.5 – 5.0% additional value to the property; and (b) may result in the property being sold more quickly.

While this aspect is important, there is a lot of variability around such a valuation, and this was therefore not included in the investment analysis.

9.0 DISCUSSION/CONCLUSIONS

Overall, the analysis has shown a significant return on investing in a stock water reticulation system, both in monetary terms and farmer well-being. All of the farms showed a return greater than 8% (range 14-85%), which was the targeted rate of return.

The general sequence of events leading up to the improved stock numbers/performance is:

- Installation of the water reticulation scheme, followed by
- Increased subdivision, followed by
- Better grazing management, followed by
- Improved pasture utilisation, and/or better pasture production, followed by
- Improved stock numbers and/or performance

Often several of these happen concurrently, but the installation of the water reticulation is the primary prerequisite. A couple of the case study farms had increased subdivision first, thereby triggering the requirement for a better water supply. All the farms had sufficient storage to provide a 24-48 hour buffer (at worst) in case of pump breakdown or major breakage in the system.

Given the sequence above, the overall benefits of the increased stock numbers/stock performance have been attributed to the water reticulation scheme, albeit also including the capital cost of subdivision fencing and extra stock. Within this, it must be noted that the benefits of good subdivision have long been noted (Squire, 1986).

There could, however, be a number of other factors which are also contributing to the increase in performance. An example here is lambing and calving performance. While the better feeding as a result of improved grazing management would undoubtedly be a major factor in improving performance, the input of better genetics and selection pressure would also assist. On one farm, a water scheme was installed just after the farm was taken over. While it was a material factor in boosting the farm's performance, the overall better management of the farm would have also assisted.

These factors are difficult to readily monetise, but could mean the returns calculated are slightly overstated.

In noting this, there are also other beneficial factors which have not been included in the analysis. A key component of this is the "peace of mind" factor, which all of the case study farmers mentioned, particularly relating to having water available during dry/drought periods. This benefit is (a) very significant; but (b) very much an intangible benefit and therefore difficult to monetise.

Another "under-valued" factor was the significant reduction of pulling stock out of muddy dams, especially during droughts. Almost all of the farmers mentioned this as a benefit, and in a number of instances a significant one. The value of this is partially captured in the "drought benefit" discussed in Section 3, although the vast majority of this benefit relates much more to the productive impact rather than the time and effort involved in rescuing stock.

Overall, therefore, there could be a number of "overs and unders" relating to the return figures calculated. Nevertheless, the figures are relatively robust, and assuming that the unders and overs did not balance out, then at worst a degree of downward movement would still indicate a very strong return from investing in a stock water reticulation system.

The pre-reticulation system for the case study farms was that stock water was supplied by "natural" sources, primarily a few streams or creeks, and mostly via dams. The reticulation system therefore was a major step forward in supplying good, reliable water to most paddocks. Given the situation where a farm had good reliable natural water in most/all paddocks with easy access for stock, the return from reticulating water could be expected to be much less.

For the case-study farmers, the main motivation was to provide water into areas of the farm that had limited or poor quality natural water, particularly over the summer period. With reliable stock water available, this then allowed for further subdivision, which in turn allowed for better grazing management and improved animal performance.

All the farmers reported improvements in animal health and welfare linking the increased performance to health, and feed supply. This was in addition to the previously mentioned benefits of not having to pull stock out of muddy dams, and animals not having to walk long distances for a drink.

Costs or benefits of clean, fresh water for animal health and welfare have not been well documented and is difficult to quantify in a study such as this. Rather, farmers were asked if they observed any benefits. The authors feel that further work on quantifying this in New Zealand farming systems would be hugely beneficial to the agricultural sector.

Another avenue for further research would be the link between water and the provision of good shade. This was not explored with the case study farmers, who mostly had good shade from bush, scrub or planted species such as poles for erosion protection.

While not readily quantifiable, the case study farmers reported 'peace of mind' and reduced stress since the water system was installed, and where relevant, reduced stress and pressure on staff. It could be assumed that this reduced stress meant that more effort could be channelled into management decisions contributing to the increase in performance.

All the farmers reported on co-benefits from installing their system for the environment including stock exclusion from waterways, protection of native bush and the protection of wetlands and dams. They reported that they now have 'confidence' to protect these areas without the concern that stock will not have access to water.

With pressure on the sheep and beef industry to exclude (particularly) cattle and deer from waterways, so called, 'win-wins' are an important tool in helping farmers to achieve this without detrimental impact on their farming business, particularly for extensive sheep and beef farming systems. Supporting hill country farmers by allowing water reticulation systems as an alternative to fencing streams, may be a better way to encourage stock exclusion in the interim. While stock exclusion is a very important tool for managing water quality, many of these farms have significant stream lengths and there may be minimal benefit in 10's of kilometres of fencing for both the environment and the farm, which may be obtained by stock water only.

The increase in the proportion of cattle on some of the farms could pose an increased environmental risk in these systems, particularly with respect to nitrogen leaching. This will vary, as a number of these farmers had also changed cattle type; e.g. reduced breeding cows, increased finishing cattle, which could reduce nitrogen leaching level. The authors chose not to analyse this impact as it was likely to be minimal, and OVERSEER outputs for hill and high country properties across the broad range of soil types and topography that the case study farmers were farming have not been validated. Thus, it would only provide an indicative output with little confidence. Case study farmers who had an OVERSEER Nutrient Budget all showed low to average outputs of nitrogen leaching within their current system. Further, more comprehensive work may be required to determine if this is real.

For these farm systems, the risk of phosphorus and sediment loss is likely to be greater than nitrogen, and the increased subdivision fencing to contour, riparian fencing and planting, regeneration of scrub and fencing of bush are all likely to have delivered more environmental benefits than a possible shift in OVERSEER numbers.

The case study farmers interviewed were all clear on the benefits they have observed from their respective systems, and on this basis their main advice to other farmers considering installing systems was 'Just do it!', with a range of additional practical advice. Interestingly, most of them suggested putting in a scheme that was over-specifications for what was planned. Given the relatively short period of time these schemes have been in place this is further evidence to support the value of a scheme. Most are looking at expanding their existing scheme or adding additional schemes in the coming years.

Commentary from the farmers and the comprehensive investment analysis demonstrate a clear benefit to hill country farmers of investing in stock water reticulation. The financial benefits are positive, with even the lowest IRR of 14%, still being significantly higher than the 8% discount rate used as a baseline. Further, the non-monetary benefits such as reduced stress, improved animal health and welfare, confidence to protect waterways, improved grazing management and peace of mind during a drought indicate that this investment is unlikely to be detrimental to the health of the farming business. With adequate planning, high quality advice, and good quality contractors supporting installation, these systems will provide a positive return on most New Zealand hill country sheep and beef farms.

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11.0 APPENDIX 1: CALCULATION OF THE 8% REAL DISCOUNT RATE

(Treasury, 2008)

The 8% real is calculated as follows:

WACC (real) = [(1+WACCn) / (1+i)]-1

Where: WACCn = [RFR x (1-Tc) + (Ep x βa)] / (1-Te)

Tc (corporate tax rate) = 30%

Te (effective tax rate) = 20%

Ep (equity risk premium) = 7%

RFR (risk free rate) = 6.4%

i (inflation rate) = 3%

βa (asset beta) = 0.67

WACC (weighted average cost of capital)

WACCn (nominal weighted average cost of capital)

12.0 APPENDIX 2: STOCK WATER RETICULATION STUDY QUESTIONNAIRE

General Questions Farm Identity	
Farm Location	
When was the system installed?	
What were the reasons for installing a stock water reticulation system?	
What analysis did you complete before making a decision	
What assumptions around benefits did you make?	
Who else was involved in the decision?	
Were there any factors during installation that were unexpected?	
What costs have occurred which you weren't expecting?	
What benefits have actually eventuated?	
What advice would you give to other contemplating installing a stock water system?	
If you knew at time of installation what you know now, would you do anything differently?	

Farm Details

Total Area (ha)		
Flat area (ha or %)		
Rolling - cropable (ha or %)		
Rolling – non cropable (ha or %)		
Steep (ha or %)		
Number of paddocks	Pre:	Post:
Effective area (ha)	Pre:	Post:

Stock Numbers Wintered

	Pre water system	**Post water system**
MA Breeding Ewes		
2th ewes		
Ewe hoggets		
Mixed sex hoggets		
Rams		
MA Breeding cows		
R 2 heifers		
R 1 heifers		
R 3 Steers		
R 2 Steers		
R 1 Steers		
R 2 Bull Beef		
R 1 Bull Beef		
Breeding Bulls		
Other stock:		

Stock performance (averages for pre & post)

	Pre water system	Post water system
Lambing % (lambs docked/ewes mated)		
Lambs weaned (% or number)		
Number ewe lambs retained		
Number or % lambs sold store		
Lamb kill weights (kg)		
Total wool weight (kg)		
Calving % (calves weaned/cows mated)		
Number or % cattle sold store		
Number of heifers retained		
Cattle kill weights (kg):		
Were hoggets mated?		

Description of reticulation system (including source of water and energy source)

Fertiliser

	Pre water system		Post water system	
Type	Kg/ha	$ applied	Kg/ha	$ applied

Supplementary feed

	Pre water system		Post water system	
Made on-farm	Tonnes/bales	Cost	Tonnes/bales	Cost
Purchased in	Tonnes/bales	Cost	Tonnes/bales	Cost

Grazing management

Pre water system	Post water system

Other Factors

Animal health Do you use the reticulation system for animal health, e.g. zinc dosing? Any improvement in animal health?	
Animal Welfare Influence of the water system on animal welfare	
Future plans for subdivision/stock exclusion from streams	
Future plans for extension of the water reticulation system	
Do you have a Farm Environment Plan/SLUI Plan? What influence does the water reticulation system have on this?	
Do you need to treat the stock water?	

Are you planning any shade/shelter/riparian planting? Fencing-off of scrub/forestry blocks for regeneration? What is the influence of water system on this?	
Influence of the water system on your drought management	
Access to natural water Km of water ways fenced/% fenced off Need for culverts/stock crossings Influence of reticulated water system	

Capital Costs

	Cost ($)
Pump(s)	
Electricity	
Pipes	
Storage tanks	
Pressure relief tanks	
Troughs & fittings	
Earthworks	
Metal	
Contract labour	
Fencing	
Council Consent	
Extra stock	
Extra fertiliser	
Other (specify):	
Subdivision fencing	
Cost saving from maintaining dams	

Capital Costs – Farmer input

Farmer time (hours)	
Tractor (horsepower/hours)	
Digger (horsepower/hours)	
Bulldozer ((horsepower/hours)	
Other (specify)	

Operating Costs

	Cost ($)
Repairs and maintenance	
Insurance	
Electricity	
Fuel	
Farmers time (hours/week)	
Other (specify):	

13.0 APPENDIX 3: STANDARD COSTS AND RETURNS USED

The following gross margins, schedules and animal values are based on 5 year average values from Beef + Lamb New Zealand Economic Service

Gross Margin ($/SU)		Sheep	Cattle	Deer
NI Hill country		$70.02	$67.72	
SI Hill Country		$68.23	$58.88	
Bull Beef			$89.01	
SI Hill Country				$48.61
Average Returns ($/hd)				
SI Hill Country	Prime Lamb	$89.15		
	Store Lamb	$67.66		
NI Hill Country	Prime Lamb	$89.95		
	Store Lamb	$70.30		
Schedules ($/kg)				
All grades Lamb		$5.59		
YM Lamb		$5.68		
MX1 Mutton		$3.28		
P Steer and Heifer - 270.5-295.0 kg		$4.35		
M Cow - 170.5-195.0 kg		$3.20		
M Bull - 270.5-295.0 kg		$4.25		

NI Beef Weaner price	$603	
Prime Beef margin		
Buy 18 mnth, sell @ 2 yr+	$389	
Prime vs Store Cattle (1-1.5 yr store vs 2 yr+ prime)		
	$467.40	
Weaner Hinds	$174	
Weaner Stags	$200	
Venison schedule	$5.93	

Capital Values (5year average IRD values)	
Mixed-age ewes	$123
Two-tooth ewes	$140
Ewe hoggets	$94
Ram and wether hoggets	$85
Breeding rams	$278
Mixed-age cows	$1,065
Rising two-year heifers	$870
Rising one-year heifers	$571
Rising three-year and older steers and bulls	$1,227
Rising two-year steers and bulls	$1,005
Rising one-year steers and bulls	$675
Rising two-year steers and bulls	$1,005
Rising one-year steers and bulls	$675
Breeding bulls	$2,197
Mixed-age hinds	$413
Rising two-year hinds	$365
Rising one-year hinds	$197
Breeding stags	$1,471
Rising one-year stags	$240
Rising two-year and older stags (non-breeding)	$450

Contract rates					
Tractors		Bulldozer		Digger	
HP	$/hour	HP	$/hour	Tonnes	$/hour
150	110	160	160	22	$170
110	81	140	140	13	$150
90	66			10	$135
80	59				
40	35				