IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of the proposed Variation 2 to the Proposed Canterbury Land and Water Regional Plan - Section 13 Ashburton

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STATEMENT OF PRIMARY EVIDENCE OF MARK NEAL FOR FONTERRA CO-OPERATIVE GROUP LIMITED AND DAIRYNZ LIMITED

15 MAY 2015

RUSSELL McVEAGH

B J Matheson / A L McConachy
Phone 64 9 367 8000
Fax 64 9 367 8163
PO Box 8
DX CX10085
Auckland

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1. INTRODUCTION

1.1 My full name is Mark Beaumont Neal. I am employed by DairyNZ Limited ("**DairyNZ**") as a Farm Systems Specialist, working across research and development at the interface of farm, financial and environmental impacts. I have been employed with DairyNZ since July 2014.

Qualifications and experience

1.2 I hold a degree in Agricultural Economics (First Class Hons) from the University of Sydney (1999). I have completed the Intermediate Sustainable Nutrient Management course, which uses the Overseer model. I also have training in the use of Farmax, a farm modelling tool.

1.3 At the University of Sydney, for my final year thesis, I created a whole farm model of a dairy farm to analyse optimal management decisions. I later published an advanced version of this model in the Journal of Dairy Science (2007), and expanded it to consider risk in both climate and prices in a later publication for the Australasian Dairy Science Symposium (2010).

1.4 I have published research on farm modelling, and presented at numerous conferences on a range of work on the scientific, economic and environmental aspects of dairy farm systems. A list of my papers, publications and industry presentations is attached as Appendix 1 to my evidence.

1.5 At the University of Queensland, I worked with the Risk and Sustainable Management Group on, amongst other projects, a sophisticated economic model of land use, farm profits and resource use operating at a catchment level to evaluate alternative property rights regimes.

1.6 I was responsible for developing the economic and optimisation capability in the DairyNZ Whole Farm Model, which is used for modelling research projects around farm systems, both by DairyNZ and with other industry partners.

1.7 I have extensive practical dairy farming experience, including with my family's dairy operation of a 700 cow dairy farm in Australia, and have managed grazing-based dairy operations in North America and South America.

Background

1.8 My involvement in the proposed Variation 2 to the Canterbury Land and Water Regional Plan - Section 13 Ashburton ("**Variation 2**") commenced in August 2014, where I was involved in the modelling process of representative farms, as performed by Mr Alfredo Adler under contract for DairyNZ. The aim of this modelling was to determine the cost of mitigation under the proposed rules, checking these results with farmer and industry groups, and assisting the scenario modelling aggregated at a catchment level carried out by Dr Brian Bell, of Nimmo Bell.

1.9 I am familiar with the provisions of Variation 2 to which these proceedings relate. In preparing my evidence I have reviewed the relevant parts of the section 32 Report and the section 42A Report.

1.10 I have also read the evidence of Ms Hayward, Dr Fairgray, Dr Bell, Dr Brown and Mr Willis.

Code of Conduct

1.11 I have read the Code of Conduct for expert witnesses contained in the Environment Court's Practice Note as updated in 2014 and agree to comply with it. In that regard, I confirm that this evidence is within my area of expertise, except where I state that I am relying on the evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in this evidence. In respect of paragraph 7.2(b) of the Code of Conduct, I record that I am an employee of DairyNZ.

2. SCOPE OF EVIDENCE

2.1 In my evidence I provide an assessment of the economic impact of Variation 2 at a farm-scale on 10 existing farmers as case studies in the Lower Hinds/Hekeao Plains Area.

2.2 I have also assessed on the same case study farms the effects of DairyNZ/Fonterra's proposed alternative solutions, as set out in the proposed amendments to the rules in Appendix 1 of the evidence of Mr Willis.

2.3 In this evidence I will:

(a) Outline the deficiencies of the on farm modelling relied on by Environment Canterbury for the economic evaluation, and describe the impact of these deficiencies.

(b) Show the effect on farm Earnings Before Interest and Taxes ("**EBIT**") and cashflow of Variation 2, and compare this with alternatives that meet the same catchment targets at a lower cost to farmers and the community.

(c) Describe how the timing of reductions is important to minimising adverse on-farm impacts.

(d) Describe the likely land use change and associated benefits based on current knowledge on alternative land uses and their respective environmental impact and profitability.

(e) Outline how current research and development activities can enhance environmental and economic outcomes, complementing and informing the regulatory process.

3. EXECUTIVE SUMMARY

3.1 I do not consider that Environment Canterbury's assessment of the on-farm impacts of Variation 2 is accurate. In my opinion, the analysis relied on by Environment Canterbury contains several incorrect assumptions that are not justifiable. These assumptions overstate the ease of mitigation for farmers, and severely understate the costs involved in the required mitigations. In combination, these assumptions imply that it is profitable for dairy farmers to reduce their N leaching, and to continue large scale dairy conversions at a leaching cap of 27 kg N/ha/yr.

3.2 In reality, I consider that Variation 2 is likely to lead to a much higher cost of implementation than that modelled by Environment Canterbury, mainly because on farm mitigation is more costly for dairy farms than assumed by the mitigation options set out in Environment Canterbury's analysis. The incorrect assumptions at an on-farm level have led to Environment Canterbury's assumptions at a catchment-wide level being incorrect.

3.3 I have modelled the on-farm impacts of Variation 2, using different assumptions to those used by Environment Canterbury, which I consider to be more comprehensive, accurate and realistic. (For ease of reference, I refer to the proposed ECan solution, as modelled with more realistic inputs, as "ECan Amended Variation 2.") The key differences between Environment Canterbury's model and the ECan Amended Variation 2 is set out in Table 1 in Section 4 below. Adjusting the inputs to more realistic assumptions shows that the impacts of the 45% proposed N reduction for dairy in Variation 2 would lead to a reduction in EBIT (adjusted) of between 25% and 33%. This is in stark contrast to the overall positive impact predicted by Environment Canterbury's economic modelling.

3.4 In my opinion the significant economic impact of the proposed N reductions is such that a slower transition to large percentage reductions is justified. This would allow debt levels and capital values to rebalance, and allow for new cost-effective mitigations to be demonstrated at farm scale and adopted across the catchment.

3.5 DairyNZ/Fonterra have proposed an alternative solution that would apply a fixed rate of N reduction of 36% across all high emitters (including both dairy and dairy support), in order to achieve the same objective as Variation 2 (being a root zone N concentration of 9.2mg/L).

3.6 DairyNZ/Fonterra have modelled two different situations, a 3-stage or a 4-stage option, for which reductions are staggered over time to reach 36% by 2035. The DairyNZ/Fonterra 3-stage option is less costly than both the 4-stage option or Variation 2 as proposed. Both options proposed by DairyNZ/Fonterra would achieve the same objective as Variation 2 (a root zone N concentration of 9.2mg/L), but at less cost.

3.7 Although DairyNZ/Fonterra's 3-stage option delays the requirement for a 15% N loss reduction until 2025, I consider that some relatively cost-effective mitigation is likely in the period 2017 - 2020 through implementation of the good management practices required by the Matrix of Good Management ("**MGM**") process.

3.8 Less upfront mitigation is also justified based on the potential effectiveness of Managed Aquifer Recharge ("**MAR**"), improvements in science and the cost-effectiveness of alternative mitigations, as well as improvements in science that support ongoing enhancements to Overseer.

4. DEFICIENCIES IN ON-FARM MODELLING RELIED ON BY ENVIRONMENT CANTERBURY

4.1 Before I explain the alternative modelling undertaken by DairyNZ, I will set out what deficiencies result with Environment Canterbury's economic modelling and why I considered it necessary to amend some of the inputs to the Environment Canterbury model prior to undertaking a comparative assessment between the Environment Canterbury and DairyNZ/Fonterra solutions.

4.2 Environment Canterbury modelled the on-farm impacts of Variation 2 in the report prepared by McFarlane Rural Business titled "Hinds Catchment Nutrient and On-Farm Economic Modelling" ("**MRB On-Farm Report**"). There are stark differences in the results of the MRB On-Farm Report and the modelling undertaken by DairyNZ.

4.3 These differences are largely responsible for the variances that occur in the wider economic impacts described in the evidence of Dr Bell and Dr Fairgray, compared with those in the "Economic impact assessment of the Hinds water quantity and quality limit setting process" ("**Hinds Catchment Economic Report**"). DairyNZ's modelling of mitigations start from the premise that simple mitigations will be costly, on the basis that if it were simple and profitable to reduce N leaching, farmers would do this voluntarily, negating the need for a regulatory approach. This is consistent with the recommendations from the policy framework in Figure 2 of the Hinds Catchment Economic Report.

4.4 A summary of the difference in assumptions between Environment Canterbury and DairyNZ/Fonterra is set out in Table 1, below.

Table 1: Difference in Environment Canterbury and DairyNZ/Fonterra assumptions

	MRB model	**Fonterra/Dairy NZ model**	**Implication for Environment Canterbury Economic Impact Assessment of using MRB modelling/report and comments**
Assumption: Milk price	The assumed milk price of $6.40 (including dividend, p66) is similar to the 2012/2013 payout of $6.33, and is considered reasonable.	The assumed milk price of $6.61 (including dividend) is derived from a 5 year average (deflated).	No significant impact on conclusions by itself.
Assumption: Baseline dairy EBIT	2 dairy farms modelled, with Current EBIT of $4,289 and $3,686 per ha (Table 2).	10 dairy farms modelled, based on actual farms. Average profit (adjusted for milk price) is similar to the 2012/13 region average of $2,714 (DairyNZ 2014).	Benefits of all options vastly overstated by MRB by having dairy farm EBIT 36% to 58% above region average. No apparent basis for MRB to use such a high EBIT.
Assumption: Irrigation method	Uses Overseer "Actively Managed" option to reduce drainage below root level at low cost.	Uses "Method Only" as per Overseer Best Practice Data Input Standards.	Ease of mitigation severely overstated/cost severely understated.
Assumption: Improvements in per cow production	Assumes a 10% increase in kg milk solids/cow (back calculated from table 5) from Current/GMP to Advanced Mitigation 1("**AM1**"). This is reasonable if assumed to occur over ten years, and consistent with historical trends. However, none of the real increase in costs (eg labour, materials) that would accompany this timeframe have been included.	Assumes per cow production is determined by farm factors and managerial ability, and does not vary in the short term. Any increase in per cow production will also be accompanied by increases in real costs, so cannot be modelled independently.	Ease of mitigation severely overstated/cost severely understated.
Assumption: Debt	Average debt assumed.	Sensitivity to debt levels modelled.	The risk of excessively fast adjustment to steep % cuts in N leaching was not explicitly considered on farm solvency, and the potential flow on to capital values and industry stability.
Result: Cost of mitigation to reduce N leaching by 45%	For the two dairy farms modelled, moving from Current to AM1 reduced N leaching by more than 45% (table 3), while EBIT did not decrease, but **increased** by 0.8% to 7.9%. The effect on Net Profit after Tax (NPAT) was mixed (due to the cost of some infrastructure), but there was still a benefit to dairy 1 (+12.1%), and a relatively modest cost to Dairy 2 (-13.9%).	For dairy farms over 20kg threshold, the impact of a 45% reduction was between 25% and 33% **reduction** in EBIT (adjusted).	This key difference in results is a significant influence on many of the subsequent aggregated modelling results, and would, in my opinion, lead to different options to be considered, with different conclusions reached.
Assumption: Profitability of Dairy farms at 27 kg N leached /ha/yr	Farms are still potentially very profitable at leaching levels below 27 kg N/ha/yr (being AM1 for Dairy 1, and AM2 for Dairy 2, Table 3).	The profitability (EBIT) of farms at a leaching level of 27 kg N/ha (on soils comparable to the potential area of expansion) is significantly reduced, making conversion unattractive from a financial perspective, and hence much less likely. Thus the available N for intensification is assumed to be used with only 5,000 ha from Sheep and Beef to Dairy, 10,000 ha of mixed farming intensified with some dairy support activities, and 22,500 ha of flexibility cap intensification.	The expansion assumed to occur from sheep and beef to dairy or dairy support is not viable anywhere near the scale of 30,000 ha if conversion is dependent on meeting a limit of 27kg N leached per hectare per year. Intensification is possible on a reasonable number of hectares, but the changes in enterprise will be more modest, with a correspondingly modest improvement in EBIT.

4.5 As shown in Table 1, adjusting the key assumptions relied on in the MRB On-Farm Report significantly alters the modelled impacts of EBIT of dairy and dairy support in the Lower Hinds/Hekeao Plains Area.

4.6 Two differences explain a great deal of the variation between the EBIT results of the MRB On-Farm Report and those presented by DairyNZ/Fonterra. These two key differences are irrigation efficiency and cost less increases in per cow production. Each of these are discussed in more detail below.

Irrigation efficiency

4.7 The use of irrigation efficiency, largely by moving from "method only" to "actively managed" irrigation in Overseer was assumed by the MRB On-Farm Report to be low cost, but highly effective at mitigating N leaching. This arbitrary Overseer input selection, is however, not permitted by the Overseer Best Practice Data Input Standards for dairy farms ("**OMSK 2014**"). These input standards and recent significant changes to the irrigation component of Overseer (Overseer VS.) highlight the significant influence of irrigation options on Overseer nitrogen loss results. Indeed, sensitivity analysis carried out in the MRB On-Farm Report (Table 18, page 56) showed that for the Dairy 1 farm, while using "actively managed" irrigation, the Advanced Mitigation 2 scenario reduced N leaching by 55%, while "method only" or "volume specified" irrigation reduced N leaching by only 37%, implying that the much more expensive Advanced Mitigation 3 would be required to meet reductions of 45% proposed by Variation 2.

4.8 Another difference in irrigation modelling is that the modelled described as "Dairy 2" assumed 15% of the area was in border dyke irrigation and was converted to centre pivot irrigation. The current land use assessed in Dr Brown's evidence suggests only 3% of dairy land is border dyke irrigated. Furthermore, the remaining border dyke areas are likely to be small areas, such as corners of farms, that are not easily converted to spray irrigation, as is assumed in the MRB On-Farm Report. This further overestimates the possible gains.

4.9 Finally, I consider that the reliance on irrigation efficiency may be counter to some of the desired outcomes of Variation 2, namely a reduction in shallow groundwater concentrations. This is discussed in Ms Hayward's evidence.

Increases in per cow production

4.10 The approach used by the MRB On-Farm Report for improved production per cow, in combination with reduced stocking rates, is theoretically possible, but not routinely found in practice over short timeframes. Over time, we can expect such improvements incrementally, but not realistically on all farms to the full extent that some can achieve it. Regardless, some improvements could apply (within reason) equally to the Variation 2 and DairyNZ/Fonterra alternatives. However, at the expected pace of improvement based on historical practice, this would not provide the "win-wins" suggested by the MRB On-Farm Report. Indeed, these slow historical improvements have done little more than counteract the increases in costs that are also expected to occur into the future.[1]

5. COMPARATIVE ASSESSMENT OF THE EFFECTS ON EBIT OF PROPOSED VARIATION 2

5.1 I assess the effects on EBIT of proposed Variation 2 at a farm-scale on 10 existing farmers in the Lower Hinds/Hekeao Plains Area, using the assumptions set out in Table 1. Due to the deficiencies described above, in order to accurately determine the farm scale impacts of Variation 2, the percentage reductions were modelled as occurring in the farm level models developed by DairyNZ.

5.2 In this section I:

(a) Set out my method of analysis;

(b) Compare the effects on EBIT on dairy and dairy support for:

(i) Environment Canterbury's proposed Variation 2;

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1 For example, over the 20 year period from 1992 to 2012, milksolids production per cow in NZ rose from 259 kg MS per cow to 346 kg MS per cow, a compound annual growth rate of less than 1.5% (Dairy Statistics 2014). The MRB report assumes from GMP to AM2 per cow production increases around 10% (table 5). Over the 10 year timeline from GMP to AM2 assumed by the report "Economic impact assessment of the Hinds water quantity and quality limit setting process", this implies a compound annual growth rate that could possibly be achieved relative to historical rates, but over ten years, real increases in costs would also be expected to occur, so the implied productivity (and EBIT) benefit is enormously overstated.

(ii) DairyNZ/Fonterra's proposed 3-stage approach; and

(iii) DairyNZ/Fonterra's proposed 4-stage approach.

Method of analysis

5.3 The Lower Hinds/Hekeao Plains Area is approximately 127,008 ha in area and is made up of the following land uses area (estimates of land use are detailed in Dr Brown's evidence):

(a) 49,089 ha of dairy;

(b) 27,547 ha of mixed dairy wintering or support;

(c) 14,138 ha of sheep/beef/sheep and beef; and

(d) 36,234 ha of other (including arable).

5.4 Of these, the enterprises most affected by the proposed nitrogen controls in Variation 2 are dairy operations and dairy support. To estimate the effects of Variation 2 on these farm systems, a group of 10 representative dairy farms and an intensive dairy support farm were modelled. The process used real farm information to calibrate Farmax and Overseer models (Overseer V6.1.3[2]), and mitigations were then carried out from this base. This analysis was undertaken by Mr Alfredo Adler, a farm systems modeller under contract to DairyNZ. I reviewed Mr Adler's analyses as part of DairyNZ's internal review process.

5.5 The mitigation approach was to follow a process of de-intensification. This would start with a reduction in N fertiliser, which would result in lower grass growth, and so a pro-rata reduction in stocking rate was carried out. The diet of the cow (and hence milk production) was kept constant, consistent with the managerial ability currently being exhibited. Having said this, some progress in skills is implicitly assumed to manage the more frequent and rapid swings in feed supply from surplus to deficit and back again with lower stocked systems.

5.6 This modelling approach is transparent, reasonably consistent with current managerial ability and does not require irreversible investment in infrastructure (eg barns, discussed further in section 9.4, or irrigation

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[2] Overseer V6.1.3 was used for the farm modelling following the OVERSEER® Best Practice Data Input Standards for modelling dairy farms.

efficiency, which is potentially incompatible with the desired goals of Variation 2 (see evidence of Ms Hayward)).

5.7 One of the assumptions in the modelling work was that the dairy farms were modelled as dairy platforms. Specifically, the area of land that milking cows used during the lactation period was used as the basis for the modelling. This is, as far as I can tell, consistent with the approach of the MRB On-Farm Report. The dairy-related activities that are not situated on the dairy platform are considered in the modelling of dairy support.

5.8 An assumed average milk price of $6.61 per kg MS was used. This was determined as the average real milk price ($2013) over the 5 years to 2012/13, based on payout data, deflated with the CPI (Statistics NZ). This is also quite consistent with the short term average of the two most recent years for which Fonterra payout data (including dividend) is available of $6.63, being made up of 2013/14 ($8.50, much higher than average) and 2014/15 season estimate ($4.75, much lower than average).

5.9 Farm costs were determined from the 2012/13 season, which was a year with a payout of $6.33, which is reasonably close to the assumed long term average of $6.61.

5.10 Each of the ten dairy platforms were assumed to represent a percentage of the dairy platforms in the catchment. The percentage representation of each farm was determined by first grouping farms into two soil categories (light-free draining soils, and heavy/poor draining soils). Further characterisation and representation of farms was based on production and profitably in consultation with DairyNZ/Fonterra staff who are familiar with farms in the Hinds/Hekeao Plains Area, and supported by a survey of 40 Hinds/Hekeao Plains dairy farmers. The survey gathered information of farm systems, general management practices and dairy support systems.

5.11 Dairy farms belonged to one of three leaching categories:

(a) Those leaching less than 20kg N/ha/yr, where N loss reductions are not required by Variation 2. Two representative farms fitted into this category.

(b) Farms leaching between 20 and 36 kg N/ha/yr, which would hit the threshold of 20kg N/ha/yr before a full 45% reduction was required. Three representative farms were in this category.

(c) Farms leaching more than 36 kg N/ha/yr, of which a 45% reduction would be required by 2035. Five representative farms fitted into this category.

5.12 The farm EBIT was modelled. There were no major changes in capital investment or farm system with the process of de-intensification, but lower milk production meant less co-operative shares were required,[3] and less cows meant that less capital was invested in cows. An adjustment for this "freed up" capital was made to the EBIT for consistency and comparability. This EBIT adjusted for changes in capital structure will be referred to as "EBIT (adjusted)". In other words, the benefit of freed up capital under de-intensification means that EBIT (adjusted) is slightly higher than the comparable EBIT figure would be.

Effects on EBIT on dairy and dairy support of proposed Variation 2

5.13 Table 1 summarises the findings regarding changes in EBIT (adjusted), which are explained in the following paragraphs and displayed in the following figures (1-5).

Table 2: EBIT (adjusted) per hectare as impacted by percentage reductions in N leaching. [4]

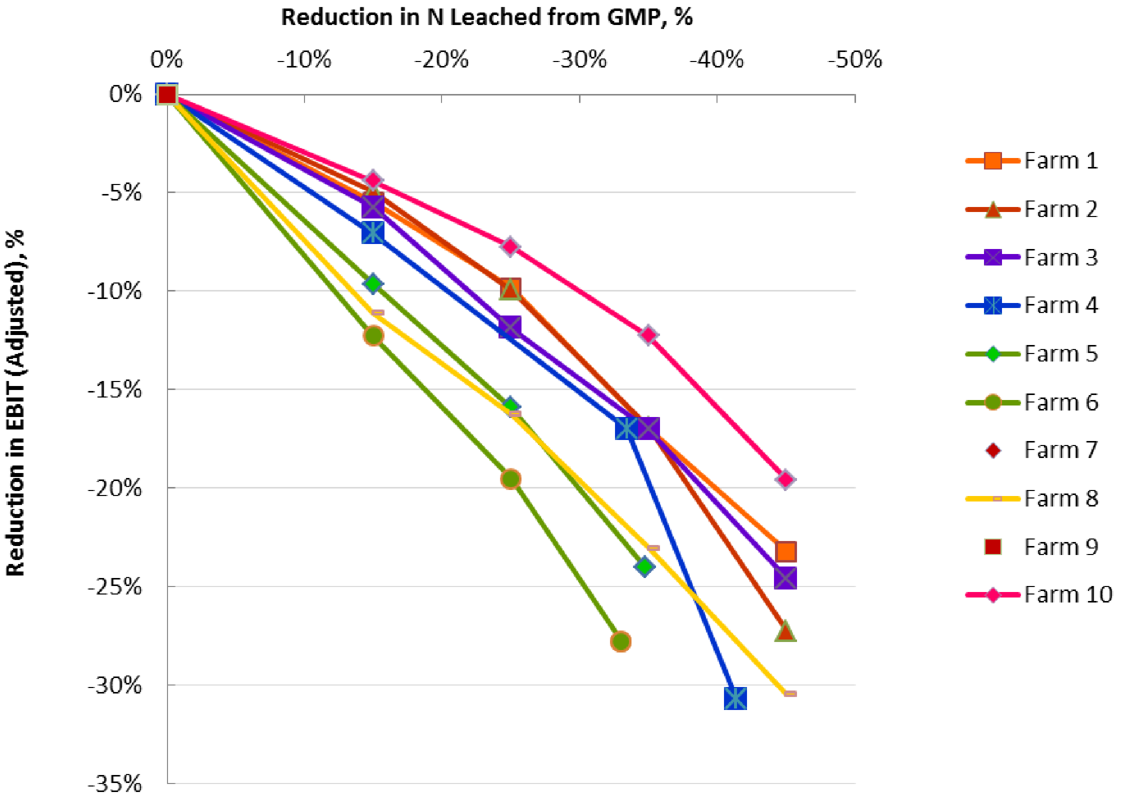
			Earnings after interest (Before tax, $)		
Year	*N leaching reduction*	*EBIT (ad) % reduction*	*25th percentile of debt/assets (ie low debt)*	*Median debt/assets*	*75th percentile of debt/assets (ie high debt)*
	GMP	-	879 to 3,873	144 to 3,138	-591 to 2,403
2020	*15%*	*4 to 12%*	604 to 3,613	-131 to 2,878	-866 to 2,143
2025	*25%*	*8 to 20%*	442 to 3,354	-293 to 2,619	-1,028 to 1,884
2030	*35%*	*12 to 31%*	256 to 2,987	-479 to 2,252	-1,214 to 1,517
2035	*45%*	*20 to 31%*	256 to 2,529	-479 to 1,794	-1,214 to 1,059

3 There are two alternative dairy companies to Fonterra that operate in the Hinds Area, one of which is also a farmer-owned cooperative, but Fonterra still has more than 80% of supply base.

4 Table is for the 8 farms affected by the Variation (Two had leaching of less than 20 kg/ha, being Farm 7 and Farm 9).

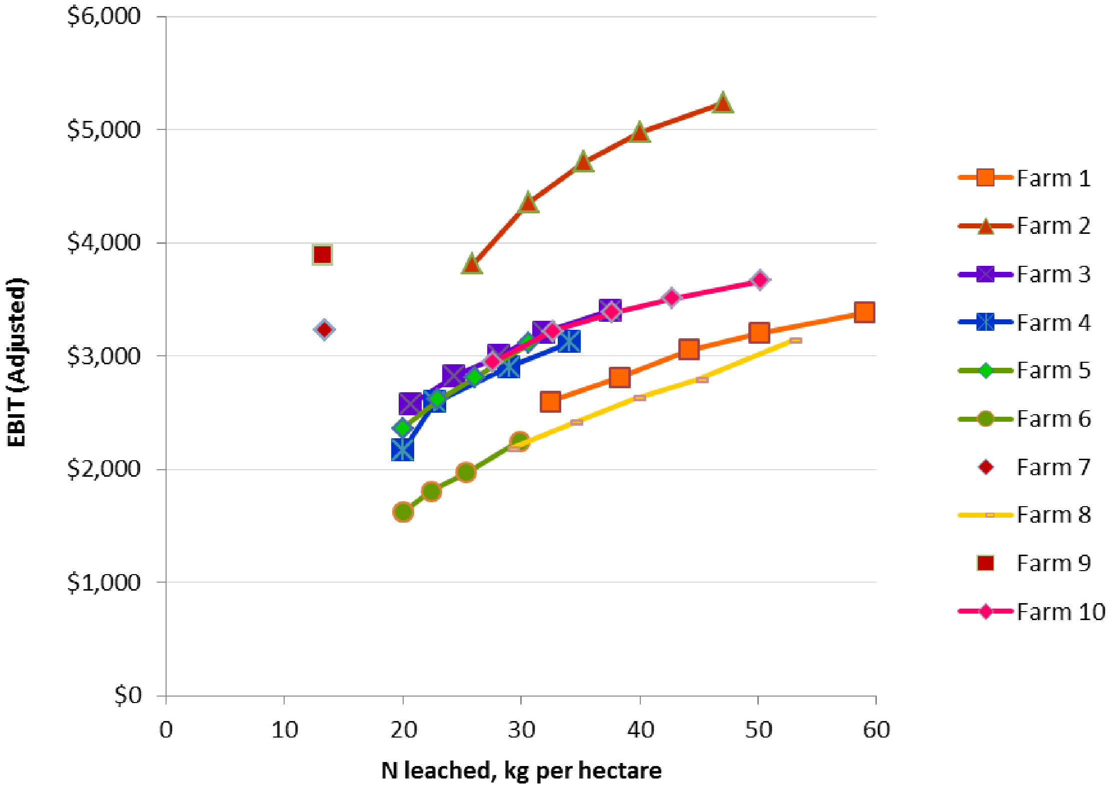
5.14 Figure 1 shows that for farms that need to make adjustments (based on a threshold of 20kg N per hectare per year), a 15% reduction will cost around 4% to 12% of EBIT (adjusted), whereas a 45% reduction (stopping at 20 ken/ha/yr if it is reached) costs 20% to 31% of EBIT (adjusted).

Figure 1: Percentage change in EBIT (adjusted) as a result of required percentage reductions in N leached from GMP



5.15 Figure 2 shows the same information as Figure 1, but in terms of absolute rather than percentage change. Highly significant reductions in EBIT (adjusted) are seen across all farms that leach over 20 kg at GMP as they mitigate to 45% or the threshold, averaging $881 per hectare.

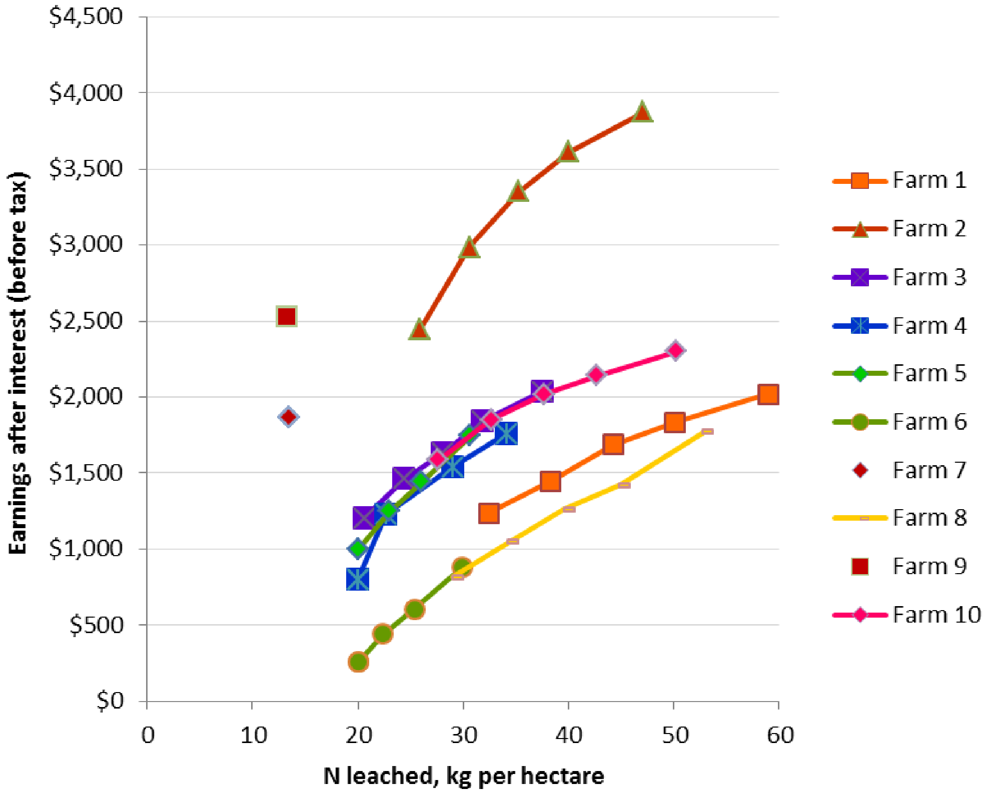
Figure 2: Change in EBIT (adjusted) per hectare as a result of reductions in N leached from GMP



5.16 Interest is an unavoidable expense for any farm carrying debt, which is the overwhelming majority of farms. However, well-defined distributions of debt at a catchment level are difficult to obtain. Through discussions with informed rural professionals, and reference to internal databases from which national debt distributions are determined (for example, Figure 5.1 of the Economic Survey (Dairyman 2014)), a uniform distribution of debt to assets from 15% (lower limit) to 85% (upper limit) was assumed to be reasonable. The implied median debt to assets ratio is then 50%, with the 25th percentile being 32.5%, and the 75th percentile being 67.5%.

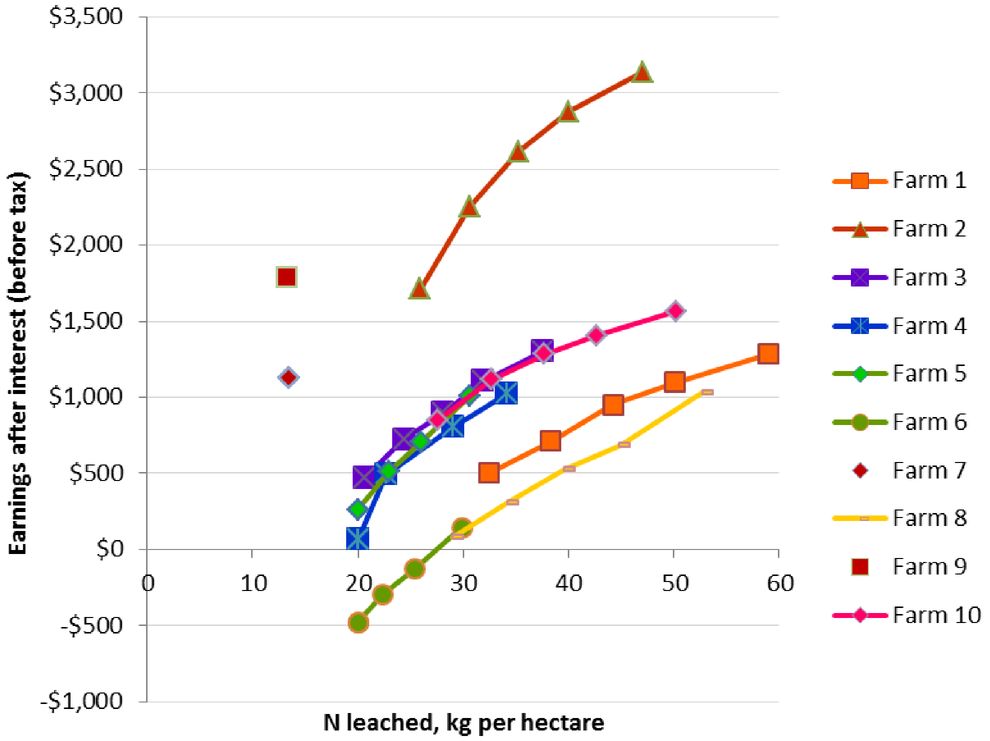
5.17 The impact on the farm of the debt level can be considered by taking the interest expense from the EBIT for the 25th, median and 75th percentile of debt to assets (assuming total assets per hectare of $60,000 per hectare). This is shown in the next series of figures. Figure 3 shows that all representative farmers with the lowest 25th percentile of debt to assets ratio can pay their interest bill, even at the maximum mitigation level of 45%. However, some farms would be making very little operating return on equity (ie working for nothing but capital gain).

Figure 3: Earnings after Interest (but before tax, per hectare): 25th Percentile of Debt to Assets ratio (ie low debt)



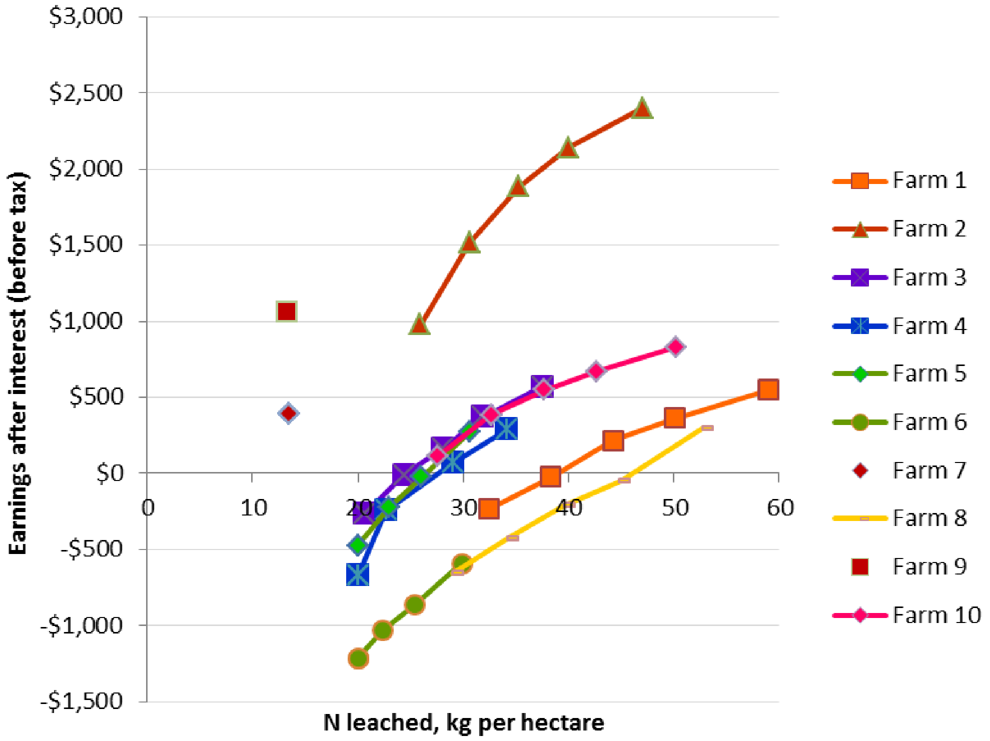
5.18 Figure 4 shows that three farms with median debt levels (near the zero line) would be making effectively no operating return for their invested equity in the absence of capital gains. Additionally, one farm, the poorest performing, would not be able to replace any depreciating capital in order to pay interest expenses.

Figure 4: Earnings after Interest (but before tax, per hectare): Median Debt to Assets ratio



5.19 Figure 5 shows that most farms with debt levels at or above the 75th percentile are under severe financial strain at a 45% mitigation level. I estimate that four farms would need to do more than stop replacing depreciating capital. Some could seek additional external equity to continue operations, but this equity injection would require them to accept a significant reduction (or downward revaluation) of their existing owner equity.

Figure 5: Earnings after Interest (but before tax, per hectare): 75th Percentile of Debt to Assets ratio

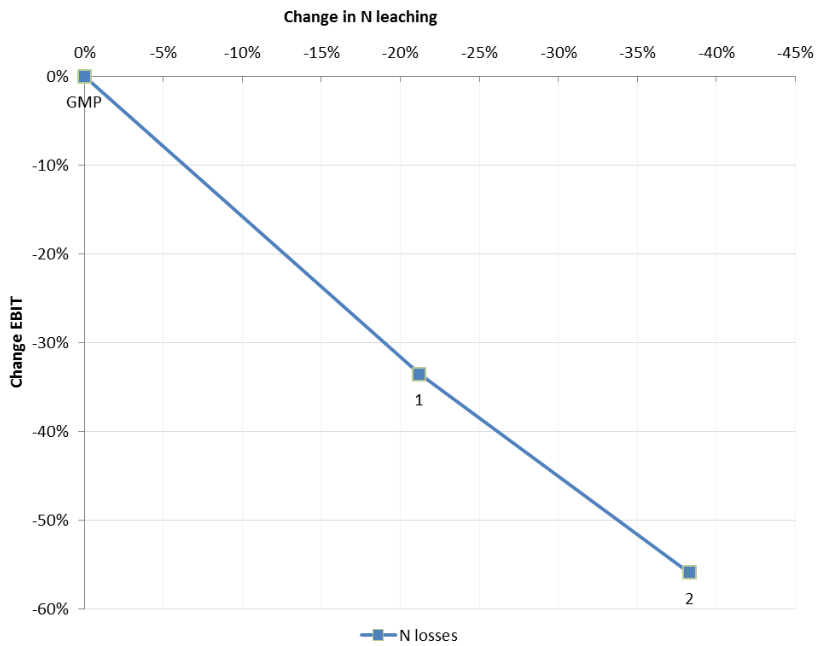


Impact on dairy support operation

5.20 In respect of the modelling of dairy support, one intensive wintering support farm was chosen and applied to a representative area consistent with wintering virtually all the cows in the catchment (11,047 ha is needed to feed 171,484 cows in winter on feeds used by the representative farm). This is based on the assumption that most of the dairy cows are wintered in the catchment, which corresponds with the survey data of current practice. The intensive wintering support is based on a real farm in the Lower Hinds/Hekeao Plains Area. In reality dairy support farms range from the intensive system used in this modelling to much less intensive systems that are integrated into other farm systems (e.g., arable, mixed farms). This explains the far greater area mapped as dairy support by Dr Brown. On mixed farm systems, the proportion of dairy support that makes up the farm would vary to such an extent as to make transparent mitigation modelling extremely difficult. Furthermore, the exact interpretation and definition of dairy support, and how percentage reductions would apply, was considered to be an area of uncertainty that could be avoided with the approach of modelling intensive dairy support.

5.21 The mitigation approach for the intensive dairy support farm was to lower the stocking rate of wintered cows consistent with the lowered stocking rate for the dairy platform modelling. There was also a switch from kale to beet, with beet being a higher yielding crop that allows a reduction in the area allocated to wintering. The "freed up" area was then allocated to a low leaching option (ie cut and carry pasture). Figure 6 shows the resulting impact on EBIT. Although it appears relatively costly in percentage terms, a higher cost of wintering could be an efficient transfer met through market adjustments in the price of wintering, due to the lower relative returns of dairy versus dairy support.

Figure 6: Percentage change in EBIT (adjusted) as a result of required percentage reductions in N leached from GMP



5.22 DairyNZ maintains a range of databases, primarily for internal use, but used as the basis for a number of reports that are publically available. As a validation of the dairy modelling, the milk production of the farms was found to be fairly consistent with the Dairy Statistics (DairyNZb 2014) publication for the Ashburton region, and consistent with a survey carried out across 40 (20%) of the farmers in the catchment. Average EBIT was consistent with the Economic Survey (DairyNZa 2014) for the Canterbury region in 2012/13, taking into account the additional revenue generated by the difference between assumed and actual milk prices and dividends. Furthermore, when the data was aggregated with the current land use area and using the representative percentages described above, taking into account the respective areas of non-effective area, the estimated milk production was within 2% of the actual milk production of the catchment.

5.23 The aggregate impact of the farm level impacts is further developed and discussed in the evidence of Dr Bell, and the wider impact at a regional level is discussed in the evidence of Dr Fairgray.

Effects on EBIT on dairy and dairy support of DairyNZ/Fonterra's proposed 3-stage approach

5.24 The DairyNZ/Fonterra 3-stage approach assumed MGM applied from 2017,[5] with a 3-stage phasing of a 15% reduction by 2025, a 25% reduction by 2030, and a 36% reduction by 2035 (shown in Table 3 below, as DairyNZ/Fonterra 3-Stage). This meets the same catchment targets as discussed by Ms Hayward by having a consistent reduction percentage target across high emitters (consisting mainly of dairy and dairy support). This approach has the benefit of being on the trajectory to meeting catchment targets, particularly in light of the lower than expected time lags identified in the evidence of Dr Brown, but imposing lower upfront costs.

5.25 Table 3 summarises the findings regarding changes in EBIT (adjusted) on dairy and dairy support of DairyNZ/Fonterra's proposed 3-stage approach.

[5] The benefits of reduced N leaching from the MGM process were not explicitly included in the modelling.

Table 3: EBIT (adjusted, per hectare) as impacted by percentage reductions in N leaching - 3-stage solution

			Earnings after interest (Before tax, $)		
Year	*N leaching reduction*	*EBIT (adj) % reduction*	*25th percentile of debt/assets (ie low debt)*	*Median debt/assets*	*75th percentile of debt/assets (ie high debt)*
	GMP	-	879 to 3,873	144 to 3,138	-591 to 2,403
2025	*15%*	*4 to 12%*	604 to 3,613	-131 to 2,878	-866 to 2,143
2030	*25%*	*8 to 20%*	442 to 3,354	-293 to 2,619	-1,028 to 1,884
2035	*36%*	*13 to 31%*	256 to 2,933	-479 to 2,198	-1,214 to 1,463

5.26 The extended timeframe for deeper cuts also allows for the cost effectiveness of MAR, other off-farm mitigations, as well as the science and economics behind alternative mitigations (such as those discussed in section 9) to be resolved over the next seven to ten years. The benefit of lower "early on" percentage reductions allows time for a recalibration of equity levels and capital value, lowering the likelihood of undue disruption to farming businesses (through insolvency or illiquidity), impacting the farmers that own or manage those enterprises. The non-linear impact on resiliency is discussed further in the following section.

5.27 While no financial or environmental impacts were modelled for the initial move from current practice to GMP, there would be expected to be some low cost gains and some "win-wins" associated with the implementation of Farm Environment Plans and adoption of the MGM (described in more detail in section 9.2 to 9.4).

5.28 Including dairy support to mitigation levels consistent with other high emitters (ie dairy at 36% by 2035) results in a higher percentage impact on dairy support than under Variation 2. However, the net effect for the catchment across all high emitters is a lower EBIT impact than for Variation 2. This is because the higher percentage impact on EBIT is offset by the lower starting point for EBIT, so the "dollar" cost per hectare is lower. Also, having a single percentage reduction level for high emitters could be expected to have benefits of transparency, and potentially prevent footprint "shifting" that would otherwise be incentivised by leaching reduction differentials between enterprises.

5.29 Overall, the 3-stage approach achieves the same water quality outcome as Variation 2, but at a lower overall cost to existing farmers and the wider community.

Effects on EBIT on dairy and dairy support of DairyNZ/Fonterra's proposed 4-stage approach

5.30 The DairyNZ/Fonterra 4-stage approach assumed MGM applied from 2017,[6] followed by a 9% reduction by 2020, 18% by 2025, 27% by 2030, ending at 36% at 2035. This approach has more impact on farm EBIT in earlier years.

5.31 Table 4 summarises the findings regarding changes in EBIT (adjusted) on dairy and dairy support of DairyNZ/Fonterra's proposed 4-stage approach.

Table 4: EBIT (adjusted) as impacted by percentage reductions in N leaching - 4-stage solution

			Earnings after interest (Before tax, $)		
Year	*N leaching reduction*	*EBIT (adj) % reduction*	*25th percentile of debt/assets (ie low debt)*	*Median debt/assets*	*75th percentile of debt/assets (ie high debt)*
	GMP	-	879 to 3,873	144 to 3,138	-591 to 2,403
2020	*9%*		714 to 3,717	-21 to 2,982	-756 to 2,247
2025	*18%*		555 to 3,535	-180 to 2,800	-915 to 2,065
2030	*27%*		408 to 3,277	-327 to 2,542	-1,062 to 1,807
2035	*36%*	*13 to 31%*	256 to 2,933	-479 to 2,198	-1,214 to 1,463

5.32 Overall, the 4-stage approach achieves the same water quality outcome as Variation 2 (and the three stage solution) as discussed by Ms Hayward, but at a higher up-front cost to existing farmers and the wider community than the preferred 3-stage solution.

6 The benefits of reduced N leaching benefit from the MGM process were not explicitly included in the modelling.

6. OVERALL COMMENT ON TIMING OF REDUCTIONS: 3 STAGE OR 4 STAGE

6.1 The previous section shows that (pre-existing) higher levels of debt lead to financial pressure, as demonstrated by the increasing number of farms experiencing negative earnings after interest expense (shown as dropping below the zero axis of figures 3 to 5). If reductions were introduced too swiftly, this could potentially induce a short term market correction in capital values and create significant concerns for business solvency.

6.2 Section 9 describes several of the research and development activities being carried out to support adoption of cost-effective mitigation options. However, it is important to recognise that it will take time for new farm management practices and mitigations to be widely adopted, even once the scientific aspects have been resolved. Allowing sufficient time for adoption of these options is likely to prove important in minimising the cost of reductions in N leaching.

6.3 In my opinion the significant economic impact of the proposed reductions is such that a slower transition to large percentage reductions is justified. This would allow debt levels and capital values to rebalance in an orderly fashion, and allow for new cost-effective mitigations to be demonstrated at farm scale and adopted across the catchment. I therefore consider that the 3-stage regime of reductions proposed by DairyNZ/Fonterra would be a more appropriate way of ensuring that the overall objective is met, while allowing farmers sufficient time to make the required changes to their operations.

7. IRRIGATION EXPANSION AND LAND USE CHANGE ANTICIPATED

7.1 Land use change driven by new or additional irrigation is assumed to occur in two main components, totalling 15,000 ha. This is considerably less than the 30,000 ha proposed in Variation 2, but this lower number is within the reasonable range identified by Dr Brown (13,390 to 24,390 ha) based on land use potential, and aligned with expert and farmer views about the relative profitability and hence likelihood of conversion from existing land uses to a mitigated dairy enterprise.

7.2 First, 5,000 ha of dryland sheep/beef enterprises are assumed to convert to irrigated dairy but limited to a nitrogen loss of 27 kg N/ha/yr. This is assumed to phase in over five years involving 1000 ha per year from 2015 to 2020. It is assumed that the dairy farm is located on light soils, where most of the opportunity to expand irrigation is located. It is also assumed the dairy farm would need to operate in a mitigated way to meet the N leaching limit of a farm on lighter soils. The EBIT for these farms is determined from an equal split between the mitigated Farm 8 (Adjusted EBIT of $2021 per effective hectare) and Farm 10 (Adjusted EBIT of $2782 per effective hectare). These representative farms were chosen for being closest to an area of likely conversion.

7.3 Second, 10,000 ha of sheep/beef enterprises are assumed to move to a slightly more intensive sheep/beef dairy support mixed farm, including more irrigation. The phasing is expected to take ten years, consisting of 1000 ha/yr from 2015 to 2025.

7.4 Additionally, a further area could be intensified, either through a consenting process to allocate an additional load (Variation 2), or a flexibility cap (DairyNZ/Fonterra alternatives). In the absence of good understandings on precisely how these would be applied, this further area of intensification was modelled assuming the same EBIT benefit and use the same N tonnage between the two options.

7.5 The DairyNZ/Fonterra proposal of a flexibility cap is composed of two parts. Firstly, a flexibility cap (Tier 1) whereby those farms leaching less than 15 kg N/ha/yr are permitted to increase N leaching to 15 kgN/ha/yr. This allows, for example, arable/mixed farmers to intensify as prices change over time. This was assumed to deliver a gain to EBIT of $100 per hectare. This flexibility provision was assumed to be taken up by 17,500 ha, as discussed by Ms Hayward.

7.6 Secondly, a flexibility cap (Tier 2) whereby those farms leaching between 15 and 20 kg N per hectare are permitted to increase leaching to 20 kg/ha. Again, this allows, for example, arable/mixed farmers to intensify as prices change over time. This was also assumed to deliver a gain to EBIT of $100 per hectare, and applies to an area of 4,500 hectares, as estimated by Ms Hayward. Although the estimates are subject to some uncertainty, in my opinion the net effect represents a reasonable estimate.

7.7 The wider impact of Variation 2, and a comparison with the Fonterra/Dairy NZ alternatives described in the previous sections, are aggregated in the evidence of Dr Bell and detailed in evidence of Dr Fairgray, using the assumptions described here about farm performance.

8. RESILIENCE OF FARMERS AS A RESULT OF MITIGATIONS

8.1 Farmer (financial) resilience to adverse climatic or market conditions (risk) can be modelled and assessed quantitatively. A simplified example using Monte Carlo analysis is described in detail in **Appendix 3**, with this section summarising key points.

8.2 When moving from current/GMP to high mitigations (eg 45% reductions), there is a significant change in the financial profile of businesses as a result of meeting mitigation requirements. There is a higher probability of a negative cash surplus, and losses are higher. This reduction in resilience is compounded by positive cash surpluses being experienced less often, which are significantly lower when they do occur.

8.3 One year of negative cash surplus would be considered manageable (albeit unwelcome) for many farm businesses. Negative cashflows over a cumulative two year period are significantly exacerbated by high mitigation levels (eg -45%), particularly when combined with a pre-existing higher debt/assets level and higher than average cost of production.

8.4 There is a risk that if too high a proportion of farmers are undergoing significant financial stress at the same time under conditions of reduced resilience, a disruptive market correction could occur with asset sales into a falling market leading to impacts on other farmers that would otherwise have been considered to be in a relatively comfortable position.

8.5 Farmers need time to pay back debt so that the debt to asset ratios adjust back to acceptable levels where bankers feel comfortable farmers will be resilient enough to survive two or more consecutive years of low MS payouts. This is an important consideration when considering the timing of reductions.

9. HOW CURRENT RESEARCH AND DEVELOPMENT ACTIVITIES MAY ENHANCE THE ENVIRONMENTAL AND ECONOMIC OUTCOMES OF ON-FARM ACTIONS

9.1 Mitigation options other than those assumed in our analysis could be used, but in general, will require more time to be developed as science-backed, cost-effective and adoptable mitigations. DairyNZ, as the levy funded industry good organisation for the dairy industry, has made substantial investments in research and development in the area of sustainability and reducing environmental footprint of dairying. A number of these projects, and some of the challenges associated with widespread adoption, are described below.

Matrix of Good Management

9.2 Environment Canterbury is leading the MGM project. MGM is a collaborative initiative with primary sector organisations (DairyNZ, Deer Industry New Zealand, NZPork, Beef + Lamb New Zealand, Horticulture NZ and the Foundation for Arable Research) and Crown Research Institutes (AgResearch, Plant and Food Research and Landcare Research). The project aims to quantify the typical nitrate nitrogen and phosphorous losses that are expected to occur from the range of farming systems, soils and climates across Canterbury when managed to GMP.

9.3 Although there is widespread support for the implementation of good management practices across primary industries, there are no commonly agreed definitions of GMP, nor a good understanding of the nutrient losses that occur with farms operating at GMP. This information is essential to assess the nutrient losses from different land uses under good management practices which cans be used to support the development of effective resource management policy.

9.4 I understand from Mr Ryan that Environment Canterbury is expected to notify a change to the Proposed Canterbury Land and Water Regional Plan in September 2015 that will define the GMPs expected to be adopted by all farmers from 2017. While it is expected that GMP will evolve over time, the adoption of GMPs by all farmers will be an important first step that will help achieve some "win-wins" for the environment and farm profit, and set expectations about the level and timeframes required for change.

Pastoral 21

9.5 Pastoral 21, a collaborative project involving DairyNZ is using farmlet trials of lower stocking rate solutions in conjunction with higher production per cow, both in the Waikato and Canterbury. While these options appear promising (the Lincoln farmlet reduced N leaching by around 30%), so far they have only been demonstrated at farmlet level, and with a level of oversight and expertise that would be met only on the highest performing farms. The Lincoln University Dairy Farm ("**LUDF**") is now completing the first year of farm "scale up" of the strategy employed at the Lincoln-based Pastoral 21 farmlets. Overseer estimated N leaching has reduced significantly as expected, but full year profit results are not yet available. Although LUDF is considered as a top 10% performing farm, and is using the same stocking rate and N fertiliser as the P21 farmlets, the profit results are unlikely to meet the P21 projections, as MS per cow is still 5% lower, despite feeding an additional 0.2t DM silage per cow (LUDF, 2015). This underlines the difficulty in immediately transferring scientific expectations to on-farm implementation. I would expect that differences in pasture management ability are required to handle the rapid swings in pasture availability from shortage to surplus in low stocking rate systems like those proposed. There is also a reduced ability to take advantage of higher milk price seasons with lower stocking rates.

Forages for Reduced Nitrate Leaching

9.6 Forages for Reduced Nitrate Leaching is a six year $20 million project led by DairyNZ to look at crop and pasture agronomy and how they can be modified for reduced environmental impact. For wintering of dairy cattle, beet is a promising option, with higher yields, and lower N content compared to more traditional options such as kale. There is ongoing field research on the leaching losses under these options, with initial results suggesting that leaching losses under both kale and beet may be overestimated by Overseer V6.1.3. This is potentially due to modern practises where N fertiliser use is reduced compared with historic practice, and so less N is cycling through the animals wintered on these crops.

9.7 Options to include a "mop-up" crop to reduce leaching after wintering are undergoing research, and if beneficial, need to fit within a farm rotation system. Again, these research projects suggest some options with promising potential, but have not been carried out for enough time to validate the results, as would be expected to make the relevant changes to Overseer to provide the "credit" for making system changes to reduce N leaching by these pathways.

9.8 Work is also underway on the potential benefits of mixed pasture swards for grazing dairy cattle, with the lower N content of these forages potentially leading to a reduced leaching impact in a cost effective way. These research results have potential, but may not have been carried out for enough time to make the relevant changes to Overseer, which is necessary to provide the "credit" for making system changes to reduce N leaching by these pathways.

9.9 It is worth noting that three of the nine monitor farms that are involved in the Forages for Reduced Nitrate Leaching project are situated in the Ashburton zone. This provides important opportunities to showcase extension opportunities to support improvements in farm management practices that will, in turn, support the implementation of Variation 2.

Removing nutrients from water

9.10 Field level trials for removing nutrients from water are ongoing. For example, a "nitrate catcher" project is being undertaken in Southland (Waituna catchment) and an artificial wetland is being trialled at Lichfield (upper Waikato catchment), with care being taken to document good process, the costs, and overall effectiveness. These options may be appropriate to limited areas of the Hinds catchment, but further work is required to determine their suitability.

Cow housing options

9.11 Cow housing options, also referred to as barns, have been suggested as a possible cost-effective solution for mitigation of environmental impact. The soon to be released barns report (Economic and Environmental analysis of Barns, DairyNZ 2015) studied 14 farms in depth for financial and environmental implications of integrating a barn into their farm, including three in the Canterbury area. The results showed that a barn could be used to generate more profit, or to reduce environmental footprint (N leaching), but that both goals had not been achieved simultaneously. This shows that barns may have a place as a tool for mitigation under some circumstances, but they would incur an investment cost (that is irreversible) to achieve this result.

9.12 While many of these studies are showing promising results, time and considerable resources will be needed to achieve a widespread level of uptake, even of those options that are demonstrated to be effective at the farm scale. This is one of the key reasons why appropriate timing of the implementation of nitrogen reduction regimes is of considerable importance. The scale of reductions sought from farmers in the Hinds/Hekeao Plains Area (even at a 36% reduction) is significant and difficult to achieve with current knowledge without significant financial burden and risk. While the first 10 to 15% reduction in nitrogen is likely to be possible on farms over the next 10 years using current knowledge and technology, and extension support, beyond that, the implementation of systems such as trialled above or other technological advances are likely to be needed to achieve the full extent of reductions sought without considerable disruption to the continuing operation of potentially many farm businesses.

Mark Beaumont Neal

15 May 2015

Appendix 1 – Papers, Publications and Industry Presentations

- Neal, M. (2015) Teaching examples for the state contingent approach to production under uncertainty, Presented at the Conference of the Australian Agricultural and Resource Economics Society, Rotorua, February 2015.
- Neal, M. (2014) Mobile milking: Potential application and spatial land use implications, 2014 Australian and New Zealand Spatially Enabled Livestock Management Symposium, Hamilton.
- Neal, M. (2014) Technological innovation, Dairy Research Foundation Symposium, June 19-20, Pokolbin (Repeated for OneFarm Webinar and DairyNZ Seminar Series)
- M.B. Neal, J.S. Neal, W.J. Fulkerson (2010) Optimal Choice of Dairy forages: Considering risk, Proceedings of the 4th Australasian Dairy Science Symposium 2010 151
- Neal, M. (2010), LiDAR technology for mapping farms and understanding drainage, Dookie Campus, University of Melbourne Field Days
- Neal M, Neal J, Fulkerson WJ. (2007) Optimal choice of dairy forages in eastern Australia. Journal of Dairy Science. 2007 Jun;90(6):3044-59.
- Chapman, D. F.; Malcolm, L.R.; Neal, M; Cullen, B. R. (2007) Risk and uncertainty in dairy production systems: Research concepts, tools and prospects. In: D.F. Chapman, D.A. Clark, K.L. Macmillan, D.P. Nation, eds. 'Meeting the Challenges for Pasture-Based Dairying', Proceedings of the 3rd Australasian Dairy Science Symposium, Melbourne, VA. Australia, National Dairy Alliance. Pp 476-491.
- Neal, M (2007) Estimating Complex Production Functions: The Importance of Starting Values, Paper presented at 51st Annual Australian Agricultural and Resource Economics Conference, February, Queenstown
- Neal M, (2006) The potential cost to New Zealand dairy farmers from the introduction of nitrate-based stocking rate restrictions. International Association of Agricultural Economists, August 12-19, Gold Coast.
- Neal, M. J. Neal, and W. Fulkerson (2006) Choosing the best forage species for a dairy farm – The Whole-farm approach., Joint ADSA ASAS Meeting, July 6-13 Minneapolis, Minnesota
- Neal and WJ Fulkerson (2006) "Traits and the Farm System, Paper presented at 50th Annual Australian Agricultural and Resource Economics Conference, February, Sydney One size fits all"? – The Relationship Between the Value of Genetic
- Neal, M., Drynan, R., Fulkerson, W., Levy, G., Wastney, M., Post, E., Thorrold, B., Palliser, C., Beukes, P., and Folkers, C. (2005) Applying differential evolution techniques to a whole-farm model to assist optimal strategic decision making, MODSIM 2005, 12-16 December, Melbourne.
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- Beukes, P., C. Palliser, W. Prewer, V. Serra, J. Lancaster, G. Levy, C. Folkers, M. Neal, B. Thorrold, M. Wastney (2005) Use of a Whole Farm

Model for Exploring Management Decisions in Dairying, MODSIM 2005, 12-16 December, Melbourne.
- M Neal, W Fulkerson, and R Drynan (2005) How much feed-related capital is profitable?, Dairy Research Foundation Symposium, Camden
- Neal, M. , Drynan, R., Fulkerson, W., Levy, G., Wastney, M., Post, E., Thorrold, B., Palliser, C., Beukes, P., and Folkers, C. (2005) Optimisation of a Whole-farm Model, Paper presented at 49th Annual Australian Agricultural and Resource Economics Conference, 9-11 February, Coffs Harbour
- Neal, M, Fulkerson, W, and Drynan, R, (2005) How can farm returns rise?, Australian Dairyfarmer, March-April
- "Optimizing return in a whole-farm model under conditions of risk" Australian Dairy Science Conference, Shepparton, Friday, 27 February 2004
- Neal, M (2004) Re-ranking of individual firms using alternative performance measures: The case of New Zealand dairy farms, Proceedings of the Asia-Pacific Productivity Conference, Brisbane, 14-16 July
- "Ranking of individual firms using alternative performance measures" ANU PhD Conference Canberra, Thursday, November 11 2004
- Neal, M (2004) Optimising return in a whole-farm model under conditions of risk, Paper presented at 48th Annual Australian Agricultural and Resource Economics Conference, 11-13 February, Melbourne
- Neal, M. (2003) Maximizing profit: a farm systems approach, in Proceedings of the Dairy Research Foundation Symposium, University of Sydney, Camden 2-4 October 2003
- Neal, M. "Integrating economics into a whole-farm model" Waikato University Student Research Conference Hamilton, 22 October 2003
- Neal, M (1999) Modelling Seasonal Production on a New South Wales Dairy Farm, Undergraduate thesis - BAgrEc, University of Sydney.

Appendix 2 – References

AgResearch (2014) Economic impact assessment of the Hinds water quantity and quality limit setting process, Report prepared for ENVIRONMENT CANTERBURY, R14/82

DairyNZ (2014a) 2012-13 DairyNZ Economic Survey. DairyNZ, Newstead, New Zealand.

DairyNZ (2014b) New Zealand Dairy Statistics 2013/14, DairyNZ Newstead, New Zealand.

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ENVIRONMENT CANTERBURY (2014) Hinds/Hekeao Plains Compendium – Technical reports and Memorandums, ENVIRONMENT CANTERBURY, R14/87

Lincoln University Dairy Farm (2015) Lincoln University Dairy Farm Focus Day Handout, 7th May 2015

Macfarlane Rural Business (2013) Hinds catchment nutrient and on-farm economic modelling, Report prepared for ENVIRONMENT CANTERBURY, R13/109

Overseer Management Services Limited (OMSL) (2014). Overseer Best Practice Data Input Standards. April 2014.

Appendix 3 – Resiliency modelling

Financial resilience is dependent upon the characteristics of negative cashflows, and then corresponding characteristics of positive cashflows. Specifically, the characteristics these cashflows are the:

1) probability of negative cashflows (which then implies the probability of positive cashflows);

2) time for which cash flow is negative;

3) size of negative cashflows; and

4) size of positive cashflows.

The probability of negative cashflows is important not just for a given season, but for the following season, as the impact can compound. The probability of two seasons having a negative cashflow, if the probabilities are independent[7], would be the probability squared. As an example, moving from a two year in ten (20%) chance of negative cashflow to a three years in ten (30%) chance of negative cashflow would more than double the chance of two sequential years of negative cashflow, with significant implications for solvency and resilience. To summarise this first point, there is a non-linear (increasing) relationship between the probability of negative cashflows, the time for which cash flow is negative and reduced resilience.

Resilience was considered to depend on the cash surplus available to pay tax and compensate owners of equity capital per hectare ("**CS**"). This was determined as revenue less farm working expenses, less an allowance for capital replacement (but not including depreciation), and less interest expense on debt. The allowance for capital replacement assumed no capital replacement at the lowest milk price, but very modest capital replacement at the highest milk price, equal to 25% of the farm depreciation. Capital replacement at intermediate milk prices was by linear interpolation between zero and 25%.

The distribution for CS was determined by Monte Carlo analysis assuming only risk (variation) in milk price[8] relative to a fixed cost structure. More complex

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[7] An analysis of milk prices found that any season's milk price effectively provided no information about milk prices in the next season. In terms of statistical analysis, there was no first order autocorrelation in annual milk prices.

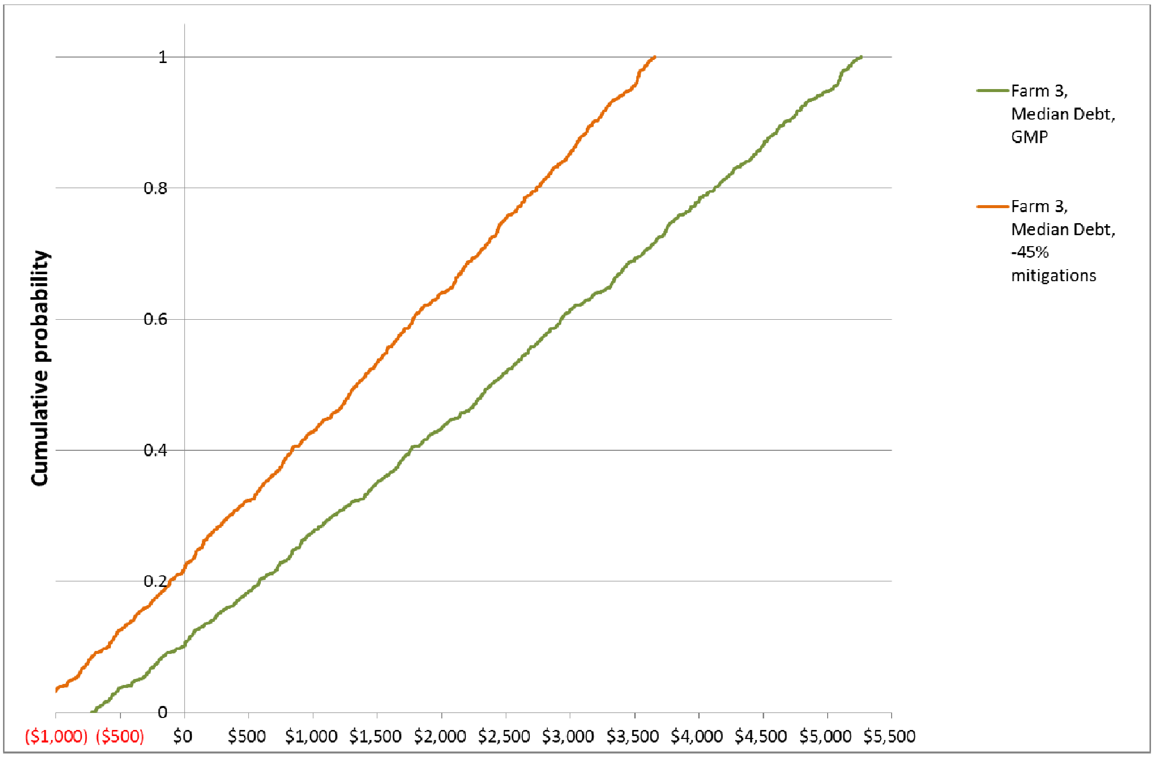
[8] The milk price distribution used was a uniform distribution between 4.60 and 8.60. This was based on ten years of deflated milk prices, and a uniform distribution appeared to have less bias than properly specified normal or lognormal alternatives.

analysis could include variation in other prices and climatic variability, and the correlation structure of these variables, but that was considered to be detail unnecessary to demonstrate the broad impacts.

Farm 3 was chosen for resiliency modelling as it would be a reasonable guide to impacts on a typical farm (noting some farms would be more affected, and some would be less so). It is close to average for milk production per hectare, slightly below average for farm working expenses per kg MS at current/GMP, and the percentage costs of mitigation at 45% reductions in N leaching.

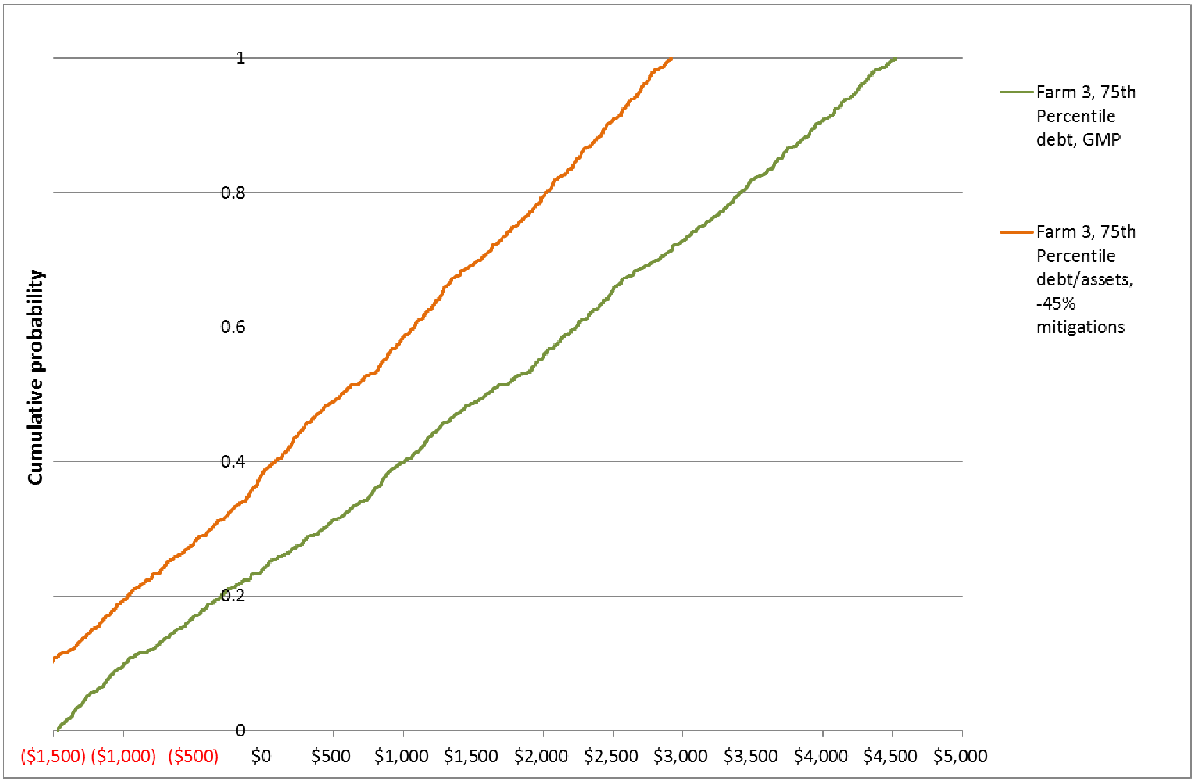
The distribution of CS for Farm 3, when assumed to have median debt/assets, was modelled for current/GMP vs 45%. The cumulative distribution of CS is shown in figure A3.1. The green curve is the cumulative probability of CS at GMP and the orange curve is the cumulative probability of CS at -45% NL. The probability of a negative CS can be read as the number where the cumulative distribution crosses the vertical axis. This demonstrates that there was a 10% chance of negative annual CS at GMP, but this increased to a 22% chance at a 45% mitigation level (for median debt/assets). This implies, without considering other factors, a significant increase in the risk of two years of negative cashflows from just over 1 year in 100 (1% at GMP) to almost 1 year in 20 (4.8% at 45% mitigation).

Figure A3.1: Cumulative distribution of Cash Surplus, median debt/assets



This risk compounds rapidly with increases in the cost of production and lower debt/assets, and statistically approximately half of all dairy farms would sit in this compounding risk category, having higher than median debt/assets, and higher than average costs per kg MS. As an example, the same farm (slightly lower than average costs), by only changing the debt to assets ratio from median level to 75th percentile, has increased the probability of a negative CS under GMP from 10% (1 year in 10) to 24% (almost 1 year in 5). Under -45% mitigations, the risk of a negative CS has increased from 22% to 38%.

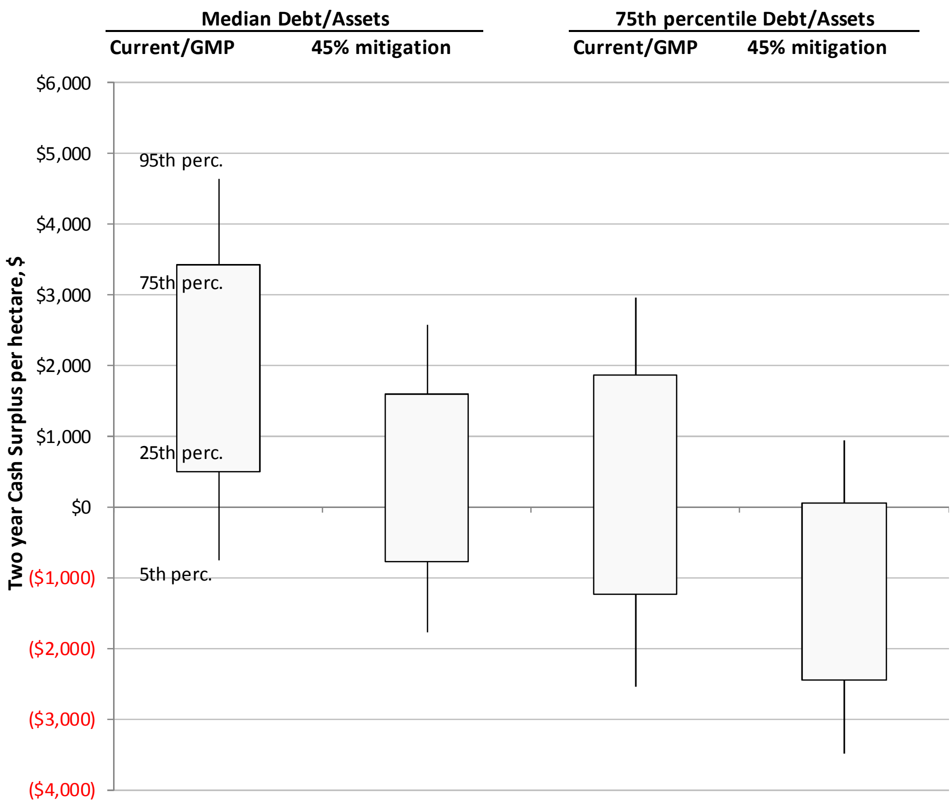
Figure A3.2: Cumulative distribution of Cash Surplus, 75th percentile debt/assets



Under median debt, when a loss was incurred, the average loss was roughly twice as high at -45% mitigations compared with GMPM. When this was combined with the reduced probability of a positive CS, and a significantly reduced average profit when the CS was positive, there would be a significant impact on the solvency and hence resilience of the farm business. This is illustrated in figure A3.3, where a distribution (box and whisker) assuming the two year cumulative CS of a poor year

(1 in 10 year adverse CS[9]) followed by a random year is plotted for Farm 3. Firstly median debt/assets is assumed (GMP and -45%), and then 75th percentile of debt/assets (GMP and -45%). This shows the compounding effect of the above factors to reduce resilience substantially, particularly when pairing high debt and high mitigations. In other words, a very patient bank/debt holder would be required under the high debt/high mitigations combination, as cashflow to pay interest may not be available for an extended period. The implication is that a reasonable timeframe needs to be allowed in order for higher debt farms to unwind this position through retained earnings, and allow the signal for debt loadings to reduce relative to capital values in the market over time.

Figure A3.3: Effect on two year cumulative cashflow of increasing debt and mitigation level (assuming the first year is a 1 in 10 year adverse milk price)



9 Approximated by 5th percentile of CS.