Review of the Transforming Dairy Value Chain Primary Growth Partnership

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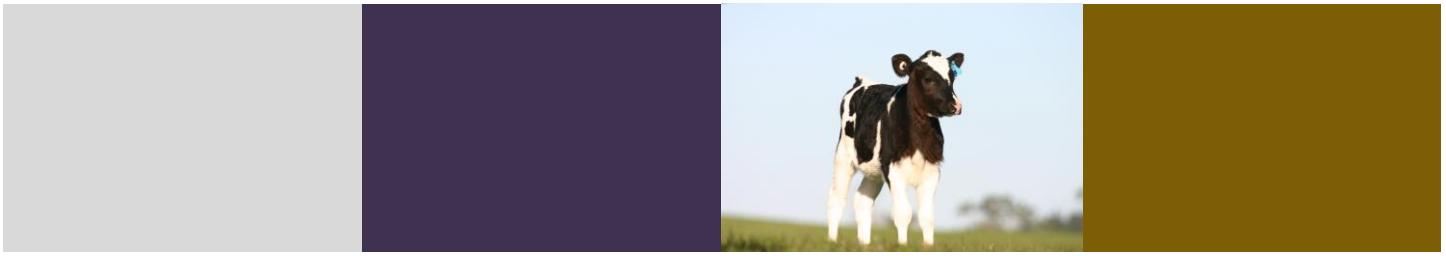
November 2019



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Glossary

Abbreviation	Stands for
6WICR	6 week in-calf rate
ASL	Agricultural Services Limited
BAU	Business as usual
BCR	Benefit-cost ratio
BCS	Body Condition Score
BV	Breeding Value
BW	Breeding Worth
CEFBM	Centre of Excellence in Farm Business Management
CML	Complex milk lipid
CNMA	Certified Nutrient Management Advisor
CNLMs	Cumulative Nitrogen Leaching Maximums
CPD	Continuing Professional Development
DCV	Society of Dairy Cattle Veterinarians
DESC	Dairy Effluent Storage Calculator
DHB	District Health Board
DIAAS	Digestible Indispensable Amino Acid Score
DIGAD	Dairy Industry Good Animal Database
DM	Dry matter
DOC	Department of Conservation
DWN	Dairy Women's Network
FDE	Farm Dairy Effluent
FE	Facial Eczema
FEP	Farm Environmental Plan
FRDC	Fonterra Research and Development Centre
FVI	Forage Value Index
GHG	Greenhouse gas
GMP	Good Management Practice
GWAS	Genome Wide Association Studies
IAP	Investment Advisory Panel

IQF	Individually quick frozen
LIC	Livestock Improvement Corporation
LUC	Land use capability
MFGM	Milk fat globule membrane
MPI	Ministry for Primary Industries
MS	Milk solids
N	Nitrogen
NBO	National Breeding Objective
NMACP	Nutrient Management Adviser Certification Programme Ltd
NOF	National Objectives Framework
NPS-FM	National Policy Statement for Freshwater Management
NPV	Net present value
NVPOP	Notified Version of the Proposed One Plan
NZAEL	New Zealand Animal Evaluation Limited
NZIER	New Zealand Institute of Economic Research
NZIPIM	New Zealand Institute of Primary Industry Management
NZVA	New Zealand Veterinary Association
NZWETA	New Zealand Water & Environment Training Academy
NZYF	New Zealand Young Farmers
PAT	Process Analytical Technology
PGP	Primary Growth Partnerships Programme
PHO	Primary Health Organisation
PICA	Primary Industry Capability Alliance
PLM	Professional Land Managers
PSC	Planned Start of Calving
RBN	Rural Business Network
RFI	Residual Feed Intake
RHANZ	Rural Health Alliance of New Zealand
R&D	Research and Development
RD&E	Research, Development and Extension
RMA	Resource Management Act
RMHI	Rural Mental Health Initiative

RMPP	Red Meat Profit Partnership
RPs	Rural Professional
SCC	Somatic cell count (Bulk milk somatic cell count)
SFF FUTURES	Sustainable Food and Fibre Futures
SMASH	Smaller Milk and Supply Herds
SMP	Sustainable Milk Plan
SNC	Significant Non-Compliance
TDVC	Transforming the Dairy Value Chain
W&W	Wellness and Wellbeing
WFA	Whole Farm Assessment
WGS	Whole genome sequencing
WOF	Warrant of Fitness
UHT	Ultra heat treated

Executive summary

Transforming the Dairy Value Chain programme was a broad and complex undertaking with audacious goals. It broke new ground for New Zealand and all parties involved as it demanded a level of collaboration not previously seen across industry, government and academia.

It was worth the effort and money. We show this by setting out our estimate of the additional benefit created through the programme, over the years. We also highlight several unquantifiable but equally important areas of value.

Path dependency and the nature of industry development

Agricultural innovation systems have path-dependencies that reflect socially constructed, historical patterns of practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organise time and space, and provide meaning to their social reality (Thornton & Ocasio, 1999, p. 804; cited in (Turner, Klerkx, Rijswijk, Williams, & Barnard, 2015)).

The development of New Zealand's dairy industry has been and will continue to be shaped by numerous environmental and institutional factors. Stating that history matters and will continue to matter may seem trivial, but it is useful to set out the processes of technological change present in the dairy industry, as once pursued, strategies and investments cannot be rapidly undone – even when market and social conditions change.

The programme was intended to be transformational and, therefore, to change or materially shape new directions for the dairy industry. We highlight areas where changes could be considered material.

Responding to the challenge; underpinnings of continued social license

For the past 20 years, New Zealand's dairy income predominantly came from seasonal production which was processed by farmer-owned cooperatives and sold into commodity markets. The industry has been highly successful at growing milk production, but this volume growth brought the environmental consequences of dairy into the public spotlight. The result is bigger farms with a change in expectations placed on farmers and a negative challenge from how the public view dairy farming. In short, farmers and dairy farmers require a social licence to operate.

There were several important initiatives aimed at supporting that social license which would be sorely missed, if they had not happened at that time. Central government and Regional Council environmental policy and regulatory initiatives would have been greatly hindered if this programme of activity had not been undertaken.

Capability and capacity in nutrient management has grown materially

There have been a series of other environmental initiatives which are leading changes in farmer attitude and farm management practice, including increased quality of advice. Train the Trainer advanced nutrient and effluent management provided timely capability.

There are now more certified rural professionals helping farmers to shift towards a whole systems approach to farm management. There were a broad range of nutrient and effluent management training programmes that prepared the sector for regulatory changes targeting improving water quality. Evidence based training material was developed and rural professionals were instructed in its use. These rural professionals assist farmers to meet the requirements of emerging farm sustainability plans in a way that was not possible before. There is a clear means to measure and monitor nutrients and properly manage effluent and a group of rural professionals trained to assist farmers to achieve that necessary goal.

The nutrient management and effluent management objectives of the PGP certainly appear to have contributed to initiatives that have lessened the environmental effects of the dairy sector already. More importantly, these initiatives were undertaken at a time the industry recognised the need to respond, to continue to meet its social license, and means there is industry initiative to back up regulatory process. The highlights that we identify are as follows:

- By the end of the 2016/17 season the 4th Sustainable Dairying: Water Accord showed 94 per cent of farms had their nitrogen loss and nitrogen conversion efficiency performance data collected and reported back to them. As the PGP concluded, there were increasingly diverse organisations with trained advisers including councils, sector organisations, professional services firms, farm consultancies and fertiliser industry agents.
- The 2018 TDVC Business Plan (dated June 2017) noted that the year 3 report for Sustainable Dairying: Water Accord showed 83 per cent of farms had nutrient budgets (DairyNZ, 2016). This had increased to 94 per cent by the year 4 report for the 2016/17 season. The final year 5 report showed the 94 per cent level had been maintained.
- The Sustainable Milk Plan project has lead to changes in farmer practice; the Upper Waikato Project was completed with 642 SMPs delivered.
- As of January 2018, there were 20 Farm Dairy Effluent System Design accredited companies. According to the annual 2014 DairyNZ farmer survey, 69 per cent of respondents had either invested in an effluent system upgrade in the last 12 months or were planning to in the next 12 months. Significant non-compliance reported by regional councils dropped from 15 per cent to 5.2 per cent from the PGP's beginning to the end of May 2016. However, it has risen marginally to 5.3 per cent according to the 4th Sustainable Dairy: Water Accord Progress Report (DairyNZ, 2017, p. 25). The Progress Report credited some of this to the PGPs investment.

These initial efforts have become business as usual for the dairy industry. DairyNZ provides continued oversight and support of the effluent management project areas under its 'Meeting environmental obligations' project.

First steps around greenhouse gases

The greenhouse gas management work followed the same method of training and accreditation to give the sector the tools and support needed to adapt to Paris Agreement emissions targets. These targets are now becoming more real and there is a cadre of trained professionals available to assist.

The programme established GHG minimum knowledge requirements; evaluated a GHG training course and the possibility of a certification programme for farm consultants; developed a framework for assessing the impact of GHG mitigation options on the farm business; and recommended a tool for accounting for GHG reductions.

Animal welfare assessment capability has been enhanced and has improved productivity

The Body Conditioning Score (BCS) certification and training projects raised the standard of assessments and improved the capability and availability of trained assessors. It was aligned with a non PGP programme - Body Condition Management to encourage adoption and stimulate user demand for trained assessors. Body Condition Scoring is recognised as effective way to maximise production and monitor the wellbeing of dairy cows. Post PGP funding BCS certification and training shifted to a user pays model.

There is some anecdotal evidence of benefit attributed to the Cow Skills pilot. One of the farming businesses noted: Their somatic cell count last season was 230,000, and this season it is at 94,000. **"I put that down to CowSkills. They (workers) are cleaning their hands after finding mastitis cows, they know how and why to strip so not only are they doing it but they are doing it well and they teat spray properly"** (DairyNZ, 2018, p. 4).

The dairy industry leadership pipeline was strengthened

The suite of initiatives to attract talent to farms and provide a stronger research and education footing, has been successful. The highlights we identify are as follows:

- The TeenAg club network was considered one of the bigger success stories of the PGP funding, with 105 schools and 2300 members. One hundred and sixty TeenAg students transitioned into NZ Young Farmer clubs at the start of 2017. There is a strong platform for TeenAg to build on, but this aspect of the program has not become self-sustaining.
- The logic of the professional land managers training programme appears sound. Success in the delivery of appropriate training should lead to better decision-making on farm by managers and owners. In turn, this better decision making will lead to improved productivity and profitability. Coaching sessions and conference calls suggested that virtually all farmers had grown in confidence

through the programme and most farmers could cite evidence of implementation on farm.

- Research and teaching capability in agri business management increased although the centre of excellence faltered. Interviewees identified to us that there is a cohort of trained professionals contributing to the dairy industry and the whole primary sector. Departments are stronger, good talent is coming through, so it appears the work has built momentum and capability.
- PGP funding created a significant level of research and provided opportunities and encouragement for individual staff to undertake research. Research outputs increased and staff who had not been involved before were engaged in the development of projects, research and presentation of results. There are indicators that the project has improved the capability of farm management staff and students and that this research has involved resources from other universities and agricultural professionals

There were gains in the quality of farm management and leadership. People Lift provided evidence that the use of Certified People Management Consultants can result in significant change to leadership and management of farm teams and result in benefits. Seventy per cent of consultants indicated that the programme had lifted their confidence and the quality of advice they were providing to clients.

Evaluation of farmers who have been involved in Whole Farm Assessments showed that the majority have made significant changes as a result of the process, with several farmers indicating that the 'whole of systems approach' has 'kick-started' them into change. Key changes related to staff structure, leadership and management; business strategy; pasture management and monitoring; improved reporting systems; farm systems (stocking rates, feeding levels, calving times); business focus – profit focussed rather than production focussed; use of advisers; financial management and monitoring systems; and environmental compliance and management.

Farmer wellbeing and wellness was brought to the fore

Thousands of farmers and rural professionals have the tools to stay healthy, happy and productive, and the networks to communicate and share new innovations (Final Report, 2018, p. 39). There was real progress in recognising and addressing mental health issues, with a view to improving the resilience of those working on farms and likely also owning farms. Part of the programme set out to assist members of the dairy workforce to improve their health and wellbeing. GoodYarn, a mental health identification and support workshop, involved 22 organisations to reach over 3,000 people. The model is now being applied to other industries.

These programmes, particularly those around mental health and resilience, are an important backdrop to rural settings today. M. Bovis cull represents a new challenge to farmer resilience. The proposed counterfactual is that without the programme the industry would not have been in as strong a position to support rural communities. Previously, the only services available were considered to be "at the bottom of cliff", but now there are tools and services that enable earlier interventions.

Smaller farm business support improved. SMASH is either providing or has the potential to deliver an efficient mechanism of supporting smaller farms. This could be considered a future cost saving generated by the PGP investment. The benefits of SMASH include improving the resilience of smaller farms and, increasing social cohesion as farmers involved seem to enjoy supporting each other. The market does not have competitive pressures that discourage knowledge sharing.

Pre farm gate research was accelerated, with substantial benefit

The programme took some existing industry science capabilities and increased resourcing, thus allowing the industry to run faster. Genomic progress was significant and impressive.

The genomic work from theme one is a highlight with long term benefits to 2040 estimated in excess of $1 billion NPV. This value was produced by improving the accuracy of gene selection which increased farmer confidence in using genomic sires. Early in the PGP the genome objective established an important bioinformatics capability to allow genomic information on important dairy animal traits to be extracted. The PGP's research discovered genetic markers that affected milk production, including the AGPAT6 marker for milk composition. The research discovered genetic markers that affect milk production and increased ability to avoid selection of undesirable genetic variations. The PGP has bedded in the capacity and processes to rapidly identify the genomic cause of animal abnormalities if they are found on farm.

The industry continues to invest in genomics and a new 7-year, $25 million innovation programme was announced on 13 June 2019. It is known as "Resilient Dairy: Innovative Breeding for a Sustainable Future" and is being led by LIC with investment and support from MPI and DairyNZ.

This research has spill-overs to wider genetic and bioinformatic research. Research that formed part of the gene sequencing objective identified the causative variants of several bovine disorders. These discoveries had the potential to shed light on mechanisms of analogous human diseases.

Post farm gate research has long-running benefits

There has been increasing bi-partisan political pressure for the dairy industry to produce more value with lower impact. Shifting up the value chain became a required strategy but the knowledge, system and capital requirements for the production, processing and marketing of whole-milk powder differ significantly from branded consumer products. Comprehensive investments were required to substantially change the product mix. The presence of path-dependencies suggests these investments elicit further moves in the same direction (Steward, 2016). This is what we observe in the area of post farm gate research.

The science-driven, linear, technology transfer-oriented approach to innovation in New Zealand has traditionally lacked end-user involvement. This co-investment approach represented a shift towards a co-innovation approach, bringing together relevant actors from the agricultural sector to increase research and development efforts in a coordinated and interactive fashion, the likes of which has never been fully implemented in New Zealand agricultural R&D (Turner, Klerkx, Rijswijk, Williams, &

Barnard, 2015). We observe much closer integration of markets with science although it would appear the innovations are science led rather than market led, which is a surprise to us.

The collaborative approach and investment model produced award winning science. The model was praised by leading local, and global late-career researchers. The investment developed a pipeline of commercially focussed academic researchers supported by returning acclaimed international academics.

Synlait noted the PGP investment meant they could take their blue skies concepts and, as a smaller company, leverage a high-quality research capability. In this designer milk segment, earlier work developed a novel spray dried lactoferrin product. This product succeeded and became a successful on-going business. The PGP research on adding value to protein/fats by-products also has the potential to be of value in the future as well as the further work done on specialised versions of lactoferrin.

The sub-projects of the designer milks objective spanned from the farm to the market, and because of this it was one of the best examples in the PGP of an integrated approach across the dairy value chain. Synlait's continued growth leading to it employing more people and being able to reward farmers who would have more to spend in the local economy.

Food structures research led to gains in differentiated milk properties

Commercial relationships were established and strengthened, and product range and market reach extended.

The vision was centred on creating and managing food structures to achieve differentiated physical and sensory performance in ingredients, dairy solutions and consumer products. The fundamental idea was that process leads to structure which leads to functional properties. We were told in interviews of the PGP's participants that this model has persisted and has the potential to be applied to a large range of dairy product development.

Mozzarella was an important step forward

This involved producing a shredded format product directly off the line drastically reducing the production timeframe (Johnston, 2010). According to Fonterra, production time was reduced from three months to six hours (Fonterra, 2017). This was an important breakthrough and provided the foundation for the PGP work. All the science, engineering and technology needed to fully understand the process was identified and turned into projects funded through the PGP. The PGP achieved significant progress in formulating and manufacturing mozzarella. It developed a range of scientific tools for exploring and understanding the structure of cheese. It also validated models of the pizza-baking process, and the links between cheese structure and the formation of blisters, bubbles and other facets that consumers can observe. This was coupled with machine vision applications to give objective measurements of cheese performance. It also developed and designed critical mixing and cooking operations of cheese production, including mapping the relationship between the mechanical work in mixing and final cheese product. PGP de-risked the project at least allowed earlier

commercialisation and scale-up of the innovation. This food product sells into the food services market which is a growth market for Fonterra and one that grew considerably during the PGP.

A point much argued is whether the investment in mozzarella would have happened without this programme's intervention. From interviews, we are clear that this product development would have either happened at much slower pace, or not at all. Our view is the PGP investment in mozzarella brought in good returns.

The breadth and depth of science invested in furthering the IFQ Mozzarella process advanced the manufacturing process enough to provide Fonterra the confidence for over $300 million in capital investment. We were told this model has persisted and has the potential to be applied to a large range of dairy product development.

Endgame creams are a result of underpinning PGP research

Timely PGP research on UHT creams boosted sales and lead to growth particularly in the all important Chinese market. The leader of Theme 3 commented that there was no new product in UHT category that did not have the underpinning PGP research. She stated that the Waitoa plant expansion was based on the work of the PGP.

The UHT creams work has broadened the food-service category and is fundamental to future UHT product launches. Fonterra's production of UHT cream has almost trebled since 2015, earning some of the highest gross margins within the product category.

The Endgame creams programme also attracted several young scientists to work alongside Fonterra. The work also built good international relationships with Australian and Canadian universities as well as universities in New Zealand. This has helped to grow Fonterra's supporting academic networks.

Signature milks were investigated

Signature milks also investigated scientific, technical and consumer insights for use in the development of future dairy beverages and the ability to deliver long shelf-life dairy beverages, with elevated levels of protein and minerals. As a result of the PGP Fonterra's R&D team and Massey University now have an ongoing relationship with the research team at the University of Queensland.

Quality management progressed a generation

> **"The work translates into a change in Fonterra's innovation process. We have changed the infrastructure around measuring risk. We would not have been able to do it without the PGP."**
>
> **"Fonterra's data capability and understanding has been advanced by five years"**

Big data advances were taken up earlier and are in-house. Data measurement and management improved manufacturing efficiency and helped reduce risks of batch failure. The theme four data work significantly advanced Fonterra's position in and understanding of data; requirements, warehousing

and analytics. The benefits are realised through greater efficiencies in powder processing and a more top-quality product sold at a premium. This area of activity was named a "strategic imperative" by Fonterra.

The PGP enabled the big data aspect of milk fingerprinting. By investigating milk composition beyond fat and protein, the team discovered they could delve into other quality aspects. The work contributed to the development and deployment of the fat evaluation index - a tool to measure and enforce rules around the use of supplementary feed. It provides a direct link between farm inputs and quality aspects of final product which has important implications as milk is no longer able to be viewed as homogenous. It is now recognised that practices and locations produce milk with different quality attributes. Fonterra farmers have rapid feedback on the quality of their milk fat and can manage their supplementary feeding to maintain product quality within acceptable limits.

Academic and commercial relationships in the field of process engineering have improved, and capability has increased through use and implementation of "big data" methods and techniques.

> **"We know how to do it and there is a cadre of trained process engineers."**

The product quality and processing information database will be used as a teaching resource at the University of Auckland which is an important spin-off for all graduates undertaking this study. The process engineering capability available to dairy companies generally and to other New Zealand processing industries has increased.

Functional foods research broke new ground

The theme five area shifted Fonterra towards the functional foods market. Most of the work was around investing in human health trials. The functional food messages were developed for consumer markets and deployed through product relaunches largely targeting Asian markets. The same story and messages, and same features of products, met the needs of business-to-business marketing too. Now, we observed product managers have a staged development plan for functional food products with linked therapeutic claims and plans for investing in the science needed to make those claims and plans.

Further, this investment in functional foods is leveraged in the food ingredients business. Fonterra is a large contract manufacturer and its ability to source some high-quality ingredients as well as to access a dossier of evidence on therapeutic claims is valuable, and difficult for competitors to replicate.

Now, after a long period of science investment through the PGP, we are told the benefits of science investment are seen more clearly in Fonterra management. Several interviewees noted the co-investment funding and long-term nature of the contract meant that management was able to see the benefits of investment in trials. Otherwise, the risk of the trials may have been too great for what is seen as a risk-averse culture. The true value is the significance of Fonterra breaking through into consumer markets with products able to make functional food claims.

The Anmun product range has expanded consumer market presence in Asia. The science supporting this consumer product range has been leveraged in the ingredients business, in business-to-business sales.

Thinking across the value chain happened, over time

Pre and post farmgate began to look over the fence. The projects proceeded in silos for much of the time, but the transparency of activity brought about through joint governance and one programme manager, meant the integration started to work at the end. The next (albeit unsuccessful) PGP was worked up as a fully integrated PGP, looking at the entire supply chain.

The return on investment was substantial and sustained

There is certainly evidence of beneficial outcomes, valuing many of these is problematic. However, for an investment of this size, valuation is well worth the effort.

The $1.86 billion valuation of net benefit is outlined in Figure 2 and translates into an annual return of around $135 million in today's dollars. In calculating this value, we have been conservative in estimating benefits because of the difficulty of trying to understand what might otherwise have happened, and due to data availability particularly in commercial production.

Here are some highlights:

- The genomic work from theme one produced long-term benefits from herd improvements estimated to give a $1 billion plus NPV.
- The 'Train the Trainer" programme produced a suite of programmes, the nutrient and effluent work $219 million value relates to the avoided production loss if water quality impacts were not addressed in a timely fashion.
- Animal welfare projects improved the capability and availability of skills that improve productivity to the benefit of $74 million.
- The breadth and depth of science invested in furthering the IFQ Mozzarella process advanced the manufacturing process enough to provide the confidence for significant capital investment. The $60 million value relates to the position that the PGP investment materially brought forward this processing initiative.
- The theme 4 data work advanced Fonterra's position in and understanding of data requirements, enabling efficiency gains, premiums on powders, and reducing the risk of quality failure, contributing to a $20 million benefit.
- The theme 5 work enabled Fonterra to leverage science backed claims into the marketing for the ingredients business. This was in addition to supporting the development of Anmum and Anlene consumer brands. Associated benefits are valued at $56 million.

We have not valued possible other benefits such as the change in attitude to post farmgate science although these flow-on benefits may well be very material.

Themes	Workstreams	Objectives	Valuation
1	Resilient cows	1.2.1 Increased generic gain through gene sequencing	**$1,380m**
		1.2.2 Increased genetic gain through improved phenotypic data	**$41m**
	On-farm technologies	1.2.3 Designer milks	**$1m**
		1.2.4 Improved pasture performance	NA
		1.2.5 Precision agriculture	NA
	Dairy data network	1.2.6 Dairy data network	NA
2	More and better advice	2.7.1 Nutrient management training and quality assurance	**$219m**
		2.7.2 Effluent management training	NA
		2.7.3 Greenhouse gas management training and tools	NA
		2.7.4 Animal welfare management	**$74m**
		2.7.5 System integration, risk assessment & people management	NA
		2.7.6 herd reproduction management	NA
	Better farm decisions	2.8.1 Leadership pipeline	**$1.2m**
		2.8.2 Professional land managers	**$0.9m**
		2.8.3 Centre of excellence in farm business management	NA
		2.8.4 Large farm business	NA
		2.8.5 Farmer wellness & wellbeing programme	**$8m**
		2.8.6 Smaller farm business support	NA
3	End game mozzarella	3.1.2 Semi-solid and solid foods	**$60m**
	End game creams/signature milks	3.1.3 Extreme composition fluids	Probably covered costs
	Zespri	3.1.5 Kiwifruit structure	NA
4	Process analytical technology	3.2.3 Process analytical technology	**$20m**
	Food safety & quality	3.2.5 Food safety& quality	Significant but unquantifiable
5	Mobility & protein	3.1.3 Mobility & protein	**$56m**
	Paediatrics	3.3.4 Paediatrics	Significant but unquantifiable
			$1,861m

There were "failures" and some projects were not durable

We would expect failures and there were failures. For instance, work on "night milk" did not result in a successful outcome. Also, the human trials ended with positive functional benefits but those were not necessarily what was hypothesised.

Some research areas such as pre farmgate investigation into the efficiency of feed conversion were shelved as gains were not enough to justify implementation. Breeding companies did make some progress creating a measure of how efficient a cow is at using feed for body maintenance or milk solids production. If successful, then it could save farmers money in feed costs. Parts of this programme will be renewed, and techniques reused with today's current closer focus on addressing climate change. Techniques developed and lessons learned in the residual feed intake research have been applied to a new study, funded by MPI.

There were, however, other failures through co-ordination and communication issues. The programme lacked cohesion initially. Some programmes such as workforce initiatives with Young Farmers were successful while funded but stopped when not funded. The effects were not durable without continued investment.

Herd reproduction management gains were largely unrealised

The potential gains of improving herd reproduction management estimated at hundreds of millions remain unrealised. However, some tangible progress was made particularly in in-calf training and heifer rearing.

- PGP funding allowed a two-day training workshop to be developed by experienced veterinarians targeting the capability of end users like dairy cattle vets and contract heifer graziers.
- Feedback from the heifer field days indicated that attendees thought they were high quality and of high value. Attendees rated them 8.75 out of 10. Attendees indicated that they had made practice changes across all key heifer management areas.

Feed requirements for grazing dairy heifers' pdf was the most downloaded information from the DairyNZ site (Dirks, 2017). Graziers who allowed their businesses to be focus farms had all benefited from being part of the programme by increasing grazing rates and/or becoming more sought after for grazing. All these graziers had increased the number of heifers that they graze on their farms

There was an important change in farm advisory practice by veterinary businesses. Interviewees suggested that the larger veterinary businesses have developed dedicated resources focused on advisory activities separate from clinical work. This is usually at the level of two or so FTEs so estimated to be around 30 people throughout New Zealand. Large animal veterinary work is very physically demanding so often the people moving to focus on consultancy work were more experienced vets who were shifting away from the rigours of clinical work. This trend was probably accentuated by the PGP which highlighted the value for these businesses in structuring themselves to support consultancy approaches.

Precision agriculture and data linking was encouraged but uptake slow

LIC Automation developed testing protocols and this work was presented internationally. The work was aiming to get into other standards for other precision agriculture systems, to get standardised approaches to testing, protocols and reporting. Improved methods were developed for using

information and automation technologies to monitor animal status (e.g. reproduction management, animal health and condition), leading to improvements in animal health, labour, and farm efficiency.

The final report admits uptake of Farm Data Accreditation and Data Linker has been slow. It optimistically offers "there is a substantial change occurring with organisations willingness to share data across both dairy, sheep and beef sectors performance (e.g. paddock performance assessment)

Was the programme too big?

There are also some cautionary notes. Stakeholders were mixed with some seeing the benefits of large and complex programmes and suggesting that the knowledge and experience gained from this PGP would improve outcomes of large future investments.

> **"There was such a broad range of activities, we could close down and open up new areas of activity."**

> **"No reason why you can't do one of this scale – just need to focus on counterfactual and serious eye on quantifying benefits as best able."**

Without the broad base of investment there wouldn't be the confidence to propose investments with an appropriate risk profile. There is an intrinsic dislike of failure whereas the reason for co-investing is because of recognised under-investment in risky research and industry change.

> **"My view on this, if always successful, why would government fund it?"**

Others thought the programme tried to do too much and would have produced better outcomes if it was more focussed.

> **"In retrospect, I think it was too big and it was too complex. Not too big, too complex. Too many areas to measure."**

> **"Could have had five programmes, not a high degree of interdependence between the themes. Overall value picture is a sum of all five, predominantly additive."**

> **"I think that if someone came to MPI with a similar size project, complex and bitsy, they would not invest in it again."**

> **"No one would argue that if we had been able to concentrate on fewer things it would have been a better structure."**

Communication was at times poor and the success of the programme has not been fully understood or reported. Having a communications adviser earlier in the life of the programme would be good. It would have been able to disseminate popular articles in readable formats to farmers (e.g. use of

drones, robotic milking). This was happening at the end of the programme but it would have been good to have it happening earlier. It was a popular way of getting information out.

For those active in the programme, a once-a-year presentation of everything to the wider PGP programme team would have been useful and could have assisted the goal of integration across the value chain.

To effect change on-farm, there is a need for "proof of practice" demonstrations that integrate successful advanced management technologies with farm scale systems.

Table 1: **Key lessons from the programme**

Lesson 1: The long-term investment horizon was crucial

The commitment to an investment programme over the seven-year period was vital to the successes. The programmes survived several strategic resets and a significant dairy downturn. The PGP commitment ensured funding streams could not be cut. We were told by stakeholders: "PGP funding over a long period allowed us to develop and continually invest."

Lesson 2: The flexible nature of investment was crucial; fund the effort not the work

The ability to change tack and shift resources during the programme ensures that the most promising areas are allocated the most resources and encourages less promising areas to be discontinued. Money could be used elsewhere, with agreed control procedures. In science, there can be delays in getting the right people identified and in place for PhD projects. The appointment of academic chairs and expert panels relies on identifying and attracting the right level of talent. In human trials, the results are sometimes not what would be expected.
"Avoid funding a student, fund the programme the student is working on. Easier to roll with the inevitable changes in people."
"Take instant quick-frozen mozzarella – 15 per cent of the science went into the final design but I could not have told you what in the beginning." "The flexibility of the programme helped redirect funding into promising areas as plans and strategies changed the initial investment plan."
"The core strength of the PGP was the ability to explore and adjust activity as the programme evolves."

Lesson 3: Link commercial with scientific enterprise.

The Theme 3 model was widely praised as a replicable and extremely successful approach. The approach included; attracting top international scientists to NZ academic institutions, academic and commercial co-supervision for funded researchers, funding academic chairs and an expert panel, a suite of carefully selected academic projects with a parallel set of commercial projects running so any findings could be implemented immediately. "The theme leader spent 3 months fulltime before the first meeting coming up with things that made sense. Then refined them further. Only choosing a third by asking do you really think this is going to have any impact on the business."

Lesson 4: Agree on benefits measures and how to track them before contracting

Identify specific benefit measure targets up front before a programme begins, and track and trace benefit measure achievement as part of the execution of the programme. This should include agreement on appropriate documentation, a counterfactual and a disclosure of the current programmes of work spanning the targeted areas.

Lesson 5: An independent chair helps governance but reporting needs to be clear

We understand an independent chair is now standard practice. Aligning internal reporting with PGP reporting would be helpful in reducing duplication. It is unclear how much value the reporting procedures created.

"It was worth the effort and money"

Benefits and value generated by The Primary Growth Partnership / TDVC

Pre Farm Gate

$1B NPV Estimated long-term benefits of genomic progress

Led to 'Resilient Dairy', a seven year $25 million innovation programme

Post Farm Gate

Award winning science a result of collaboration and investment

Estimated long-term benefits $100m + NPV

Leadership pipeline strengthened

TeenAg involves

105 schools

2300 members

Research capability has increased

Whole Farm Assessments result in significant changes

Strides in quality management

Big data advances

Risk of batch failure reduced with data measurement and management

Efficiencies in powder processing and premium quality product

Milk fingerprinting

Improved academic and commercial relationships

Farmer wellbeing acknowledged

Mental health issues recognised and addressed

GoodYarn involved

22 organisations

3000 people

Greenhouse gas develoments

GHG minimum knowledge requirements established

GHG training course evaluated;
Impact assessment framework developed;
GHG reduction tool recommended

Animal welfare improvements

Body Conditioning Score certification raised the standard of assessments

BSC certification has moved to a user pays model

Benefit attributed to Cow Skills pilot

Nutrient management improved

94% of farms collecting nitrogen loss data 2016/17

642 Sustainable Milk Plans delivered

94% of farms have nutrient budgets, up from 83% in 2017

20 Farm Effluent System Design accredited companies

Regional council non-compliance reports down to 5.2% from 15% in 2016

PGP objectives contribute to environmental impacts

Practices are now BAU

Functional food broke new ground

Staged development plan for functional foods

Investment leveraged in food ingredients business

Differentiated milk

- Mozzarella
- Endgame creams
- Signature milks

Some failures

Night milk

Feed conversion

Young Farmer workforce initiatives lost funding

Herd reproduction gains unrealised

Slow update of precision agriculture & data linking

Lessons learned

- Long-term horizon was crucial
- Flexible nature of investment was crucial: fund the effort, not the work
- Link commercial with scientific enterprise
- Agree on benefits measures and how to track them before contracting
- An independent chair helps governance but reporting needs to be clear

Some questions remain

Did programme try to do too much?

Would more focussed outcomes result in better results?

Could communication have been better?

Is the success of programme fully understood and reported?

Review of Transforming Dairy Value Chain PGP

Introduction

1. The objective of this assignment is to provide the MPI Sustainable Food and Fibre Futures (SFF FUTURES) team with evaluation achievements and expected outcomes from the Transforming the Dairy Value Chain (TDVC) Primary Growth Partnerships Programme (PGP) which ran from February 2011 to January 2018. It will also investigate the programme's execution and governance, and identify any lessons that would benefit other MPI investment programmes.

2. The MPI Sustainable Food and Fibre Futures programme co-invests with primary industry partners in long-term, sustainable, innovation programmes. It is designed to help industries to raise the amount of market-led, high-value product development and farm improvement to lift productivity and profitability in the sector. The long term aim is to deliver economic growth and sustainability across New Zealand's primary industries. Overall, the SFF FUTURES programme seeks to encourage more private investment in research and development in the primary sector and to share the risk inherent in ambitious, large-scale transformational initiatives, which would proceed much more slowly, or not at all, without government funding.

3. The TDVC PGP was established in 2011 by agreement between MPI and partners, DairyNZ and Fonterra, to commit NZD$170 million towards its objectives over seven years. The TDVC aimed to transform the dairy value chain by creating new products, increasing on-farm productivity, reducing environmental impacts, and improving agricultural education.

4. Synlait Milk Limited, Livestock Improvement Corporation, Zespri Group Limited, New Zealand Young Farmers, Agricultural Services Limited and Landcorp Farming Limited also became part of the TDVC as commercially subcontracted partners.

5. The focus of TDVC has been on two areas as follows:

    - Two pre farm gate themes led by DairyNZ (1) on-farm innovation and (2) capability & capacity.
    - Three post farm gate themes led by Fonterra (3) food structures, (4) quality management and (5) nutrition and health.

6. The five themes are split into 13 workstreams and further into many separate TDVC projects.

7. The seven year programme is at its end. This review sought to answer key questions that MPI wanted answered. This will give MPI greater confidence about the forecasted benefits of the TDVC. We also investigated whether the TDVC programme's engagement and partnering projects supported effective initiation, establishment, planning and execution of co-investment programmes. Our work took existing reviews as a starting point and aimed to uncover useful new findings.

Approach to this review

Objectives of this review

8. A key question addressed is about the TDVC's outcomes. Specifically, what has been accomplished by the programme and what are the potential future benefits of the TDVC programme to New Zealand?

9. Another critical focus for this report is to answer the question about how well the TDVC programme was executed. Lastly this review seeks to highlight lessons that can be learned from the TDVC programme and how those lessons might apply to other PGP programmes and PGP investment management.

Scope

10. The scope of this report is be focused on assessing the effectiveness of processes used to develop and maintain the programme's Outcome Logic Model, benefits register and Business Case. It will review the findings and recommendations of the TDVC's planning, governance and management documents, progress reviews and audits. Assessing how the benefits and risks to those have been updated in response to emerging intelligence, information, research, investigations and evaluations is within our remit.

11. We assess how MPI communications, engagement and relationship management practices have contributed to effective TDVC governance and execution. Finally, we investigate the assumptions made in modelling and forecasting of the TDVC's benefits.

Out of Scope

12. This report did not assess the TDVC's alignment with current Government policy or critique the PGP model and the rationale for investing in the programme. It also did not assess the quality of intelligence, information, research, investigations, audits and evaluations used by the programme's workstreams and projects or assess how MPI has revised baselines for financial, economic and other benefits in the period after Programme completion.

13. MPI's monitoring and forecasting processes are not in scope. Assessing engagement and relationship management practices after programme completion is another topic outside our remit. Finally, we are not completely re-modelling or re-forecasting the TDVC's benefits.

Reviewers

14. Our team consisted of David Moore Sapere's Managing Director, Peter MacIntyre a Sapere Principal and Ben Barton a Sapere Consultant. We were assisted by sub-contractors Steve Murphy and Dr Bruce Campbell who provided specialist experience and technical knowledge.

Review method

15. Sapere was the lead reviewer for this review. Sapere provided administrative, logistical and analytical support.

16. The TDVC programme was an ambitious and complex undertaking that underwent several changes in strategy, leadership, oversight and reporting. As the programme is complete and many of the key personnel involved have moved on to new roles, we used a two-stage approach to this evaluation.

17. Stage one – completion of the activity statement (with theme and project timelines levering off the work on this done by Deloitte for Fonterra on the Fonterra focused activities), interviews with close partners and core governance, complete statement of evidence and gaps on value.

18. Stage two – further stakeholder interviews and development of a statement of summary value, the evidence for it, and the analysis behind it.

19. We used the process discussed below for the evaluation.

Document review

20. This involved desk-based review of programme documentation as listed on page 8 of the terms of reference, including the business plan and annual plan updates, the PGP agreement and variations, progress reporting and relevant expert panel reports, technical reports and audit reports.

Inception planning

21. We held an inception meeting and prepared a finalised two-page evaluation plan building on our original proposal and setting out the evaluation objectives, methodology and approach; timeframes, list of stakeholders and the terms of reference interview. The plan also outlined our roles and responsibilities.

Stakeholder interviews

22. We utilised the terms of reference interview questions but built on those. Semi-structured interviews were undertaken with key stakeholders and other relevant parties as listed in the terms of reference. This began with the programme manager who provided an initial stakeholder list that included key programme staff, such as theme leaders, Programme Steering Group members, and MPI staff. MPI assisted along the way directing us to the appropriate members of the PGP Investment Advisory Panel (IAP). The initial group of approximately 20 interviews provided names other people they though useful to talk to, documentation was also used to expand the list. Some stakeholders were interviewed face-to-face. Other stakeholders were interviewed by telephone. A number of the core stakeholders were interviewed multiple times as our understanding of the programme evolved so we could establish and confirm findings. We used our contacts especially those

of the Subject Matter Experts (SMEs) to ensure that we explored a wider set of views including those of firms developing and implementing alternative strategies and capabilities and industry insiders not involved in the TDVC programme. At this stage we have conducted interviews with 46 individuals, with multiple interviews being conducted with a number of stakeholders our count is well over 50.

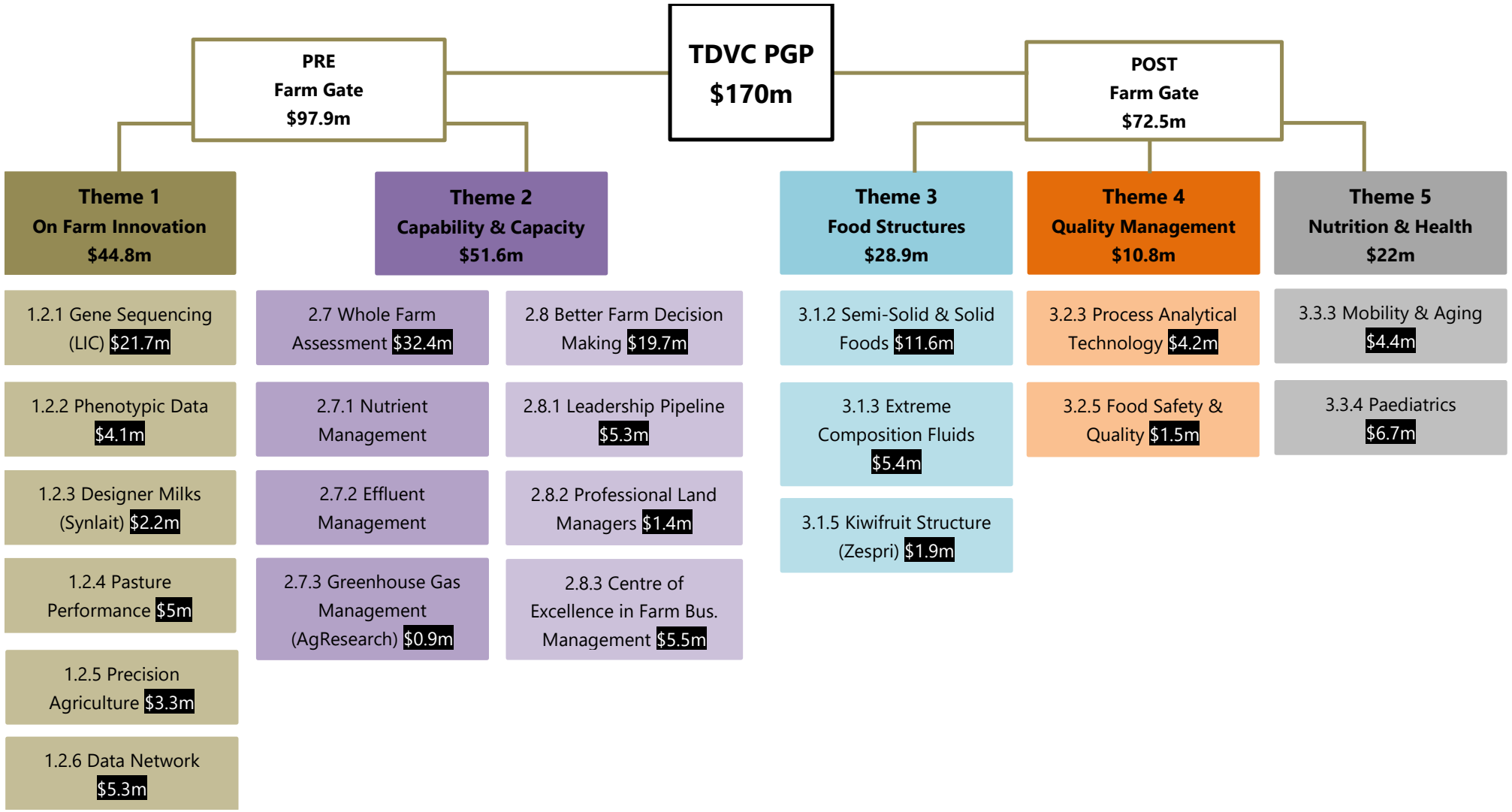
Synthesis and analysis

23. We thematically coded the notes from the stakeholder interviews and cross referenced these with the evidence from the document review to formulate overall findings. We used these to develop conclusions against each of the evaluation questions, and validate the findings with our expertise. The evaluation team met with the MPI Investment Manager and the PGP Programme Manager to present initial findings.

Reporting

24. This report presents the findings, conclusions, and recommendations of the review. We incorporated feedback from the MPI Investment Manager, the PGP Programme Manager, and the Programme Steering Group into this final report. We also delivered a presentation on findings and recommendations to MPI.

Figure 1: Objectives of TDVC PGP[1]



[1] The final spend is accurate to the theme level, below that the figures represent the predicted spend at the progress review as in (Deloitte, 2015).

TDVC Programme Valuation

Figure 2: Valuation summary covering the period from PGP inception to 2040

TDVC programme valuation

Themes		Workstreams	Objectives	Valuation
	1	Resilient cows	1.2.1 Increased generic gain through gene sequencing	**$1,380m**
			1.2.2 Increased genetic gain through improved phenotypic data	**$41m**
		On-farm technologies	1.2.3 Designer milks	**$1m**
			1.2.4 Improved pasture performance	NA
			1.2.5 Precision agriculture	NA
		Dairy data network	1.2.6 Dairy data network	NA
	2	More and better advice	2.7.1 Nutrient management training and quality assurance	**$219m**
			2.7.2 Effluent management training	NA
			2.7.3 Greenhouse gas management training and tools	NA
			2.7.4 Animal welfare management	**$74m**
			2.7.5 System integration, risk assessment & people management	NA
			2.7.6 herd reproduction management	NA
		Better farm decisions	2.8.1 Leadership pipeline	**$1.2m**
			2.8.2 Professional land managers	**$0.9m**
			2.8.3 Centre of excellence in farm business management	NA
			2.8.4 Large farm business	NA
			2.8.5 Farmer wellness & wellbeing programme	**$8m**
			2.8.6 Smaller farm business support	NA
	3	End game mozzarella	3.1.2 Semi-solid and solid foods	**$60m**
		End game creams/signature milks	3.1.3 Extreme composition fluids	Probably covered costs
		Zespri	3.1.5 Kiwifruit structure	NA
	4	Process analytical technology	3.2.3 Process analytical technology	**$20m**
		Food safety & quality	3.2.5 Food safety& quality	Significant but unquantifiable
	5	Mobility & protein	3.1.3 Mobility & protein	**$56m**
		Paediatrics	3.3.4 Paediatrics	Significant but unquantifiable
				$1,861m

Expected benefits of TDVC PGP

25. The original goal of this PGP was to **"increase benefits to New Zealand by $2.7 billion every year from 2020."** This was also expressed as **"to enable doubling of the value of dairy for New Zealand by 2025"** (Transforming the Dairy Value Chain Final Report (Public), 2018, p. 12). The first major goal was pushed out from being achieved in 2020 to 2025.

26. The valuation outlined in Figure 2 translates into an annual return of around $130 million given a constant discount rate and constant payments from 2011 to 2040.

Theme 1: On Farm Innovation

Objective

> The aim of Theme 1 was to improve the way knowledge and technologies were delivered to farm practitioners to increase dairy production without increasing environment effects. It focused on breeding more resilient cows, on-farm technologies and information exchange.

Key Outcomes

- A new genomics model that allows better statistical techniques and marker selection.
- Breeding Values for Facial Eczema tolerance available to farmers.
- Synlait developed and successfully commercialised products.
- Greater sector understanding of pasture persistence issues.
- Development of structure for industry to benefit from data sharing and technology adoption.

> **"Some ideas didn't work, we tried ideas and moved on. Big learning is the gaps between the work and when it is needed. Lots of stuff is moving and meets further out in time."**

Table 2: Theme 1 Overview

Planned core work areas	Investment plan	Progress	Final investment
1.2.1 Increased genetic gain through gene sequencing 1.2.2 Increased genetic gain through improved phenotypic data 1.2.3 Designer milks 1.2.4 Improved pasture performance 1.2.5 Precision agriculture 1.2.6 Dairy data network	Industry $21.9m MPI $23.3m Total $45.2m	Reporting on the genotype and phenotype objective became - Resilient Cows. Designer milks, pasture performance and precision agriculture became - On-farm technologies	Industry $21.5m MPI $23.2m Total $44.8m

27. While centrally managed by DairyNZ a large part of the theme was subcontracted, with LIC and Synlait responsible for over half the investment. Technology issues is the common strand in this disparate group of objectives.

Table 3: Theme 1 On farm innovation components

Objectives	Partners/Programmes	Activities	Outputs	Impact
Resilient Cows	LIC	Gene sequencing phenotype data	Identified markers and methods	Improved herd productivity
Designer Milks	Synlait	Research from farm to market of 5 sub-projects	Commercialisation of colostrum and lactoferrin products and development of a range of research which may be of value in the future	Increased revenue and profit from commercialised products
On-farm technologies	Pasture performance, Precision agriculture	Research and collaboration	Greater understanding of issues	Marginal
Dairy data network	Rezare, Scarlatti	Creation of Dairy Industry Good Animal Database	Data standards, code of practice, Data Linker	A step in the right direction

Objective 1.2.1 Increased genetic gain through gene sequencing

28. **Increased genetic gain through gene sequencing – objective 1.2.1** involved Livestock Improvement Corporation (LIC) subcontracted by DNZ to improve the accuracy of estimates of cow genomic breeding values (BVs).

Key Outcomes

- Research discovered genetic markers that affected milk production.
- 19 markers for production, differentiated product, fertility and animal health were discovered as part of the research on this objective.
- A new genomics model allowed better statistical techniques and marker selection.
- Increased rate of genetic gain potentially worth $1,380 million (NPV to 2040 at a 6 per cent discount rate[2]).

[2] $948 million at an 8 per cent discount rate

"Very easy to come up with big numbers based on the $300 million,[3] and the impact across such a large number of animals (five million cows)."

Table 4: Objective 1.2.1 Increased genetic gain through gene sequencing

Inputs	Partners	Activities	Outputs	Impact
$20 million PGP investment LIC knowledge and datasets	LIC	Whole genome sequencing Improving algorithms Sire screening	Sequence enhanced Genomic Animal Evaluation models	Significant gains to genetic worth of NZ dairy stock

29. Genetic gains may be driven by a number of different traits. These might improve a cow's production milk solids compared to her feed intake, increase her fertility, lower her likelihood of animal health problems or reduce her environmental impact. These genetic gains compound every year because as better genetic stock is selected, it improves the productivity of the calves she produces and the heifers entering the national herd next season. Each year as dairy cows are mated by artificial insemination to the best available bulls their daughters provide better production or environmental gains than their mothers.

30. The rate of genetic gain each year results from four key drivers:

    a) How well animals with better traits are identified or "selection accuracy". This is the difference between estimated and true genetic merit. Selection accuracy is higher when the trait is very heritable and there are good records on the animal of interest and its pedigree.

    b) Intensity stems from the number of animals selected for breeding compared to all animals available for selection. The lower the number of animals selected the higher the selection intensity. Finding a great bull from a huge population is much more possible than from just a few. You try to select the best animals to breed from.

    c) The level of genetic variation in the population is also important. The greater the level of genetic variation, the better. This means that within the population the difference between traits is high. If there is little variance between the best and worst animals, it is much more difficult to improve the genetics of the population towards that of the best animals.

[3] See Amer, P. (2012), Cost Benefit Implications of a New National Breeding Objective for the New Zealand Dairy Industry. Report to NZAEL

d) The pace of genetic improvement is also key. The generation interval is the average age of the parents when their offspring are born. This can be different for males and females. For example, if the best bulls can be identified earlier, when they are younger, their semen can be used for artificial insemination earlier. This reduces the waiting time before the next generation's genetics are available which is normally around four to six years in dairy cattle. This accelerates the rate of genetic gain each year.

31. Care is needed though, because with intensity and variation the best parents are often related. Also, accuracy and generation interval can conflict because there can be less information when using semen from young bulls.

32. Early in the PGP the genome objective established an important bioinformatics capability to allow genomic information on important dairy animal traits to be extracted. This involved a lot of whole genome sequencing (WGS) and genetic mapping of several hundred bulls and cows. Genome Wide Association Studies (GWAS) with over 100,000 animals was then completed using WGS, RNA-sequence, genotype, and phenotype data sets.

Benefits of 1.2.1 increased genetic gain through gene sequencing

Direct Benefits

33. Analysis done in 2014 by Nimmo Bell estimated that this objective would yield the largest gain of any of the pre farm gate objectives in the PGP at $818 million (Nimmo Bell, 2014). This was calculated as net present value over 30 years at an 8 per cent discount rate from 2011 to 2040. Genetic gain is calculated as the annual marginal net income generated by cows' genetic improvement. It is reported in a national selection index called Breeding Worth (BW) which is calculated using a notional feed unit of five tonnes of dry matter per cow per year (Montgomerie, 2014). We reviewed the $818 million estimate of the value of this objective and where it finished up in early 2018 with the help of Richard Spelman, the Chief Scientist at the Livestock Improvement Corporation (LIC) and Andrew Scott also of LIC.

34. The counterfactual rate of genetic improvement before the PGP began was estimated in Nimmo Bell's report to be 10BW per annum which translated into a rate of genetic gain worth $300 million per annum.[4] This estimate remains valid according to our two interviewees.

35. The problem that needed addressing before the PGP began was that the rates of genetic gain had not been what were expected. This was principally due to limitations of the sequencing and analysis technologies. The PGP was to enable genetic sequencing technology which would be a significant improvement in the accuracy of selection and the depth of the data available. This genomics objective involved taking DNA from bull calves and calculating the bull calf's BW from its genetic markers. The BW semen from the top bull calves was taken for inseminations which sped up the pace of genetic improvement in the

[4] One per cent is therefore $3m of incremental per annum.

national herd compared to traditional approaches which involved waiting four years before a heifer calf would provide good production information after her first lactation.[5] The PGP funded research to allow more realistic improvements in genomic progress and more confidence in sequencing variations.

36. The 2014 report noted that 25 to 30 per cent of farmers were using genomic selected semen which resulted in an 8–10 per cent increase in genetic merit per annum. The expectation in 2014 was that another 5 to 10 per cent of the market might shift to genomics.

37. The original work on the value of this objective didn't include any value from the change in market share of genomics that the PGP may have triggered. However, over the period of the PGP there has been a significant change in confidence in using genomic sires and the number of farmers using these has increased materially. This will have further increased the value of this objective in comparison to the 2014 benefit calculation. The share of farmers using genomics has improved from 25 to 30 per cent to 40 per cent over the period since 2014. LIC has advised that it would be valid to assume that the differential of 15 per cent could be compared against international estimates of the value that could be added to genetic gain if the whole market were to move to genomics. This genomic gain has been assessed conservatively at 35 per cent, with international evaluations of this gain being as much as 50 per cent (Schaeffer, 2006). So, the base rate of incremental genetic gain of 0.35 x 0.15 x $300 million means that another $15 million per annum in gain could be added to the value of this objective. This produces an incremental increase in the net present value of the whole genomics objective. It is lifted by $128 million due to the improved market share of genomic sires.

38. While the PGP may have been completed in 2018 it would, in our view, be fair to assume that the change in farmer confidence that it has engendered could have some on-going benefits. On this basis we have assumed that the market share of genomic sires continues to improve due to the PGP's investment from a 15 per cent incremental improvement in genomics market share to 25 per cent between 2018 and 2028.[6] This assumption raises the estimate of $128 million net present value from this component of the overall objective to $184 million.

39. The PGP's research discovered genetic markers that affected milk production, including the AGPAT6 marker for milk composition. Analysis of this marker showed that it was likely to produce a genetic gain of around 5 per cent per annum. This estimate was based on published studies including by Meuwissen & Goddard (2010) on the use of sequence data for genomic selection compared to using alternative DNA chip technology (Nimmo Bell, 2014, p. 20). A genetic gain of 5 per cent per annum from AGPAT6 was equivalent to an

[5] With traditional breeding a new bull will provide 570 inseminations which will result in 80 daughters lactating and providing production information after 4 years. (Assumes conception rate 50 per cent, sex ratio 50 per cent and retaining 56 per cent also accounting for losses before first lactation).

[6] So the share of farmers using genome sires rises from 25 per cent at the PGP's beginnings, to 40 per cent by its conclusion and this rises further so that half of farmers use genomics by 2028.

incremental $15 million per annum benefit on top of the underlying rate of the value from genetic gain of $300 million per annum.[7]

40. Currently rather than the 5 per cent rate of genetic gain per annum estimated in 2014, the rate could be tracking as high as 8 per cent per annum driven by an 8 per cent increase in accuracy of selection.[8] This improvement in accuracy has come from a new genomics model that was introduced in February 2019 which has allowed new and better statistical techniques and better marker selection. LIC are currently looking at using the sequence data to further select markers in the coming 12-18 months. However, LIC's advice is that 5 per cent per annum remains a good conservative estimate and so we have not changed this aspect of the valuation.

41. In 2014 PGP funded researchers had also found 40 variations that were thought worth further research. At that point two undesirable variations which caused costly negative traits were identified. The first trait caused animal wastage in that small calves were born which looked like one-year old heifers when they were in fact two years old. These small cows also produced only 80 per cent of expected milk. Because of this, they were usually culled and replaced at a cost estimated by Nimmo Bell at $1,800 per cow to lactation stage. The other negative trait caused cows to abort foetuses early and then not calve. The benefit of removing each of these variations was estimated at $4.5 million per annum (this probably assumed an allele frequency of 5 per cent in the bull and cow populations so that 2,500 progeny would be affected per negative variant[9]). The previous work assumed that using Datamate could avoid 50 per cent of the at-risk matings which would generate an on-farm value of these avoided negative traits of $4.5 million[10] per annum. This benefit was thought to be available from the 2014/15 season onwards.

42. The 2014 report also noted that LIC was testing a further 4000 variations and it was expected that over the following 12 months a further five new negative variations would be identified from the LIC sequencing dataset. Assuming that on average they would have an allele frequency of 5 per cent in the bull and cow populations there would be 2,500 affected progeny per negative variant. For each embryonic lethal variant the cow would be dry. The earlier work estimated that each embryonic lethal would be worth $4.5 million/year.[11] For each variant where a calf was not viable it estimated that the cost would be $500 for each heifer calf that could not be reared. Each calf defect was therefore worth $625,000/year.[12] In discussions with LIC, Nimmo Bell assumed three were embryonic lethals and two were calf defects. It also assumed that Datamate could avoid 50 per cent of the at risk matings. Given

[7] As calculated by Nimmo Bell in consultation with LIC in the 2014 report.
[8] Trait selection accuracy has moved from the mid to high 50s per cent to ~65 per cent. Richard Spelman email of 12 June 2019.
[9] The same assumption was made about the five negative variants discussed in the next paragraph.
[10] 2,500 x $1,800 = $4.5 million/year/negative trait x 2 = $9 million/year x 50 per cent = $4.5 million/year
[11] 2,500 x $1,800 = $4.5 million/year.
[12] 2,500 x $500 x 50 per cent females = $625,000/year.

these assumptions the value generated was approximately $7 million[13] per year on farm. It was assumed that this would be realised from the 2016/17 season.

43. The May 2018 Final Report explained that 19 markers for production, differentiated product, fertility and animal health had been discovered as part of the research on this objective.

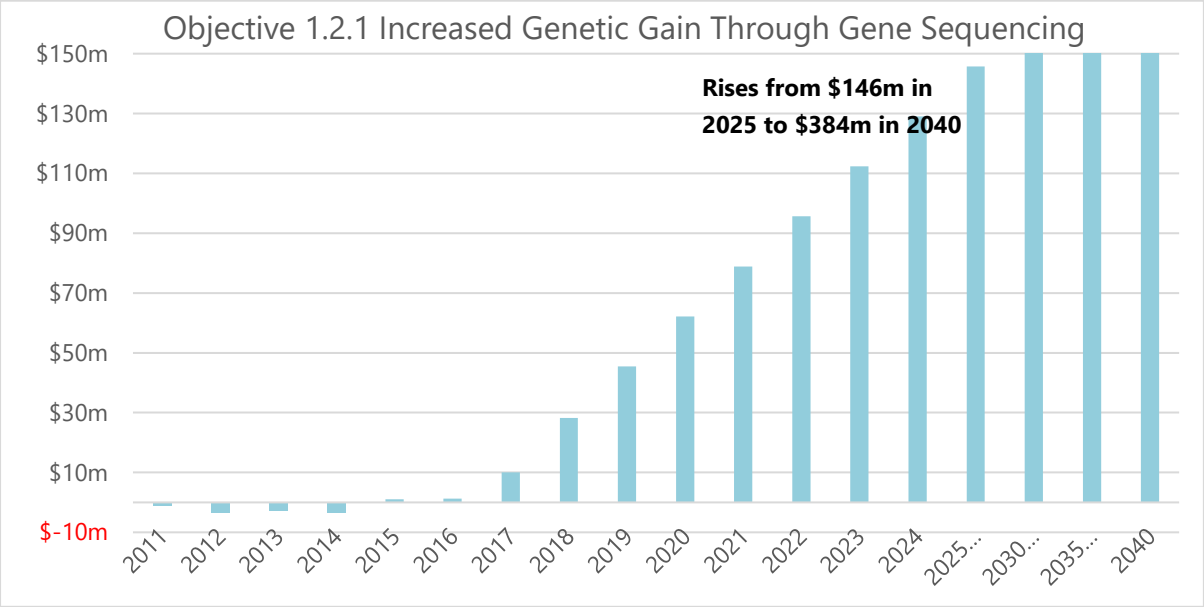
44. Our interviews with LIC confirmed that the assumptions about negative variants and their value made in 2014 were still sound in 2019 as there had been 10 verified variants identified. Five of these were negative variants in Datamate as predicted in 2014. There were another five which could yield on-going value depending on the findings of further work and the nature of these negative variants.

45. Figure 3 below shows the refreshed pattern of cash flows estimated for the genome objective. There was expenditure of $15.1 million during the PGP which is predicted to provide a significant pay off with an NPV estimated at $1380 million over the period to 2040 at a 6 per cent discount rate. If the discount rate is higher, the estimated NPV falls to $948 million. These values are driven by the productivity gains from:

    - The AGPAT6 marker for milk composition. Its benefits are $15 million per annum. This drives a significant amount of the value illustrated in Figure 3.
    - Removal of the two undesirable variations identified in 2014 which has an on-going value of $4.5 million.
    - Removal of five more undesirable variations currently being worked on.
    - Increase in the market share of genome sires which increases the pace of genetic improvement by reducing the generation interval. It has an estimated value of $15 million each year to 2040.
    - Market share of genomic sires rises from 40 per cent in 2018, by 1 per cent per year, to 50 per cent by 2028.

[13] (($4.5 million/year x 3) + ($625,000 x 2)) x 50% = $7.4 million/year rounded down to $7 million.

Figure 3: Estimated cash flows from genome objective



Sensitivity Testing

46. Given the compounding nature of genetic gain the value estimate of objective 1.2.1 is quite robust if subjected to poorer scenarios. If a challenging 10 per cent discount rate were used the objective's net present value would fall by $716 million to a total of $664 million. Even if the genetic gain has been overestimated for all discovered gene variants by half the overall value remains significant.

On-going benefits

47. The net benefit calculations above include on-going benefits as listed. However, from our interviews there would appear to be significant on-going value from the foundations put in place by objective 1.2.1. As discussed earlier, LIC has introduced a new genomics model which should yield an 8 per cent genetic gain per annum and is looking to select new markers in the coming 12-18 months. There is also potential value in the continuing work on the five newly identified negative variants depending on what is discovered about these. This could see the net benefits increase further. It is also possible that the market share of genomic sires could exceed the estimates included in Figure 3. This might be possible if there is some type of snow balling in farmer confidence in these sires due to the many improvements made in these technologies as part of the PGP.

48. The PGP has bedded in the capacity and processes to rapidly identify the genomic cause of animal abnormalities if they are found on farm. An example was the discovery of the slick gene (prolactin receptor) in Senepol cattle that provides heat tolerance. The potential to cross this gene into New Zealand Holstein-Friesian dairy cattle is being explored by LIC.

49. The Final Report on the PGP listed the patent applications had been filed or completed because of the programme (Transforming the Dairy Value Chain Final Report (Public), 2018, p. 71). Thirteen out of the 17 patent applications were for genetic markers and the uses

thereof. It also explained 11 of these patents, noting that they were lodged for 10 variants (small calf syndrome, slick gene, four fertility variants and four production variants and 'slick' gene test).[14]

50. In addition, a new seven-year programme $25.68 million innovation programme was announced on 13 June 2019. It is known as "Resilient Dairy: Innovative Breeding for a Sustainable Future" and is being led by LIC with investment and support from MPI and DairyNZ. It is following on from the work of the TDVC PGP and will invest in new disease management technologies and advancements in genomic science to improve cow productivity, and produce better cows with improved health, well-being, and environmental resilience. It will utilise genomic methods and data collection enabling the dairy sector to maximise genetic gain.

Indirect and spill over benefits

51. Given the increases in the production and the productive efficiency of the national dairy herd that this objective has achieved, and is likely to continue to provide, it would have material economic multiplier effects. These would be strongest in the regions with prominent dairy sectors through increased external services provided to farmers and Fonterra to collect and process the increased production.

52. Final Report noted that research that formed part of the gene sequencing objective identified the causative variants of a number of bovine disorders. These discoveries had the potential to shed light on mechanisms of analogous human diseases. It also highlighted that collaboration with international scientific communities had improved access to technologies and development of skills in New Zealand in the areas of genomics and bioinformatics.

Objective 1.2.2 Increased genetic gain through improved phenotypic data

53. **Increased genetic gain through improved phenotypic data – objective 1.2.2** A key aim of this objective was to improve dairy industry animal genetics by improving how the breeding value (BV) for fertility was estimated. It also covered the development of new BVs for Facial Eczema (FE), lameness and Residual Feed Intake (RFI), and evaluating predictor traits for RFI. This work was designed to see more robust cows bred which would result in lower animal health costs and increased productivity of the national herd.

Key Outcomes

- Improved Fertility BVs.
- Breeding Value for Facial Eczema tolerance is available to farmers.

[14] These patents are owned by LIC

Table 5 Objective 1.2.2: Increased genetic gain through improved phenotypic data

Inputs	Partners	Activities	Outputs	Impact
$4.5 million PGP investment	Lincoln CRV-Ambreed AgResearch AbbacusBio	Validation of improved Fertility BV Lameness research Development of new BVs for Facial Eczema (FE) Residual feed intake trials	Improved accuracy in BW index	Better selection tools, healthier and more productive national herd with estimated NPV of between $12 and $37.5 million.

Key Activities

Fertility

54. Phenotypic data was used to improve the fertility breeding value (BV). This process of improvement was implemented, and sires re-ranked by value for fertility. This re-ranking was based on improved estimates of between-breed effects. The fertility work demonstrated a 10 per cent improvement in heritability with an increase from 3.0 per cent to 3.3 per cent and was completed in December 2017.

55. An updated BV was released to the dairy industry on a trial basis via breeding companies and to NZAEL for inclusion in Breeding Worth at the same time, in December 2017. The official and full release was expected in February 2019 but was delayed until February 2020 due to breeding company concerns on potential long-term effects of inclusion of one factor, namely gestation length. Prototype BVs were circulated to breeding companies to inform their selection decisions and it is likely this additional information will affect which bulls are used in future years.

Lameness

56. An early report by Dennis , Amer, Santos, & Byrne (2013) on lameness showed that it had a national incidence of 9.03 per cent with an average rate of lameness reoccurrence of 9.20 per cent. This report explained that lameness had low heritability in the range of 0.02 to 0.05, but it had a reasonable amount of genetic variation, particularly in herds with a high incidence.

57. The economic cost of lameness was estimated at $109.10 per lame cow. This cost was based on treatment costs, the discard of milk during antibiotic treatment and feed inefficiency to mobilise body reserves during the period of lameness and then replace these reserves during recovery (Nimmo Bell, 2014). In its report, Nimmo Bell predicted that the impact of inclusion of a lameness breeding value in the National Breeding Worth (BW) would be worth $1.6 million on an annualised basis. However, early research into a lameness BV found that implementation required much better phenotypic data. The project was therefore stopped in

May 2015 as it was decided that it would not be possible to achieve its aims due to lack of suitable data (Programme Management Office, 2018).

Facial Eczema

58. Early in the PGP this objective developed a breeding value (BV) for facial eczema (FE) tolerance, based on a sire testing regime. It was made available to farmers through CRV Ambreed and completed in August 2015. We do not have a basis for valuation of this achievement and it is not considered to be material.

Residual feed intake (feed conversion efficiency)

59. Two residual feed intake (RFI) trials to assess the feasibility for implementing RFI were also completed. Residual feed intake is a measure of feed conversion efficiency or an animal producing the maximum out of a unit of feed. One trial involved researching phenotypic and genetic breed differences in residual feed intake between Jerseys and Friesians. The genetic variation within Jerseys was estimated and an evaluation of predictor traits extended to Jerseys.

60. The preliminary analysis found there were no significant differences between Jerseys and Friesians. However, there were problems with corrupted data sets which caused delays. That is why this research was 'substantively' complete by the end of January 2018. However, to be certain of the results, the scope of the analysis was expanded to include additional datasets. Approval was therefore sought from the TDVC to transfer the final steps in this project to the DairyNZ Efficient Herds project for completion (Programme Management Office, 2018).

61. The second trial consisted of an enhanced genetic analysis using realized relatedness coefficients based on existing and new single nucleotide polymorphisms in genotypes (a genetic variation test) and residual feed intake data. However, this was not completed by the end of the PGP in January 2018 due to delays in the LIC contract, problems with technical staff resourcing for on-farm tissue sampling as well as late delivery of data from partners and coding problems. This project was therefore transferred from the TDVC to DairyNZ's Efficient Herds project for completion (Programme Management Office, 2018).

62. The Final Report estimated an economic benefit from the work on an RFI BV of $20 million per year (Programme Managment Office, 2018).

63. Unfortunately, this RFI work showed the cost of phenotyping and on-going research to support implementation of the RFI programmes could not be justified given the expected benefits. The benefits didn't outweigh the costs even when the likely future cost of methane emissions was priced in at ($50/tonne CO_2 equivalent). Consequently, the RFI programmes were shelved and the Final Report's benefit estimate of $20 million per year is not included in our estimate of value. However, parts of this programme will be renewed, and techniques reused with today's current increased focus on addressing climate change, (see heading below on On-going Benefits).

Benefits of 1.2.2 Increased genetic gain through improved phenotypic data

Direct benefits

Fertility

64. This objective was about improving cow fertility.

65. The 2014 Nimmo Bell review explained that fertility was already included in BW so any change to improve accuracy would be incorporated directly into BW and provide economic value from better genetic selection. The review noted that such gains were additive and cumulative. Further, it explained the national gain was 10.0 BW units per annum; better accuracy in the BW index could shift this to 10.1. This small gain was expected to deliver an annual benefit of $85.20 per herd rising to $852 marginal gain per herd per annum after ten years and continue for 22 years to 2040.

66. As noted above, there has been a delay in the official release of this Fertility BV. This will have delayed the benefits compared to those estimated in 2014 and lowered its value. However, an 8 per cent discount rate was used in 2014 rather than the 6 per cent rate used generally in this report. If a 6 per cent rate were used it would increase the estimate of the benefit of this project. Given these off-setting effects, we calculate that the 2014 estimate of a NPV of $40.5 million of the benefits of this component of this objective may still be a reasonable view its value.[15]

67. The Final Report quoted an economic evaluation of the improved fertility BV of between $15-25 million per year (Programme Managment Office, 2018, p. 41). This was based on an estimated increment of value on the overall underlying rate of genetic gain of $300 million/ year. This estimate is explained further in an analysis undertaken in 2016 by Katarzyna Stachowicz and Peter Amer (Amer & Stachowicz, 2016). Their report covered the development of a new system for genetic evaluation of fertility traits and the details of the model and genetic parameters to be implemented in routine genetic evaluation using the fertility BV and the Mix99 software system. This estimate was higher than that calculated by Nimmo Bell in 2014. In that evaluation an annual value of circa $15 million is not achieved until 2035. Considering the uncertainties as to how both approaches calculated the benefits of the fertility work, we propose retaining the lower estimate.

[15] We were unable to trace back the calculations that underpinned this estimate because the 2014 values were hard coded. A more conservative view of the value might shorten the period of the gain from 22 years to 10 years reflecting that new technology may supersede the existing approaches and value estimates. A 10 year time horizon would lower the estimated benefit to $15.2 million.

Lameness

68. As noted above the work on lameness ceased in 2015 due to lack of quality data. The 2014 work estimated an NPV of the benefits of this component of the objective at $13.6 million over 22 years to 2040. This needs to be subtracted from overall NPV estimated for this objective.

Facial eczema

69. AbacusBio (2014) estimated the annual cost of facial excema (FE) was around $30 million with zinc prophylactic treatment in 2013. But if this treatment was not available then the cost could rise to $97 million annually, or 32 per cent of the underlying annual genetic gain benefit which has been estimated at $300 million.

70. As of mid-2019 the ban on using zinc as a prophylactic had not occurred.

71. Semen was available to farmers from FE tolerant sires in 2014, but the level of uptake suggested farmers were then not specifically selecting for FE tolerance.

72. At that time, it was reasoned that the sires were still young, and farmers were waiting for progeny testing to finish before they would begin using them. Nimmo Bell therefore stated that it was too soon to gauge the extent of possible demand for FE tolerant semen and it was not able to quantify the benefits of the FE research.

73. The Final Report noted that FE cost the sector over $100 million a year in lost production, treatment costs and animal loss and that improving FE tolerance in animals on FE-prone farms had positive animal welfare and production outcomes (Programme Managment Office, 2018). It also stated that milk production of animals with subclinical FE can be depressed by up to 50 per cent. Finally, it estimated for every three in 100 cows showing clinical FE, about 70 per cent of the herd may have subclinical FE. Evidently there is value in addressing this affliction. However, in mid-2019 farmers were still holding back so take up remains slow. Given this cautious take up, and the uncertainty about how this will play out over time, we, like Nimmo Bell, have not estimated a value derived from the FE work.

On-going benefits

74. Aspects of the research on residual feed intake (RFI) could have on-going benefits. Through the PGP, DairyNZ and breeding companies did make some progress creating a measure of how efficient a cow is at using feed for body maintenance or milksolids production. If it were successful, then it could save farmers money in feed costs. For example, if a cow consumes 1kg DM (dry matter) less per day for the same production of milksolids compared to another cow, then farmers could save $85 per year in feed costs by swapping to the more efficient cow.

75. Recently renewed Government focus on addressing climate change has meant that the techniques developed and lessons learnt in the RFI research have been applied to a new study, funded by MPI. This study uses CRV and LIC and is testing methane emissions from young bulls; the idea being to breed low emitting bull stock. If this work comes out with a

positive and significant result, then RFI would be needed to control for stock feed, to estimate the genetic link to methane emissions.[16]

76. There was also some on-going value from the work on lameness. The lack of good data gave some impetus to pursue the InfoHerds concept in DairyNZ's new programme. This initiative aims to improve data collection for a variety of traits such as lameness.

Objective 1.2.3 Designer milks

77. **Designer milks – objective 1.2.3** involved Synlait and other subcontractors aiming to produce designer milks by developing integrated farm management and manufacturing techniques. Synlait used research support from Otago, Lincoln and Auckland universities in this work (Deloitte, 2015, p. 50). Specifically, it sought to develop a range of high value, differentiated dairy-based powders – through screening and selection of cows to create special milk herds, vaccination technologies, manipulation of feeding or milking regimes on farm, or process changes within the manufacturing plant. Success was defined as adding value to Synlait Milk Ltd and to its suppliers through increased farm gate milk prices and premiums for supply of specialty milks.

Key Outcomes

- Market ready for increased demand for lactoferrin.
- Development of high melatonin and high alpha-lactalbumin milks.
- Successful colostrum business model developed.
- Experience assisted the A2 business by allowing Synlait to hone and improve its contracting and rewarding of its farmer suppliers.

"PGP has been critical in the commercialisation of Synlait blue sky concepts. This is especially important for smaller players who perhaps don't have the resources of larger businesses."

Table 6: Objective 1.2.3 Designer milks (Synlait)

Inputs	Partners	Activities	Outputs	Impact
$2.2 million PGP investment Synlait in-kind investment	Immuron Otago, Lincoln and Auckland Universities	Trials, concept and market development	Models proved	Ready for lactoferrin market and able to develop A2 model

[16] Email of Objective leader of 16 August 2019.

78. The Synlait objective consisted of five sub-projects over the period of the PGP.[17]

- **2.3.1** Phenotype and genotype screening of a minimum of 500 immunised cows for IgG levels of colostrums that exceeded two-fold the normal concentration. It also comprised pilot production of milk powder from the high IgG milk. These activities were completed in December 2015 and March 2016 respectively. The 2014/15 Q4 public quarterly reported explained that Synlait had successfully optimised large scale on-farm production of hyperimmune colostrum to suit New Zealand conditions and had started commercial production. The product – processed via spray drying to tight specifications – was subsequently incorporated into antidiarrheal capsules. It was, at that time, offered for sale in several countries throughout Asia (Programme Management Office , 2015). A successful on-going business was developed with Immuron - an Australian pharmaceutical company. In the current year the colostrum powder is not being produced because the plant is being used to produce lactoferrin which currently has higher margins (according to one interviewee, 10 times higher revenue per kg). However, the development of an Ig hyperimmune milk protein concentrate – Stolle, was discontinued due to a number of challenges including animal welfare concerns from the required two weekly immunisation of the cows.
- **2.3.2** Development of high melatonin and high alpha-lactalbumin milk. The goal was to develop at least one high value, differentiated dairy product aimed at wellness and quality of life. This was achieved by creating a hydrolysed high-melatonin 'Night milk' product to assist sleep[18]. The "iNdream3" ingredient brand was created for this product and a Korean customer launched the first retail product, Sleepiz containing iNdream3 in early 2015. Unfortunately, due to changes in regulations the strength of the claims that could be made on this product diminished significantly despite the strong effects shown in the clinical trials. Significant further investment was needed to generate data from multiple trials to support the approvals process for these claims. Due to these issues, the concept was put on hold in May 2017 pending consideration of Synlait's wider strategy and work circled back to the development stage. The focus has been on developing an easier to manufacture non hydrolysed version of this product and collecting further data to support its manufacture and performance. It may yet re-launch in a different product format.
- **2.3.3** This sub-project was terminated at the time of the 2013/14 Business Plan. It included the Healthy Milk Herd Development. This involved researching health fats and fatty acids in milk looking at genetics and feed regimes. This work was

[17] Removal of company names for public version

[18] Two years of independent clinical trials by the Otago University Sleep Research Centre, which was separate from the PGP research, showed that Sleepiz could help people sleep by assisting them to get to sleep more quickly, spending longer in the deepest phase of sleep so they functioned better the following day. This research provided strong evidence of effect.

dropped as it was thought to be commercially unviable, so effort was redirected to work on melatonin and colostrum extracts (Deloitte, 2015, p. 50).[19]

- **2.3.4** The aim of this sub-project was to develop a range of high value dairy extracts. Six products were explored with half from cream streams and half from milk. Earlier work developed a novel spray dried lactoferrin product. This product succeeded and became a successful on-going business. Later in the PGP the focus shifted to investigating its functional properties and further development of specialised versions of lactoferrin - liquid lactoferrin and endotoxin free or 'Pharma grade' product. It was necessary to test Synlait's unique manufacturing of its lactoferrin powder compared to conventional freeze dried approaches to test its physical, chemical, and biological activities. It performed well and the testing work was thought to be helpful in the manufacturing process and likely to be used in future technical and sales literature. A standard operating procedure (SOP) for testing lactoferrin was developed by Callaghan Innovation and eventually aligned with a Chinese Guobiao test method and fully implemented. The final PGP work was focused on sampling and testing to determine seasonal variations in the level of endotoxin in the lactoferrin. Low endotoxin lactoferrin was successfully manufactured and there was some customer interest. The production and storage abilities of aseptically packed liquid lactoferrin were also tested. The liquid lactoferrin was progressed to commercial a version but had not been commercialised as of July 2019.
- **2.3.5** This sub-project sought to value-add by transforming low value product streams and develop at least one new product. A range of prototype products were tested targeting adult, veterinary and feedstuffs industries. In 2016 the feasibility of a process for drying mixed protein/fat waste was pilot scaled and shelf life trials were carried out. A feasibility study of the technology was completed but it was believed that it was still in its infancy and further development was required. Two important changes caused this sub-project to be put on hold. The first was that there was more demand for these by-products from piggeries which were an important part of the existing market. There were also difficulties of further development and manufacture of animal feedstuffs on sites whose primary focus was milk products for people. A commercial analysis would be needed before any further investment and as of January 2018 it was not on Synlait's priority list. It could, however, be revisited in the future.

79. The sub-projects of the designer milks objective spanned from the farm to the market, and because of this it was one of the best examples in the PGP of an integrated approach across the dairy value chain.

[19] Interview with [Synlait]

Benefits of 1.2.3 Designer milks

Direct benefits

80. Our interviews with key Synlait people underlined the importance of the PGP to Synlait. It was stated that the PGP had been critical in the commercialisation of Synlait's blue sky concepts. It was noted that this was especially important for smaller players who perhaps didn't have the resources of larger businesses. The assistance from the PGP had allowed Synlait to take advantage of opportunities and be market ready for example for the demand for lactoferrin. Synlait felt that it had approached the PGP in a very commercial way, with an eye on the specific end game (e.g. A2 and lactoferrin) and used PGP funds with this in mind. One interviewee explained that the funds supported the company's strategy and core business rather than driving its strategy and core business. The funds had helped the core business deliver on strategy more quickly and more effectively.

81. Synlait's objective achievement measures for the PGP were:

    - Development of breeding and selection criteria for the production of modified milks suited for infant formula and mental wellness for adults within commercial herds for enhancing the value of milk (high immunoglobulin milk, elevated alpha-lactalbumin).
    - The creation of high value innovative milk products based on immune enhancement, protein products with demonstrated health and wellness attributes and healthy fats. These products developed as functional ingredients will attract a 15 per cent ($500-$200/tonne) value-add premium compared to standard milk powders within 10 years of the completion of this programme.

82. The first of these was a partial success in that a successful business was developed from sub-project 2.3.1 focused on colostrum. While production has stopped, it could restart in the future. Likewise, sub-project 2.3.2 made some important progress and could be restarted in the future. The second objective achievement measure has been significantly surpassed given that both the colostrum powders and lactoferrin are earning revenues per tonne significantly higher than standard milk powders.

83. The two sub-projects which led to successful commercialisation are likely to have more than covered the total costs of objective 1.2.3 over the seven years.

    - Sub-project 2.3.1 involved developing and producing three to four tonnes per annum of colostrum powders. This was sold at about $300/kg or around 50 to 100 times the price of standard milk powders. Colostrum was produced for two seasons and assuming a lower initial volume of production, this could have bought in revenues of around $2 million to date. Synlait suppliers of colostrum (10 to 15 per cent of Synlait's supplier base) were also well rewarded for the additional work involved in immunising and managing their cows with some of the larger suppliers getting a six-figure incremental annual pay-out under their

contracts. If gross profit to revenue margins were 50 per cent,[20] Synlait could have made circa $1 million gross profit from this sub-project so far.

- Sub-project 2.3.4 involved developing and producing lactoferrin. This initiative had started before the PGP but was making slow progress due to significant technical hurdles. When other sub-projects ceased due to lack of perceived market potential the PGP supported its development. The 2018 Synlait annual report noted that Synlait produced 11 tonnes of lactoferrin in 2017 at a gross profit of $0.8 million or $76,666/tonne. By 2018 this had risen to 16 tonnes for a gross profit of $4.4 million or $285,757/tonne. This has risen further to production of around 30 tonnes. If it is assumed that the PGP only helped Synlait bring on its lactoferrin sub-project one year earlier, it has already almost covered the cost of Objective 1.2.3. For example, this effect only covered 2017 and 2018 and as a result without the PGP 5 tonnes had been produced in 2017 and 11 tonnes in 2018 due to slower scaling up due to continued technical road blocks then Synlait would have missed out on gross profits of $1.9 million.

84. In summary, an indicative total estimate of the direct benefit to Synlait of the PGP is likely to be in the order of $3 million compared to overall costs of a bit over $2 million[21]. This assumes that the PGP assisted Synlait to ramp up production 1 year more quickly than they would otherwise have been able to and that the 2 years of colostrum production would not have occurred without the PGP.

On-going benefits

85. Although some of Synlait's sub-projects did not lead to products that could be commercialised during the period of the PGP, it is possible that the work done could lead to re-launches or other product development built on the foundation of PGP research in the future. These sub-projects have still provided option value. Examples are Sleepiz and the value add to protein/fat by products. Further work on Sleepiz may overcome the regulatory hurdle about the claims that can be made about the product and it may prove possible to produce it more cost effectively through a non-hydrolysed manufacturing process. The PGP research on adding value to protein/fats by-products also has the potential to be of value in the future as well as the further work done on specialised versions of lactoferrin.

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[20] Synlait's 2018 annual report noted that it made a gross profit of $4.4 million from 16 tonnes of lactoferrin in 2018 (See Synlait Milk Limited Annual Report 2018 Presentation, Page 30). Our interviews with Synlait personnel indicated that the price of lactoferrin has varied from as low as $180/kg to $3,000/kg. An article by the dairy section of Farmers Weekly on 12 April 2018 cites an intermediate price of $500/kg (See : https://farmersweekly.co.nz/section/dairy/view/top-dairying-businesses). Taking this price as an average Synlait could have earned revenues of circa $8 million from lactoferrin in 2018 which would be equivalent to a profit gross margin of 55 per cent. It is assumed that the colostrum products could be similar to this lower bound estimate.

[21] This estimate is based on a few data points and without detailed company data about any incremental overheads that could be allocated to these projects. The Deloitte's mid-term review noted the costs of this objective at $2.2 million. However, the final report reported that Synlait's final spend was $1 million compared to a planned $1.1 million.

86. Synlait's A2 business has boomed. Although this was not part of the PGP programme the work done in the sub-projects on colostrum, night milks (Sleepiz) and Stolle did provide experience that assisted the A2 business to grow. This was because it allowed Synlait to hone and improve its contracting and reward systems for its farmer suppliers.

Indirect benefits and spill over effects

87. Commentary from Synlait interviews also emphasised that there would be wider economic benefits that would flow into communities e.g. Synlait's continued growth leading to it employing more people and being able to reward farmers who would have more to spend in the local economy.

Objective 1.2.4 Improved pasture performance

88. **Improved pasture performance – objective 1.2.4** comprised DairyNZ mostly subcontracting to AgResearch, but also some others, to define traits and management to improve pasture persistence in response to low farmer confidence in pasture renewal.

89. Some things were known about the role of endophyte in pasture persistency, but this objective set out to get a more systematic understanding of persistency in a different area.

90. The pasture persistence research programme monitored shoot and root trait responses to stress (2012), characteristics of ryegrass survivor populations (2014), and phenotypic-genotypic analysis of these (2016). Six seasons of longitudinal persistence experiments were undertaken, tracking genotypic and phenotypic structure changes as plants transition to unproductive states.

Table 7: Objective 1.2.4 Improved pasture performance

Inputs	Partners	Activities	Outputs	Impact
$4.5m PGP funds	AgResearch	Systematic understanding of persistency issues	Incorporating persistence into the Forage Value Index	Increased knowledge of persistence problem

91. Key findings include:

1. Poorly-adapted ryegrass plants are eliminated within six months of sowing. Underlying persistency traits are those that support vigorous plant growth (tiller density higher).

2. Genotype-by-sequencing analysis shows no evidence of genetic differentiation within perennial ryegrass populations over time.

3. Collapse of ryegrass populations after sequential droughts where soils were prone to insect infestations revealed these are key risk factors contributing to poor pasture persistence.

92. The work ruled out several factors that were not involved in persistence and cleared up some myths. The pasture persistence research objective was achieved by systematically

analysing the causes of loss of persistence of yield in perennial ryegrass. The finding then used to support farmer uptake of high-yielding pastures that maintain productivity between re-seeding, and encourage plant breeders to continue developing advanced cultivars.

93. The key finding that supports both outcomes is that "recent trends in ryegrass breeding (with the broad aims of increasing DM production and nutritive value) have not led to the 'persistence problem' – contrary to much popular anecdotal reporting that lays the blame on the plant" (Ludeman & Chapman, 2019, p. 12).

94. In the Waikato, persistence failure was more associated with environmental factors such as dry summers and insect problems. It was also established that sowing rates were not causing the problem of population collapse.

Benefits of 1.2.4 Improved pasture performance

Direct benefits

95. Our interviews indicated this was one of the more difficult objectives in the PGP to value in terms of benefits because many of the outcomes were intermediate.

96. The work has led to a continuing effort on the Forage Value Index, an economic index that now includes pasture persistence as a trait in the performance values for different ryegrass functional types (diploids and tetraploids). This expanded the Forage Value Index to be greater than just Dry Matter and Metabolisable Energy. In this revised Index, persistence of the yield advantage of tetraploids drops away faster than for diploids. Farmers in the upper North Island consider that this has increased the relevance value of the Forage Value Index to them.

97. Incorporating persistence reduced the difference in overall Forage Value Index (FVI) value between tetraploids and diploids by $117 to $202/ha (depending on diploid heading date, and region), partially re-balancing the sharp rise in tetraploid values and rankings resulting from incorporation of the metabolisable energy (ME) content trait (Ludeman & Chapman, 2019). Implementing persistence in the FVI at the ploidy level is the first step toward inclusion of cultivar-specific persistence information. This next step will require persistence data for cultivars, plus more information on processes and criteria used by farmers when they decide to renew pastures.

98. Pasture renewal is a vital step in the introduction of improved plants and endophytes into farm systems. Business and Economic Research Limited and the Pasture Renewal Charitable Trust identified profitability lifts of $NZD 1 billion/year on New Zealand dairy farms if higher yielding pastures could be successfully introduced.

99. This objective turned information into knowledge but did not solve the problem.

> **"We have a clear understanding of the problem; the answer is the triple threat. Rye has to rebuild itself in the last 12 months, it will stand two threats but not three."**

100. The triple threats include; extreme temperatures, insect damage and over grazing.

"We now know it is not the cultivar. Great story but hasn't solved the problem."

On-going benefits

101. The persistence work has allowed better engagement with breeding companies.

102. Findings from the pasture persistence research have been taken up by plant breeders and senior agronomists from major New Zealand plant breeding companies to identify implications for farmers, and for use in breeding programmes. Results and recommendations have been provided to the Forage Value Index Technical Working Group. These provide a strong scientific foundation for future decisions on inclusion of persistence in the FVI. Plant resources have been provided for ongoing research (Pastoral Genomics research consortium) into biologically and economically effective options for restoring perennial ryegrass density in run-out pastures, and investigation of alternative forage options that utilise either tolerance (e.g., relative summer dormancy or dormancy-like traits, and/or ability to resist grass grub attack) or avoidance (e.g., annual growth habit) mechanisms to reduce the total stress load on plants during critical periods, leading to improved profitability compared with continuing with the status quo.

Indirect benefits and spill over effects

103. The pasture persistence research has shown persistence is connected with soil type, and there is a strong suspicion that cultivation is damaging soil structure. Farmers are beginning to see cropping soil damage linked to pasture losses. Farmers are starting to accept that they need to change management practices, such as reduced grazing pressure and increasing post-grazing residuals. Up to this point this has been generally resisted because of the focus on production.

Objective 1.2.5 Precision agriculture

104. Precision agriculture was a DairyNZ work stream and focused on independent validation for developing precision farming technologies for monitoring animal and paddock performance e.g. protocols for the field evaluation of Automated Mastitis Detection Systems and precision feeding technologies.

Key Outcomes

- Role of DairyNZ in developing capability within precision dairy farming networks defined and agreed with stakeholders.
- Open access publications on farming technology.

Table 8: Objective 1.2.5 Precision agriculture

Inputs	Partners	Activities	Outputs	Impact

$2.8m PGP	AgResearch LIC Automation	Research	Publications and reports	Transition into ongoing DairyNZ projects

105. This research aimed to build knowledge and expertise to underpin the development and adoption of advanced tools necessary to optimise farm production, mitigate labour constraints, improve animal welfare and broaden lifestyle choices. Broadly, the project focused on the use of automation technology to reduce manual labour and information technology to improve decision-making.

106. Some of the systems tested included:

- Heat detection
- Mastitis detection
- Individual feeding technologies
- Pasture measurement
- Walk-over weighing

107. In the last few years the work focused on what farmers want from pasture measurement devices. This set a standard for what farmers want, and developed guidelines for development of pasture measurement technology. This was provided on a website and published in the Grasslands Conference Proceedings so information was publicly available.

108. LIC Automation testing protocols work was presented internationally. The work standardised approaches to testing, protocols and reporting for precision agriculture systems. This was done by helping farmers and working with companies to do things they could not do themselves to standardise practice between stakeholders.

Benefits of 1.2.5 Precision agriculture

Direct benefits

109. Quantitative benefit estimation is difficult. There are a number of separate technologies which have been studied but benefit estimates are limited and specific to each technology. The work to evaluate the integration of the technologies into whole farm systems is also at an early stage. It is therefore not possible to complete a cost-benefit appraisal of this project.

110. Highlighted outputs from the programme (Payne, 2017) are:

1. Mastitis standards – to provide companies with a legitimate process for testing mastitis technology (LIC automation used these standards in their in-house testing, also were taken to an sensing committee to use as a basis for developing an international protocol). The mastitis detection technology research also led to one company revising their technology to improve accuracy.

2. Pasture measurement technique guidelines – used in interactions with Ballance Agrinutrients, Ravensdown, LIC, Farmote, Fonterra, Gallagher.

3. Heat detection research – led to a company changing their algorithms to suit NZ pasture-grazed systems rather than the barn-based system they were designed for.

111. However, there was concern not to become the "Consumer Institute" for these products as it was not DairyNZ's role. It could be an international standard setter but was stalled because of the "politics" of having one.

On-going benefits

112. There is now a base of independent information with standards, to be able to talk to farmers and companies about new precision agriculture technologies. This gives the opportunity to give advice to farmers to make good choices based on need rather than based simply on a technology offering.

113. The ongoing benefits of this programme include:

- improved methods for using information and automation technologies to monitor animal status (e.g. reproduction management, animal health and condition), leading to improvements in animal health, labour efficiency and farm performance (e.g. paddock performance assessment)
- farmers making informed decisions when investing in automation and information technologies leading to more cost-effective capital investment
- enhanced ability to work with technology providers fast tracks the adoption of technologies that deliver improved on-farm productivity.

Indirect and spill over effects

114. Some of the feedback was that commercial companies developing automation technologies could connect better with DairyNZ and research as a result of the PGP programme. The programme got competing companies together in a safe, sharing environment to learn how to become more relevant to the needs of farmers.

Objective 1.2.6 Dairy data network

115. The overall goal of the dairy data network roadmap was an improved operational environment for maximising use of data in the industry. This included:

- making the most of data available to drive quality decision-making across the industry and continuous improvement in breeding worth
- ensuring exchangeable data of high integrity is available to, and used by, all parties
- creating an environment where data from various sources can be shared and is used in new ways to drive innovation and productivity (Transforming the Dairy Value Chain Final Report (Public), 2018, p. 43).

Key Outcomes

- Transition of LIC Core database to DairyNZ.
- Foundational components delivered; Data standards, Farm Data Code of Practice, Data Linker.

"Learnt many of the IT systems in NZ are rubbish"

"With data linkage, part of what we have is lessons about what didn't work."

Table 9: Objective 1.2.6 Dairy data network

Inputs	Partners	Activities	Outputs	Impact
Dairy Core Database $4.25m PGP funds	Rezare Scarleatti	Transferring of database	DIGAD Data standards Code of practice Data Linker	Some progress

116. The environment for maximising the use of data in the industry, has been advanced in several areas and aspects:

- Transition of Dairy Core Database to industry good management (Dairy Industry Good Animal Database, DIGAD).
- Data standards were published.
- The Farm Data Code of Practice is in place with five organisations accredited and six more assessing readiness.
- DataLinker – a mechanism to support exchange of data, was established with 12 organisations implementing or commencing implementation of DataLinker APIs (Transforming the Dairy Value Chain Final Report (Public), 2018).

117. Some important components of the Dairy Data Network have been developed, but a robust commercial model is not an outcome.

Benefits of 1.2.6 Dairy data network

118. No benefit yet realised from this area of work. It is incredibly difficult to get industry participants to agree on data rights and ownership. Then, achieving critical mass is just as difficult. There is no evidence of progress in these key areas.

"DIGAD been successful, it is running now. We are still bringing CRV and breed societies in, it takes to get people into it and make stuff happen."

119. The final report admits uptake of Farm Data Accreditation and Data Linker has been slow. It optimistically offers "there is a substantial change occurring with organisations willingness to

share data across both dairy, sheep and beef sectors (Transforming the Dairy Value Chain Final Report (Public), 2018, p. 44)."

Potential benefits

120. DairyNZ's Bryant summarised the potential benefits of the Dairy Industry Good Animal Database (DIGAD) project under five points:

- Long-term security of the National Breeding Objective (NBO). The transfer of the core database will safeguard the NBOs leading to farmers having more confidence in the NBO and being more willing to contribute data.
- Reduced risk of alternative BW indices being created. CRV AmBreed NZ undertook to withdraw their alternative genetic index if the Anderson Review recommendations were implemented. There is general agreement that industry fragmentation leading to sub-optimal use of leading sires imposes a large cost on the industry.
- Level playing field leading to enhanced innovation. While the database is in the custodianship of a commercial entity, there will always be a perception that that entity has an unfair advantage in access to industry data.
- Better control to develop the NBO and access data for research. Access to data for research purposes will not be controlled by a commercial entity which has other imperatives.
- Future ability to build off core data. DIGAD can facilitate the acquisition of New Zealand dairy herd data required by industry participants for a range of participants and uses. While not attempting to evaluate this extensive list of benefits, it appears clear that DIGAD and the Dairy Industry Network have the potential to deliver very substantial benefits for farmers and the dairy industry (Bryant, 2013).

121. AbacusBio (2014) concluded that the investment in DIGAD should be primarily viewed as an insurance policy to make sure the potential benefits from future genetic improvements are fully realised (AbacusBio, 2014).

Theme 2: Capability & Capacity

Objective

> Theme 2 was about raising the dairy farmers' decision-making capabilities and capacities to improve on farm productivity. The investment in this theme was aimed at supporting industry competitiveness by improving capabilities, upskilling rural professionals, developing and supporting networking and attracting people into the industry.

122. Theme 2 consisted of a suite of programmes spilt into two sub-theme areas:

    (a) The 'Train the Trainer' programme also referred to as 'Whole Farm Assessment' sought to improve the provision and availability of advice for environmental effects such as nutrient management, effluent management, farm animal welfare and people management.

    (b) The capability development was about providing support to farm professionals, improving the pipeline of future farmers, looking after the mental health of farmers and networking small farms/ emerging Iwi enterprise.

123. Two objectives were added to Objective 2.7 post 2014. These were:

    - Greenhouse gas management training and tools (2.7.3)
    - Herd reproduction management (2.7.6)

124. Together the work aimed to improve capabilities, expand the pool of skilled rural professionals, develop and support networking and attract people into the industry.

Key Outcomes

- More certified rural professionals helping farmers to shift towards a whole systems approach to farm management.
- Decreased threat to social licence.
- Industry readiness for legislation change enhanced.
- 4173 plans delivered by rural professionals trained and/or using tools developed through the PGP Train the Trainer programme.

"This PGP set the sector up for sustainability."

"The capability pieces has gone well in some places and not others. Are where we at where we need to be? No. but we have some building blocks."

Table 10: Theme 2 Overview

Planned core work areas	Investment plan ($ millions)	Progress	Final investment ($ millions)

2.7 Research and sustainability 2.8 People and business	Industry $22.8m MPI $29.8m Total $52.6m	2.7 More and better advice 2.8 Better farm decision making	Industry $22.5m MPI $29.1m Total $51.6m

Objective 2.7 More and better advice

"It needs to continue. Need a team focussed on continuous improvement. The idea was the professional bodies would keep it alive, but I expect it to decay over time."

"Very influential in starting people on the sustainable track"

Objective 2.7.1 Nutrient management training and quality assurance

Key Outcomes

- By November 2017, 200 people had been through the certified nutrient management adviser (CNMA) programme - 169 people were still certified.
- By the end of the 2017/18 season, the 5th 'Sustainable Dairying: Water Accord' showed 94 per cent of farms had nutrient budgets.
- 14,000 farms were reported in a 2017 Progress Report (the majority being dairy farms) to have nutrient management budgets and it was estimated that the CNMA programme might have been involved in 13 per cent of these.
- 1,937 Sustainable Milk Plans (SMPs) which support farmers in regions where "farming within nutrient limits" is required, were completed by May 2017.
- A wide range of land management workshops and seminars were provided, and material embedded into related training programmes.

Origins of nutrient management training and quality assurance objective

125. Industry leaders identified that the dairy sector was facing mounting constraints due to regional and unitary council setting water quality and quantity limits at regional or catchment scales (e.g. Horizons One Plan and Healthy Rivers for the Waikato). Limits on nutrient loss were being set for existing farms and restrictions placed on new farms and conversions. These trends would, in DairyNZ's view, drive increased farmer demand for independent and quality-assured advice on nutrient management planning (DairyNZ, 2018).

126. Objective 2.7.1 was therefore designed to develop the training and quality assurance systems (i.e. Nutrient Management Advisor Certification) and support structures (e.g. regional nutrient management indicators and Audited Nutrient Management System) that would be able to address these pressures on the industry.

127. The Land Management project in Objective 2.7.1 is a good example of how this programme of work was designed to respond to regulatory responsibilities. It involved developing dairy farmer land management guides in key regions to help farmers, and farm consultants, manage the impact of sediment and phosphorus on freshwater. This was regionally focused to take account of regional differences in soil types, cropping, wintering and off-paddock farming systems etc. A key component of this was the 'Riparian Planner' software which at the end of 2017 had over 600 users. This guide was designed to help farmers respond to emerging regulations; as DairyNZ pointed out, all dairy farmers with a 'Sustainable Dairying: Water Accord' waterway would soon have to create a riparian plan.

What was achieved?

Nutrient Management Adviser Certification Programme

128. This objective was about producing training material and then training nutrient certification advisors. In this, it was successful. In the first few years the focus was on developing and implementing training, accreditation and monitoring systems. There was continuing work supporting implementation but most of this was aimed at administering the programme and developing new professional development training modules.

129. Nutrient management advisors were taught how to advise farmers about managing nutrients to meet environmental limits. Experience and qualifications to use the OVERSEER nutrient management tool is one of the skills that certified nutrient management advisers learn.

130. At the end of the PGP, the certification programme was being delivered by Nutrient Management Adviser Certification Programme Ltd (NMACP) with support from the DairyNZ Vibrant Workforce project.[22] NMACP wanted to make sure that it was continuing to build the credibility and value of the Programme. It also wanted to ensure that advisers were at the expected quality standard. To this end, an auditing programme was launched in October 2017 for nutrient management plans done by certified advisers. Eleven audits had been conducted as at December 2017. Also, in July to September 2017 an external review of the NMACP was undertaken.

131. By November 2017 200 people had been certified and 169 people were certified at that time with another 60 in the application pipeline. Just over 30 had left the programme since it began, mainly due to changes in their roles. As the PGP concluded there were increasingly diverse organisations with trained advisers including councils, sector organisations, professional services firms, farm consultancies and fertiliser industry agents.

132. The 2018 TDVC Business Plan (dated June 2017) noted that the year 3 report for Sustainable Dairying: Water Accord showed 83 per cent of farms had nutrient budgets (DairyNZ, 2016, p. 17). This had increased to 94 per cent in the final and 5th report for the 2017/18 season (DairyNZ, 2018).

[22] See http://www.nmacertification.org.nz/Site/Nutrient_Management/default.aspx

133. In a 2017 Progress Report it was stated that 14,000 farms (across all sectors of which Dairy largest proportion) had existing or notified plans under regional council requirements which would have incorporated nutrient management budgets. It also noted that no data had been collected on Certified Nutrient Management Adviser (CNMA) involvement in the development of these plans but this was estimated to be at least 13 per cent (Bowditch, 2017, p. 15).[23]

Audited Nutrient Management System

134. The purpose of the Audited Nutrient Management System is to collect farm data on nitrogen loss and nitrogen conversion efficiency for each farm using the latest version of Overseer 6.2. It covered around 11,500 farms supplying the dairy companies Fonterra, Miraka, Open Country, Synlait, Tatua and Oceania. Data collection is incorporated into farmers' supply agreements and was used to create graphs showing regional benchmarking and where each farm sits compared to peer benchmarks. Under the 'Sustainable Dairying: Water Accord', all milk companies have been required to supply data on nitrogen loss using this system.

135. The last work stream in this project was providing training workshop on 'Dairy farm system options to reduce nitrogen losses' for rural professionals. A pilot workshop was run in 2016/17 that incorporated the existing science along with what had been learned from nitrogen loss programmes run for farmers in the Horizons region. In April to June 2017 two workshops were held in the Selwyn and Hinds catchments with 55 consultants and 7 leading farmers attending. This workshop has been integrated into DairyNZ's Meeting Environmental Obligations project which is designed to go beyond PGP.

136. The 2017 Progress Report explained that on this project, nitrogen loss and nitrogen conversion efficiency performance data was collected and reported back to 83 per cent (9,517) dairy farms in the 2015/16 season. However, the Accord commitment was that 100 per cent of dairy farms had information collected by 31 May 2015 and reported by 30 November 2015 (Bowditch, 2017, p. 17). This report also commented on the on-farm impact. It described how independent verification of 80 supplier farms across participating dairy companies had found that farmers had received the feedback, but farmers' understanding and use of it depended on their experience and knowledge.

Sustainable milk plans

137. The aim of this project was to develop nutrient management and farm management expertise and make it available to support dairy farmers in regions where "farming within nutrient limits" was a requirement. It was delivered by speciality trained rural professionals providing one on one consultancy to individual farmers, using Sustainable Milk Plans (SMPs) to address nutrient, water quality and resource use requirements.

138. This project began in 2012 and was first developed for the Upper Waikato industry project. The TDVC PGP funded about a third or $700,000 of the cost. This work set the framework, processes, and tools for use in other catchments. It also contributed to existing and future

[23] Margaret Bowditch personal communication with Vera Powers (2017 analysis undertaken by CNMP Ltd).

Regional Council Farm Environmental Plans (FEPs) and, where SMPs were accepted by regional councils as FEPs, for example Environment Canterbury.

139. The SMP project had trained 176 rural professionals by May 2017[24] with the majority based in the Waikato or Canterbury. This project appears to have had some funding from the PGP. However, much of it was developed outside the PGP. The Progress Report (Bowditch, 2017, p. 21) explained that SMP consultants were contracted by DairyNZ within an industry project (outside PGP Programme) and have been provided with classroom and farm training, completed "live" in the field plans and been given feedback.

140. At the time the Progress Report was written there had been 2,660 recorded rural professional attendances at workshops/extension activities linked to SMPs/ FEPs & consenting or environmental policy. Also a total of 1,832 of a planned 1,985 SMPs were completed to 31 May 2017. An extra 105 plans which used a modified version were delivered for Miraka farmer suppliers so that including Miraka SMPs, 1,937 SMPs were completed at the time of the Progress Report.

141. The SMP project provides some of the best evidence of changed farmer practices. For example, the Upper Waikato Project was completed with 642 SMPs delivered. These included 5,921 individual recorded actions covering water use and nutrient, effluent, waterway and land management.

    (c) In July 2015 nearly 600 of the 642 SMP farms were surveyed to see what the potential impact had been. This surveying found mean reductions in farm nutrient losses of 5 per cent for nitrogen and 12 per cent for phosphorus. These mean reductions were forecast to increase to 8 per cent and 21 per cent respectively when all actions were taken across all SMP farms.

    (d) In 2014, 5 per cent of these SMPs were audited for their quality and it was found that all consultants who had completed these SMPs were meeting the required standard. This audit found that between 73 per cent and 92 per cent of on-farm actions taken on the 5 target categories had been completed.

    (e) A later (2016) internal DairyNZ evaluation of SMP farmers in four dairy catchments also showed a fall in the estimated average farm nitrogen and phosphorus loss ranging from 4 per cent to 19 per cent for nitrogen and 20 per cent to 34 per cent for phosphorus (Bowditch, 2017, p. 22).

Land management

142. This project began in 2014 and was rolled out regionally through workshops and seminars (rural professionals and farmers), and material embedded into related training programmes.

143. At the time of the Progress Report the land management project had developed the following:

[24] 129 consultants from at least 28 organisations plus 47 DairyNZ Consulting Officers and DairyNZ Extension specialists). Spread nationally Northland (2); Waikato (55); Horizons (9); Hawkes Bay (3); Canterbury (50); Otago (5); Southland (5) Ibid Page 20

- Seven comprehensive land management guides covering: Northland, Northland/Auckland, Waikato, Bay of Plenty, Canterbury, Otago, and wintering on crops in the South Island.[25]
- Developing riparian planting guides for 13 regions, launching extension activities[26] and creating a riparian management plans.
- A series of technical notes "Waterway technical notes: Practical approaches to waterway management."[27] These were designed to increase farmer understanding about how various land management practices affect the environment, profit, animal welfare and farm staff.
- A Farm Enviro Walk (Tool): an interactive online environmental risk and management tool used to generate farm environment reports for farmers. It can be used to develop FEPs and SMPs. The aim was to reduce phosphorus, sediment, and *E. coli* from entering waterways. These guides were also used in farmer extension events and rural professional training. This work was completed in April to June 2017.

Objective 2.7.2 Effluent management training

144. The aim of this project was to reduce rates of significant effluent non-compliance around New Zealand by:

- Increasing the skill level of the effluent service industry through promotion of farm dairy effluent system design accredited companies and via developing an industry-supported placement scheme to bring more skilled workers to the industry.
- Increasing on-farm awareness and knowledge of effective effluent management. including working with regional councils to develop technical resources e.g. rural engineering infrastructure and mitigation measures.
- Engaging with regional councils and milk supply companies about policy and technical issues for on-farm effluent assessment programmes and integrating these into the Whole Farm assessment programme.

Key Outcomes

- Significant non-compliance reported by regional councils dropped from 15 per cent to 5.2 per cent from the PGP's beginning to the end of May 2016. It has risen marginally to 6.15per cent by the 2017/18 season. Some of this reduction in non-compliance can be credited to the PGP.
- From 1 June 2011 to 31 May 2017 around 3,800 farmers and 1,930 RPs attended 146 extension events designed to improve effluent management awareness.

[25] See http://www.dairynz.co.nz/environment/land-and-nutrient/land-management-guides/
[26] See http://www.dairynz.co.nz/environment/waterways/planting-waterways/
[27] See https://www.dairynz.co.nz/media/4329877/waterway-technical-notes.pdf

- As of May 2017, the programme trained 219 rural professionals in Farm Dairy Effluent System Design and Management.
- By January 2018, there were 23 independent effluent WOF assessors around NZ and by the end of 2017 over 330 WOFs had been provided to farmers.
- As of January 2018, there were 20 as Farm Dairy Effluent System Design accredited companies.

2.7.2 Effluent management training

What was achieved?

145. This project was one of the first as there was a lot of pressure to improve the sector's performance from regional councils etc.

The FDE System Design Accreditation programme

146. This programme aimed to have accredited companies provide new and upgraded farm dairy effluent system designs to farmers that met Farm Dairy Effluent Design Code of Practice and Standards. These companies were accredited for a 2-year period once they had demonstrated design competency in accord with the Code.

147. Farmers were under pressure to improvement their treatment of effluent to lower its environmental impact. This programme assisted them as DairyNZ and the milk supply companies were able to agree on the importance of the Code and endorse the use of accredited companies when farmers approached them, often in response to regulatory pressure.

148. It was administered by Irrigation NZ Accreditation Ltd and was put in place in 2012. In 2015 an analysis was carried out that showed that 45 companies were focused on farm dairy effluent in New Zealand. At that time there were 21 accredited companies and 10 of the 24 non-accredited companies accessing design advice via accredited companies. The status as of 31 January 2018 was 20 registered accredited companies (down two from the high of 22). The 2016/17 4th Sustainable Dairy: Water Accord Progress Report noted that interest and awareness in the accreditation programme remained high, with key stakeholders such as the milk supply companies increasingly recommending accredited companies.

149. The programme trained 219 rural professionals in the FLRC course Farm Dairy Effluent: System Design and Management as at 31 May 2017. This included effluent system designers; specialist farm consultants and others such as regional council and dairy company staff.

150. Farm plans for upgrading effluent management are not compiled but the Progress Report noted that all farms that use an accredited company for design of a system build or upgrade would achieve Code compliant infrastructure. The Progress Report emphasised that:

    - According to the annual 2014 DairyNZ farmer survey, 69 per cent of respondents had either invested in an effluent system upgrade in the last 12 months or were planning to in the next 12 months.

- Around 65 per cent of effluent system designers were working for accredited companies according to an internal DairyNZ Report (July 2015).
- A mid 2015 survey by Federated Farmers and DairyNZ estimated that in the previous 5 years around $700 million had been spent NZ wide on effluent system upgrades.
- Significant non-compliance reported by regional councils dropped from 15 per cent to 5.2 per cent from the PGP's beginning to the end of May 2016. However, it has risen to 6.15 per cent according to the 5th Sustainable Dairy: Water Accord Progress Report (DairyNZ, 2018, p. 22). The Progress Report credited some of this to the PGPs investment.

The Dairy Effluent WOF

151. This was launched in 2014 and consisted of a voluntary, independent inspection of a farmer's effluent infrastructure and practices by certified independent assessors. These assessments take a Certified WOF Assessor about 3-4 hours and checks how farm dairy effluent is contained, stored and irrigated onto land. These assessments provide farmers with a report advising them of areas of concern, why and what actions should be considered. The Quality Consultants NZ administers the WOF system and certification programme and this is in turn overseen by an industry advisory group. DairyNZ supported training by providing staff. At the time of the September to December 2017 Quarterly Report it was expected that this would become fully commercial in 2018. As of January 2018, there were 23 independent assessors available with national coverage. As at the end of 2017, over 330 WOFs had been provided to farmers (130 in 2017). According to the same Quarterly Report, Quality Consultants NZ has continued a promotional programme.

152. Dairy Effluent Storage Calculator (DESC) software was being rewritten to enable it to be accessible on the web from DairyNZ's website. It was believed in late 2017 that this would increase its reach and make it easier to access. Transitioning the code was complex but DairyNZ was to continue work on this.

153. DairyNZ intends to provide continued oversight and support of the effluent management project areas under its current 'Meeting environmental obligations' project.

Pond design & construction training

154. This project started in 2012 and aimed to train Research Providers (RPs) in effluent pond design and construction and list them for farmers to access. It was administered by NZWETA and finished in 2016. As of September 2015, it had trained 197 RPs with most being contractors from design and construction companies and a lesser number being specialist farm consultants or regional council staff.

155. A 2012/13 Versus Research Ltd Survey of all farmer attendees showed that 70 per cent were considering further investment in effluent ponds while 25 per cent purchased, installed, or upgraded an effluent pond storage after attending a workshop. Also as discussed above Significant Non-Compliance (SNC) with regional council rules reduced in the period to 2016

but backtracked in the 4th and 5th Water Accord reports.[28] The Progress Report stated that some of the credit for this improvement could also be attributed to this project.

Effluent Management Awareness

156. This project started in 2011 and aimed to make farmers and RPs more aware of, and knowledgeable about, effluent management requirements as well as motivate farmers to contact RPs for assistance when needed. It was carried out through technical and extension workshops and seminars for farmers and RPs. From 1 June 2011 to 31 May 2017 around 3,800 farmers and 1,930 RPs attended 146 extension events. In addition, programme material was embedded into aligned training programmes.

Benefits of 2.7.1 Nutrient management training and quality assurance and 2.7.2 Effluent management training

> **"Fonterra hired 10-12 sustainability advisors all trained through this programme, people couldn't say it was too hard, then they had to play."**

Direct and on-going benefits

157. In 2014 Nimmo Bell estimated direct and on-going benefits for Objective 2.7.1. Due to the difficulties in assessing the value of the other three sub-objectives[29] in the Train the Trainer programme at the time, it included the costs of these but only estimated the benefits of Objective 2.7.1. We have followed this approach to a point by combining the benefit analysis for Objective 2.7.1 Nutrient management training and quality assurance and 2.7.2 Effluent management training. This is because these two sub-objectives are closely related in that they both target better environmental outcomes through improving water quality. In addition, the approaches to valuation that have been used to assess the benefits of the PGP and approaches to valuing the environmental effects on freshwater quality have tended to bundle these issues. We have, however, examined the benefits of the other sub-objectives in the Train the Trainer programme separately based on their own merits.

158. Nimmo Bell (2014) used two approaches to estimate the benefits of the four sub-objectives within Objective 2.7 as it was at that time: a top down estimate and a bottom up approach.

[28] In the 2013/14 & 15/16 Sustainable Dairying Water accord progress reports noted a key reason for Significant Non-Compliance was inadequate effluent storage facilities-ponds with insufficient freeboard or over-flowing.
[29] These three sub-objectives were 2.7.2 Effluent management training, 2.7.4 Animal welfare and off paddock management advisory and training capability and 2.7.5 System integration, risk assessment and people management.

Top down analysis

159. Nimmo Bell estimated a NPV of $572[30] million using its top down approach (using a discount rate of 8 per cent over 30 years from 2011 to 2040). It stated that the key benefit of the Train the Trainer programme was a sustainable increase in production e.g. milk solids (MS) through continuous improvement in dairy farm productivity without increasing its environmental footprint. The counterfactual was unsustainable growth with an increasing environmental footprint. Its approach focused on regional councils' approaches to the trade-off between economic and environmental objectives and how effectively councils implemented environmental policies and the flow on effect as to what farmers could do on-farm.

160. It estimated that with the PGP it would be possible to have a faster transition to environmental Good Management Practice (GMP). The PGP would allow this to be achieved in 3–5 years rather than 10–15 years. This would achieve cleaner rivers faster while allowing incremental growth of 1.0 per cent in MS. The PGP would therefore - facilitate growth in MS to be higher at 2.5 to 2.8 per cent compared to a counterfactual of 1.5 to 1.8 per cent should the PGP not proceed.

161. Nimmo Bell used this 1 per cent compound increase in total MS production annually, and a marginal profit of $3.64/kg MS[31] to estimate a top down view of the PGP's value. In the counterfactual it was assumed the environment was likely to get worse, placing New Zealand's clean green image at risk. Under this scenario it was thought that public pressure would likely curtail growth in MS e.g. 1.5 to 1.8 per cent[32].

162. This top down approach is heavily dependent on the view that the incremental value of the PGP's efforts to improve environmental outcomes is a 1 per cent annual compound increase in total MS production. This was underpinned by the assumption that the PGP's efforts would significantly reduce the time it would have otherwise taken for farmers to reach good management practice. Nimmo Bell used the top down approach as a check on its bottom up approach but relied on the bottom up approach in its overall estimate the value of the pre-farm gate portion of the PGP. We agree that the bottom up approach provided a better way to explore the value of the nutrient and effluent work.

Bottom up analysis

163. Nimmo Bell's second estimate of the value of Objective 2.7.1 was a NPV of $756.7 million (using a discount rate of 8 per cent over 30 years from 2011 to 2040). This analytical approach drew

[30] Nimmo Bell's report quotes $527.4 million over 25 years to 2035. We have adjusted this estimate to be consistent the valuation time horizon used in other work of 30 years to 2040.
[31] Average 2013 operating profit with overheads added back based on Horizons analysis see Cost Benefit and Economic Impact Analysis of the Horizons One Plan, A report prepared for DairyNZ and Horizons Regional Council, 31 October 2013
[32] Nimmo Bell argued that without the input of science and good economics emotional based rules would be imposed and very strict limits set. This would restrict MS growth to 0.8 per cent. However, this would be offset by MS growth of 0.7 per cent from industry good arrangements.

heavily from its work done on the economics of the Horizons One Plan for the dairy sector in October 2013 (DairyNZ and Horizons, 2013).

164. The counterfactual it used for the scenario without the PGP, was that Horizons proposed nitrogen limits policy would be fully adopted by other regional and unitary councils around the country. The economic analysis showed that would have resulted in a 32 per cent reduction in nitrogen leached and a 28 per cent reduction in farm profit at full adoption. In contrast, the scenario with the PGP in place would result in farm system changes that would achieve a lower level of reduction in nitrogen leached of 18 per cent but with only a 4 per cent reduction in farm profit. The marginal change of adopting the PGP was therefore 14 per cent more nitrogen leached than the tighter limits assumed without the PGP but with a 14 per cent better level of annual farm profit (Nimmo Bell, 2014, p. 60).

165. The bottom up method scaled up the incremental effect of the Horizons One Plan on affected farms within the relevant regulatory boundaries to cover dairy farms in New Zealand. The scaling up was calculated as follows. The One Plan analysis estimated a total impact on the 440 affected Horizons dairy farms of $137 million as a present value calculated over the 20 years of the One Plan (DairyNZ and Horizons, 2013, p. 28).[33] This was a projection of the aggregate farm profit foregone for the affected farms. It represented the difference between the scenario of a 32 per cent reduction in nitrogen leached and a 28 per cent reduction in farm profit compared to one of a 18 per cent reduction in nitrogen leached but with only a 4 per cent reduction in farm profit. The margin between these two policies was equivalent to an average NPV of $310,000 per farm for the affected Horizons farms over 20 years.

166. DairyNZ then estimated that the PGP's efforts might ameliorate the impact of this predicted profit foregone by 40 per cent therefore saving each farm $124,000 compared to what would otherwise have happened. Account was taken of how the introduction of policies based on Horizons' stricter nitrogen leaching limits in other regional and unitary council areas might roll out over time. This analysis assumed the counterfactual would have affected a total of 7,290 farms around New Zealand as set out in Figure 4 below.

[33] Table 13, $137m comes from the bottom row of the table "Combined" group and is the difference between Profit/Loss 'Sc1 Limits' of $170m and 'Sc3 Within System' of $33m.

Figure 4: Regional implementation of environmental management plans assumed in Nimmo Bell 2014 valuation

Region	Farms impacted	Year of implementation
Waikato		
Upper Waikato	700	2012
Waipa	900	2015
Waihou-Piako	1,500	2018
Lower Waikato	700	2018
Bay of Plenty	600	2014
Hawkes Bay	70	2015
Horizons	440	2014
Wairarapa	460	2013
Canterbury		
Hurunui	60	2013
Selwyn	200	2015
Hinds	200	2016
South Canterbury streams	70	2016
Opihi, Orari, Pareora	100	2017
Otago	390	2014
Southland	900	2015
Total	7,290	

167. The farms in Figure 4 were those where it was assumed that nitrogen limits would be likely to affect their profitability at a level equivalent to what was proposed in the Horizons One Plan in 2013. It was therefore assumed that all farms[34] in Southland, Canterbury, Otago, Waikato, Hawkes Bay and Bay of Plenty would be affected by equivalent N limits (Nimmo Bell, 2014, pp. 61-62).

168. It was anticipated that nitrogen controls would be put in place across these farms. However, some regions were thought to potentially be subject to lesser controls, for example, those in Northland, Taranaki and the West Coast. In these regions, councils had other focuses for concern such as controlling sedimentation and *E coli* etc.

Appraisal of Valuations

169. Looking at these projects from 2019, with the benefit of hindsight, the bottom up valuation of Objective 2.7.1 may have been aggressive on both the differential value and the timetable for its implementation across New Zealand's dairy farms.

Value differential

170. The scenario without the PGP in the bottom up approach replicated 'Scenario 1' in the 'Cost Benefit and Economic Impact Analysis of the Horizons One Plan' of October 2013 (DairyNZ and Horizons, 2013). In this 'Scenario 1" all representative farms were forced to achieve nitrogen leaching levels no greater than the target levels specified in the One Plan (DairyNZ and Horizons, 2013, p. 10).[35] These limits were to be met by the farms across a time horizon of 1, 5,

[34] The estimate of 7290 farms was thought a bit low and 8,000 was proposed as being likely to be more accurate and there was discussion of the number being as high as 10,000.

[35] This was based on the version that was used in the Environment Court in 2013 and values for year 1 were derived using Overseer 5.4, while values for subsequent years were derived administratively. In the One Plan

10 and 20 years. It is unclear whether this scenario factored in the phasing options available in the One Plan.

171. An example of these phasing options is Policy 14-6 covering resource consent decision-making for intensive farming land uses. Under this policy the Horizons Council can make exceptions on resource consent applications. These are permitted where the existing intensive farming land use occurs on land that has 50 per cent or higher of the more vulnerable Land Use Capability (LUC) Classes IV to VIII and has an average annual rainfall of 1,500 mm or greater. Exceptions were also allowed where the existing intensive farming land use could not meet cumulative nitrogen leaching maximums in year one. In this case, resource consents were to be managed through conditions to ensure year 1 cumulative nitrogen leaching maximums were met within four years (Manawatu-Wanganui Regional Council, 2018, p. 36).

172. There were scenarios investigated during the Horizons planning process that might have had more severe impacts on farm profitability. For example, Horizons' modelled reductions in nitrogen for existing dairy farms based on an approach proposed by Fish & Game and DoC in the Environment Court earlier in the planning process. This Fish & Game and DoC scenario modelled a 37.4 per cent reduction in nitrogen leaching from 2008–2028 by meeting the Notified Version of the Proposed One Plan (NVPOP) limits over a 10-year timeframe (DairyNZ and Horizons, 2013, pp. 13-14). This compares to the bottom up approach's 32 per cent reduction in nitrogen leached and 28 per cent reduction in farm profit. Given the shorter 10 year timetable in the Fish & Game and DoC scenario, and the higher level of nitrogen reduction it proposed, this scenario implied even more significant economic impacts.

Timetable

173. The timetable of regional and unitary councils' implementation of controls on nutrient leaching appears to have been slower than predicted in Figure 4. In addition, while regulation of nutrient leaching has progressed in many regions, the resulting rules have often not been applied in the binary way that seems to have been assumed in the bottom up valuation. In many cases, while the environmental benefits are being pursued, this is happening in a phased way which seeks to avoid the sort of sharp impact on the economics of dairy farming represented in the no PGP counterfactual scenario. The evolution of the One Plan itself provides an example of the more measured way in which the trade-off between environmental and economic objectives has played out since 2014.

174. The Horizons One Plan was made operative in December 2014. Subsequently the Horizons Regional Council has evaluated freshwater quality in 2016 and undertaken a more detailed evaluation of the One Plan's nutrient management provisions in 2018 (Horizons, 2019).

175. Re-evaluation of the One Plan has been driven by factors such as changes to the OVERSEER model used to estimate nutrient losses by Land Use Capability Class under the Horizon Council's 'natural capital' approach. These changes to OVERSEER increased the modelled

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2014 an amended version of this table can be found at, amended by PC 1, Discharges to Land and Water, 2016 14-8.

nitrogen loss below the root zone. As a result, the nutrient limits that had been set, known as cumulative nitrogen leaching maximums (CNLMs), (Horizons, 2014)[36] became difficult to achieve on most farms using good management practices (GMPs) (Manawatu-Wanganui Regional Council, 2018, p. 3). Because of this, farmers applying for resource consents for their farming activities couldn't meet key One Plan rules.[37] Moreover, following the court case *Davidson Family Trust v Marlborough District Council,*[38] the Horizons section 35 report stated that the directive wording of the One Plan's intensive farming provisions required that these land use activities could not exceed the limits set in Table 14.2 (Horizons, 2014). The section 35 report consequently noted that this was likely to have significant economic and social implications for the region's existing intensive farmers who could not get resource consents. It argued that this was because for some farms meeting the costs of implementing the CNLM limits would make them unviable. Horizons has stated that this means that provisions to manage the effects of intensive farming land uses on water quality in the region could not achieve what was intended in the One Plan – water quality improvement within the means of most farmers. Therefore, the One Plan needed to be adapted (Horizons, 2019).

176. Horizons is therefore looking to change the One Plan for existing intensive farming land uses via Plan Change 2. This is focused on: fixing the impractical consenting pathways, developing clear criteria for approval or refusal of resource consents based on overall environmental impact, ensuring that nitrogen limits reflect the latest science and assessing the evidence and information needed for consenting and its cost. Following the full standard planning process as set out in Schedule 1 of the RMA 1991, the Horizons adopted Plan Change 2 for notification on 25 June 2019. In the second half of this year, submissions will be made and assessed by an independent hearings panel. Horizons is running a separate plan change process for new intensive land use activities (Plan Change 3). It is aiming to notify this plan change before the end of 2019 (Horizons, 2019).

177. Since 2014 many farmers have been unable to get resource consents (Galuszka, 2017) and these are likely to be in areas with higher levels of nutrient leaching as they are farmers who cannot meet the One Plan limits easily from the outset. These delays in when the One Plan provisions actually apply will have deferred the implementation of measures to meet these nutrient limits. Some will occur anyway as farmers pre-empt the One Plan but those that need the motivation of regulation to invest in measures to reduce nutrient leaching are likely to defer these investments.

Timetable in the National Policy Statement for Freshwater Management

178. The pace of regulation to address nutrient leaching in New Zealand has been a focus for successive Governments. The National Policy Statement for Freshwater Management (NPS-FM) has been part of the Government's on-going reforms to improve the way that fresh water is

[36] means the total kilograms of nitrogen leached per hectare per year for the total area of a farm (including any land not used for grazing) and is calculated using the values for each land use capability class specified in Table 14.2.
[37] Controlled activity Rule 14-1 and Rule 14-3, or meet the policy test in Policy 14-5
[38] R J Davidson Family Trust v Marlborough District Council [2017] NZHC 52

managed in New Zealand. Regional and unitary councils are required to give effect to the NPS-FM via setting objectives and limits for freshwater quality and quantity, and to ensure that land use and water are managed in an integrated way. Water quality must also be maintained or improved within a region to give effect to the NPS-FM.

179. In 2014, the Government amended the NPS-FM by including a National Objectives Framework (NOF). This established compulsory national values for fresh water and included a set of national bottom lines for attributes of water quality, such as total phosphorus, nitrate and ammonia toxicity, dissolved oxygen and a faecal indicator (*Escherichia coli*).

180. The NPS-FM contains section E which sets out its progressive implementation programme. Under Policy E1 (b) "*every regional council is to implement the policy as promptly as is reasonable in the circumstances, and so it is fully completed by no later than 31 December 2025*". However, this can be extended to 31 December 2030 if the regional council considers that meeting the earlier date would result in lower quality planning or it would be impracticable for it to complete implementation of a policy by that earlier date (MfE, 2017).

Progress by Regional and Unitary Councils

181. As noted in the Ministry for the Environment 2017 National Policy Statement for Freshwater Management Implementation Review, regional council progress implementing the NPS-FM has varied across the country (MfE, 2017, p. 25). It stated that many councils had made good progress identifying objectives and setting limits including Horizons, Canterbury, Waikato and Otago. Others, however, have made much less progress. However, it also explained the no council had implemented the NPS-FM in its entirety.

182. This 2017 report contains a table which summarises regional council implementation programmes as publicly notified before 31 December 2015 as required by Policy E1 of the NPS-FM (MfE, 2017, pp. 20-21). However, the dates in this table appear to have been updated to 2017 when the report was published. The table shows a range of dates for the regions of some regional councils that are comparable to those in Figure 4. However, there are a number that appear to have been significantly delayed including the Bay of Plenty, Hawkes Bay and Wairarapa. Others show smaller delays of a year or two and a few are advanced compared to Figure 4.

183. The date for Horizons aligns in both Figure 4 and the 2017 Ministry for the Environment report. But as described above, these dates do not necessarily align with when regulation affects farmers individually. As explained, the Horizons process is continuing to evolve, and the full pressure of the provisions is yet to apply to many farming operations. This is not unusual as explained in the 2017 National Policy Statement for Freshwater Management Implementation Review. This report stated that most regional plans with nutrient management limits as required by the NPS-FM had rules that did not apply immediately or could be achieved over long timeframes. These long timeframes were for various reasons, including giving land users reasonable time to make the necessary changes on the ground (especially where a large cost was involved) (MfE, 2017, p. 59).

184. The table from the 2017 Ministry for the Environment report also includes an estimated end date for compliance with the NPS-FM for each region. These dates are significantly different to

those assumed in Figure 4 with dates ranging from 2025 to 2027 for all the major dairying regions. Moreover, it is also possible that these dates could slip further and still be in compliance with the NPS-FM because, as discussed above, if a regional council considers that meeting a date earlier than 31 December 2030 would result in lower quality planning, or it would be impracticable for it to complete implementation of a policy by that earlier date, it can delay implementation.

Conclusion on Benefits from Avoided Loss of Farm Profit

185. Based on this, it would appear that there have been many delays in the dates that were assumed in Figure 4 The original earlier dates drove the value differential between the scenario based on the no PGP - the counterfactual and the scenario in which the PGP provided value by avoiding greater losses in farm profitability (the factual). It is also very likely that the differential of $310,000 per farm overestimated the appetite of councils to approve nutrient leaching provisions and consent conditions that have significant economic effects on farmers. Because of this, the bottom up approach's assumption that DairyNZ's efforts in the PGP would have avoided 40 per cent of loss of farm profit, or $124,000, is also probably overstated.

186. Despite this, the bottom up approach provides a useful lens for exploring the question of the value of Objective 2.7.1. But given the way that council provisions and resource consents have be applied in practice since 2014, we believe it could be useful to examine more muted alternative values that could reasonably be estimated for Objective 2.7.1 based on:

    1) Lower values for the PGP efforts that resulted in avoided loss of farm profit of $62,000 per farm.

    2) A longer time horizon for the implementation of the regulation e.g. 2030 instead of 2018.

    3) Both of these: lower avoided loss of farm profit and a longer time horizon to 2030.

Table 11: Scenarios of Value of Nutrient Management (2.7.1)

Scenario	Benefits
Original Projected Benefit from Avoided Loss of Farm Profit	$757 million
1) Scenario of $124k per farm with all farms implemented by 2030	$596 million
2) Scenario of $62k per farm with all farms implemented by 2018	$306 million
3) Scenario of $62k per farm with all farms implemented by 2030	$241 million

187. Table 11 shows the impact on the avoided loss of farm profit of these scenarios. Mapping the progress of each regional council or unitary authority in applying nutrient limits in their rules and their resource consents and the likely economic impact of those on dairy farmers is very challenging. However, from the comparison of timetables used in the bottom up valuation in Figure 4 with the way nutrient limits appear to have been applied in practice means that we suspect that the 3rd scenario may provide a more realistic estimate of the value that might be attributable to sub-Objectives 2.7.1 Nutrient management and 2.7.2. Effluent management. If the 3rd scenario is calculated using an 8 per cent discount rate the value falls to $209 million.

The value of improved waterways

188. While one way of viewing the value of the PGP's work is to see it as managing potential reductions in dairy farm profit, another is the degree to which it improved the quality of New Zealand's freshwater resources. New Zealanders experience a wide range of benefits from being able to enjoy their freshwater resources in a variety of ways. The benefits from freshwater are often not monetised but include the value of recreation and cultural values amongst other reasons.

189. These values are reflected in the pressure on both central and local government to protect New Zealand's freshwater resources. Successive governments have responded to this by implementing key legislation designed to protect these values such as the Resource Management Act (RMA) 1991. Under the RMA's provisions, regional councils and unitary authorities must give effect to its purpose and principles by establishing, implementing, and reviewing objectives, policies, and methods to achieve integrated management of the natural and physical resources (section 30). Part of this includes maintaining and enhancing the quality and quantity of water in water bodies.

190. The way people 'value' freshwater is complex and defining values is challenging. For example, cultural values may not be distinct from social values; social values can overlap with environmental values or economic values, etc. Various methods have been used to try to understand questions of the value of environmental outcomes where non-use values can play and important part. Some examples include Total Economic Value (TEV), Ecological Services, Contingent Valuation, Choice Modelling, Hedonic Pricing, Travel Cost, Cost Methods and Multi-Criteria Analysis.

191. There have been some studies in New Zealand that have sought to measure the non-use values New Zealanders have for freshwater (Marsh & Mkwara, 2103, p. 38). An apt example is a Lincoln University study published in the New Zealand Journal of Agricultural Research in September 2011 (Tait, Baskaran, Cullen, & Bicknell, 2011). This study used a choice experiment to estimate economic values of agricultural impacts on rivers and streams in Canterbury. It investigated three impacts on freshwater attributes: health risks of pathogens from animal waste, ecological effects of excess nutrients, and low-flow impacts of irrigation. It described three states of freshwater streams[39] using these attributes. It found that on average Canterbury households were willing to pay $154 per annum for middle levels of water quality improvement and $213 per annum for the best quality improvement. This amounts to $34 million and $46 million per year respectively if scaled across the Canterbury region.[40]

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[39] (1) No change 60 people per 1000 get sick from recreational contact each year, ecological quality is poor, and there are 5 months of low-flow conditions. (2) Management Fair 30 people per 1000 get sick from recreational contact each year, ecological quality is fair, and there are 3 months of low-flow conditions and (3) Management Good 10 people per 1000 get sick from recreational contact each year, ecological quality is good, and there is 1 month of low-flow conditions.

[40] This is equivalent to Cantabrians being willing to pay about $134 million to achieve the middle level scenario and about $186 million for the best freshwater management outcomes (Calculated as a compensating surplus

192. These valuation approaches have been criticised as choice experiments and similar methods struggle to replicate actual choices made by people parting with actual cash, and as a result can overstate willingness to pay by as much as 1 to 4 times (MacMillan, 2004).[41] These measures do, however, allow us to compare a fresh water valuation with reduced farm profits to some extent.

193. The value becomes quite significant when scaled from Cantabrian to New Zealand households; willingness to pay scales to $351 million per year for the best scenario and circa $254 million per year for the middle level scenario. We take a conservative approach and reduce these numbers to one fourth, which is the upper limit of estimated overstatement of value by methods such as choice experiments. Then, New Zealand households might be willing to pay over $1.2 billion for the best freshwater outcomes and $873 million for the middle level outcomes (Discount rate of 6 per cent over 30 years to 2040).[42] As a comparator New Zealand's GDP was $206 billion in one year – 2017, compared to these estimates of household willingness to pay over 30 years discounted to a present value. While these estimates are only indicative, they are between three and a half to around five times more than our reassessed avoided losses in farm profit set out in Figure 5: N loss by Region over 4 years of the Sustainable Dairying Water Accord.

194. The extent to which the PGP has improved freshwater quality is difficult to assess because of the difficulty of establishing clearly the link between on farm activity and water cleanliness. Figure 5 below shows the annual estimates of average nitrogen losses across the four years included in the Sustainable Dairying Water Accord. There is not much of a discernible trend in the data due to changes in OVERSEER versions. For example, comparing average regional nitrogen loss in the 2013/14 season with the most recent season shows that all except two regions had an increase in estimated nitrogen leaching.

195. There is limited ability to determine what the underlying trend in the regional averages might be as opposed to changes in key inputs into OVERSEER's calculations.[43] We understand that back casting using an older version of OVERSEER to try to assess trends on the same basis may be possible in OVERSEER from now on but for previous years the software was not designed to allow this to be easily achieved.

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using a declining discount rate over five years and assuming that those who didn't respond to the choice experiment survey valued freshwater in the same way as those who did.

[41] Another criticism of these methods is that while being logical and consistent approaches to assessing freshwater values and choosing between different objectives, they are still trying to measure something essentially fickle. The values are highly contextual and may not be conducive to being reduced to categories for 'objective' elucidation and measurement. See Natash Berkett, Ian Challenger, Jim Sinner, Marc Tadaki, Cawthron Institute, Report No. 2353 July 2013 available at https://www.landcareresearch.co.nz/publications/researchpubs/Berkett_2013_Values_collaborative_process.pdf

[42] As a sensitivity test, at an eight per cent discount rate New Zealand households might be willing to pay circa $987 million for the best freshwater outcomes and $714 million for the middle level outcomes.

[43] Email from DairyNZ 19th July 2019

Figure 5: N loss by Region over 4 years of the Sustainable Dairying Water Accord

	2013/14		2014/15		2015/16		2016/17	
Region	Average N-loss	Sample size (no. of farms)	Average N-loss	Sample size (no. of farms)	Average N-loss	Sample size (no. of farms)	Average N-loss	Sample size (no. of farms)
Northland	24	258	22	628	23	687	26	825
Auckland	23	131	20	206	20	237	21	262
Waikato	32	2101	35	2940	34	3446	35	3735
Bay of Plenty	38	254	43	513	42	57	44	638
Gisborne/Hawkes Bay	34	74	34	83	36	86	38	81
Taranaki	48	765	54	1195	51	1329	54	1565
Manawatu	28	477	29	640	28	696	31	803
Wellington	31	85	32	141	33	154	37	167
Tasman	63	83	72	94	69	125	73	111
Nelson/Marlborough	37	33	42	45	42	51	37	47
Canterbury	34	650	52	831	64	1073	59	1143
Otago	25	226	36	272	39	362	38	399
Southland	40	399	36	575	32	699	35	851

196. Despite these measurement difficulties, the nutrient management and effluent management objectives of the PGP certainly appear to have contributed to initiatives that have lessened the environmental effects of the dairy sector. Most measures are of inputs e.g. workshops held or rural professionals certified. There are only a few measures that indicate some possible tangible progress that are linked to the PGP. Examples of those are:

- The 2017 Progress Report that Certified Nutrient Management Advisers (CNMA) were probably involved in developing about 13 per cent of nutrient management budgets of the 14,000 farms that had these in place. Most of these farms were dairy farms and were meeting regional council requirements.
- The surveys of Upper Waikato SMP farms in 2015 which found mean reductions in farm nutrient losses of 5 per cent for nitrogen and 12 per cent for phosphorus.
- The 2016 research on a range of SMP farms showed falls in average nitrogen losses ranging from 4 per cent to 19 per cent and for phosphorus between 20 per cent and 34 per cent.

197. The measured effects of PGP related initiatives so far show a small amount of largely regional progress relative to the indicative willingness to pay for freshwater attributes as investigated in the Canterbury region in 2011 by Lincoln University. While New Zealanders might be willing to pay quite a bit for better freshwater, so far there have only been small steps taken to deliver results that will change freshwater attributes by meaningful amounts.

198. As a thought experiment it is possible to speculate on the value of the environmental improvement that might have resulted from the PGP. For example, if it were assumed that:

- The PGP's contribution to improving water quality across New Zealand was 13 per cent based on its contribution to nutrient management plans.
- These nutrient management plans were largely implemented as appears to have been the case.
- The 2015 Upper Waikato and 2016 analysis could be generalised across the 14,000 farms around New Zealand. This might be optimistic but by 2019 there will have been more progress of the sort measured in the Upper Waikato and other catchments with SMP farms. If this was conjectured it could imply an

average improvement in freshwater quality of 10 per cent relative to the measures of improvement used in the Lincoln University study.

- Finally, it could also be supposed that this 10 per cent improvement moved waterways 10 per cent along the path between a current state and an improved state e.g. $873 million for the middle level improvement.

199. Based on this speculation, the PGP might have contributed an indicative additional $11 million[44] that could be added to the avoided losses in profit estimated earlier as a possible value of the nutrient and effluent management sub-objectives of $199 million.

Managing reputational risks

200. There is a growing connection between food companies' brands and sustainable production. Building and protecting food brands is subject to risk when problem activities can be broadcast by anybody who finds a problem and has a social media connected device. There could be major impacts if customers chose alternatives to New Zealand's dairy products due to events that badly sullied the reputations of New Zealand's dairy companies. The PGP would have helped lower this risk.

> **"The on-farm benefits may come more from the off-farm signals."**

Spill overs specific to effluent management

201. The FDE System Design Accreditation programme resulted in some spill overs benefits that were described in the Progress Report (Bowditch, 2017, p. 26). These included the development of the New Zealand Milking and Pumping Trade Association funded 'Farm Dairy Effluent Hydraulic Design' course. This focuses on selecting the right pumps for effluent systems and over 110 people had been trained in this by May 2017. The Progress Report also led to the Irrigation Accreditation programme that was based on FDES Design Programme format/templates. There were five accredited companies by May 2017.

Objective 2.7.3 Greenhouse gas management training and tools

202. This work area followed the path of the nutrient and effluent work to provide tools and knowledge for building a Greenhouse-gas-capable workforce. The programme established Greenhouse gas (GHG) minimum knowledge requirements; evaluated a GHG training course and the possibility of a certification programme for farm consultants; developed a framework for assessing the impact of GHG mitigation options on the farm business; and recommended a tool for accounting for GHG reductions. Consultants will use the knowledge and tools to

[44] $873 million willingness to pay of New Zealanders for improved freshwater outcomes calculated using a discount rate of 6 per cent over 30 years to 2040 x 0.13 x 0.1

support farmer decision-making about GHG management options. This will provide farmers and the industry with increased confidence in the impacts of implementing GHG management options on farm (Programme Management Office, 2017).

Key Outcomes

- GHG course has been set up to provide the training and competency assessment.
- Overseer evaluated for GHG on-farm assessment use.
- The cost/benefit of different mechanisms through which farmers can claim carbon credits in the future was investigated.
- The industry is now at the table collaborating on the GHG approach.

"Visionary in GHG, we were two years early, we already have the people ready to help farmers understand the coming changes."

Table 12: Objective 2.7.3 Greenhouse gas management training and tools

Inputs	Partners	Activities	Outputs	Impact
Combined with nutrient and effluent objectives $17 million PGP investment	Massey AgResearch	Developed training and certification models	Structure to measure impacts and implement change on-farm	Enabled industry to be willing and ready for regulatory changes

203. The GHG programme:

- Defined the minimum knowledge around GHG emissions from dairy sector
- Developed a Risk Assessment matrix
- Delivered a professional training course for rural professionals to upskill
- Raised awareness amongst large group of rural professionals servicing dairy farms
- Created a mechanism to spread research information and mitigation options to dairy farmers so they can make informed decisions when required (Wilson, 2017).

204. A pilot course 'Introduction to New Zealand's Agricultural Greenhouse gas emissions and management' held in 2017 had 27 rural professionals attend.

205. Nine GHG101 workshops for rural professionals were delivered in 2017 with 430 rural professionals participating (DairyNZ, 2018).

206. There is a need to build capability for GHG emissions advisors as the New Zealand government prepares to declare through the Paris Agreement how, as a country, each sector will reduce its GHG emissions. All sectors that emit GHG gases will be involved in contributing to reduction programmes although timeframes and exact reduction targets are still in development. As most of agricultural emissions come from farms with ruminant animals, what's required will be farm system change and/or new technologies to be implemented on farm to reduce the farms GHG

emissions. To do this the farm owner will need access to high quality advice to assess their farms options.

Benefits of 2.7.3 Greenhouse gas management training and tools

207. While there are no direct measurable benefits from this work, it is considered fundamental to getting the dairy industry to the table and ready to work towards and respond to coming legislation.

208. Farmers can use Overseer to calculate on-farm emissions, the enabling measurement is a key step toward management and mitigation.

> **"Can you actually have a sustainable industry without the tools?"**

Objective 2.7.4 Animal welfare and off paddock management advisory and training capability

209. This project aimed to develop advisory and training capability in animal husbandry and management on-farm. The Body Condition Score Assessor Certification, off paddock management and informal practical skills training programmes were designed to deliver proficient trainers and advisors in areas where advice and information has been lacking and of poor quality (DairyNZ, 2018).

Key Outcomes

- The Present Value (PV) of the BCS programme benefits was calculated to be $105 million (Bell, 2017).
- Assumptions are updated to represent best information available, 315 Certified as BCS Assessors available to provide BCS services.
- A cost side is added to provide a revised maximum NPV of $74m.

Table 13: Objective 2.7.4 Animal welfare management

Inputs	Partners	Activities	Outputs	Impact
Approx. $10m PGP funds Previous DairyNZ BCS project	Primary ITO NZVA (Vets)	Body Conditioning Assessor training and certification programmes Up-skilling farmer training	The BCS Assessor Certification Programme 315 Certified BCS Assessors	Increased use of BCS assessors

Body condition scoring management

210. Set out to reduce animal welfare risk and increase cow productivity through better management of cow body condition by increasing and improving Rural Professional (RP)

capability relating to body condition scoring of NZ dairy cattle. The Body Condition Score (BCS) project was the most significant area of work under this objective and aligned with a non PGP programme - Body Condition Management to encourage adoption and stimulate demand. It is important to note DairyNZ Project AN1105 was a precursor to the BCS Certified Assessor project.

211. A review of the business case for the programme conducted in April 2016 highlighted the need to develop and refine it to ensure sustainability post PGP. Initial requirements for certified assessors were replaced with an annual on-farm calibration event to reduce the burden of certification while maintaining an industry standard (Bell, 2017).

212. The overall management of the programme has been moved back internally within DairyNZ. DairyNZ will continue to provide oversight of the programme, maintain the participant database, publish certified assessors via the DairyNZ website and monitor/moderate activity to ensure that the integrity of the programme is maintained.

213. Post PGP funding BCS certification and training has shifted to a user pays model.

Off paddock management

214. Delivered base resource materials for building and managing off paddock facilities available for download from DairyNZ website. Developed web tools to assist selection of appropriate facilities.

Improving Farmer Training

215. The "Up-Skilling Farmer Trainers" subproject developed training capability (primarily targeting vets) and modules for delivery of training to farm staff.

216. The capability build provided refresher training for existing programmes like Healthy Hoof which reports 22 RPs trained from a group of approximately 80 current providers.

217. Discussions with NZVA/DCV to embed train the trainer along with other DairyNZ vet training products (InCalf, Healthy Hoof, SmartSAMM etc.) into a proposed post graduate diploma as part of NZVA's Continued Professional Development. Appears to have been unsuccessful.

218. Outcomes are unclear, interviewees cite difficulty getting Vets to continue the training products developed.

219. Cow Skills is a non-formal practical skills training model that aimed to expand the StockSense delivery, through trained trainers and partner organisations. "Cow Skills" was transitioned to Dairy Training Limited as a user pays model in the 17-18 season with early uptake of five multi farm businesses. One Māori farming business utilised their own in-house trainer (DairyNZ, 2018).

Benefits of 2.7.4 Animal welfare management

220. The value BCS programme was assessed in 2017 by Nimmo-Bell. For other areas of this objective there is either not enough evidence of impact or benefit is not attributable to the PGP.

The benefits assessment below focuses on updating benefit estimates for the BCS project and adding in a cost side to get an NPV.

221. The benefit cashflow approach makes a number of assumptions (see table below) and builds them into a model over time from the starting of the programme in 2013 to 2038, by which time the benefit is assumed to cease. The Present Value (PV) of the programme benefits is estimated to be $105 million assuming a discount rate of 8 per cent (Bell, 2017).

Table 14: Valuation of the BCS programme was based on these assumptions[45]:

Nimmo-Bell 2017	Updates and changes 2019	Results
By 2020 there are 350 certified BCS assessors targeting 3,575 farmers (30 per cent of all herds) making an average of ten farmers per assessor	As of 2017 there are 315 certified BCS assessors this is expected to reduce as the model switches to user pays and maintain at 300	$0.5 million reduction in PV of benefits
83 per cent of these 3,575 farmers adopt a plan to change management to improve BCS, making 2,968 farmers	83 per cent of the farmers adopted a change management plan at a cost of $500p/y and RPs costs $1000p/y	Adds $15 million of costs or reduction of benefits (PGP costs reduce benefit by another $6 million)
In the first year 53 per cent of these farmers achieve a moderate to large impact (increase BCS from 4.25 to 5.0) rising to 66 per cent by year 3, making 1,959 farmers	Test halving rate of moderate to large impact; 27 per cent, to 33 per cent, making 969 farmers	Reduces benefit by half to $53 million or when combined with updated RP assumption to $48 million
32 per cent of these farmers attribute the impact to the higher confidence in the BCS making 627 farmers who directly benefit from the certified assessor	Unchanged	Unchanged
Raising BCS prior to calving from 4.25 to 5.0 increases operating profit by $223/ha/year.	Tested at half benefit $111.5/ha/year	Reduces benefit by half to $53m, combined with updated RP assumption and impact rate $24m
8 per cent discount rate	6 per cent discount rate	Increases PV to $120 million

222. The 2017 progress report documents 315 BCS certified rural professionals (Bowditch, 2017). With the model switching to user pays, we update the model to maintain this level out to 2020

[45] Bell (2017) authors note there is little or no hard evidence to support the figures.

and reducing to 300 BCS certified rural professional by 2025. This reduces the PV to $96m at 8 per cent discount rate.

223. Adding a cost side, which includes the approximate $10 million PGP investment, ongoing costs to farmers using BCS assessors and adopting a plan to improve BCS of $500-1000p/y and RPs maintaining certification $1000-2000p/y. The low range of costs of the programme become $21 million PV reducing the net benefit to $74 million. Doubling the farmer and RP costs increase the PV of total costs to $36 million and reduces net benefit to $60 million with 8 per cent discount rate.

Table 15: Revised NPV of Body Conditioning Score

Model ($m)	Nimmo-Bell 2017	Six per cent discount rate	Half rate of impact	Half value of impact
Nimmo-Bell 2017	105	120	53	26
Revised no. RP certified in BCS	96	107	48	24
Costs low (high)	21 (36)	25 (43)	21 (36)	21 (36)
Revised NPV (high cost)	74 (60)	82 (64)	27 (12)	3 (-12)

224. The basis for costs levels is rather arbitrary and should be explored further as it highlights the importance of considering the burden of certification in a user pays environment and the cost to farmers of adopting changes.

Other benefits

225. There is some anecdotal evidence of benefit attributed to the Cow Skills pilot. One of the farming business noted: Their SCC last season was 230,000, and this season it is at 94,000. "I put that down to CowSkills. They (workers) are cleaning their hands after finding mastitis cows, they know how and why to strip so not only are they doing it but they are doing it well and they teat spray properly" (Manager, Group C). This reduction has meant they now receive an additional two cents extra per milk solid with their dairy processor, which has meant an increased profit of $8,000 (DairyNZ, 2017).

Objective 2.7.5 System Integration and Risk Assessment and People Management

226. The Whole Farm Assessment and Planning project had a number of name iterations, for a while it was known as, Gap Assessments and Business Plans, but finished as System Integration and Risk Assessment and People Management. The project aims stayed more consistent than the name, it sought to develop capability and industry standards for farm

systems and farm people management through the development of tools and processes, training, and certification schemes.

Key Outcomes

- Certification providing industry benchmark for rural consultants.
- Increased collaboration and coordination in sector.

Table 16: Objective 2.7.5 System Integration and Risk Assessment and People Management

Inputs	Partners	Activities	Outputs	Impact
$4.5m PGP investment	Rural consultants Massey NZIPIM NMCAP IrrigationNZ Agri One	Collaboration and co-development of certification People lift	Two certification schemes Trained RPs WFA	Improved farm management

Key Activities

227. DairyNZ and NZIPIM co-developed two certification schemes in collaboration with twelve firms.

- NZIPIM Dairy Farm Systems Certification - created to increase the capacity of rural professionals to provide a whole of systems approach.
- NZIPIM Farm People Management Consultant Certification - created to recognise the specialist expertise of farm people management consultants who could then be actively referred by other rural professionals working in the field, and in turn, lift the people management standards of farmers.

228. Worked with Agri One for the co-development and commercialisation of training to support certification, the Agri One business model was not viable and has now closed. DairyNZ delivers training for Dairy Farm Systems certification through its Foundation Training model.

229. As a response to low demand for People Management consultants the People Lift project sought to better understand the value of people management consultants and develop a value proposition that could be used for promotion.

Table 17: Objective 2.7.5 Outputs

Certification	Completed	Targeted	Enrolled
Farm People Management	8	14	-
Dairy Farm Systems	17	24	77

- Nineteen firms and 12 independent consultants engaged in the Dairy Farm Systems Certification and training, 17 consultants achieved certification in Dairy Farm Systems against a target of 24 for the programme.
- Eight consultants certified in People Management against an end of project target of 14.
- People Lift provided evidence that the use of Certified People Management Consultants can result in significant change to leadership and management of farm teams and result in benefits.
- A value proposition for People Management Consultants was developed after the project was completed: 'Get your farm team doing what you need and want with a people management consultant delivering tools, coaching and confidence for change.'
- Twenty-five DairyNZ staff were involved in the development and delivery of 18 online assessment modules and four training programmes for the Dairy Farm Systems Certification Scheme. This resulted in significant gains in the collaboration and consistency of resource development across the organisation.
- Examples of Dairy Farm Systems, Sustainable Nutrient Management, and Farm People Management certification schemes being referred to by banks, regional councils and DairyNZ (Sargeant, 2017).

230. A transition plan was in place for the ongoing leadership and management of the NZIPIM certification schemes and associated training. However, the market is still struggling to generate sufficient demand for certified farm systems consultants and the program is requiring ongoing industry good support to maintain.

Benefits of 2.7.5 System integration, risk assessment and people management

231. The value added to consultancy businesses is difficult to quantify. There is little evidence of increases fees or number of clients, however 70 per cent of consultants indicated that the programme had lifted their confidence and the quality of advice they were providing to clients.

232. NZIPIM reports that the strength of their organisation has increased significantly in terms of capability, capacity and scale. Resources and confidence to apply far reaching strategies have led to a membership increase from 650 to 1000 during the project. The capacity of NZIPIM has increased from two part-time staff (1.25 FTE) and revenue turnover of $208,400, to four staff (3 FTE) plus contractors, with revenue expected to exceed $400,000 in the year ending 2018, with minimal support from industry projects (Sargeant, 2017; Office Programme Management, 2018).

233. Whole Farm Assessment (WFA) case studies have shown financial gains of more than $1300/ha/year. These financial gains are difficult to scale up given the sample size, variation in the WFA recommendations, and resulting changes (systems changes are more likely to result in measurable financial gain compared to business strategy, people management or compliance-related changes) (Sargeant, 2017; Programme Managment Office, 2018).

234. Evaluation of farmers who have been involved in WFAs showed that the majority have made significant changes as a result of the process, with several farmers indicating that the 'whole of systems approach' has 'kick-started' them into change. Key changes related to staff structure, leadership and management; business strategy; pasture management and monitoring; improved reporting systems; farm systems (stocking rates, feeding levels, calving times); business focus – profit focussed rather than production focussed; use of advisers; financial management and monitoring systems; and environmental compliance and management.

235. Firms are using the programme to provide structure to their capability development, and as a 'minimum standard' for their consultants. Individuals are engaged as a means of benchmarking themselves against other consultants, and some identified certification as a point of difference that they could market themselves for.

236. There are a few examples of Dairy Farm Systems, Sustainable Nutrient Management, and Farm People Management certification schemes being referred to by banks, regional councils and DairyNZ that start to reveal the potential value. However, the project is unlikely to continue at the level required to realise these benefits.

237. At best we see a return equal to the investment but more likely a net loss in this area.

Objective 2.7.6 Herd reproduction management

238. The purpose of objective 2.7.6 was to improve the national 6 week in-calf rate (6WICR)[46] by building the capability of rural professionals that have an influence on dairy herd reproduction via the services they provide to dairy farms. Specifically, PGP funding was invested in developing the capability of dairy cattle vets and contract heifer graziers. Some more skilled vets and DairyNZ personnel provided training to other vets and graziers. The trained vets would then use their skills in their work with farmers (i.e. a train the trainer approach).

239. The End of Project Report stated that at the outset, the national 6WICR was at 64 to 65 per cent while the industry target was 78 per cent (Dirks, 2017, p. 2). Three quarters of all farmers would need to improve their herds' reproductive performance (Dirks, 2017, p. 5) to achieve this 78 per cent target. If this performance gap were bridged, the dairy sector could benefit by up to $500 million per annum in farm profit.[47]

240. This increase in farm profit was calculated by utilising various online tools and guidance designed to help individual farmers to improve their on-farm herd reproduction management. These farm level tools were scaled up to provide estimates of what value that could come from improving the New Zealand dairy herd overall. The online tools and

[46] The six week in-calf rate is a good measure of overall herd reproductive performance. It represents the percentage of cows that are in calf within 6 weeks of mating.

[47] Dirks, S. 2016. Heifer extension recommendation for future funding: Primary growth partnership milestone 2.7.15.8. Unpublished. Internal report for DairyNZ referenced in Dairy Herd Reproduction, PGP Schedule 2 7 f, End of Project Report Sarah Dirks, DairyNZ Developer, Te Awamutu, 29 September 2017, page 20.

guidance focused on enhancing performance on the 6WICR (e.g. the in-calf gap calculator), lowering the not in-calf rate and improving heifer rearing practices across the national herd.

241. DairyNZ ran a campaign addressing herd fertility to help on-farm practices change, seeking to lift three-week submission rates on farm. The three-week submission rate is the percentage of the herd inseminated within three weeks of the start of mating.

Key Outcomes

- The potential gains of improving herd reproduction management estimated at hundreds of millions remain unrealised.
- However, some tangible progress was made particularly in heifer rearing.
- That progress is likely to have recouped the costs of this objective.

Table 18: Objective 2.7.6 Herd reproduction management

Inputs	Partners	Activities	Outputs	Impact
$1m PGP investment	NZ Veterinary Association	Training of vets and events and information resources to support farmer decision making	Training workshops, events and on-line tools	Small marginal gains

Key Activities

In calf advisory

242. When the PGP began, only 10 to 20 veterinarians were providing advanced in-calf advisory services in the dairy sector at the level needed. However, there were 600 plus trained in-calf advisers available, with skills at a lower level. The majority were veterinarians. It was also believed that before the PGP around 15 per cent of the industry had engaged reproduction consultancy services, well short of the 75 per cent desired. It was projected that 100 plus advanced trained veterinarians were necessary to provide the capacity for the desired level of in-calf advisory services.

243. A number of assessments had identified that vets generally did not possess the 'soft skills' necessary to affect farmers' decisions.

244. PGP funding allowed a two-day training workshop to be developed by experienced veterinarians targeting the capability of end users like dairy cattle vets and contract heifer graziers. Eight training workshops were held through 2015 and 2016 in Hamilton, Palmerston North, Ashburton and Gore. These were attended by 98 vets from 39 practices. The workshops covered reproduction benefits, farm finance and client engagement. Surveys showed that attendees valued the course, scoring it an average of 4.5 out of 5.0 over the two years which is higher than the average of courses run by DairyNZ (which we understand is usually around 4.2 to 4.3). Attendees also found the farm finance session most useful. By the end of the programme there were 118 trained professionals which exceeded the original

target for vets trained in advanced in-calf skills. The End of Project Report explained that the New Zealand Vet Association (NZVA) considered the market need to be met for this type of training, for the next three years. After three years, there may be enough vets who would get value out of participating in the course again (Dirks, 2017).

Heifer rearing

245. This component of the objective sought to improve on the situation at the outset of the PGP, in which there were over 2 million mixed age heifers being grazed that entered the herd 11 per cent below their target weight pre-calving (on average) (Handcock, Lopdell, & McNaughton, 2016). This below-target weight was lowering the overall productivity of the New Zealand dairy herd.

246. In mid-to-late 2013 a series of meetings with relevant industry stakeholders and eight regional focus groups developed a strategy for improving heifer growth. Four key areas were identified:

- establishing strong leadership
- improving knowledge access
- building economic analysis tools
- tools to improve communication between dairy farmers and contract graziers (Dirks, 2017).

247. The programme of activity was developed and implemented, involving 40 plus organisations and 300 plus individual contributors. The programme was provided through focus groups, working groups, focus farm events and online tools such as four economic calculators, seven relationship management tools, and information resources on heifer rearing.[48]

248. By the time the PGP finished, this project was estimated to have reached 10,163 attendees at 440 events. This included 30 field days involving DairyNZ with total recorded attendance of 810; presentations at six farmer and vet conferences with an estimated attendance of 465; DairyNZ Consulting Officers having access to tools and information to help them deliver to 404 discussion groups in which dairy heifers was a topic area, exposing an estimated 8,888 farmers to this work; plus 191 additional contract graziers recorded in DairyNZ's customer relationship management (CRM) database since 2013.

249. Feedback from the heifer field days indicated that attendees thought they were high quality and of high value. Attendees rated them 8.75 out of 10. Attendees indicated that they had made practice changes across all key heifer management areas. The most common change was

[48] It also set a number of targets including for heifer weights in the national database. These were: improve heifer live-weights so that less than 50 per cent of animals entered into the database were 5 per cent or more behind their target live-weight; 1 million heifers with 5 or more weighing events and 70 per cent of heifers born would have 2 or more weights entered before 4 months of age. Other targets were designed to improve herd reproductive performance as measured by Fertility Focus Reports including: calving pattern of first calvers improves from 91.3 per cent having calved at the end of six weeks from the beginning of calving to 93 per cent; and submission rates of first calvers increases from 76.8 per cent to 83.4 per cent of eligible cows which are served within 3 weeks.

25 per cent of farmer attendees had heifers meet minimum weights on arrival/exit of their property and 21 per cent altered heifer feeding (Dirks, 2017).

250. The online project tools and information were made available on the DairyNZ website. The level of activity on the heifer section was reported as outstanding with viewing and download statistics placing it in the top 10 per cent most accessed information on the website. Viewership increased by 4.5 times over 18 months, with 7,705 views to the end of September 2017 and average viewing time was 2:35 which was much better than the targeted time of 30 seconds plus. This suggested that farmers were finding useful information. Over the 2016 - 2017 season the 'Farmfact 3-21: Feed requirements for grazing dairy heifers' pdf was the most downloaded information from the DairyNZ site (Dirks, 2017).

Benefits of 2.7.6 Herd reproduction management

Direct benefits

251. A 2016 report by DairyNZ and LIC documented that up until that date no measurable progress had been made in improving 6WICRs (DairyNZ and LIC, 2016). The End of Project Report also noted that an earlier report on herd reproduction problem areas[49] identified a series of challenges that still existed as this objective was wrapped up. These were:

- paralysis or lack of coordination and cooperation between industry partners
- a narrow market as few farmers were willing to pay for vets' reproduction advisory services
- a lack of coordination of DairyNZ research, development, and extension (RD&E) activities
- limited resourcing to deliver the momentum needed for change.

252. In addition, the timing of some of the PGP work coincided with the low milk prices in 2014/15 and 2015/16. The End of Project Report explained that this changed the priorities of veterinary practices and their confidence in investing in consultancy, which slowed down the rate of delivery.

253. The End of Project Report also listed a mixed set of outcomes but with some metrics improving:

- **Extension funding**. The funding for future extension had not been secured due to the changes within DairyNZ structures. It was the intention that the herd reproduction management activities would become part of everyday extension activity. However, other issues took priority, so this had not happened as at mid-2019.
- **Heifer weights.** Industry data has shown improvements particularly from 9 – 20 months of age. Before the PGP, national heifers averaged 45 per cent of mature liveweight going in to mating, compared to the industry target of 60 per cent of mature liveweight. The 2016 review found this had increased to 59 per cent at 15

[49]Harris Park, 2013

months leading to more heifers calving earlier at first calving (Handcock, Lopdell, & McNaughton, 2016). However, the number of heifers calving within at least 5 per cent of their target liveweight had only increased by 4 per cent rather than the project goal of 23 per cent. This data was drawn from LIC Minda software. Users of Minda tend to be more performance-oriented farmers so this data would not represent the national situation.[50]

- **Improved reproductive performance**. Fertility Focus Reports confirmed in 2017 that there had been a 2.2 per cent increase in the number of heifers calving in the first three weeks from the planned start of calving (PSC) and a 0.9 per cent increase in the first six weeks from PSC, 47 per cent less than the goal (Dirks, 2017).
- **Grazing relationships**. The project was unable to collect case studies of improved grazing relationships. But graziers who allowed their businesses to be focus farms had all benefited from being part of the programme by increasing grazing rates and/or becoming more sought after for grazing. All these graziers had increased the number of heifers that they graze on their farms.

254. The End of Project Report also pointed out that vet practices were indicating increased reproduction consultancy, BCS services and heifer weighing. While industry statistics show that some progress had been made in heifer liveweight gains and heifer calving rates.

255. Overall it would seem that there was a little progress made in this objective. A few metrics moved positively, seemingly as a result of the PGP. The most tangible were probably the evidence of some changes in behaviour, the increase in mature liveweight going in to mating from an average of 45 per cent to 59 per cent and a 2.2 per cent increase in the number of heifers calving in the first three weeks from the planned start of calving. These increases, if they have persisted, are very likely to have improved the annual farm profits on those farms where improved practices were implemented. If these amounts could be measured and added together the sum would represent a small proportion of the estimated $500 million per annum of gains possible in the total New Zealand dairy herd discussed earlier. Unfortunately, because the paucity of formally surveyed 'before' and 'after' measures in this objective, it can only be conjectured what exact proportion these gains would sum to. However, it is reasonable to believe that the estimated $900,000 cost of this objective would have easily been recouped.

256. The potential gains of hundreds of millions remain just that - potential. This PGP objective would have realised a small amount of that potential but improved herd reproduction management across the national herd remains an area of considerable potential value for the industry.

[50] According to interview of leader of herd reproduction management objective through most of its implementation, except for the last year.

On-going benefits

257. It was thought that in-calf training could be incorporated into the NZVA continuing professional development (CPD) programme. However, in 2017 the NZVA was adapting their programme into a pathway for an internationally recognised post-graduate diploma with Massey University. The training course would have to meet a number of criteria to be approved within the Massey curriculum. The pathway was to start development in early 2018, however, it would appear that this has not happened. Regardless, DairyNZ has retained the right to deliver this course in 2-3 years time as the market requires (Dirks, 2017).

258. DairyNZ has revamped the in-calf training introductory course. It now includes the training on consultancy as an important component of the course as a result of how popular the modules on this proved to be in the courses held as part of the PGP. However, it is a hybrid course and isn't as detailed or as intensive as the PGP's second in-calf training course had been.

259. At the time of the September 2017 End of Project Report, it appeared that the heifer grazing work was going to be incorporated in an efficient herds project which was part of DairyNZ's improving Farm Performance programme. DairyNZ was considering four options for continuing the aims of objective 2.7.6, ranging from on-going marketing and promotion to employing extension specialists for further engagement with contract graziers and rural professionals.

260. Interviews suggest that the basic technology of what is being proposed in herd reproduction management has not changed. Currently DairyNZ catches up with graziers approximately annually and at those meetings herd reproduction management is covered. It was thought likely that the best opportunity for these topics to be pursued would probably be in the context of discussions about handling greenhouse gases.

261. Interviews suggested that the larger veterinary businesses have developed dedicated resources focused on advisory activities separate from clinical work. This is usually at the level of two or so FTEs so estimated to be around 30 people throughout New Zealand. Large animal veterinary work is very physically demanding, so often the people moving to focus on consultancy work were more experienced vets who were shifting away from the rigours of clinical work. This trend was probably sparked by the PGP which highlighted the value for these businesses in structuring themselves to support consultancy approaches.

Objective 2.8 Better Farm Decision Making

262. The people and business side of the approach to this theme was split evenly between infrastructure and direct support objectives. The goals were to:

    (a) Build and grow a larger workforce that has the capability to do the right thing at the right time.
    (b) Work with farming networks to motivate members to participate in professional development opportunities.

(c) Create a pipeline for the growth of new leaders and stimulate demand for farm education and training.
(d) Address the wellbeing of farmers to minimise risks.
(e) Deliver programmes suited to large to smaller herd businesses.

263. Dwindling capacity in agribusiness management was identified at Massey and Lincoln universities who were down to eight staff between them. An aim was to revitalise this academic capacity. Three objectives were developed:

- 2.8.1 Leadership pipeline
- 2.8.2 Professional Land Manager
- 2.8.3 Centre of Excellence in Farm Business Management

This was complemented with targeted programmes to directly supporting farmers:

- 2.8.4 Large Farm Business
- 2.8.5 Farmer Wellness and Wellbeing
- 2.8.6 Smaller Herd Farmer Business

Key Outcomes

- Good Yarn workshop model.
- Increased academic capability.
- Promotion of agricultural careers.
- Understanding of health of farmers.
- Targeted programmes in working with Iwi farm enterprises and networking of smaller herd farm businesses.

Table 19: Objective 2.8 Better farm decision making

Inputs	Partners	Activities	Outputs	Impact
$19.25 million PGP funding	Massey Lincoln New Zealand Young Farmers (NZYF) Farmstrong Smaller Milk and Supply Herds (SMASH)	Research and teaching Youth engagement Farmer training Māori governance development Events and networking	Qualified professionals Research papers Pilot programmes Workshops Events	Increased knowledge and understanding of farm and farmer issues

Objective 2.8.1 Leadership pipeline

1. NZ Young Farmers was contracted to provide a leadership pipeline for young people in the dairy industry from AgriKids, TeenAg, NZ Young Farmers through to the Rural Business Network (New Zealand Young Farmers, 2016). The project aimed to build a group of highly skilled and engaged people who maximise the productivity, sustainability and positive public perception of the dairy industry. The pipeline starts at Primary School (AgriKids) through Secondary Schools

(TeenAg), NZ Young Farmer Clubs (18-31) and Rural Business Network (Full Workforce Age) ensuring talent identification, leadership development and continuing education raises the standard of ability across the dairy workforce in the future.

Key Outcomes

- Extension of the Young farmer of the year model into schools with combined membership of over 6,000.
- Twelve hubs capable of delivering 44 events a year to groups of up to 100 people.
- Inability to secure sustainable funding model.
- Large losses sustained by NZYF.

Table 20: Objective 2.8.1 Leadership pipeline

Inputs	Partners	Activities	Outputs	Impact
$5.25m PGP funding	NZYF RBN Red Meat Profit Partnership (RMPP)	Ag Kids Teen Ag RBN hubs and events	Combined membership over 6000 Platform to deliver 44 events a year across 12 locations	Noticeable increase in quality and quantity of Young Farmer pipeline

AgriKids; successful but not sustainable

264. AgriKids was created in 2011 to add an introductory layer in the pipeline. The network sponsored regional and national competitions and resources to develop and assist teachers in supporting the dairy and pastoral industries. The focus until the end of the project was to develop the AgriKids into a full school by school network mirroring the structure of TeenAg.

265. The programme was highly successful:

(a) During the PGP, AgriKids reached a high of over 2,000 members due to the success of the AgriKids national competitions. AgriKids was poised to grow rapidly by converting the National AgriKids club into a school-based network.

(b) In 2018 funding from RMPP sought to get 100 primary schools (one class per school) to complete a module and for NZYF to organize and facilitate a farm visit (DairyNZ, 2018).

266. The programme has not been sustainable. In 2019, NZYF reports significant losses due to the cost of running these programmes and no industry interest in funding the deficit. AgriKids project will likely finish once the RMPP funding comes to an end.

TeenAg; successful but not sustainable

267. TeenAg aimed to introduce and promote a positive picture about agriculture and agricultural careers by showing the fun side of agriculture to students. Participants could become members of a regional TeenAg Club through their school or participation in TeenAg competitions. Members would receive quarterly newsletters and competition updates.

268. The TeenAg club network was considered one of the bigger success stories of the PGP funding, with 105 schools and 2300 members. One hundred and sixty TeenAg students transitioned into NZ Young Farmer clubs at the start of 2017. There is a strong platform for TeenAg to build on, but this required a combination of industry and corporate funding that has not materialised (DairyNZ, 2018).

The Rural Business Network (RBN) is now inactive

269. The Rural Business Network (RBN) was a nationwide programme that organised keynote speaker events. The RBN operated with one employee and a network of volunteer run Hubs. Each hub was supported by the NZYF National office. Participants would pay between $10 and $15 each to contribute to the running cost of each evening (DairyNZ, 2018).

270. At the conclusion of the PGP Programme the RBN consisted of 11 hubs with 1,515 members and was running approximately 44 events a year for groups of 20-100 people. This network was reported to be self-sufficient and therefore not require industry funding to continue (DairyNZ, 2018).

271. From stakeholder interviews we find this reporting does not reflect the current situation. From the website we observe that RBN is no longer running events. Once PGP funding ceased the programme stopped as alternative funding could not be secured.

Outcomes

272. The Dec 2017 detailed quarterly report to MPI states "The overall achievement from this PGP funding has allowed New Zealand Young Farmers to transition from a membership organisation to an industry organisation in its own right offering strategic solutions for talent attraction and development on behalf of the Primary Industry." (Programme Management Office, 2017, p. 47)The programmes that have been invested in on behalf of the PGP programme (with the exception of Rural Mentor) were poised for further growth and continuation with funding mechanisms in place for 2018 and beyond. (DairyNZ, 2018)

273. Stakeholder interviews reveal:

    (a) Significant resources have been focussed on an extensive search for new sources of funding.

    (b) TeenAg and AgriKids programmes will likely cease to exist once the RMPP funding ends.

    (c) Membership levels across all programmes are over 6,000.

    (d) Over 10,000 people have passed through the programmes, approximately 1,400 per year some of which have gone into primary sector roles.

    (e) A 15-20 per cent increase in NZYF membership is attributed to the PGP.

    (f) An observed increase in the quality of NZYF members.

Benefits of 2.8.1 Leadership pipeline to build technical business and people management capability

274. The focus of this programme was to attract school leavers to the industry. Benefit calculation work was based on farm teams being able to recruit farm workers with innate ability typical of the top third of farm workers which is modelled to increase the profitability of a 100ha dairy farm by $19,000 per year. This is expanded to give an indicative impact on industry profitability if repeated for all farms of ~$200 million per year (Scarlatti, 2016). Thus, if AgriKids and TeenAg leads to 500 farm workers with innate ability typical of the top third of farm workers, then the industry gain would be $19 million per year (Scarlatti, 2016).

275. Around 26,500 farm workers are employed on dairy farms, with sector employment growth averaging 3.1 per cent per year since 2000 (Destremau & Siddharth, 2018, p. 10). Meaning about 820 new jobs are added per year. The industry requires another 930 jobs per year assuming a replacement rate of 3.5 per cent based on 7 per cent of dairy farmers being over 65 and 6.8 per cent under 20 (Census, 2013); although some of this quota will be filled by farmers working beyond the age of 65.

276. The assumption of 500 extra new recruits with top third ability every year, for the pre-programme does not seem feasible, nor does the assumption that these 500 will convert to on-farm workers. The percentage of total industry recruits (~4900 per year) looks too high as does the number progressing through the programmes per year (36 per cent of 1400). Either way it is difficult to attribute attraction of an additional 500 top third recruits to the programme.

277. Fifty is more supportable number which would deliver approximately $2 million per year benefit. Applying this to the last three years of the programme delivers $5.3 million PV with 6 per cent discount rate. NPV is $1.2 million net of programme costs. The benefits are attributable to the red meat industry as well as to dairy. We are not sure how to split the benefits, but the split is not material given the small size of the benefits from the programme overall.

278. The benefits are unlikely to be ongoing with the current state of NZYF. However, the Primary Industry Capability Alliance (PICA) has taken on the role of attracting talent to the sector.

Objective 2.8.2 Professional land managers

279. The Professional Land Managers (PLM) project sought to grow the capability of NZ dairy farm managers by developing a professional network of land managers that facilitates leadership and professional development opportunities and promoting land management as a professional career opportunity to attract and retain talent in agricultural industries.

280. The project did not progress as intended and has not achieved a sustainable model.

Key outcomes

- Pilot training programme delivered, refined and adapted to regional needs.

Table 21: Objective 2.8.2 Professional land managers

Inputs	Partners	Activities	Outputs	Impact
Approx. $1.4m	Agricultural Services Limited (ASL) Extension 350 Primary ITO	Pilot business management programme	60 farmers trained	Improved capacity for better on-farm decision making

281. ASL investigated the viability of creating a professional association for farmers, it found insufficient demand to formalise an association (Nimmo-Bell, 2014). After a review in 2013, ASL reshaped objectives to focus on continuing training and development opportunities.

282. The Professional Primary Producers – Business Management Programme (PPPBMP) pilot learning intervention was developed and delivered. The programme included:

    (a) A two-day workshop on 'Building a High Performing Team' focussed on staff selection and maximising team performance.

    (b) A three-day workshop on 'Business Sense for Dairy Farm Success' to increase understanding and responses to the business environment and drivers of profitability, managing risk and volatility, monitoring and benchmarking, and analysing investment.

    (c) The workshops were supported by a variety of pre and post workshop learning interventions such as one on one coaching and facilitated conference calls.

283. The pilot programme was revised and repeated with a further cohort of farmers in 2017 (Programme Managment Office, 2016). Delivery of the second Professional Primary Producers – Business Management Programme (PPPBMP) began in Q4 F17, was completed in Waikato and Canterbury but the Northland based programme struggled with participation. Twenty-six farmers participated in the initial pilot programme (Baker & Neild, 2016). A total engagement of 60 farmers is the final number documented (Programme Management Office, 2017).

284. Primary ITO and DairyNZ agreed to work collaboratively to progress the project beyond the project end (Programme Management Office, 2017). The next two detailed quarterly reports document delays to this objective and without further documentation this is taken to indicate this programme did not transition beyond PGP funding.

Benefits of 2.8.2 Professional land managers

285. The logic of the professional land managers training programme appears sound. Success in the delivery of appropriate training should lead to better decision-making on farm by managers and owners. In turn, this better decision making will lead to improved productivity and profitability. Coaching sessions and conference calls suggested that virtually all farmers had grown in confidence through the programme and most farmers could cite evidence of implementation on farm (Programme Managment Office, 2016).

286. Scarlatti modelling suggests high returns to upskilling farm owners and managers - if business owners previously holding only a farm assistant level qualification gained an agribusiness diploma, then it would equate to an increase in profitability of a 100ha dairy farm by $54,000 per year for a potential $500m benefit if achieved for all farms (Scarlatti, 2016).

287. We note there are quite a few intervening factors determining variation in farm profitability in addition to that of training. At a stretch we could apply this modelling to the 60 participants reported to engage with the pilot training programme. The $54,000 gain from training applied to 60 participants results in a $3.2 million improvement per year. We feel this represents more comprehensive training than was delivered. Scarlatti suggests a benefit of $16,800 per year applies to untrained farm workers achieving formal qualifications. This seems more appropriate, with 60 participants delivering gains of $16,800 per year, making the total benefit approximately $1 million per year.

288. With 26 participants trained in the initial pilot delivering three years of benefit and 34 in the second pilot returning two years, suggests an NPV of $0.9 million using a 6 per cent discount rate.

289. Assuming these yearly benefits of training continue for five year produces an NPV of $2.8 million (6 per cent discount rate).

Objective 2.8.3 Centre of excellence in farm business management

290. Prior to the PGP it was identified that university staffing and capability in agribusiness farm management had fallen to critical levels. The two main agribusiness campuses industry were concerned research and education capability in the area could be lost as there were only eight staff in agribusiness campuses.

291. The Centre of Excellence in Farm Business Management (CEFBM), sought to combine the dwindling capability from Massey and Lincoln universities to ensure the ongoing delivery of research and education that enhanced the understanding of farm business management and advocated global best practice. Normally a Centre of Excellence in a university would be created at a time when an active group of established researchers were at the peak of their capability and experience; in this case it was driven by the importance of the discipline and the implications for industry (Zwart, 2017).

Key outcomes

- Research and teaching capability in Agri business management increased.

Table 22: Objective 2.8.3 Centre of Excellence in Farm Business Management

Inputs	Partners	Activities	Outputs	Impact
Approx $5.5m PGP funds	Massey Lincoln	Increased collaboration, research capability and	28 research projects 21 scholars	Increase in Agri business management

		activity though the Agri One joint venture	25 academics 40 webinars 4 RP courses	research and education capability.

292. Summary of activity:

- Lincoln and Massey universities appointed research capable staff.
- The scholarship programme drew inexperienced staff into research supervision roles.
- Existing staff became involved in research studies and supervision of postgraduate students.
- Research outputs increased substantially with research reports, and conference papers presented in NZ and overseas.
- Postgraduate programmes for rural professionals were developed.
- The CEFBM has established a web presence.
- An online service for farmers and professionals presents and reviews a wide range of tools for farm management support.
- Collaboration between university staff across the range of activities increased providing a focus on the growth and capability within the farm management discipline (Zwart, 2017).

293. Agri One was a joint venture between Lincoln and Massey Universities. This joint venture was established in 2011 to lift collaborative responsiveness to industry requirements. In 2017, Massey University and Lincoln University decided to wind up Agri One on the completion of the PGP. The impact on post-PGP support for the CEFBM is significant as Agri One had become the 'vehicle' for the CEFBM (DairyNZ, 2017).

Benefits of 2.8.3 Centre of excellence in farm business management

294. The CEFBM no longer exists post PGP funding but the full economic impact of the investment will depend on the long-term influence and response to the research that has been produced.

295. Interviewees indicated the universities have regressed back to past behaviour and collaborative efforts have essentially ceased. However, there is a cohort of trained professionals contributing to the dairy industry and the whole primary sector. Departments are stronger and good talent is coming through, so it appears the work has built momentum and capability.

296. The PGP funding created a significant level of research and provided opportunities and encouragement for individual staff to undertake research. Research outputs increased and staff who had not been involved before were engaged in the development of projects, research and presentation of results. There are indicators that the project has improved the capability of farm management staff and students and that this research has involved resources from other universities and agricultural professionals (Zwart, 2017).

297. University based Centres of Excellence are well accepted and understood around the world and exist in other areas at both Lincoln and Massey universities. They are normally driven by teams of academic staff with established research capabilities who are able to attract funding and

retain post graduate students in the focus area. This situation did not exist in the case of CEFBM but the importance of supporting research capability and post graduate students has been recognised in the strategy and investment decisions.

298. There is no monetisable benefit.

Objective 2.8.4 Directly Supporting Farmers - Large farm businesses

299. The objectives of this project were:

(a) Work with farm owners, supervisors, managers, and advisors to develop governance and management skills that will result in resilient farm businesses that remain profitable, sustainable, and competitive.

(b) Transfer the developed Governance Program into private ownership

(c) Implement action plans around the identified key themes of the Māori Dairy Strategic plan:

(i) Youth & Career – Vision; Māori businesses are intergenerational, meaning youth development and succession planning is essential.

(ii) Governance – Vision; Governance in Māori organisations is world class, delivering prosperity, ensuring sustainability, and creating positive change for future generations.

(iii) Productivity – Vision; Māori organisations have some of the top performing dairy farms in the country. World class farm systems enable them to achieve long-term sustainable returns.

Key outcomes

- The DairyBase Māori organisation represents close to 60 per cent of national Māori milk production. This was less than 8 per cent in 2010.
- Governance development programme transitioned into commercial operation/management.
- National Māori Engagement programme established.

Table 23: Objective 2.8.4 Large farm business

Inputs	Partners	Activities	Outputs	Impact
Approx. $2.8m PGP investment	Federation of Māori Authorities Business Torque Systems Whenua Kura	Developing Whenua Ora He Mauri Ohooho	40 Whole Farm Assessments Recruitment targeted at Māori youth Governance development DairyBase use	Improved data and governance

Key Outputs:

- Forty Whole Farm Assessments with Māori organisations.
- Dairy organisation financials, representing >60 per cent of Māori production held on DairyBase.
- The Rural Governance Development Programme transitioned to private management and has been rolled out to four Māori organisations within the Māori Bay of Plenty cluster initiative.
- Contributed to the National Māori Youth programme (Whenua Ora), which focuses on increasing Māori youth awareness and engagement into the opportunities within the Primary Industries. This initiative has been achieved through the collaboration and support of multiple industry partners.
- The roll out of "He Mauri Ohooho" in the eastern Bay of Plenty to build capability in governance, farm workforce and operations, environmental management, and rangatahi with an interest in dairying careers.
- Positive engagement and desire to improve farming behaviours that will improve business results (DairyNZ, 2018).

Benefits of 2.8.4 Large farm businesses

300. Māori are an important contributor on both the demand (workforce) and supply side (milk production, supply and exporting) of the dairy industry. Efficient management of large Māori dairy business has been seen as critical in overall industry development and specifically targeting and supporting dairy farmers in this segment has been a key strategy.

301. Improvements in governance are material. The average change in governance practice of the 2013 course participants as measured by their second Business Torque Governance increased from 59 per cent to 65 per cent and the most significant aspect coming from farmer and advisor feedback was the much higher levels of confidence that they had in their governance practices (DairyNZ & Coutts J&R, 2017).

302. PwC suggest a BCR of 2 for investments in improving the productivity of Māori dairy farms (PwC, 2014). The focus on management is predicted to have large benefits (Scarlatti, 2016)

Objective 2.8.5 Farmer wellness and wellbeing

303. This part of the programme set out to assist members of the dairy workforce to improve their health and wellbeing. The majority of the work in this area falls under three areas; GoodYarn, Health Pitstops and partnering initiatives.

- GoodYarn is a licensing programme which trains other organisations, to lead and deliver the GoodYarn workshops - 2.5 hour, skills-based workshop focused on building mental health literacy in the rural context. It was named joint Best Mental Health Promotion/Illness Prevention scheme at the 2016 Australia and New Zealand Mental Health Services Conference. The programme was first aimed at anyone living or working in rural communities but evolved to become the

GoodYarn Workplace Programme with plans to serve businesses, urban and rural, nationwide.

- Health PitStop is a short medical assessment providing an immediate health report based on simple measurements of height, weight, blood pressure, non-fasting blood cholesterol and blood glucose, and responses to a short questionnaire. DairyNZ has been running Health Pitstops at Farmsource stores around the country.
- Partnering initiatives involved; outreach, advocacy, networking, support and incorporating wellness training into tertiary programmes.

Key outcomes

- Estimated return of $8 million.
- GoodYarn is expanding and evolving to deliver the model to other industries.
- Data collected from 4761 health checks is displayed on the DairyNZ website giving insight into the health and wellbeing of dairy farmers.
- Media coverage of at least 27 articles and six radio interviews (DairyNZ, 2017).
- Support for organisations operating in farmer wellbeing space such as Farmstrong and Rural Support Trusts (RSTs) contributed to better functioning environment.

"If you don't have well people the rest is irrelevant."

Table 24: Objective 2.8.5 Wellness and wellbeing

Inputs	Partners	Activities	Outputs	Impact
Approx. $3m PGP funding	New Zealand Institute of Rural Health AgResearch Rural Support Trusts Rural Health Alliance Aotearoa New Zealand Dairy Women's Network Farmstrong Wellsouth PHO	GoodYarn delivery and licensing. Health Pitstop check-up and data display. Outreach, advocacy, networking and support. Wellness at tertiary institutes	8774 trained 73 presentations 42 workshops 13 interactive events 16 tertiary courses 26 Health Pitstop events	Behaviour change Productivity increases Reduced health costs Resilient workforce

GoodYarn

304. A Licensing Programme for GoodYarn was created which demonstrates the effectiveness of the collaboration of stakeholders. It has reached over 3,000 people and involved 22 organisations to date. It was based on the workshop Rural Life, Keeping the Balance which was developed by Wellsouth PHO.

305. The programme has transitioned to operate as an independent trust.

Health Pitstops

306. Health PitStops were redesigned to allow for better data collection and reach, and to make them financially sustainable. The current iteration uses trainee nurses. An interviewee reports that cost were reduced by approximately 80 per cent.

307. A dashboard is updated by DairyNZ to monitor the physical and mental health of dairy farmers. The dashboard is a collection of the Health PitStops data, government data and contributions from programmes like Farmstrong.

308. Analysis of Health PitStops data found that the prevalence of depression among dairy farmers was slightly lower than national data, and the prevalence of a mood or anxiety disorder was higher. Twenty per cent of respondents were identified with unacceptable scores associated with depression and/or anxiety and were subsequently followed-up. Over four years of surveying there appeared to be an improvement in the prevalence of emotional wellbeing (Botha & White, 2014).

> **"As a direct result of the check-ups about 30 per cent go and see a GP as a follow up, some chronic conditions were also identified and referred immediately to further medical attention."**

Partnering

309. Initiatives in the people space of the Wellness & Wellbeing (W&W) program were initially operating independently with very little cross-connect or information flow between them. A big part of implementation was creating strong relationships with stakeholders to ensure collaboration and contribution. The key stakeholders identified were the Mental Health Action Group, Rural Health Alliance of New Zealand (RHANZ), Dairy Women's Network (DWN), Federated Farmers, Farmstrong, District Health Boards (DHBs), Fonterra/Farm Source, Young Farmers, and the Rural Support Trusts (RSTs)

> **"RSTs needed better governance, they needed support to get better structures in place, now they are much more self-functioning as a result of the PGP"**

310. The RHANZ was actively involved and influenced work with clinicians from a holistic view point of how to look at health in rural communities. Advocacy for health needs of rural communities started and continues.

311. A peripheral project arose which was funded separately but which was woven into the fabric of the programme and ran under the same leadership. This project was the Rural Mental Health Initiative (RMHI) which tasked the DairyNZ W&W programme with uniting and strengthening the national Rural Support Trust network.

312. Wellness content was developed in 2015 in conjunction with Dairy Training and Farmstrong and this content was formalised as modules into the NZ Diploma in Agribusiness Management. Fourteen courses were run in 2016 and 2017 reaching 176 students.

Challenges

313. There were several challenges including:

    (a) managing Health PitStop data

    (b) running a dairy programme in the wider primary sector

    (c) engaging DHBs

    (d) depending on Rural Support Trusts as the main farmer support network

    (e) ineffectiveness of GoodYarn "ghost licenses"

    (f) inability to attract participants to community targeted workshops

    (g) influencing the programme such that it did not become over medicalised

    (h) complaints about the saturation of wellness messages

    (i) working within an industry which struggles to value health exclusive of profit (DairyNZ, 2017, p. 26).

314. Out of the 17 organisations which purchased a GoodYarn license, seven were Rural Support Trusts. The RST license differed from the commercial organisations in that the RST license allowed them to deliver to farmers and the community. The RSTs struggled to get good attendance at their workshops and many became disheartened with the effort and money put in to reach so few people. They are unlikely to renew their license. This is in contrast to larger organisations which could run a workshop and require staff to attend.

315. Some farmers and stakeholders consider the wellness message has been overdone. However, considering the average person needs four exposures to an idea before making a change, saturation, to some extent, is necessary for change.

Benefits of 2.8.5 Farmer wellness and wellbeing

316. The final report states **"GoodYarn and Health Pitstop programmes are well established and transitioned to sustainable models. There is strong industry and health sector support and collaboration, with progress measured through a wellness dashboard"** (Final Report, 2018, p. 47). This is supported by media coverage, source documentation and stakeholder interviews.

    - Thousands of people have been reached, industry culture has improved, and individual lives have been saved (DairyNZ, 2017, p. 32).
    - The programme has reached more than 5,000 farmers and rural professionals through a series of workshops around the country. Twenty-two organisations are licensed to deliver the GoodYarn programme across a range of industries (Taunton, 2019).

317. The final report states benefit as:

- The farmer wellness and wellbeing project reached over 8,000 people and provides at least $8 million in value through improved farm outcomes (Final Report, 2018, p. 48).
- GoodYarn is being delivered by more than 20 organisations, providing over 3,700 people with skills to support the mental health of others in pastoral industry workplaces (Final Report, 2018, p. 36).
- Thousands of farmers and rural professionals have the tools to stay healthy, happy and productive, and the networks to communicate and share new innovations (Final Report, 2018, p. 39).

318. The final Wellness and Wellbeing programme report sets out the following two ways of estimating the financial impact of the programme.

By reference to Australian workplace return analysis

319. The Australian Government invested in a Mentally Healthy Workplace Return on Investment Analysis[51] and concluded that the national economy was losing AUD$11 billion each year due to workplace illness.

320. In the absence of a similar study in New Zealand and assuming the rural stressors are the same in Australia and NZ[52], a report estimated, based on the relative sizes of the economies, that $2 billion is lost each year in NZ. The steps in the calculation are:

(a) With 4.5 per cent of the workforce involved in the Dairy Sector, this report estimated that $90 million is lost each year due to unwell dairy industry workers.

(b) If the W&W programme directly reached 10 per cent of dairy farm workers through its initiatives and if one third of those reached made a change which improved their health (evaluations found about one third of farmers who participated in Health PitStops made a change and the GoodYarn post-training phone survey saw one third of trainees using their skills) it could be estimated that 3.33 per cent of $90 million has been saved. That's $3 million worth of value obtained (DairyNZ, 2017, p. 25).

By reference to the effect of an unwell worker

321. DairyNZ estimates that 15 per cent of farms have an unwell worker resulting in a 10 per cent decline in milk production. That's 1,790 farms affected. An average herd production of 155,000 kg MS per year suggests 15,500 kg MS lost per year on those farms. This in turn implies $235 million lost to the industry based on an average milk price of $6.50 plus $2.00 for transport, processing and sales. With 3.33 per cent of industry workers positively affected by the programme, DairyNZ estimates $8 million of value (DairyNZ, 2017, p. 25).

322. The conclusion is that at a minimum the programme paid for itself and has set the industry up for millions of dollars of savings each year but savings are more likely $8 million if not more

[51] Australian Economy PWC analysis, 2014 (Beyond Blue study)
[52] Sustainable Farm Families 2012 (Susan Brumby)

(DairyNZ, 2017, p. 24). While the methods are rather rudimentary; provide no counterfactual or effort to isolate the PGP component from other contributing investments and programmes, and require a number of assumptions the $8 million figure appears to be conservative and replicable using other literature:

(a) The Wellness and Wellbeing Assessment and Recommendations report cites a Harvard review of 36 studies that showed that absenteeism costs fell by about US$2.73 for every dollar spent on workplace wellbeing (DairyNZ, 2017, pp. 24-25). A review of literature on the returns from investing in Mental Health in the workplace supports at least this level of return on investment.
(b) A UK review of 23 investments in improving mental health found overwhelmingly positive returns. The average return per £1 spent was £4.20 (with a range of between 40p and £9), this is supported by international academic literature in the form of meta-studies (Stevenson & Farmer, 2017).

323. Applying an average rate of return of the two reviews, (3.4) to the $3 million investment indicate a value in excess of $10 million. Considering the reported successes and continuation of the GoodYarn programme this value may also be conservative. However, it does not account for the incremental nature of the investment. The GoodYarn programme built upon foundational work by Wellsouth PHO. The initial input is considered significant so attribution of all the benefits to the PGP investment does not seem reasonable. Attribution is a not an easy task in this area and as the contribution is small relative to other areas of the programme's investment it is understandably overlooked or ignored.

324. Another approach to validate the claimed benefits uses the estimated cost to the New Zealand economy through lost labour productivity, increased health care expenditure and social spending on people temporarily or permanently out of work. This statistic is reported to be 4-5 per cent of GDP every year (OECD, 2018). New Zealand Institute of Economic Research (NZIER) found dairy contributes $7.8 billion to the economy (Destremau & Siddharth, 2018), 4 per cent equates to $312 million as potential loss to the dairy industry from mental health conditions. Approximately a 1 per cent improvement would cover the costs and 2-3 per cent to align with other estimates of benefits attributed to the programme.

325. While it is claimed that the programme has saved lives, we don't consider it meaningful to analyse farmer suicide rates or trends as attribution to the specific interventions of programme is not possible. Stakeholders pointed out the PGP period involved a downturn in dairy prices and the recent M. Bovis cull represents a new challenge to farmer resilience. The proposed counterfactual is that without the programme the industry would not have been in as strong a position to support rural communities. The increased access to mental health services and the timing of the programme has undoubtedly provide improved outcomes. It has also coincided with a general societal behaviour change making it more acceptable to discuss depression, anxiety and mental health in general.

326. It is fair to conclude that the programme has helped change the wellness landscape for farmers and beyond. Previously the only services available were considered to be at the "bottom of cliff", now there are tools and services that enable earlier interventions.

Objective 2.8.6 Smaller farm business support

327. In 2009, two Waikato dairy farmers, started a series of conferences for smaller herd farmers. They gathered an enthusiastic group of volunteer farmers to form an organising committee and then enlisted the support of DairyNZ. Smaller Milk and Supply Herds (SMASH) is now a farmer group utilising industry capability and resources. Reviews, feedback and consultation are used to ensure that the specific needs of smaller herd farmers are met; a previously neglected segment of dairy farmers. From 2011 to 2018 SMASH engaged around 3,000 farmers and provided support and capability development through:

- annual conferences in three regions
- regional workshops and field days
- website, farmer blogs, Facebook and emails.
- rural and regional magazines and newspapers.

Key outcomes

- Continued model post PGP funded by DairyNZ.
- Increased collaboration and knowledge sharing between farmers.

Table 25: Objective 2.8.6 Smaller farm business support

Inputs	Partners	Activities	Outputs	Impact
Approx. $1.3m PGP funds	Dairy farmers	Events and conferences	3,000 engaged farmers	Increased collaboration and access to knowledge

Activities

328. In the final year of the PGP project the team delivered twenty events across the country attracting 1,129 attendees. Topics included: progression and succession, mastitis, calf rearing, facial eczema, budgeting, effluent management, pasture silage making, heifer management, environmental management and lameness. SMASH has successfully transitioned to funding sourced from DairyNZ, under the umbrella of the extension team (DairyNZ, 2018).

Benefits of 2.8.6 Smaller farm business support

329. SMASH clearly provides a mechanism for improving the transfer of knowledge. Industry experts present at the events, giving farmers access to new information and allowing them to acquire information geared specifically towards smaller herd farmers. However, there is not yet solid evidence of how intentions were converted to actual changes and the difference this has made to productivity, profitability, environmental and/or social benefits (DairyNZ & Coutts J&R, 2017).

330. A survey of smaller scale dairy farmers found they would like knowledge and assistance in five key areas; succession, regulation and compliance, staff, technology and cashflow/profitability. SMASH is suggested to be assisting with regulation and compliance concerns by providing

workshops where farmers can access and discuss quality information to keep abreast with compliance issues, such as employment or environmental regulations (Westbrook, Nuthall, & Phillips, 2016).

331. Compliance issues are becoming increasingly time-consuming on dairy farms. These issues require similar amounts of work regardless of the size of the farm. Similarly, it takes small farmers just as much time to investigate new technologies, but the overall returns are less than for the bigger farmers. SMASH is either providing or has the potential to deliver an efficient mechanism of supporting smaller farms. This could be considered a future cost saving generated by the PGP investment.

332. The benefits of SMASH include improving the resilience of smaller farms increasing social cohesion as farmers involved seem to enjoy supporting each other. The market does not have competitive pressures that discourage knowledge sharing.

333. The most monetisable benefit is the transferring of knowledge from the higher producing small farms to the lower profit per hectare farms. This is likely happening, but we do not have the data to support modelling. Farmer feedback surveys indicate that attending events does translate into on-farm changes. Isolating these changes from myriad variables affecting productivity is not possible.

334. The benefits of the PGP investment are additive as this initiative began in 2009. A counterfactual situation is very difficult to establish. The PGP investment can certainly be credited with expanding the reach of SMASH faster than would have occurred without the funding. It proved to DairyNZ that it was a worthy investment of levy money.

Theme 3: Food Structures

Objective

> Theme 3 focused on designing food structures. This involved food science and engineering along with non-food material science. Through this work at the Fonterra Research and Development Centre and at a number of universities new complex foods and ingredients were to be developed, networking facilitated and people attracted into the industry.

Key outcomes

- Understanding of the behaviour of the protein, fat and water phases and how to manipulate and measure these in mozzarella production provided the confidence and support for investment in scaling up production.
- Next Generation Mozzarella commercial trials successful.
- Hi-moisture options for mozzarella patented.
- Increased production of UHT cream (trebled since 2013).
- Commercial and academic relationships established with research capability developed.
- Professional development of students and early career researchers.
- Researchers employed by Fonterra.
- Model of dual supervision (commercial and academic) heralded.

Table 26: Theme 3 Overview

Planned core work areas	Investment plan ($m)		Progress	Final work areas	Final investment ($m)	
3.1.1 Capability resourcing 3.1.2 Semi-solid and solid foods 3.1.3 Extreme composition fluids 3.1.4 Restructuring lactose 3.1.5 Kiwifruit structure	Industry	18	Lactose work was terminated due to market changes Objectives 3.1.2 and 3.1.3 produced three final work areas	Endgame mozzarella Endgame creams Signature milks Kiwifruit structure	Industry	16.4
	MPI	16.5			MPI	12.5
	Total	34.5			Total	28.9

335. Food Structure Design was a strategic research programme that aimed to deliver world leading science involving the successful development of products valued by consumers in key geographies. It was a multidisciplinary and multinational programme spanning a dozen

universities and research organisations. The vision was centred on creating and managing food structures to achieve differentiated physical and sensory performance in ingredients, dairy solutions and consumer products. **The fundamental idea was that process leads to structure which leads to functional properties.** We were told in interviews of the PGP's participants that this model has persisted and has the potential to be applied to a large range of dairy product development.

336. Early efforts in the setup and approach appear to have been critical to the multitude of successes attributable to this theme. The programme initially appointed two academic chairs (a third was appointed outside the programme based on success of the model) and managed to attract a prestigious international panel of scientific experts. A suite of potential projects were generated and rigorously assessed and refined. Then, accepted or rejected, resulting in the selection of projects that had the most promising potential commercial significance or outcomes.

337. Another key aspect appears to have been the strong linkages between the academic research and commercial requirements. The academic projects were complemented with an internal suite of projects and a Fonterra Research and Development Centre (FRDC) staff member was appointed as a secondary supervisor. This meant that they could give direction where needed and anything interesting could immediately be taken into internal projects. The university projects focused on the key new technologies for product manufacture, while Fonterra projects integrated and built on existing and new knowledge of these key technologies to speed up the time to delivery of options for new product development.

338. The initial objectives developed into four key areas in final reporting.[53]

- semi-solid and solid foods objective was finally reported as Endgame mozzarella
- extreme composition fluids became Endgame creams
- signature milks
- kiwifruit structure remained consistent and was largely independent of the other workstreams.

Table 27: Theme 3 Food Structures Components

Inputs	Partners	Activities	Outputs		Impact
Academic chairs International expert panel Post docs PhDs	Massey University Auckland University Canterbury Universities University of Queensland	Suite of academic and commercial projects related to structure, process and functional properties.	Conference papers	46	Investment in plants Shift into food service portfolio Respected research
			Published papers	26	
			Internal report	94	

[53] Restructuring Lactose was terminated due to shifting market forces.

	Victoria University, Melbourne		Patents and other*	20	expertise and capability Changed approach to research that can be widely applied
			Replicable successful approach to research process		

Objective 3.1.2 Semi-solid and solid foods

339. The **semi-solid and solid foods objective** (3.1.2) was to investigate the processes, structures, properties, and sensory linkages in semi-solid foods. The aim was to improve their nutritional and sensory properties. This included research on reducing processing costs of mozzarella, rheology aimed at improving the scientific understanding of mouth feel, and texture of products and work on protein functionalities and casein mineral interactions to improve processes and products including mozzarella. It was renamed **Endgame Mozzarella** and aimed to develop a sound knowledge of the link between mozzarella structure, material and functional properties and the process used to make it.

Table 28: Objective 3.1.2 Semi-solid and solid foods (Endgame Mozzarella)

Inputs	Partners	Activities	Outputs		Impact
Academic chairs International expert panel Post docs PhDs Dysfunctional IQF plant	Massey University Auckland University Canterbury Universities University of Queensland University of Victoria	Suite of academic and commercial projects related to structure, process and functional properties.	Conference papers	46	Investment in plants Shift into food service portfolio Respected research expertise and capability Changed approach to research that can be widely applied
			Published papers	26	
			Internal report	94	
			Patents and other*	20	
			Replicable successful approach to research process		

Origins of the Mozzarella objective

340. The project stemmed from problems that arose at Fonterra's Clandeboye plant after its initial investment of $42 million in a mozzarella production line. This line, which began commissioning on 19 February 2008, was heralded as the first of its kind in the world. Until its opening, Fonterra had produced mozzarella in blocks at the company's Whareroa site in Taranaki and then transported these to another site for shredding and re-packing (The Timaru Economic Monitor, 2008).

341. At Clandeboye Fonterra commercialised a new method of mozzarella production, the direct from milk Individually Quick Frozen (IQF) process. This involved producing a shredded format product directly off the line, drastically reducing the production timeframe (Johnston, 2010). According to Fonterra, production time was reduced from three months to six hours (Fonterra, 2017). This was an important breakthrough and provided the foundation for the PGP work. The first production line functioned reasonably well but faced problems because it was resulting in a significant number of product downgrades which meant a lot was going to stock feed. Investigation of the problem identified that a fundamental understanding of the structural process was required. The PGP programme set out to provide the underpinning knowledge needed to sort out the production issues with the first IQF line. In our interview, the Theme three Programme Manager explained that the early production process was not sufficiently robust. By the beginning of the PGP there was a need to pull together the science, engineering and technology to improve on what had been limping along for a long time.

342. The PGP generated a suite of academic projects (mainly at Massey) focused on cheese structure. Fonterra had a parallel suite of internal projects and co-supervised the projects so findings had a direct and rapid path to commercial relevance. We were told that the PGP research programme was still being leveraged to get the IQF mozzarella plant fully operational. All the science, engineering and technology needed to fully understand the process was identified and turned into projects funded through the PGP.

343. The expert panel operated throughout the project.[54] It also involved appointing FRDC staff to be co-supervisors of the academic work, so they could give commercial direction where needed and rapidly translate findings into internal projects. Monthly meetings were held with professors and fortnightly internal meetings with supervisors and others working on the projects.

What was achieved?

344. An initial important target of the research was an all-dairy mozzarella with a moisture content of 60 per cent, up from traditional mozzarella with moisture content at 48 per cent. At the outset this was considered a significant challenge.

345. The PGP achieved significant progress in formulating and manufacturing mozzarella. It developed a range of scientific tools for exploring and understanding the structure of cheese. It also validated models of the pizza-baking process, and the links between cheese structure and the formation of blisters, bubbles and other facets that consumers can observe. This was coupled with machine vision applications to give objective measurements of cheese performance. It also developed and designed critical mixing and cooking operations of cheese production, including mapping the relationship between the mechanical work in mixing and final cheese product.

[54] The panel consisted of Professors Allen Foegeding, from North Carolina State University; Erich Windhab, from ETH Switzerland; Jason Stokes at the University of Queensland; and Dérick Rousseau from Canada's Ryerson University. It met every year to review the science and the progress of Fonterra's food structure programme.

346. The PGP also developed:

- Scientific and technical knowledge on the effect of different processing stages of the alternative mozzarella production method.
- Processes that achieved 56 per cent moisture mozzarella via manipulating structure and properties (this was the basis for commercial product development and the investment in the 3rd line).
- Processes that achieved 60 per cent moisture mozzarella via manipulating structure and/or including filler particles within the cheese. A 60 per cent moisture mozzarella was successfully made at pilot scale and a patent application was filed.
- A mozzarella process that included all the whey protein in the cheese, so there is no need for a whey processing plant to necessarily be part of the mozzarella manufacturing process.
- Options for manufacturing reduced fat cheese.

347. As part of the work to develop higher moisture cheese, the team also developed a new dairy particle emulsion technology. This was reported as having potential use across a wide range of dairy products and could potentially be used to reduce fat, sugar and salt levels (Transforming the Dairy Value Chain Final Report (Public), 2018, p. 49).

Benefits of 3.1.2 Semi-solid and solid foods

Direct and on-going benefits

348. Early in the PGP Fonterra invested $72 million in expanding its Clandeboye plant in South Canterbury.[55] This upgrade, which was planned to double production, began in mid-2014 and was completed in 2015.[56] It built on Fonterra's initial investment in mozzarella production of $42 million in 2008. In December 2016, Fonterra announced that it was going to invest a further $240 million which would double the plant's production again and make it the largest producer of natural mozzarella in the Southern Hemisphere. The investments announced in 2014 and 2016, along with the investment in the PGP objective itself of $11.6 million, resulted in increased mozzarella production that directly benefited Fonterra as well as indirectly benefited the wider community.

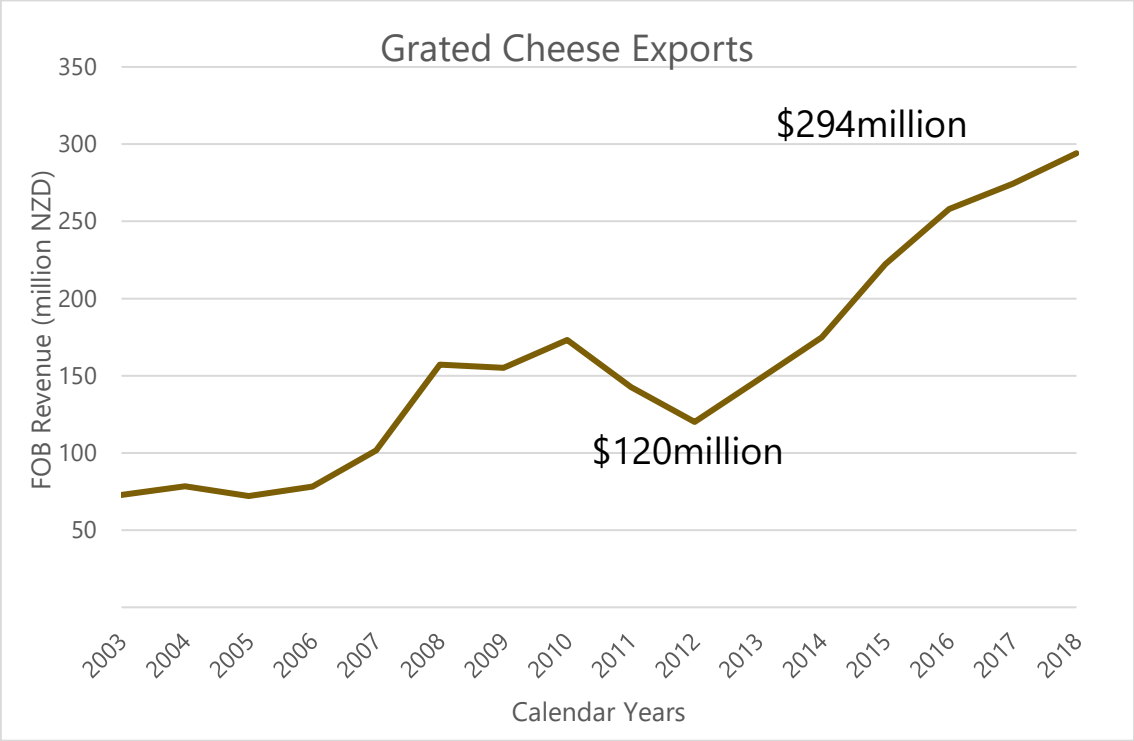
349. The expansion of mozzarella production by Fonterra over the period of the PGP from 2011 to 2018 has been very significant as is clear in Figure 6 below. Although this data is for grated or powdered cheese item no. 0406.20, it is in the vast majority Fonterra mozzarella from Clandeboye. Figure 6 aligns well with our interviews and other sources as it shows an initial

[55] In April 2017 Clandeboye housed two milk powder plants, two cheese plants, three protein plants and two cream product plants. See https://www.odt.co.nz/business/cheese-plant-expansion
[56] See http://www.stuff.co.nz/business/farming/dairy/9298433/Pizza-growth-drives-72m-Fonterra-plant-boost and https://www.dairyreporter.com/Article/2015/05/14/Fonterra-doubles-grated-mozzarella-cheese-production-with-plant-expansion

increase in the value of production post 2008 when the initial production line was commissioned at Clandeboye. It then portrays the problems with product down grades and lack of robustness that followed as the value of production dips from 2010 to 2012.

350. In the period between 2012 and 2018 with the assistance of the PGP's investment the value of these exports rose by $174 million, which doubled the highest previous value achieved in 2010.

Figure 6: Value of NZ grated cheese exports 2003 to 2018



Source : NZHSCLevel10 L10 Desc, 406200029, Dairy produce; cheese, grated or powdered, n.e.c. in item no. 0406.20

351. It is possible to compare the total investment made in mozzarella production that benefited from the PGP, as well as the investment of the PGP itself which totals a sum of $324 million,[57] with estimates of its potential benefits. The benefits are the additional cash earnings minus operating cash expenses from the mozzarella exports that resulted from the PGP and associated plant investment.

352. To be able to explore what value the PGP may have provided from this objective it is necessary to make a number of important assumptions. This includes assumptions about future prices, volumes, gross margins for mozzarella as well as discount rate and time horizon. Our assumptions on these key factors are:

- Prices are static at 2018 levels in 2019 and onwards.
- Volumes attributed to the PGP represent the delta between 2012 and 2018 only. It is conservatively assumed that there is no further value in production from the

[57] This sum includes $72 million from the 2014/15 upgrade, $240 million from the 2016 upgrade and the PGP investment itself of $11.6 million.

PGP from 2019 onwards despite the purpose of the 3rd line at Clandeboye being described as "doubling production" at its opening in September 2019 (Fonterra press release, 2018). This effectively presupposes that without the PGP Fonterra would have invested in a plant to produce mozzarella and so any increase in production resulting from the 3rd line above 2018 levels would have happened anyway. Only 2nd line production is attributed to the PGP.

- Gross margins are actuals for 2016 to 2018. From 2018 onwards they remain at the 2018 level of 15.7 per cent.
- Fonterra's actual share of the exports is used where available. Its 2018 share is extrapolated for future years.
- Investment costs include objective 3.1.2's PGP expenses and the two plant expansions undertaken during the PGP. They do not include the costs or benefits of the earlier investment in IQF mozzarella production in 2008.
- The discount rates used are 6 and 8 per cent as a sensitivity test. Eight per cent is high and therefore conservative relative to recent analysis of Fonterra's business (Northington Partners, 2018).
- The time horizon is 30 years from 2011 to 2040. This is also consistent with the time horizon used in other analysis of the PGP e.g. Nimmo Bell.

353. The 'foodservice' gross margin set out in the 2018 Fonterra annual report is an average of other products that include mozzarella. So, it provides a proxy for mozzarella. It is notable that in 2018 the 'ingredients' gross margin was significantly lower at 9 per cent while the 'consumer' gross margin was much higher at circa 28 per cent. Both these had declined marginally since 2016 (Fonterra, 2018, pp. 64-67). In contrast the gross margins the 'foodservice' category fell from 27 per cent to 15.7 per cent over this period. This decline has been attributed to competition from other suppliers, but also influenced by high commodity prices for milk (Woodford, 2018).[58] This decline makes forecasting the value of this objective very challenging because its future is not known, whereas the gross margins of 'ingredients' and 'consumer' have been more stable.

354. To make this assessment of the value of this objective it has been necessary to rely on data that only approximates what would be available to Fonterra, so it should only be read as an exploration of the likely economics of this objective. With this in mind, based on the assumptions listed above, the net present value (NPV) of the combined investment by Fonterra in its plant, and the investment by the Government and Fonterra in the PGP, could be circa $60 million at a 6 per cent discount rate ($25 million at an 8 per cent discount rate). This value is based on a gross margin estimate that stays static over the period to 2040 at the 2018 level of 15.7 per cent. However, if the gross margin were to rebound in 2019 to the 27 per cent level reached in 2016, and stay at that level, the NPV would improve to $147 million. This underlines

[58] Woodford also commented that the problem with food service was that although branded, the products were essentially sold on technical formulation and price, so it was much harder to defend a leading position in food service than it was in other product categories such as consumer goods.

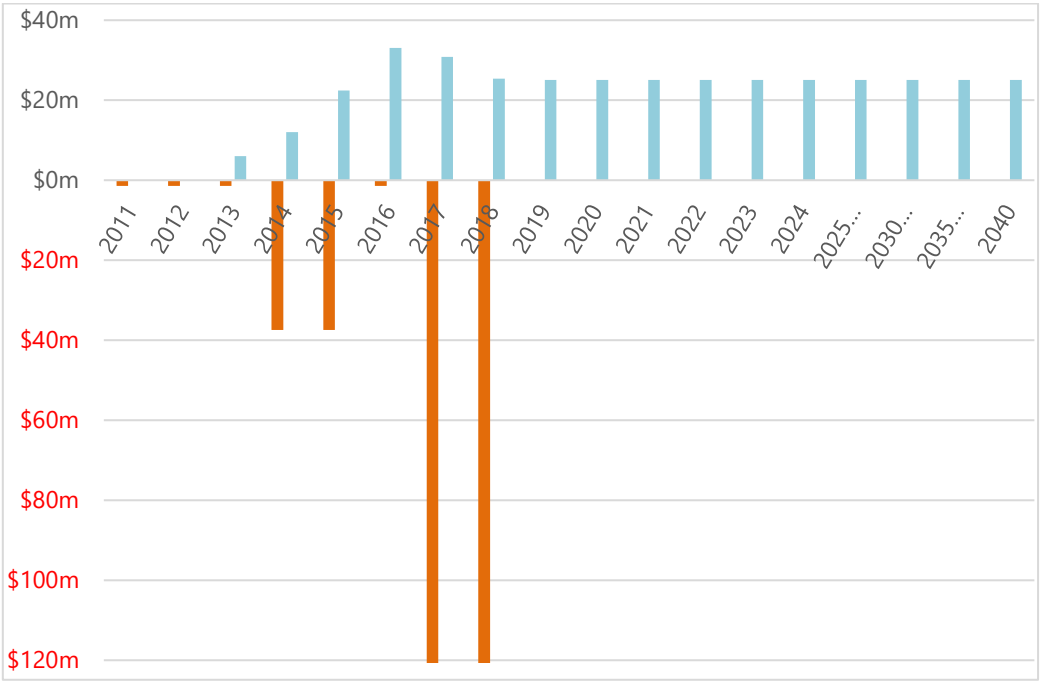
how important assumptions about the gross margin percentage are to the estimated returns from the PGP.

355. If the assumption that the PGP would not have any residual value from 2018 onwards were relaxed, this would increase the NPV. For example, if the PGP was assumed to have a residual value that increased the gross margin earned from 2019 onwards by 1 per cent per annum, it would add $18 million to the estimate of NPV of $60 million.[59]

356. This illustrates the considerable upside value that might be possible from the overall mozzarella investment at Clandeboye for Fonterra. Analysis of Fonterra's overall investment position would include the original $42 million invested in the first production line as well as the intended doubling of production using the capacity of the 3rd line from 2018 onwards.

357. Figure 7 below shows the proxy cash flows used to estimate the net present values of only the PGP's contribution. The dip in gross margin benefits is caused by the sharp drop in gross margin percentage between 2016 and 2018.

Figure 7: Proxy net cash flows of Mozzarella objective



358. These estimates represent a scenario in which the PGP was critical to the case for Fonterra's investment in expanding mozzarella production at Clandeboye through the second line. In this scenario, had the PGP not taken place, production of mozzarella would have remained static at 2012 levels as the food processing and engineering problems would have persisted with continuing product downgrades and lack of operational robustness. It is assumed that this

[59] Calculated using 6 per cent discount rate. Assumes growth of one per cent per annum in annual estimated 2018 gross margin value of circa $25 million. This is a very small assumed about of residual value compared to Fonterra's stated intention of doubling its production using the capacity of the 3rd line.

situation would have persisted until 2018 when Fonterra would have commissioned a mozzarella plant without any assistance from the PGP.

359. It is quite possible that the "without PGP" scenario could have been worse than this though. Competitors could have filled the markets that Fonterra has enjoyed since 2013 and Fonterra would not have been able to respond effectively after 2018. This seems possible as food service margins deteriorated between 2016 and 2018 due to competitive pressures. Under this scenario, if the PGP had not occurred, Fonterra would not have enjoyed the margins it did during the PGP years, and it would have been in a poorer position in the market as at 2018. In this case it would be fair to assume that the PGP does have some claim over some of any increase in earnings from Clandeboye from 2018 onwards. As noted above if this were only a 1 per cent per annum improvement in gross margins, an extra $18 million could be ascribed to the PGP investment.

360. PGP participants that we interviewed on this objective suggested that the most likely counter-factual was that the science that was needed would not have been developed with sufficient breadth and depth to enable Fonterra's investment in increasing capacity with the second line. It was also stated that without the PGP, a risk adverse capital constrained company would have struggled to resource the necessary research appropriately. So, while the investment may have happened eventually, the way the PGP de-risked the project at least allowed earlier commercialisation and scale-up of the innovation. This supports the view of the objective's value would be in the order of $60 million using a 6 per cent discount rate as outlined above.

Sensitivity Testing

361. To test this view, a more conservative way to treat the value of the PGP's investment in objective 3.1.2 would be to focus only on the $11.6 million cost and assume that Fonterra's plant expansions would have gone ahead anyway irrespective of the PGP. In this scenario, the PGP's effect is only that it allows the expansion one year earlier than would otherwise have happened. This assumes that the expansion capex for the second and third lines is delayed by a year and that delays production by a year. A one year delay in production would have lowered the NPV of the objective from the earlier estimate of circa $60 million a bit less than $14 million or $46 million less. So even if it is assumed that the PGP brought forward the investment by only one year, it would have covered the Objective's costs, which totalled $11.6 million, by four times. It means that if the PGP only allowed development of Clandeboye one year earlier than otherwise would have occurred, the returns to Fonterra paid for the Fonterra and Government spending on the PGP.

362. It should be noted that this delay scenario does not align with the views of participants that we interviewed. Their view was that without the PGP there would have been a longer delay than a year and it is possible that there would have been no expansion.

363. The $60 million point estimate of the value of the PGP and the expansions at Clandeboye is sensitive to other changes in key variables. For example, its net present value is zero at a discount rate of almost 10.35 per cent (the objective's internal rate of return). In addition, the net present value of this objective also would fall to zero if the gross margin for the foodservice product category fell to 10.67 per cent and that persisted through the forecast period to 2040.

Indirect benefits and spill over effects

364. The further development of the Fonterra Clandeboye plant has had a number of significant indirect economic benefits. The whole complex employs 900 full-time staff with about 200 working on the mozzarella plant's three lines (The Otago Daily Times, 2018). There were also significant numbers of people employed during construction of the mozzarella lines. In addition, 895 out of Fonterra's 10,500 farming families produce for Clandeboye (Newshub Sponsored Content, 2017).

365. There were also important on-going relationship benefits through world leading experts who influenced Fonterra's research system. These people had internationally respected capability and included members of the expert panel who visited on sabbaticals and provided guidance and input on other projects through the PGP.

Objective 3.1.3 Extreme composition fluids

366. The **extreme composition fluids objective** (3.1.3) was later broken into two: one dubbed **'endgame creams'** and the other **'signature milks.'**

Key outcomes

- Academic capability and relationships enhanced.
- UHT cream business development supported.
- Consumer insights supporting Fonterra's strategic shift towards consumer and food service markets.
- UHT plant expansions.

Table 29: Objective 3.1.3 Endgame creams & Signature milks

Inputs	Partners	Activities	Outputs		Impact
Academic chairs International expert panel Post docs PhDs	Massey University University of Queensland Canadian Universities	Investigation of UHT cream functionality and storage. Consumer preference studies	Conference papers	15	Assisted development of UHT cream business in Asia. Insight into consumer needs
			Published papers	7	
			Internal reports	50	
			Patents and other*	6	
			Academic capability, reputation and collaborations		

Endgame creams

367. Endgame creams investigated aggregation of milk protein particles during ingredient manufacture and in extreme composition protein beverages. The goal was to control aggregation. Two key areas of focus were improving the consistency of the performance of cream used in cooking and whipping and improving the stability of beverages and creams via

real time measurement and understanding particle formation and growth kinetics. The hope was that this would lead to expansion in UHT cream capability and capacity within Fonterra from a low base and that export volumes would increase. It would also ensure that no UHT cream product lacked the underpinning research.

368. At the outset the UHT manufacturing process was effective in stopping microbiological spoilage, but the storage and shelf-life of these products was limited due to the physical stability of the creams. The goal became to remove the need for chilled distribution for whipping creams.[60]

What was achieved?

369. The early work on this objective offered insights on different parts of the production of long shelf-life chilled creams. The outputs were the development of:

- Methods that extend the chilled shelf-life of UHT whipping and culinary creams as well as manufacturing it with consistent functionality year-round.
- Increased understanding of how formulation, processing and storage factors drive changes in critical sensory attributes of UHT creams.
- Knowledge about the links between processing controls and UHT cream function such as whipping performance.
- Insights into the causes of changes in the stability of UHT creams stored at ambient conditions over an extended shelf-life.

370. Later research work investigated a range of different technical options for temperature-robust and ambient-stable long shelf-life creams. This resulted in successful lab-scale demonstration of an ambient stable whipping cream. In addition, a novel microfluidic apparatus was developed within the 'signature milks' programme. This has enabled measurement of short-range interactions between individual fat globules within a cream. These individual particle force measurements allow phase diagrams to be created that help predict the stability of emulsions. The later work also explored partial coalescence through direct measurement of fat crystals and direct observation of morphology of fat droplets. This was important because it is one of the causes of instability on temperature cycling and is an important contributor to whipping properties of cream. A patent application was also filed from this research.

371. The research into extending the chilled shelf-life and managing the function of the UHT throughout the year was applied to the manufacture of UHT whipping and culinary creams, process trouble-shooting, and resolution of customer complaints.

[60] Although these creams still need chilling before use to enable them to whip.

Benefits of endgame creams

Direct and on-going benefits

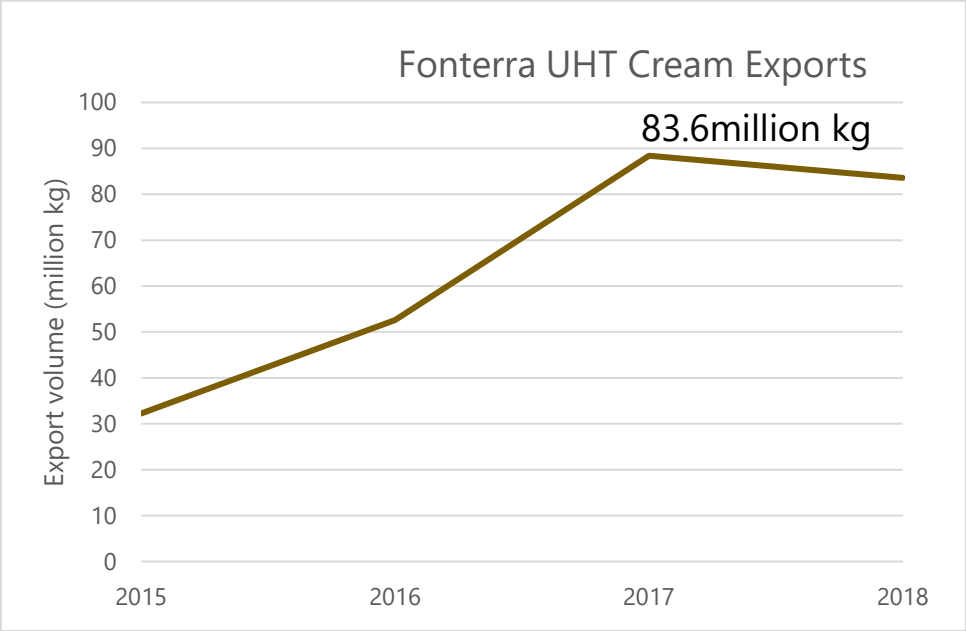
372. Fonterra has expanded its UHT production significantly over recent years. In November 2017, it completed expansion of a new UHT line at Waitoa in the Waikato. Five years earlier there was no plant on this site. In 2018 it opened two more UHT lines at Waitoa (Fonterra, 2018, pp. 9,25). Each new line can produce 15,000 packs per hour so now Waitoa has the capacity to produce up to 45,000 cartons of one litre UHT products every hour. The total annual capacity of the plant is over 250 million litres of UHT cream and milk (Fonterra media release , 2017).[61] Fonterra's total investment in UHT production at Waitoa was $162 million. This investment was driven by demand largely from Asia.

373. Our interviews with those working on this objective underlined the contribution of the PGP to Fonterra's investment in expanding UHT output. The leader of Theme 3 commented that there was no product in UHT or culinary or whipping cream that did not incorporate the underpinning PGP research. She stated that the Waitoa plant expansion leveraged the work of the PGP.

374. As can be seen in Figure 8 below, Fonterra's production of UHT cream almost trebled since 2015, although 2018 saw a marginal fall in export volumes compared to 2017. This increase has been underpinned by the objective 3.1.3 research (Coker, Munro, & Golding, 2018, p. 32).

[61] 80,000 cartons of UHT milk and cream every hour for global markets which implies 35,000 of cream.

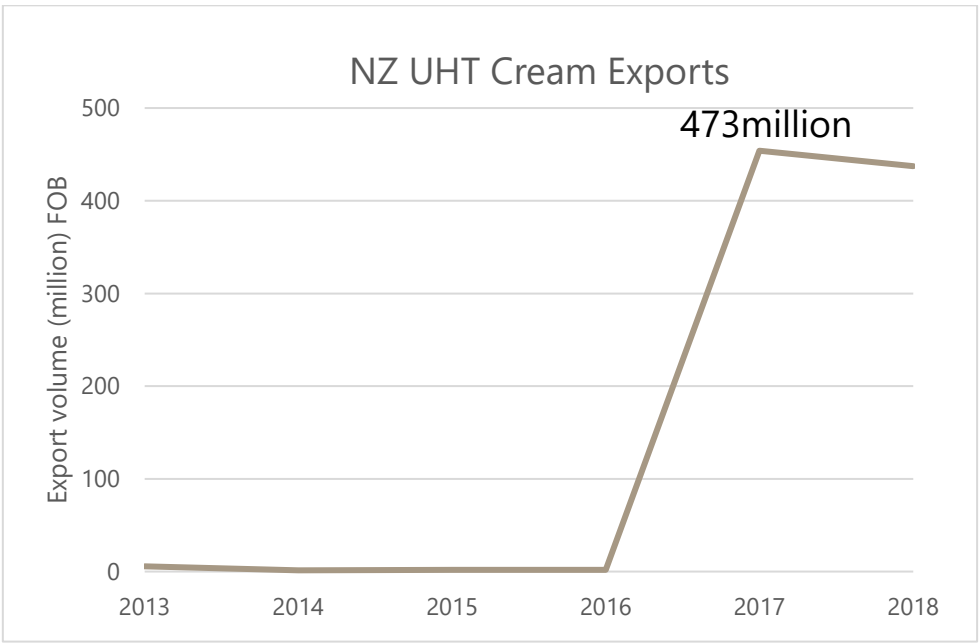
Figure 8: Fonterra UHT cream exports



Source : TDVC Benefits – Summary 180406.

375. New Zealand's total export returns from UHT creams tell a similar story. As is evident in Figure 9 below, UHT exports have ramped up significantly. There is r a problem in the data as the increased early production in Figure 8 doesn't show up in Figure 9 until 2017.

Figure 9: New Zealand UHT cream exports ($ millions)



376. Overall, over the period of the PGP, UHT creams have become a key product within Fonterra's foodservice portfolio and as at December 2017 were earning some of the highest gross margins within that product category (Fonterra, 2017). A number of factors suggest that the PGP is likely to have paid for itself. If the PGP resulted in the earlier production of

the volumes of this high margin product shown in Figure 8 (than might have been possible without the PGP), it seems likely to have covered the PGP's investment. It is not possible to estimate this accurately due to data limitations, for example, partial data on Fonterra volumes and NZ total exports. But indicatively the incremental value attached to the increases in production between 2015, 2016 and 2017 is likely to have been over $100 million per annum. At this level, even if the PGP only brought forward these sorts of returns by some months, it is likely to have covered its costs. In addition, once ambient-stable functional creams are fully developed they will allow Fonterra to sell UHT creams to second and third-tier cities in China and other countries where there isn't a reliable cold distribution chain.

Indirect benefits and spill over effects

377. Fonterra's investment at Waitoa created 150 new jobs (Fonterra media release, 2017) which would have resulted in indirect economic benefits in the regional economy.

378. The Endgame creams programme also attracted a number of young scientists to work alongside Fonterra. The work also built good international relationships with Australian and Canadian universities as well as universities in New Zealand. This has helped to grow Fonterra's supporting academic networks.

Signature Milks

379. Signature milks sought to build a sensory preference for Fonterra beverages over competitor offerings. Previously-unknown sensory preference profiles were identified as part of early work in this area of the programme. Prior to the programme differences between products and consumer's perceptions were known, but understanding of what drove preference was missing. The early work identified a preferred sensory space that no one was occupying. Products were designed to target the space and deliver superior consumer experience.

380. Signature milks also investigated scientific, technical and consumer insights for use in the development of future dairy beverages and the ability to deliver long shelf-life dairy beverages, with elevated levels of protein and minerals. Overall it aimed to accelerate the commercial product development process and help Fonterra to move an increased portion of its milk supply into consumer formats.

What was achieved?

381. Exploratory work on microparticulation paved the way for developing a novel approach to making microparticulated whey protein ingredients. Pilot scale trials at Fonterra Research and Development Centre suggested that this had potential as a future ingredient to carry high levels of protein into medical foods and sports nutrition products.

382. In addition, as part of the signature milks work, a novel microfluidics apparatus was developed at Massey University that can take measurements of interactions between pairs or clusters of particles suspended in a fluid. These were used to predict the processing and storage performance of protein-rich, dairy-based beverages. The final report noted that the design of

this equipment was world-leading and solved several technical challenges enabling automatic and rapid experiments to be undertaken over a wide range of commercially relevant conditions. In 2018, this technology was only just beginning but it showed potential to substantially reduce technology risk in commercial product developments by predicting product performance.

383. The research work on sensory preference profiles was driven by Professor Jason Stokes, and his team at University of Queensland. They applied their techniques (gap-dependent rheology and tribology) to model food systems containing particles, to better understand the modes of action for sensory properties of grittiness through to smoothness. This work identified some key design principles that are important for delivering foods (including dairy beverages and yoghurt) with targeted texture profiles. This work has been combined with consumer taste and texture preferences to deliver the consumer-preferred sensory characteristics in Fonterra's products. Due to better understanding of consumer preferences and developing prototypes, two commercial product development projects were moved forward more quickly than would have otherwise been possible. This work also provided the sensory targets for a new version of ANLENE™ which was launched in early 2018. This product had levels of dairy protein that Theme 5 research showed was enough to encourage muscle protein synthesis.

384. Another outcome of the research was that a prototype computer model was developed based on the equilibrium between the various minerals present in milks. This 'mineral speciation' approach is designed to be used to predict the long-term stability of mineral fortified dairy beverages. Through this, long shelf trials otherwise needed at the early stages of product development, can be avoided or reduced. This work and the sensory insights were thought to be a starting point for development of artificial intelligence based predictive methods for producing these beverages. In addition, the signature milks research saw the development of computer simulations to predict the impact of milk handling and transport on the quality of milk and creams intended for use in long shelf-life products such as UHT milks and creams.

Benefits of signature milks

Direct and on-going benefits

385. A key direct benefit of this research was a greater insight into the consumer's needs being factored into the early product development process. Strategically this helps Fonterra move from a dairy ingredients supplier to more of a consumer-oriented company.

386. The benefits from the signature milks research were:

- Potentially increased sales of ANCHOR™ and ANLENE™ products due to better sensory profiles of the products and lower technology risk in their production.
- Better targeting of consumer sensory properties in beverage product development, leading to improved sales.
- More rapid product development and innovation cycles which improves Fonterra's ability to respond to competitor activity.
- The potential to develop and sell ambient-stable high-protein UHT beverages.

387. These benefits are not amenable to being explicitly valued. The first two are factors amongst many others that explain, for example, the sales of ANLENE™. The value of the third benefit is complicated further by the need to understand the relative performance of Fonterra's and its competitors' product development and innovation cycles. It may be possible to directly measure the benefits of the last benefit in the list but this will depend on whether an ambient-stable high-protein UHT is ultimately developed and commercialised.

388. However, it is quite possible to believe that these benefits sum to an amount that more than covered the approximately $10 million[62] cost of the signature milks component of objective 3.1.3.

Indirect benefits and spill over effects

389. The signature milks work on sensory preference profiles has continued at the University of Queensland under an Australian Research Council (ARC) grant. It aimed to develop the gap-dependent rheology and tribology approaches. Fonterra is co-funding this work and is the sole beneficiary and owner of the research outcomes related to product (UQ owns all method developments). Fonterra is also funding a translational project that leverages the outcomes of the ARC.

390. The microfluidics apparatus developed as part of the signature milks research could be used with non-dairy beverages to help predict their long-term stability.

391. As a result of the PGP, Fonterra's R&D team and Massey University now have an ongoing relationship with the research team at the University of Queensland.

392. The Riddet Institute developed a model that integrates research supporting the development of food structures that deliver the desired consumer sensory perception and acceptance (Massey, 2018).

Objective 3.1.5 Kiwifruit structure (Zespri)

393. Objective 3.1.5 aimed to understand the physical and biochemical nature of the fruit under different storage conditions to ensure it is bought by consumers at the correct ripeness. Zespri used research support from Massey University in this work.

Key outcomes

- Understanding the relationship between rapid chilling of kiwifruit and losses.
- Zespri research investments span greater time periods.

[62] No information was available on the actual expenditure on this objective. This information was available only for Theme 3 as a whole.

Table 30: Objective 3.1.5 Kiwifruit structure (Zespri)

Inputs	Partners	Activities	Outputs		Impact
Approx. $1 million PGP investment	Massey University	Funding PhDs and post docs Spectroscopy use to predict storability	Conference papers	10	Progress on issue of fruit losses Change in the length of research investments by Zespri Increased academic and commercial collaboration
			Published papers	4	
			Training events	5	
			Patents and other*	2	

394. Zespri manages 30 per cent of the global volume and has a goal to more than double global sales revenue to $4.5 billion by 2025. The implications of this growth path include investment and innovation in supply chain systems and processes to manage over 200 million trays of New Zealand kiwifruit, and over 50 million trays grown offshore. Innovation to extend the packing window and storage of SunGold™ is needed and an additional investment of up to $1 billion is required by the post-harvest sector to keep pace with volume growth. Supporting this growth requires world-leading supply chain management, built on a deep understanding of the characteristics of the fruit (Final Report, 2018).

395. The Zespri objective involved 5 areas of work on:

- Developing non-destructive technologies for through the skin quality assessments.
- Quantifying temperature and humidity in Zespri's supply chain.
- Developing quality prediction models.
- Developing a non-destructive method for improving post-harvest inventory management
- Developing an integrated fruit softening model.

396. A PhD on developing a mathematical model for Hayward kiwifruit softening in the supply chain clarified the increased risk of chilling injury development associated with too-rapid cooling of kiwifruit, which has resulted in widespread industry change in cooling protocols.

397. A PhD on the use of non-destructive near-infrared spectroscopy to predict storability of kiwifruit showed promise at laboratory-scale in the segregation of fruit. It was followed up with a Zespri-funded postdoctoral project to test this modelling approach at an industry-scale, where machine learning algorithms continuously optimise models to improve predictions of the storability of fruit.

398. Post-doctoral research on a temperature and ethylene integrated fruit softening model accurately predicted the storage life of grower lines maturity areas at research-scale, so was followed up with Zespri-funded large-scale trial where over 36,000 individual fruit were measured from three packhouses.

Benefits of 3.1.5 Kiwifruit structure (Zespri)

Direct benefits

399. Interviews confirmed the PGP caused Zespri to invest in research on a longer time frame (seven years) than had previously been undertaken. Prior to the PGP, Zespri only invested on a 2-3 year time frame and this made it difficult to get PhDs funded and to take a longer-term approach. This delivered different outputs that were bigger in scope and has subsequently changed the approach that Zespri has taken to R&D investment.

400. Four packhouses have been involved in grower trials, running models developed from the PGP research. Predicting the storage life of grower lines, either at-harvest grading or by examining the softening curve early in storage, will enable post-harvest operators to optimise inventory management.

401. The Post Doc involved in the work has now been employed by Zespri.

402. The largest benefit was for SunGold, understanding fruit physiology, improving conditions on ships and storage prediction.

403. Selling poor-storing fruit early, and keeping the right grower lines for long storage, significantly decreases fruit quality costs (over $100 million some years) resulting in a higher return to growers and an improvement in the consistency of fruit quality for customers and consumers all over the world (Final Report, 2018).

404. Zespri has implemented models for fine-tuning fruit softening procedures from this work and has also used the information for preparing fruit for consumer sensory testing in China to inform supply chain procedures.

405. Using the $100 million fruit losses figure we can see that a 1 per cent improvement in fruit losses in a high-loss year would cover for the $1 million investment. We have no evidence to support any return. However, as an illustrative example, the NPV of the programme would be $3 million with a 6 per cent discount rate if the work resulted in a half per cent decrease in fruit losses of $100 million per year for ten years.

On-going benefits

406. Improving the quality and consistency of early-season fruit arriving in offshore markets gives customers confidence in the Zespri brand and gives consumers a fantastic eating experience that encourages repeat purchase decisions.

Indirect benefits and spill over effects

407. Cross-sector workshops held as part of the PGP were valuable because they enabled learnings to be shared between sectors.

408. The PGP encouraged longer-term research investment by Zespri. When the PGP came to an end it started a new longer-term agreement (3–4 years) so they could employ the people needed.

409. A strong collaboration between Zespri and the Postharvest team at Massey University has been established through the programme, which will deliver benefits for the kiwifruit industry in the decade to come, as fruit volumes double, and supply chain innovation becomes more critical.

Theme 4: Quality Management

Objective

> Theme 4 set out to create real time quality measurement tools, and efficient processing technologies. It was primarily focused on Fonterra's milk powder production. Early in the program it became apparent Fonterra was not interested in alternative processing investments, so work shifted into food quality management.

410. This theme involved industrial statistics, process analytical control and big data.

> **"Stuff that is difficult to justify and explain to senior managers especially as this investment was before the buzz around big data."**

Key outcomes

- Milk fingerprinting is a testing method that uses light analysis to determine the composition details of milk. It has been developed to optimise processing and on-farm production decisions.
- Milk fingerprinting assisted the development of UHT milk business in China and lead to the development of the fat index.

> **"Fonterra's data capability and understanding has been advanced by five years"**

- New product launched to capture premium on high quality milk powder.
- Risk of quality failures reduced.
- Capability building and increased academic collaboration.

> **"The work translates into a change in Fonterra's innovation process. We have changed the infrastructure around measuring risk. We would not have been able to do it without the PGP."**

Table 31: Theme 4 Overview

Planned core work areas	Investment plan ($m)		Progress	Final work areas	Final investment ($m)	
3.2.1 Capability Resourcing 3.2.2 Process design 3.2.3 Quality compliance	Industry	19.5	Process design and processing options work was not going to lead to plant investment so focus	4.1 Process analytical technology 4.2 Food safety and quality	Industry	6.1
	MPI	8			MPI	4.7

3.2.4 Processing options 3.2.5 Quality assurance	Total	27.5	shifted to food quality management		Total	10.8

411. An external review of the process analytical technology and food safety and quality technology was conducted in 2017. As a result of the external review, a revised work plan was agreed to further develop the use of meta-data and investigate alternative statistical techniques for data analysis (Programme Management Office, 2017).

Theme changes

412. The theme was renamed; Transformation of the Manufacturing & Supply Chain became Processing & Food Quality Management and finally Quality Management. Five initial objectives (including resourcing) were reported under two workstreams with three key areas of work.

413. The processing design and options objectives were terminated in 2013: Process design (objective 3.2.2) was stopped in June 2012 due to technology being too novel to be used by a large-scale processor. Processing options (objective 3.2.4) stopped due to difficulties in economics and risks of competitive lock in for overseas customers.

> **"We made milk powder bricks, we could pack into quarter of the space. It didn't fail from a tech view, it was the dominant design issue."**

Fonterra's milk powder customers were unwilling to shift systems to accommodate the cost saving change as they do not like to be reliant on only one supplier. Fonterra would have to give the technology away to its competitors for it to be accepted by customers.

414. Resources were redeployed and while there was the freedom to reallocate spending, one of the challenges was spending the money. All the research areas employed PhDs and built up research teams around them.

Objective 3.2.3 Process analytical technology

415. The field of process analytical technology (PAT) involves the systems approach in the planning, design, control and optimisation of processing plants. Work focused on creating better processes from data collection, to corralling and collation. Many key product quality properties could not be measured during processing which limited processors' ability to control the process. The programme developed process control tools and statistical approaches that linked process conditions to specific aspects of product quality and could be measured in real time.

416. Work centred around accessing and combining data to derive process and product insights. Outputs included:

- Automating the capture and consolidation of processing and product quality data.

- Assembling and analysing a dataset of milk powder processing and associated product quality information from three factories across four years.
- Identification of critical variables and analysis of how they work together.
- Software mini-tools that addressed specific processing issues in milk powder plants, including vitamin dosing and temperature optimisation in evaporator pre-heat systems (Transforming the Dairy Value Chain Final Report (Public), 2018).

Key outcomes

- Automated data capture and processing.
- New products launched to capture premium on top quality milk powder.
- Increased production of higher quality milk powder.
- Waste reduction.
- Long-term risk of quality failures reduced.
- PhD students have been hired and the work continues.

Table 32: Objective 4.1 Process analytical technology

Inputs	Partners	Activities	Outputs		Impact
Contracts Industry data Students Post docs Research Officers	University of Auckland Auckland University of Technology	Two factories trials of software mini-tools Manual database assembly	Conference papers	9	**"Position advanced by five years"** Understanding of data enhanced Employed university staff Enduing relationships and more research
			Published papers	11	
			Internal reports	28	
			Automated data capture		
			Consolidated database		
			Software mini-tools		

Benefits of process analytical technology

Direct Benefits

417. This is a Big Data project. Interviewees indicated to us that Fonterra would have implemented automated and data intensive process monitoring at some point. The counterfactual we suggest is a scenario where Fonterra would have used a contractor for the data processing and analytical work, but sometime later, and not as thoroughly.

> **"We would have got a contractor in, and it would have cost us millions. We wouldn't have had the time."**

There are benefits in the avoidance of having a contractor do the work. Internally understanding and capability were advanced making it easier to apply the learnings to other areas of the

business. There are also confidentiality benefits, as any contractor would likely leverage any learnings from the work into further work potentially for competitors.

> **"After the project McKinsey came in at the corporate level and was looking at optimising technology. It was all stuff we had already found out."**

418. An interviewee suggested that the work advanced Fonterra's position and understanding by five years.

> **"Previously the capability and system to collate and visualise data was present but with the PGP work the process was automated. This would have happened eventually but was brought forward by five years and with a better understanding, so it was implemented in a more measured way."**

419. PAT will reduce processing failures and the downgrading of milk powders to feedstock. Now problems with production can be identified as they happen and remedied.

> **"Previously could only measure quality at the end of the process – could be downgraded to lower value product of completely worthless, spread on pasture."**

420. We have been unable to get data on downgrading levels of milk powder products so we cannot approach this aspect of value robustly. An interview indicated there have been efficiency gains attributable to the programme.

> **"Incremental improvements in plant efficiencies are in the region of 0.5 per cent, wouldn't be more than 1 per cent"**

421. If we speculate a 0.5 per cent increase in production across plants manufacturing a combined total of 500,000 tonnes[63] of milk powder per year, the gain would be 2,500 tonnes of production per year. If we take the current price of whole milk powder to be $3000 a tonne and extend the benefit for five years, the PV with an 6 per cent discount rate is $32 million. Add a gross margin of 10 per cent the return is $3.2 million.

422. The final report states; "Fonterra has launched a range of differentiated milk powders that attain a higher price based on superior quality attributes (NZMP gold instant wholemilk powder). The real-time quality work enables Fonterra to reliably and efficiently produce these products now and into the future" (Transforming the Dairy Value Chain Final Report (Public), 2018, p. 55).

423. Jeremy Hill told media that the benefits will mean greater efficiencies in processing and more top-quality product sold at a premium. Fonterra manufactures up to half a million metric tonnes of instant whole milk powder each year. Each metric tonne can be worth over $50 more than

[63] Fonterra identifies in its production goals that this potentially applies to more than 1m tonnes a year. (Business plan, 2018)

regular whole milk powder (Stuff, 2016). Interviews also give us a guide on the premium achieved from the work.

> **"Results in milk powder that dissolves better, has less residual and better functional characteristics creating a premium of around $200-300 per tonne (5 to 10 per cent)."**

424. Modelling benefit requires assumptions as we do not have access to actual benefits which are regarded as commercially sensitive. We assume:

- the project brought forward the launch of NZMP gold by one year
- the premium applies to 50,000 tonnes in the first year, rising to 500,000 tonnes by year ten
- the premium is reported to range from $50 to $300 a tonne.

425. Using the conservative $50 per tonne figure gives a PV of $92 million over the period and $74 million if the launch was delayed by a year. Therefore, an estimate of the benefit would be $18 million using a 6 per cent discount rate. Using the 10 per cent gross margin, the return is $1.8 million.

426. Costly product failures including market recall and subsequent litigation will be less likely. If we use the Danone payout as a proxy for the potential cost, we have direct costs of $232 million. There are also significant internal costs and potential reputational costs.

427. The risk of a quality failure of this magnitude is very hard to assess given the rarity of the events. As a guide to the potential value if we assume a yearly risk of 1 per cent, then the PV of this risk for the next 20 years is $27 million. We are told the PGP investment has clearly reduced this risk, if we say the risk has been reduced by half then the PV benefit is approximately $13.5 million using a 6 per cent discount rate.

> **"If a 10 year view, can say that there are fewer quality failures. Tens of millions is the cost of a failure, the big ones. If there is a massive dispute around something. Often these disputes are about measurement. Often it is hard to prove, and we want to avoid that. Sometimes we have different assumptions from them. Our old assumptions were too simplistic."**

On-going benefits

428. In 2017, Fonterra executive leadership team endorsed a strategy with a strong emphasis on the development and implementation of analytics capability. Optimisations of greater than $100m/year are envisaged. In part this is due to the success and visibility of the process analytical technology/real-time quality activity that has been successfully carried out in this programme. This area is now seen as a "strategic imperative" by Fonterra (Coker, Holroyd, & Dekker, 2017).

> **"The approach could be used for other products and processes. We know you can use it for cheese."**

429. Academic and commercial relationships in the field of process engineering have improved and capability has increased. The work gave industry access to researchers while advancing knowledge of fundamental science for those involved.

> **"It pushes academic knowledge and also gives us the opportunity to collaborate on other projects."**

430. Dr Irina Boiarkina, a post-doctoral fellow working on the project was appointed as a lecturer in the chemical engineering department at the University of Auckland. In the course of her work on the project she developed an excellent set of skills in milk powder processing and seeks to focus on this area during her developing academic career. This is a strong indicator of the value creation in terms of capability development that the programme confers (Programme Management Office, 2018).

431. The funded students are very valuable to Fonterra as they already have insight into operations and domain knowledge. Professor Brent Young of Auckland University says the work on site has been invaluable for his researchers

> **"It helps their personal development as young engineers and to understand how their work relates to real industry conditions."**

432. Analysis of the multi-factory data set has provided a greater understanding of factors impacting on milk powder particle size, including the impact of processing and transport conditions. While some of these factors are inherent to factory construction, others can be controlled. Improved knowledge of how factory design impacts on particle quality helps to support product-factory alignment decisions.

Indirect benefits

433. The process engineering capability available to dairy companies generally and to other New Zealand processing industries has increased. We know how to do it and there is a cadre of trained process engineers.

434. The product quality and processing information database will be used as a teaching resource at the University of Auckland.

Objective 3.2.5 Food safety and quality

435. The food safety and quality workstream sought to expand the use of the milk fingerprinting approach and improve the statistical basis for product sampling and testing.

Key outcomes

- Milk fingerprinting has become a standard analysis tool and continues to be developed with University of Auckland.
- Collection and processing optimisation.
- Assisted with the development of UHT milk business in China.

- Lead to development of the fat index.

"The stuff around milk fingerprinting was world leading."

Table 33: Objective 4.2 Food safety and quality

Inputs	Partners	Activities	Outputs		Impact
Research fellow PhD and masters students Expert panel Data	University of Auckland MilkTest Massey	Measure acidity to guide tankers for processing decisions Analysis of feed impacts on milk composition, quality attributes and ability to process	Conference papers	9	Processing and collection linked for optimised production Milk fat evaluation Index
			Published papers	18	
			Internal reports	22	
			Milk fingerprinting Statistically more robust approaches		

436. The PGP enabled the big data aspect of milk fingerprinting. By investigating beyond fat and protein, the team discovered they could delve into other quality aspects.

"We were able to measure acidity and guide tankers so that low acidity milk went to different factories for different products."

437. The work contributed to the development and deployment of the Fat evaluation index. This is currently being implemented as a tool to measure and enforce rules around the use of supplementary feed. It provides a direct link between farm inputs and quality aspects of final product which has important implications as milk is no longer able to be viewed as homogenous. It is now recognised that practices and locations produce milk with different quality attributes.

438. The industrial statistics aspect of the work centres around the impact of uncertainty. Processing quality systems are based on normal distributions but in reality, the distribution is not normally distributed. The research put a lot of time into explaining abnormal distributions. New assumptions have been put into processing, and the results are much better, although there are still failures. It has resulted in better quality process and now is an input into work aimed at changing international trade standards (CODEX).

Benefits of food safety and quality

Direct benefits

439. Without the PGP projects would have been delayed or not even attempted.

"We would not have finger printing to the extent that we have. All projects would be seriously at risk or coming

much later. Spilling over from finger printing, we could not have done the fat evaluation index."

440. The primary benefits are a reduction in testing costs and risks associated with product quality problems. The real gain is in the way milk is treated and the opportunities that creates.

"Milk fingerprinting is done on every farm, every day."

441. The efficiency of the testing allows for the optimisation of milk production, as it allows for the specialisation of milk products at substantially lower costs. The testing is reported to have reduced Fonterra's specific testing costs by 'more than 99 per cent' and has significantly cut the 'time required to process results'.

"Milk Fingerprinting provides information about each farm's milk so rapidly that we can now send milk to the processing site that will ensure we the most value out of every drop"

442. A couple of opportunities based on milk fingerprinting are mentioned in the final report:

- Fonterra has been able to grow its white (unflavoured) UHT milk business in China without incurring the cost of wet-chemistry-based measurements. Over two million samples were analysed over a four-month period, with the cost of the equivalent wet-chemistry estimated at $30 million, which would have limited the ability to develop this business opportunity.
- Fonterra farmers have rapid feedback on the quality of their milk fat and can manage their supplementary feeding to maintain product quality within acceptable limits (Transforming the Dairy Value Chain Final Report (Public), 2018).

443. From interview these examples are considered to understate the value of this award-winning innovation that is likely to deliver large and ongoing benefits:

"The titratable acidity research could be directly attributed to the construction of a factory which sold into China."

"The fat index is making sure we do not get product that we cannot process."

444. Fonterra milk tankers generally accept 99.99 per cent of milk presented at the farm (Welsh, Marshall, & Illan, 2016). Milk collected in the 2017/18 season was 1505 million kgMS meaning around 150,000 kgMS would be rejected. With a $6.69 payout this equates to about $1 million per year. If milk fingerprinting reduced this rejection rate by 25 per cent for the next ten years with a 6 per cent discount rate this would equate to an PV of $1.85 million.

On-going benefits

445. Fonterra's NZ Milk processing operations cost over NZ$1 billion/year to run. Small gains derived from real time quality and optimised statistically based grading provide cumulative and

enduring returns and consistently higher quality product (Fonterra Programme Managment Office, 2013).

446. Fonterra identifies batches of product for further investigation through its approach to product grading, rather than directly shipping to customers, eliminating several potential complaints and associated costs. It does this through its proportion non-conforming approach.

447. The relationship with research partners delivers significant and deep linkages between industry and academia. They now know and trust each other and can share real world data in training settings. Graduating students already familiar with Fonterra are highly sought-after new hires and some university staff became Fonterra employees. This capability building within the University of Auckland has significant long-term value to Fonterra as we envisage greater use of these techniques in future research (Quarter 4 FY2017 Report, 2017). This training capability is equally important to other dairy processors and other industries.

Indirect benefits

448. Although milk finger printing technology has significantly boosted the productive capacity of Fonterra, small-scale dairy processing firms across New Zealand may not have access to the technology, therefore limiting the wider impact. However, by building academic expertise it will be easier for other milk companies and similar processing companies to access this knowledge or aspects of it to the extent that it is not patent protected.

Theme 5: Nutrition & Health

Objective

> Theme 5 developed the science backed marketing of products nutritional aspects. Projects were aimed at providing robust scientific evidence on the health benefits of dairy products including infant formulas, and products to support mobility and healthy ageing.

449. Most of the work was around investing in human health trials. This research is considered unlikely to have happened without the PGP. Historically it is not an area Fonterra has been willing to invest in, the reasoning is as there are no guaranteed outcomes from clinical trials it is not a desirable space for the risk adverse.

Key outcomes

Objective 3.3.3 Mobility and aging (protein quality)

- Recognition of Fonterra as a credible provider of high-quality research (with award recognition of conference presentations) and ingredient offerings
- Developed a value proposition underpinning sales, of dairy protein to middle-aged adults
- ANLENE™ has been refocussed around mobility, as a brand
- Demonstrated ancillary benefits on markers for joint and bone health
- Developed a stronger measure of protein quality DIAAS
- Supported development of a portfolio of protein ingredients; "Sure Protein" with two business units established; Medical Nutrition and Sports Nutrition.

Objective 3.3.4 Cognition

- Recognition of Fonterra as a credible provider of internationally-recognised research and ingredient offerings
- Increased revenue from growth in ANMUM™ consumer products
- Normal levels of MFGM (Milk Fat Globule Membrane) were defined in breast milk
- Sold as a high-value ingredient offerings to paediatrics customers
- Patent protection is being sought

Table 34: Theme 5 Overview

Planned core work areas	Investment plan ($m)		Progress	Final work areas	Final investment ($m)	
3.3.1 Capability resourcing – 3.3.2 Global nutrition research 3.3.3 Mobility & aging 3.3.4 Paediatrics	Industry	3.5	Strategic refresh terminated objective 3.3.2 and shifted focus from ingredients onto consumer business Significant increase in investment	3.3.3 Mobility & aging 3.3.4 Paediatrics	Industry	12.4
	MPI	7.0			MPI	9.5
	Total	10.5			Total	22

450. Significantly more resources were directed into this research than originally planned. This switch of resources appears to be a reallocation from Theme four. The programme of research was rescoped and adjusted for strategic changes with the initial focus of the programme almost exclusively on protein. The nutrition for health did not align with the new Fonterra strategy, parts were merged as the focus shifted while maintaining intent.

451. The trials produced a range of expected and unexpected outcomes, which is typical of human trials:

- Studies comparing the impact of dairy protein on muscle were building on animal work or other trials with other markers in humans, but these studies did not produce anything like what was expected.
- Another clinical trial that looked at functional outcomes on strength and mobility produced results as anticipated. They were not all significant. However, enough of the key ones were significant, and sufficient to develop and validate the value proposition for a consumer product.
- There was a small trial with infants, based around an animal model, and then went into a more robust infant study. It produced a result although not as strong as thought.

Benefits of Theme 5

452. There were several linkages and relationships built that weren't there before. Fonterra's consumer and the ingredients businesses work better together now. The functional food messages were developed for consumer markets but the same story and messages, and same features of product, met the needs of business-to-business marketing too. We were informed that the PGP was part of making that happen.

"We have leveraged the evidence and increased sales."

453. Several interviewees noted the co-investment funding and long-term nature of the contract meant that management was able to see the benefits of investment in trials. Otherwise, the risk of the trials may have been too great for what is seen as a risk-averse culture.

> **"The single greatest benefit is that the PGP gave us license that was risky but not blue skies."**

> **"We have now cracked through a ceiling in Fonterra. They will now undertake clinical trials."**

454. There is clearly still need to closely co-ordinate research with internal Fonterra stakeholder needs. A frustration expressed is that a lot of effort and time is spent getting internal stakeholder agreement.

455. The research underpins two major brands:

(d) The research on the protein ingredients was used by Anlene, although the work looking at mobility is yet to be fully leveraged by the Anlene brand.

(e) Ammun entered the innovation awards based on the PGP funded programme. By pooling a lot of the science collateral, it won the category for paediatric nutrition gaining recognition by the food industry that the use of science in the Ammun brand was innovative.

456. The work is on-going. We were told every four or five years products are reformulated to bring through a new story looking for an uplift of ten per cent in sales.

457. Building capability and creating international networks were stated as objectives. These are benefits but not targets in their own rights.

> **"Shouldn't ever have been the primary purpose of the project."**

Table 35: Theme 5 Components

Inputs	Partners	Activities	Outputs	Impact
Academic chair Mobility and Cognition expert panels initially Ad hoc expert panels SMEs	Auckland University Massey University	Animal and human health trials	Marketable links between milk products and health outcomes	Repositioning of Anlene brand, leveraging of science into ingredient business

Objective 3.3.2 Global nutrition research

458. Global nutrition research – 3.3.2 was stopped in 2015. The activity was rescoped and reoriented to focus on consumer outcomes. Milestone 3.3.2 - Integrating NZ with Global Protein Nutrition Research Efforts (Theme 5 - Nutrition Annual Business Plan, 2012).

Objective 3.3.3 Mobility and aging (protein quality)

459. Mobility and aging – Objective 3.3.3 sought to obtain research and build regulatory dossiers validating that dairy products supported better mobility and aging. The evidence in the dossiers was used to create new positioning for the Anlene brand that was broader than bone health.

460. The aim was to provide evidence dossiers for a pipeline of nutritional products with functional food claims in the area of mobility outcomes. Results showing that dairy protein activates muscle protein synthesis provided a strong rationale for investigating the impact of consumer milk with higher protein content in longer term studies that measure functional mobility outcomes. Ongoing work will also provide validation for a range of methods and biomarkers for faster turnaround of mobility research.

461. The Final Report notes some contributions to this ongoing stream of work

- Demonstrated the value of dairy protein in terms of amino acid appearance in the blood, stimulation of muscle protein synthesis and benefits to the impacts of exercise.
- Provided evidence that milk protein (including both casein and whey proteins) is as effective as whey protein for muscle benefits.
- Delivered a coherent benefit story for the value of dairy protein to middle-aged adults through a programme of interlinked studies (the target market for Fonterra's branded products with mobility benefits, an age group hitherto largely ignored by nutrition science).
- Demonstrated ancillary benefits of dairy protein consumption on makers of joint and bone health, providing a "total package" for mobility benefits.
- Provided initial evidence and support for an improved measure of protein quality (Digestible Indispensable Amino Acid Score: DIAAS) that will allow the superior nature of dairy protein amino acid composition to become evident, as opposed to current methods.

462. The Food and Agriculture Organisation of the United Nations has recommended a change to DIAAS as the protein quality methodology. However, the recommendation includes significant multi-centre validation work that is being implemented through the Global Dairy Platform, led by the Riddet Institute.

463. The report also notes that a lower dose of milk protein, more aligned with the content in a consumer milk product, also significantly increased muscle protein synthesis, providing a feasible target for product development. In short, there is exploratory science, and a range of candidate topics for functional food claims, as well as a way of taking those claims to market.

464. Fonterra dairy ingredients business implemented two new business units based around medical and sports nutrition to take advantage of this research - Medical Nutrition and Sports Nutrition.

Benefits of 3.3.3 Mobility and aging

465. The research underpinned a major product re-fresh, re-launch and ultimately the repositioning of a significant functional food product for Fonterra.

> **Additionally ANLENE™ is moving from a Bone Expert position to Move Young. Early work provided evidence on the role of dairy protein in building and maintaining muscle, and was a key input into the brand repositioning decision. A major product refresh which delivers a level of protein proven to enhance muscle protein synthesis is currently launching. Sensory targets for this product have also been reset based consumer preference research undertaken through TDVC** (Office Programme Management, 2018, p. 38)**.**

466. The Public Final Report notes that some of these claims were implemented in market:

> **Increased revenue from both incremental growth in Fonterra-branded consumer products (e.g., ANLENE™) and growth in returns from high-value protein ingredient offerings to customers, from purified functional proteins through to providing white-label formulations for other brand owners** (Programme Managment Office, 2018, p. 58)**.**

467. Further, it appears the functional protein expertise was able to be targeted more specifically to particular market niche such as sports and lifestyle, or being of benefit to the frail elderly.

> **Leverage of functional protein expertise and the role of dairy protein in mobility from healthy middle-aged populations to more specific nutritional needs of specialist (e.g., sports and active lifestyles) or at-risk (e.g., hospitalised or elderly) populations leading to growth of the new medical and sports nutrition businesses** (Programme Managment Office, 2018, p. 58)**.**

468. Even with proprietary knowledge of; marketing efforts and costs, product margin, current and projected sales volumes calculating the value of this shift in market share is difficult. We start by establishing a counterfactual.

469. Anlene has been a bone health product since 1980's, this value proposition gradually became less important to consumers. The market also become more competitive as other brands introduced fortified products. Sales peaked in 2013, at almost 30,000 tonnes. By 2017 sales volume was below 20,000 tonnes. In just four years approximately a third of Anlene sales had been lost.

470. In the absence of the PGP research it is possible another strategy would have emerged. It is also possible the decline would have been addressed later. However, given the history of the brand, with over 20 year of continuous bone health positioning we consider an appropriate counterfactual to be a continued decline.

471. A continuation of the level of decline seen from 2014 to 2017 may have required Anlene to withdraw from some markets.

472. Whereas we are told there is potential for the brand in China and interest from the South American team.

473. The revival strategy began in 2016 when emerging PGP research was utilised to hold Anlene's decline. Muscle and joint benefits were introduced to the value proposition. Market research had also identified that taste was an issue for the brand along with the commoditisation of bone health. The PGP rheology and mouthfeel work from theme 3 was incorporated into rapid prototyping and market testing in 2017. Significant success was reported, with Anlene moving from weak on taste to 70 per cent consumer preference in market.

474. Sales improved in 2018.The brand now has a dossier of science supporting its new position. The lag from research to commercialisation means benefit will largely be realised from 2020.

475. With several informed assumptions around; gross margin, fixed and marketing costs, market dynamics held constant and a six per cent discount rate we calculate a potential $56.2 million benefit captured by the Anlene reposition in the five year period from 2018 to 2022. This does not account for offsetting revenue from redirecting milk volume to other sales channels.

476. There is a key learning from seeing/letting a brand decline almost to the point of irrelevance. It is now understood that there needs to be a brand refresh every 3 to 5 years.

> **"We are now trying to get ahead of the curve with milk fat globule product. We don't want our brand to decline after three years, we want to fuel it."**

477. The outlook for Anlene is positive with interest from other markets. Of course, China presents a huge opportunity with a large greying population which could give significant uplift.

> **"Our team from South America visited Auckland, and they expressed interest."**

478. There is a pipeline of research and, within that pipeline, some further research around biomarkers indicative of mobility endpoints that could make the research process more efficient.

479. A promising future is seen in MFGM (Milk fat globule membrane), currently it is used in infant formula but for adult cognition and mobility Anlene's use would be unique. Chances of competitors adoption are low as there are two protections:

- MFGM is not easily available so production requires a big player with a coagulated product such as butter of which it is a by-product.
- The second protection is IP. At this stage the clinical research 'Lets move' study has a patent on it, and a publication, which will protect the brand. There is also potential for a second layer of patents.

480. The true value is the significance of Fonterra breaking through into consumer markets with products able to make functional food claims. This is no easy thing – production and marketing

needs to be closely integrated with science outputs – and those science outputs need to be relevant to consumer markets. This integration from science, to production and marketing, and then to consumer sales is a major step forward for Fonterra.

481. The long investment period in this area was instrumental in achieving these gains. Human trials in particular take longer and are harder than most to understand. Fonterra now does have this understanding and a modus operandi that it did not previously have.

Wider benefits of 3.3.3 Mobility and aging

482. DIAAS is a more accurate measure of protein quality and can be used in other food research.

483. There is a stronger network of researchers in nutrition and mobility and Riddet has cemented its position as a research leader in dairy protein.

Objective 3.3.4 Paediatrics

484. **Paediatrics – objective 3.3.4** sought to obtain research and build regulatory dossiers that validated dairy products support cognition, healthy growth and development in infants and children to support the Anmum consumer brand. It involved analysing breast milk for minor lipid components and using lipid enriched dairy products to enhance infant formula and maternal/toddler milks. It also researched gangliosides and planned to investigate ceramides and their role in brain development.

485. The focus shifted to the scientific validation of a complex milk lipid (CML) ingredient for maternal and paediatric nutrition to support brain development (Fonterra and DairyNZ, 2018). Another theme was introduced that focused on cognition for infants, and the protein area was re-scoped to be about adult mobility. This made the work much more consumer focused. The Final Report notes "Until recently, MFGM (Milk fat globule membrane) was not found in infant formulae, even though it is naturally present in breast milk. MFGM is now increasingly recognised as a premium bio-active component for paediatric nutrition, with high demand for MFGM ingredients – driven from a strong science base" (Transforming the Dairy Value Chain Final Report (Private), 2018, p. 60).

486. A dossier of evidence is needed for regulatory approval when a therapeutic claim is made. The science is one thing, the ability to persuade the regulator is another step required for market entry. The Final Report notes: "Successful regulatory approvals to allow the use of MFGM [Milk fat globule membrane] in paediatric powders, as required for each geography. Approvals are contingent on the ability to provide a portfolio of MFGM evidence (efficacy, proof-of-need, safety, etc.)." (Programme Managment Office, 2018, p. 59)This dossier was put together and regulatory approval achieved.

487. The science was implemented in the Anmum range, in Asian markets, and was introduced to the New Zealand market. The ingredient business implemented the science in "SureStart Lipid 100".

488. Patent protection is being sought. This patent protection, if successful in the appropriate market, will support competitive sales and marketing based on cognition benefits from sialyl-oligosaccharides.

Benefits of 3.3.4 Paediatrics

489. The science supporting the Anmum consumer product range has been leveraged into the ingredients business. SureStart milk lipid ingredient MFGM Lipid 100 has patent protection in several countries and a NutraIngredient-Asia award. Fonterra's consumer brand Anmum was the first to take the MFGM Lipid to market in maternal and paediatric products.

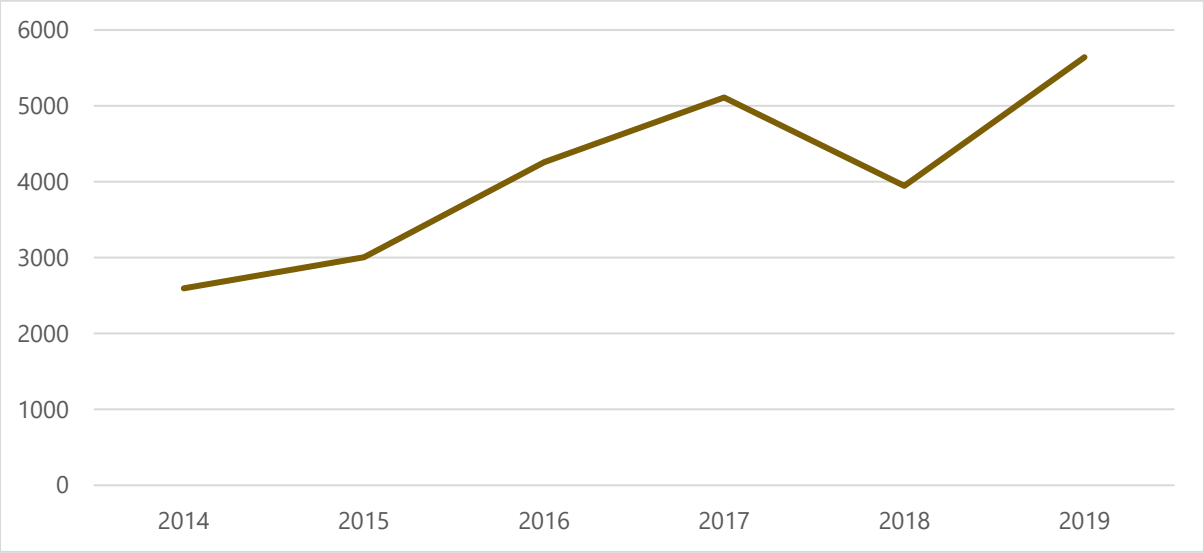
490. While we are told the Anmum product range, (over 150 products under the brand) has expanded consumer market presence in Asia. The market impact is difficult to quantify as the Anmum strategy amounted to:

> **"more of a defend and protect play, rather than targeting growth."**

491. One of nine benefit metrics devised by the PGP was tonnes of infant formula exported. It was explained as follows:

> **"Nutritional science outputs have provided the evidence required to support adding milk gangliosides to infant formula. This has led to a complete refresh of the ANMUM™ product range, commencing with the NZ launch in 2016. On-going clinical trials are expected to provide additional evidence to support communications with health care professionals on the cognition benefits of gangliosides. Chart is volume of finished infant and follow on formula exported by Fonterra."**

Figure 10: Infant formula exports (tonnes)[64]



Source : TDVC Benefits – Summary, MPI.

492. We extended the infant formula chart in figure 2 with the latest data from MPI. This timeseries does not reveal much and is deemed too lumpy to forecast.

493. In terms of a counterfactual scenario a risk identified is better resourced competitors upgrading the science backed claims in their products and leaving the Anmum brand to play catch up.

> **"Big competitors are publicising MFGM in products, if we didn't have it in, we would be in a difficult situation."**

494. Fonterra's capital constraints are a significant issue for challenging the dominant market players with large marketing and promotion budgets.

> **"We have a great product, ingredient, strong science but don't have the ability to advertise."**

495. The market is difficult, unlike other categories direct to customer communications are restricted,

> **"You can't put claims on pack, so it really comes down to the doctors."**

496. Marketing amounts to teams approaching doctors to talk to them about products. Doctors want publications. Having produced and published a nutritional benefit,

> **"there is little to stop competitors leveraging your science."**

497. Patents offer some protection but,

64 Only some monthly data was available for 2014 and 2019. These months have been extrapolated to provide a prediction of the annual tonnes exported.

"it is very expensive to defend patents."

498. Before the PGP research Anmum products had some gangliosides but they were not at the optimum level.

> **"The PGP enabled us to analyse the structure of cow and breast milk. We found out the importance of gangliosides. There wasn't a test method for gangliosides, one was developed, to this day it is important. Critical when launching commercial products."**

499. The brain and cognition research produced some unexpected outcomes. MFGM was found to decrease the risk of gestational diabetes, a provisional patent has been lodged. This could have significant implications for Materna (pre-natal milk) which is a significant proportion of the business and has follow on effects as Materna user are more likely to buy the same infant formula brand. Capitalising on the potential would require a lot of work educating and targeting pregnant women. Capital constraints has meant Fonterra consumer brands have lacked the marketing budget to challenge consumer market incumbents.

500. There is clearly commercial benefit from this research but at this stage the value is not quantifiable.

Wider benefits of 3.3.4 Paediatrics

501. Methods available to measure gangliosides, ceramides and phospholipids are applicable to a variety of food products.

502. Without the investment in nutritional science there would be no understanding and ability to transfer the benefits to consumers.

> **"Real benefit is to consumer's health and development."**

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Appendix A: Table of Outputs

The following table shows the various outputs from the programme by roadmap and output type (excluding media articles, webpage announcements, Inside Dairy or FarmSource articles, or other forms of external communications activity).

Programme roadmap	Conference papers	Published papers	Internal reports	Training events	Other Outputs[12]	TOTAL
Resilient cows	9	18	36	0	22	85
On-farm technologies	21	21	38	0	22	102
Dairy data network	5	3	65	1	84	158
More and better advisors and advice	24	3	222	186	190	625
Better farm decisions	69	6	237	202	189	703
Endgame mozzarella	21	15	44	0	7	87
Endgame creams	1	0	40	0	1	42
Signature milks	14	7	10	2	3	36
Zespri	10	4	0	5	2	21
Process analytical technology	9	11	18	0	0	38
Food safety and quality	9	18	22	0	0	49
Mobility and protein quality	1	19	5	6	0	31
Paediatrics	5	11	14	0	1	31
TOTAL	198	136	751	402	521	2008

Final Report Page 72, Other Outputs include patents and student theses.

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