WILLSDEN FARM

SELWYN, CANTERBURY

Greenhouse gas and nitrogen loss mitigation in the Selwyn catchment

A case-study on environmental performance and the effect on production and profitability

Meeting a Sustainable Future

Selwyn and Hinds | Inspiring High Performance, Low footprint farms

DairyNZ

Executive Summary

The overall objective of this project is to partner with farmers, industry, scientists, rural professionals, and government to demonstrate the feasibility and practicality of reducing GHG emissions and N-loss to water from real dairy farms, while maintaining the farm's profitability and meeting other environmental obligations.

Terry Kilday, the Camden group have been involved in this project as "we have experienced the benefits of being involved in community projects through our involvement in LUDF and how they help pave the way for other farmers. Benefits to the Camden Group of being involved are having a better understanding of the drivers of N loss and what is required to mitigate. It also has given us confidence that we can make changes and still have a highly profitable business. We know greenhouse gas emissions (GHG) are on the horizons and we are learning how one effects the other (i.e. GHG, N loss and profit)."

As Willsden is in the Selwyn Catchment, a Baseline has been set based on the 2009-2013 seasons. This has been used to compare scenarios against for how the farm can reduce their GHG emissions and meet the 30% nitrogen loss reduction on Baseline by 2022 and maintain profit. The case study also reports against the 2018/19 year for profit.

The business is focused on meeting the 30% N loss target from the Baseline year of 96 kg N/ha to 67 kg N/ha or less, while considering the effect on GHG emissions of any scenarios.

The farm is on very free draining soils with an average $PAW_{0\text{-}60cm}$ of 84 mm and is very vulnerable to N loss. The farm is already on the way reducing N loss, with 2018/19 N loss predicted at 80 kg N/ha. This reduction has been achieved by reducing N fertiliser use from an average of 267 kg N/ha N to 203 kg N/ha, while maintaining production, resulting in a decrease in N Surplus (Overseer) from 325 kg N/ha to 295 kg N/ha.

The farm needs to increase the effluent area from 68 ha to 80 ha to be compliant in applying less than 200 kg liquid effluent per hectare. However, N loss will only be reduced if N fertiliser on the increased effluent area is also reduced. Increasing the effluent area on its own by 18% does not reduce N loss for Willsden.

The next mitigation option to be considered has been to employ soil moisture monitoring and weather forecasting to only irrigate when a genuine soil deficit (not to over-irrigate to cause drainage and N loss). Applying soil moisture management decisions to Overseer to the 2018/19 season, reduces N loss from 80 kg N/ha to 57 kg N/ha. Achieving this reduction with 46% of the farm irrigated with rotorainers and K-lines will require very proactive irrigation management and forecasting. The farm may find that it is difficult to achieve the 40% reduction in water applied on the rotorainer and K-line area predicted by Overseer.

Removing April N fertiliser and reducing feed demand by culling early was also modelled for the 2018/19 season. This scenario resulted in N loss reducing from 57 kg N/ha to 54 kg N/ha (with soil moisture monitoring). However, the savings in N fertiliser are less than the lost milk production and profit is estimated to reduce by $61/ha (-2%).

As all the scenarios resulted in similar levels of milk production, methane emissions did not decrease and in 2018/19 were higher than in the Baseline years (2009-2013) as the farm produced more milk and therefore had a higher dry matter intake (DMI). Reducing N fertiliser, reduces nitrous oxide emissions.

For the farm to make reductions in methane emissions they will need to reduce feed intake (DMI) and therefore milk production. The farm will need to remove the least profitable feed to have the least impact on profit. As the farm does not feed supplement to support a higher stocking rate (they feed supplement in the autumn to get more days in milk) the supplement is very profitable as most of the costs for the season have been incurred and the farm does not have an issue with cows not being in good body condition as they are milking the cows 3 times in 2 days from mid- January onwards.

Improving the irrigation efficiency by replacing some of the rotorainers with pivots will be excellent for reducing N loss. However, Willsden predict that more pasture will be grown and hence more milk. Some supplement could be removed, however irrigation will increase pasture gown over the growing season so not only the autumn so milk production will increase going from rotorainers to pivot/s. An increase in feed eaten will increase methane emissions. The cost of investing in pivots has also risen sharply in (early 2020) due to pivots being purchased in American dollars and the exchange rate with the NZ dollar.

Farm Goals, Principles and Values

Mission Statement: Operate a profitable and environmentally sustainable business where all stakeholders achieve their goals.

"The Camden Way"

1. People/Community: We will provide our employees with a safe and supportive working environment. We will be respectful, honest and open with them and will recognise and encourage their individual personal development and goals. We want to be recognised as a preferred employer by the farming industry. We will be positive and supportive of the communities in which we live.
2. Animals: We will be respectful and take good care of the animals that we farm. We are committed to meeting all the animal welfare needs of the animals we farm.
3. Soil, water & air: We will operate our farming business to have the least possible impact on the natural environment, with the goal of leaving it in an improved state.
4. Technology/Farm Systems: We will utilise effective technologies in our farming systems to achieve our broader aims. We want to be involved with the leading farmer organisations and be early adaptors of positive change.
5. Compliance: Where possible we will endeavour to operate at standards that are higher than the minimum compliance standard, working with all industry partners to achieve this.
6. Financial: We will strive to operate a profitable, sustainable and resilient business.
7. Risk: We will identify the major risks to our business and where possible utilise tools to mitigate and manage the risk.

Farm Overview

Willsden is one of four dairy farms in the Camden Group plus support blocks. This report only focuses on the Willsden milking platform as Camden aims to have all blocks stand alone for environmental compliance even though they can aggregate them as they are part of Central Plains Water Ltd (CPWL) . Willsden was converted in 1998 by Camden Group.

Willsden runs cross-bred cows stocked at 3.5 cows/ha, producing around 1550 kg MS/ha. The farm is set up as a System 3 however, at times of poor growth more supplement is used, and the farm system creeps to a System 4. Willsden has operated an aggressive pasture renewal programme in recent years. In 2018-19, pasture made up 88% of the feed to the cows on the milking platform.

The soils are Lismore stony silt loams which are free draining with an average $PAW_{0\text{-}60\ cm}$ of 85 mm and hence have a high N loss vulnerability. Irrigation water is supplied from CPWL. There are two centre pivots irrigating 52% of the farm with the balance being 44% Rotorainers and 4% K-line.

The farm has a 50-bale rotary and employs a farm manager plus another 5 permanent employees and some casual staff. The effluent system is a pond storage (recently increased) with a sand trap. Effluent is pumped at 12-24 mm when conditions are optimal due to good storage capacity.

Leo Donkers (CEO)

Terry Kilday (Operations Manager),

Robin Hornblow (Farm Manager to June 2020)

Farm Maps

Figure 1: Willsden Farm Map

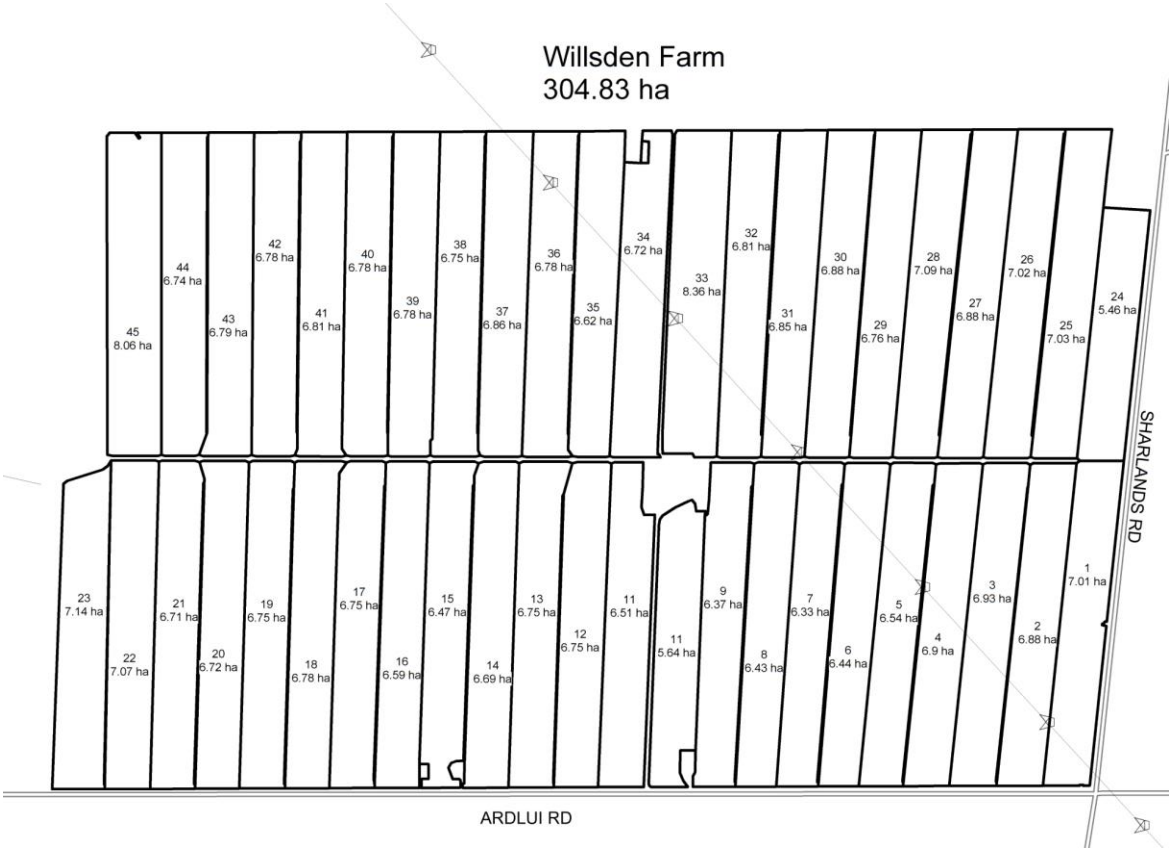


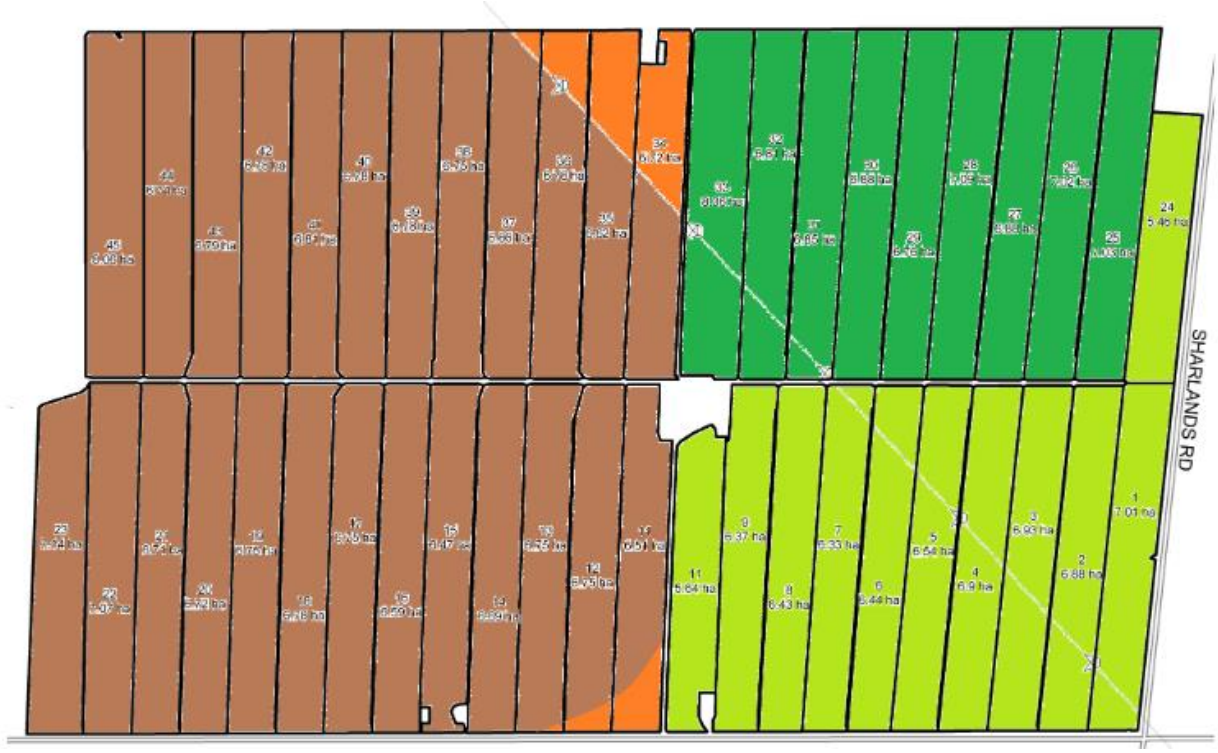
Figure 2: Willsden Irrigation/Effluent Map

1-10,24,33 Rotorainers

11-23,34-45 Centre pivot

1-10,24,33 Rotorainers and effluent

11,12,13 and 34 corners Kline



Environmental Performance

Willsden is in the Selwyn Waihora catchment, which is subject to the rules outlined in Plan Change 1 of the Canterbury Land & Water Regional Plan (LWRP). Some of the points in this plan are:

- Farms in the catchment need a Baseline Overseer file to generate the estimated N loss from the root zone that represents the farming system between 2009/10 and 2012/13 and applies "little gmp". For irrigation means the Baseline Overseer file cannot exceed "Irricalc" estimates (little gmp) for the average irrigation annual volume per hectare, plus one system application depth.
- From 2017/18, farms will have to operate at or below this Baseline level and be using good management practices (GMP).
- From 2022, dairy farms will have to operate at 30% below "little gmp Baseline"

Baseline Season and 2018/19

Both the Baseline seasons and in 2018/19 the Overseer files are based on GMP and applying "little gmp" for irrigation. For Willsden this means applying no than 640 mm for the rotorainers and K-lines and 465 mm for the pivot annually as calculated by Irricalc.

Mitigation Strategies

Farmax modelling was used to generate the 2018/19 season to model the mitigations for the farms physical and financial performance against and Overseer for the estimated N loss and GHG emissions.

Mitigation options for Willsden Farm modelled were:

Scenario 1 (Sc1) – Irrigation Decisions Based on Soil Moisture Monitoring

- All inputs unchanged for 2018-19 except for irrigation decisions based on soil moisture monitoring
    - This reduces the annual water applied per hectare from:
        - Rotorainers and K-line 640 mm to 480 mm
        - Pivot 465 mm to 390 mm

Scenario 2 (Sc2) – Remove April N and cull early to match feed demand to supply and soil moisture monitoring

- Remove April nitrogen of 26 kg N/ha, increase march n from 30 to 37 kg n/ha and cull early to match reduced feed; milk production reduced by 4460 kg MS; N applied per hectare reduced from 203 to 184 kg N per total hectares
- Use soil moisture monitoring with same assumptions as for Sc1

Scenario 3 – Increase Effluent Area

- Use the 2018/19 season, no soil moisture monitoring
- Increase the effluent area to 80 ha to enable liquid N application to be less than 200 kg N/ha to be compliant
- This is an increase of 12 ha from 68 ha

Results

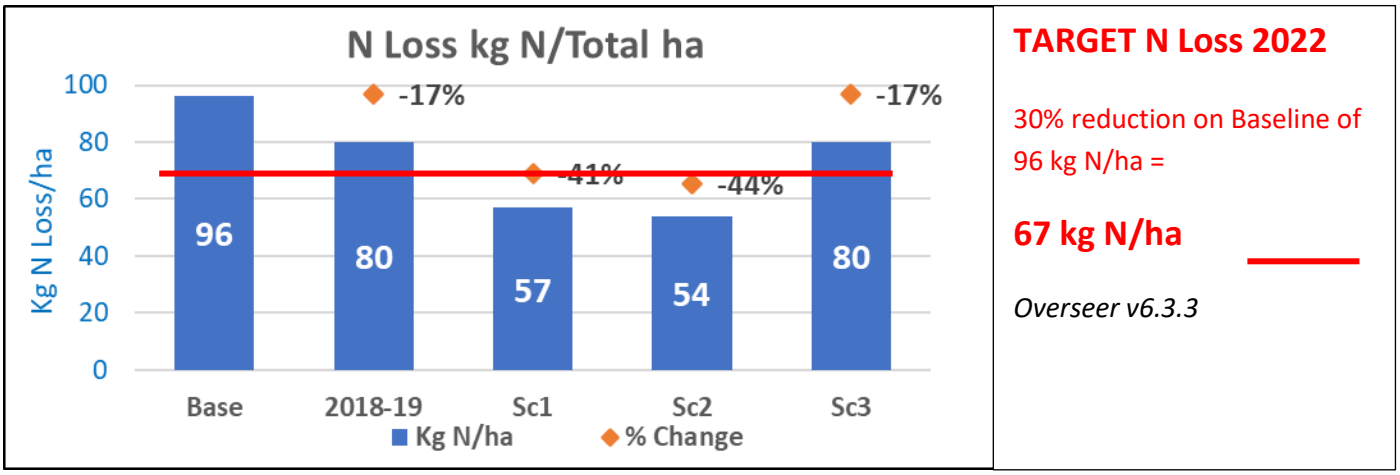
Table 1: Baseline, 2018-19 and Scenarios 1 and 2 using Overseer version 6.3.3

Overseer Version 6.3.3	Base system Year end 2013	2018-19 and Scenario 3	Sc1 – Soil Moisture Monitoring	Sc2 – No April N, cull early +soil moist monitoring
Farm parameters				
Total area (ha)	315	315	315	315
Effective area (ha)	304.8	304.8	304.8	304.8
Production (KgMS)	470,000	478,157	478,157	473,693
Peak cows	1,084	1,069	1,069	1,069
Milk production (kg MS/ha)	1,542	1,569	1,569	1,558
Milk production (kg MS/cow)	434	447	447	443
Purchased feed eaten 2/ (t DM/ha)	2.0	2.2	2.2	2.15
Grazing Off Eaten (t DM/ha)	2.2	2.2	2.2	2.15
Pasture Eaten 2/ (t DM/ha)	16.1	16.1	16.1	16.0
Total Feed Eaten (t DM/ha)	20.3	20.5	20.5	20.3
N fertiliser use (kg N/total ha)	267	203	203	184
Nitrogen				
Total Farm N Loss (kg N)	30,141	25,302	18,106	17.009
N Loss/ha	96	80	57	54
N Surplus/ha (calculated Overseer)	325	295	281	271
Greenhouse gases				
Total GHG (tCO2e/ha/yr)	15.6	15.0	14.9	14.6
Methane (tCO2e/ha/yr)	9.6	9.7	9.7	9.6
N2O (tCO2e/ha/yr)	3.7	3.4	3.3	3.2
CO2 (tCO2e/ha/yr)	2.3	1.9	1.9	1.8
Profitability				
Operating Profit ($/ha)	NA	$3,230 1/	$3,230 1/	$3,168 1/
Change from current system				
N loss % change from Baseline		-17%	-41%	-44%
GHG losses % change from Baseline		-3.6%	-4.5%	-6.4%
Methane losses % change Baseline		+1.0%	+1.0%	+0.1%
Profitability % change from 2018-19			0%	-2%

1/ Milk sales $6.37/kg MS

2/ Overseer calculated

Figure 3: N Loss from Root Zone 0-60 cm



Discussion

N Loss (N Loss from the 0-60cm root zone)

Figure 3 shows the farm's N loss (N Loss from the root zone) for the Baseline, 2018-19 and for Scenarios 1 and 2.

The farm has already achieved a significant reduction from the baseline years (-17%) by reducing N fertiliser use in 2018-19. This resulted in the N surplus (Overseer) reducing from 325 kg N/ha to 295 kg N/ha (Figure 4) in 2018/19 with the resultant drop in N leached from 96 to 80 kg N/ha. The Purchased N surplus shows a greater decrease from 231 kg N/ha in the Baseline years at 163 kgN/ha in 2018/19 (Figure 5). This drop is higher than that calculated by Overseer as Overseer does and N balance and increases the N from clover fixation which is not included in the Purchased N surplus calculation. The Overseer N Surplus calculation is a more accurate estimate of the actual N surplus of N entering the N cycle (N fertiliser, N from clover fixation, N in , irrigation and rain and N in imported feed).

The farm can achieve the 30% target reduction from the Baseline of 67 kg N leached/ha by adopting scenario 1, soil moisture monitoring and reducing water use by some 40% on the rotorainer area and 17% under pivots. In practice this may be difficult to achieve and may require the Rotorainer to be configured to apply less water and management to be very proactive to maintain a 7-day return and only start watering at a 25 mm soil moisture deficit. With soil moisture monitoring (Sc1), N loss is predicted to decrease to 57 kg N/ha due to less drainage through the soil profile.

In 2018/19 without soil monitoring the average drainage for the farm was 414mm per year. The average profile available water (PAW) for the soils is 84 mm. Therefore in 2018/19 the 0-60cm soil profile would drain on average 4.9 times (414/84). With soil moisture monitoring the amount of irrigation applied is reduced and the annual drainage is reduced to 319mm/year and the soil profile would only drain 3.8 times (319/84), reducing N leached.

Long term the farm may need to replace the rotorainers. However, due to the power lines on the property this is not a cheap solution. Pivots will make irrigation management simpler and give management more confidence to turn irrigation off when rain forecast with a return time of 3 days on the pivots compared to 7 days on the rotorainers.

Not applying fertiliser N in April and culling early to match feed supply (Sc2) only has a small effect on reducing N loss (from 57 to 54 kg N/ha Sc1 to Sc2) as N fertiliser applied only decreases from 203 to 184 kg N/ha/year.

Increasing the effluent area to 80 ha so the farm is compliant in applying less than 200 kg N/ha (Sc3 effluent N 172 kg N/ha) does not change the N leached. There could be a small reduction if the increased effluent area had less N fertiliser applied.

Figure 4: N Inputs and N Surplus (Overseer) per Hectare

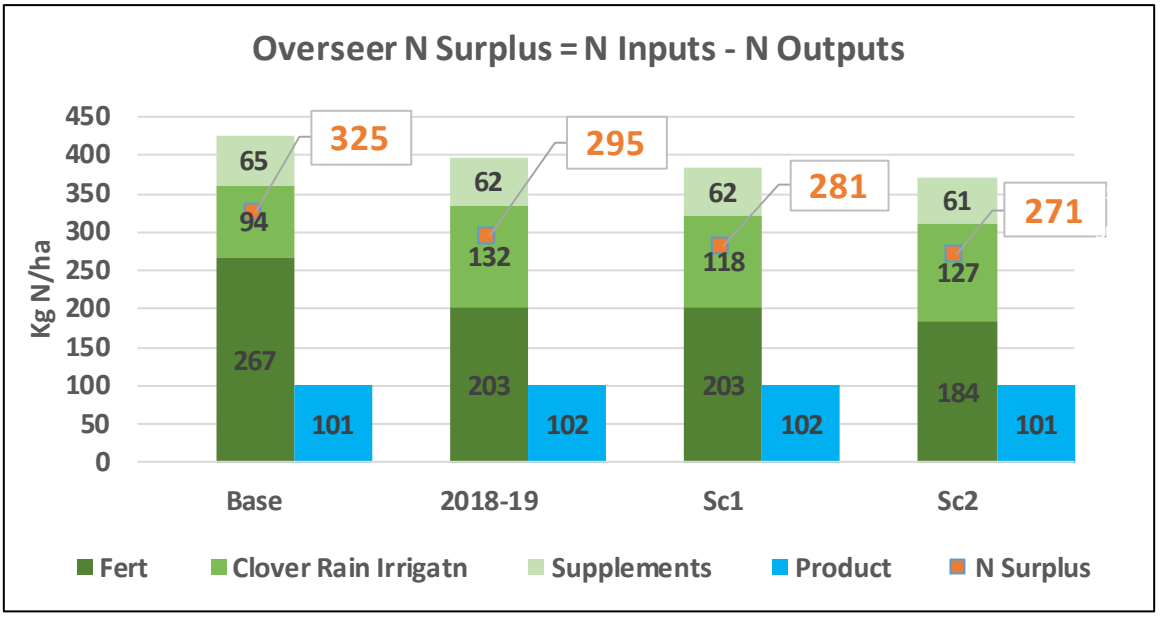
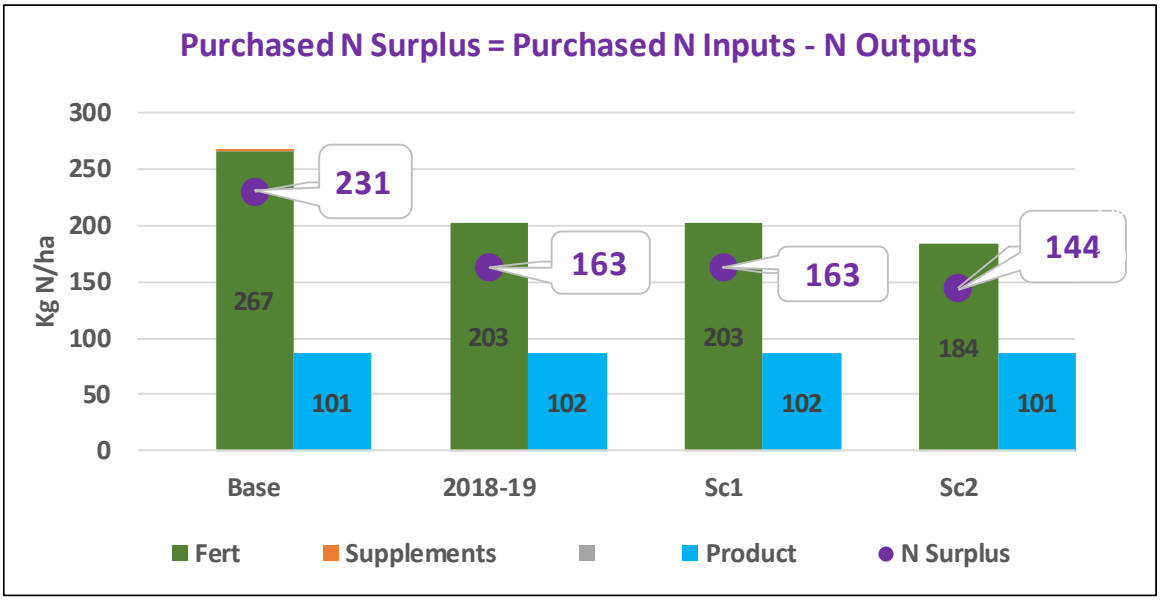


Figure 5: Purchased N Surplus per Hectare



Reduction GHG

As the scenarios focus on improving water efficiency and not total dry matter intake there are only small changes in GHG emissions. The reductions are due to a reduction in N surplus, from applying less N fertiliser and having less nitrous oxide emissions.

The efficiency of milk production does improve as shown by Figure 6 where the kg of CO2 eq. per kg milksolids has decreased from 10.1 in the Baseline years to 9.4 in Scenario 2.

To reduce methane will require the removal of autumn fed supplement and loss of milk production. This will reduce N loss but also profit.

Figure 6 GHG CO2 eq/kg MS (Total Ha)

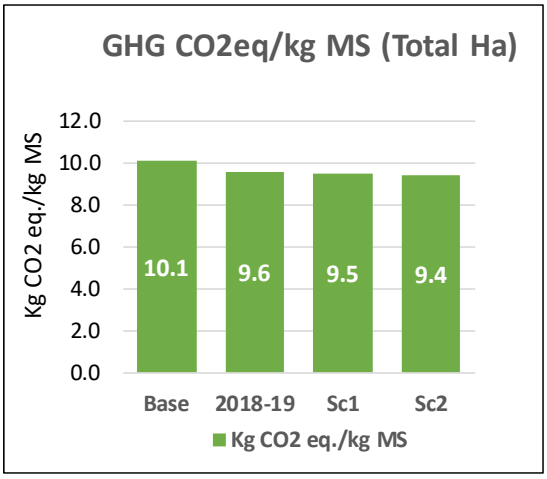
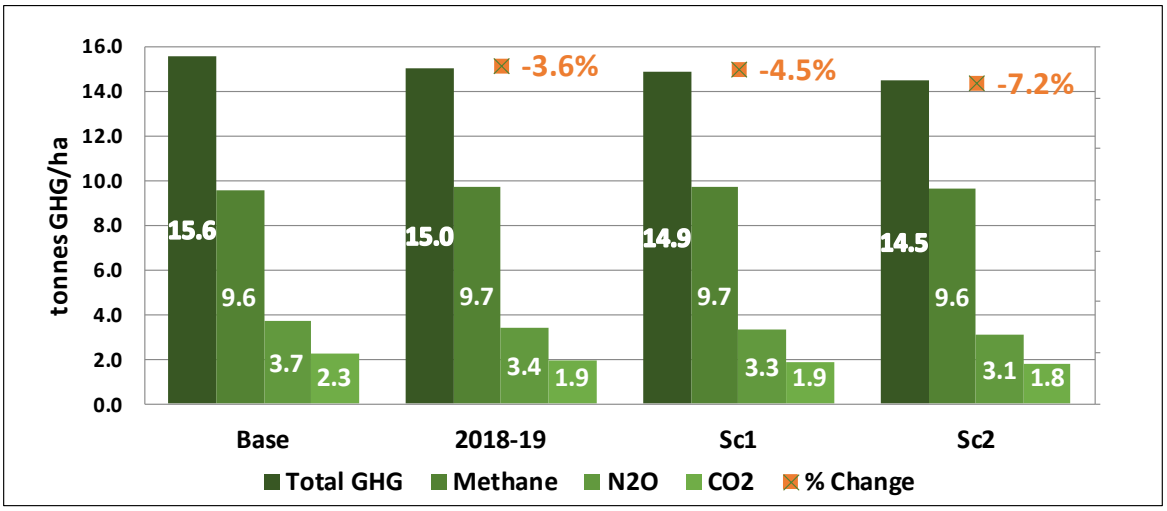


Figure 7: Green House Gases (GHG) CO2 eq per hectare (total ha)



Operating Profit

Farmax modelled the operating profit for the 2018-19 year at $3,163/ha at an average milk price of $6.37/kg MS.

As Sc1 just focused on improving water use efficiency through soil moisture monitoring, and produced the same amount of milk, profit should increase slightly due to less water purchased. However, the cost savings are small most of the cost for water from the Central Plains Water Scheme is for the fixed cost of supply per hectare irrigated.

In Sc2 there are cost savings as less N fertiliser is applied. However, milk income is reduced by more than the cost savings and Farmax modelling predicts a reduction of -$61/ha or -$19,000 per year for a 3 kg N reduction in N loss per hectare (Refer Table 1). As the farm employs the practice of milking 3 times in 2 days the farm now finds that body condition score of the herd is good going into autumn and there are fewer gains from sending culls away earlier to have more feed for the rest of the herd.

GHG emissions can be reduced with less N fertiliser. If reductions in methane are required these will have to come from removing the least profitable supplement and for Willsden will be a significant drop in profit as they do not run does not run a high intensity feeding system. Supplement is fed in the autumn to extend lactation (more days in milk from the stock farmed in the spring) not to support a higher stocking rate. Therefore, the supplement is very profitable as there are only the direct feed costs of the supplement from the support block plus labour to feed out. Willsden did not want to model this scenario and do not want to use fodder beet (a lower N content feed) in place of pasture silage due to the increased risk (low protein feed, need phosphorus supplement and high risk of losing cows from acidosis if not managed precisely).

Replacing all or some of the rotorainers with pivots will reduce water use and therefore reduce N loss. Pivots will also make irrigation management easier and the farm manager would have more confidence to turn the irrigators off as Pivots generally operate on a 3-day return compared to rotorainers at 7 days. Willsden management also expect pasture yield to increase by 1-ton DM/ha changing from rotorainers to pivots. However, pylons and the farm layout make it costly and challenging to install pivots.

Increased pasture production will increase profits and help to offset some of the investment cost of the pivot. However, if total dry matter intake increases (i.e. no supplement removed to off-set the extra dry matter grown from pasture), methane emissions will also increase. This combined with the design and cost of pivots makes the investment decision complex. Therefore, the business will aim at achieving water use efficiencies from better irrigation scheduling using soil moisture monitoring and weather forecasting before investing capital into pivot irrigation.

Summary

Willsden is largely a grass-based system which has shown that they can reduce their N fertiliser use and get some reduction in N loss. To reduce N loss significantly, soil moisture monitoring/irrigation scheduling and very efficient rotorainer management will be required to reduce water use and therefore drainage. This will be Willsden's focus over the next 1-2 years. If water use cannot be reduced without compromising pasture grown, Willsden will investigate replacing some of the rotorainers with pivot/s.

Removing April N and culling early does reduce N loss by a small amount. This scenario although not positive for profit and only a small reduction in N loss does emphasise the importance of only applying autumn N when going to get a profitable response and if not required not to apply.

Some reduction in GHG emissions (nitrous oxide) can be achieved reducing the farm's N surplus though less N fertiliser for the same milk production. However, reductions in methane emissions will only be achieved with current mitigations available by removing the least profitable supplement i.e. methane reductions will be difficult to achieve without loss of profit. Installation of pivots will make methane reductions more challenging as under pivot irrigation total pasture grown should increase.