ADVICE TO **GROW** THE RURAL SECTOR

macfarlane rural business ltd

MAR Economic Review

Version 1

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1. Glossary

EBIT	Earnings Before Interest and Tax
NPAT	Net Profit After Tax
PC2	Plan Change 2 – Hinds Plains/Hekeao
MAR	Managed Aquifer Recharge
DCD	Dicyandiamide (nitrification inhibitor)
GMP	Good Management Practice
AM1	Advanced Mitigations – Level 1
AM2	Advanced Mitigations – Level 2
AM3	Advanced Mitigations – Level 3
GWAZ	Ground Water Allocation Zone
Regional Spend	Contribution of the Agricultural Spend to the Hinds Catchment Economy
Farm Gate	Economic measure on farm
Community	Hinds Catchment
Cost per kg N	Reduction in either farm expenditure or farm operating profit per hectare, divided by the reduction in Nitrogen loss. Reported as per kg N or per kg N/ hectare.

2. Introduction

This report has been prepared by Mark Everest of Macfarlane Rural Business in consultation with Bob Englebrecht, under the direction of Brett Painter and Peter Lowe.

The purpose of the report is to review the economic feasibility of making N loss to water reduction that were modelled possible in the report "Hinds Catchment Nutrient and On-Farm Economic Modelling" (Everest. M, *et.al* (2013)) (2013 Report). The review intention was to include a re-assessment of the appropriateness of the proposed nitrogen loss mitigations; re-assessment of the costs of making nutrient loss reductions as proposed; on farm and wider community economic implications. The analysis is being completed to assist informing stakeholders as to the financial feasibility of Managed Aquifer Recharge (MAR).

Due to the fact that farming systems evolve over time it has been recognised by Bob Englebrecht and Mark Everest that some of the farm systems in the 2013 Report are no longer appropriate. It was intended that revised farm programmes, financial budgets and nutrient budgets would be prepared to represent these agricultural sectors. Due to financial constraints, revised representative farm systems have been generated for all sectors, however only the dairy system was modelled.

This report is preliminary and as such is a more condensed review of nutrient losses in the Hinds Catchment. The modelling process has been peer reviewed by Andy Macfarlane who supervised the preparation to the 2013 Report.

All nutrient losses are analysed for one soil and one climate zone only (the dominant soil and climate as prescribed in the 2013 Report) as the brief is to assess relative change potential rather than establish and absolute end point.

3. Summary

This report has been completed as a desktop analysis and does not include a complete re-assessment of on farm practices and performance as at December 2018.

Since the initial on farm economic and nutrient modelling was undertaken in 2013 by MRB, there have been some considerable improvements in farm practices resulting in more efficient resource use. Most resource (nutrient in this case) "saved" has not been removed from the system to maintain the status quo of 2013, rather it has generally been re-utilised by the farming operation to increase productivity.

This now means that the Hinds Plains have much more efficient systems, but many less levers remain to pull in order to make nutrient loss reductions in order to comply with PC2 requirements of a 36% reduction.

Currently, the Hinds catchment is regional spend contribution to regional economy is estimated to be $1,332, 400,904. In the 2013 Report, economic costs to reduce nitrogen lost to water were -$87.16/ha NPAT (-$4.82/kgN not leached) on farm. To the community, however, due to increase in economic spending to employ tools to assist in reducing nutrient loss, modelling suggests that there could be a benefit of +$86,341,810 p/a ($36.34/kgN not leached) to the community through increase in regional spend.

Since that report was commissioned, the science in behind nutrient modelling has improved significantly, and has resulted in changes to the modelled nutrient saving results. The outputs from the updated science engine in Overseer would suggest that much greater investment and more drastic input and productivity reductions (and as a result financial profitability reductions) may be required to meet the previously set PC2 targets.

Upon revision of the 2013 Report, on the basis that farm systems have not changed, in order to target the original 36% reduction targets, modelling suggests that farm systems would require significant capital and system change to get even to 29%. The modelling suggests on farm economic costs to reduce nitrogen loss to water are now -$303/ha NPAT (-$21.56/kgN not leached). The community economic impact is now likely to be a negative rather than a positive as farmers cut their inputs to achieve lower emission targets. The estimated cost to the community of achieving a 29% nutrient loss reduction is estimated at -$200,395,020 p/a ($108.37/kgN not leached).

The N loss reduction challenges that have become apparent with the evolution of the science informing the Overseer engine, are compounded by the effects of farm systems evolution resulting in higher performing and more efficient systems than originally modelled in 2013. If the Hinds Plains are still to meet the requirements of PC2 reductions, it will require the use of MAR. The cost of meeting the full reductions of 36%, as indicated by the modelling is -$364/ha NPAT (-$21.76/kgN not leached), and -$207,178,294 p/a (-$112.03/kgN not leached) reduction in spending in the community.

If MAR is not available and the community must meet 48% reductions in N loss, this will require land use change from high emitting land uses (Small Seed Arable; Dairy; Dairy Support) to lower emitting land uses. The cost of this on farm is estimated to be -$55/ha NPAT reduction greater than the 36% reductions (-$420/ha NPAT from GMP). The cost reduction in asset value is estimated to be -

$11,801/ha ($1.551bn total) de-valuation in land asset value greater than the asset value degradation for 36% reductions. The cost to the community to achieve 48% reductions, in excess of the costs to achieve 36% reduction targets is estimated to be -$163,141,563 p/a reduction in community spending resulting from lower available income to spend on farm is predicted.

4. Methodology

4.1. Revision of 2013 Report Losses

1. Fodder Crop N Loss: In preparation of The 2013 Report, the software used to calculate nutrient losses (Overseer v6.0.3) was recognised by industry as having some limitations in terms of its ability to accurately calculate nutrient losses from winter feed crops. In recognition of this limitation a "work around" (multiplication co-efficient of equivalent pasture nutrient loss) was applied to the models to adjust losses to what was believed to be a more accurate loss figure. In this report, Overseer v6.3.0 has been utilised, which more accurately reflects winter feed losses, all "work arounds" have been removed from analysis.

2. Pastures: In The 2013 Report, an attempt was made to account for developing science that was not able to be modelled in Overseer (and still are not in the current version of the software). This was diverse pastures and Italian ryegrass based pastures. There is still evolving research that suggests that these technologies will assist farmers in reducing targets, however, as they are not included in Overseer, they have been excluded in this analysis.

3. Plantain: Preliminary research suggests that particular cultivars of plantain when included in pastures at between 20 and 40%, could reduce nitrogen leaching from pastures by as much as 50%. This is not included as a loss saving mitigation in any modelling.

4. Italians: Preliminary research suggests that Italian ryegrass pastures winter activity could reduce nitrogen leaching from pastures by as much as 20%. This is not included as a loss saving mitigation in any modelling.

5. DCD: in the 2013 Report, DCD was included as a proxy for nitrification inhibitors. While it was withdrawn from the market at the time of the 2013 Report writing, the project team concluded that it was likely an equivalent product would become available for use to assist farmers in making nitrogen loss reduction targets. As there are no products yet available in New Zealand, nitrification inhibitors are not included as a loss saving mitigation in any modelling.

4.2. Revise 2013 Report Farm Systems

1. Pigs, Horticulture and Other land uses are excluded from analysis.

2. To reflect evolving farm systems, Bob Englebrecht and Mark Everest refined the original models to reflect their views of the "current" (as of 2018) typical farm management.

3. Farm systems refined:
    - 4 Arable refined to 1 Arable
    - 2 Dairy refined to 1 Dairy
    - 2 Dairy Support refined to 1 Dairy Support
    - 2 Sheep, Beef and Deer refined to 2 Sheep, Beef and Deer

4. The intention was to re-model all farm systems in Farmax, to validate technical feasibility, followed by a financial cash budget prepared and Overseer nutrient budget. No adjustments to input pricing, commodity pricing, finance rates or debt levels have been made.

5. As Advanced Mitigation 1 solutions have in large already been employed by farmers in the catchment (where applicable), the Farm Systems then would have had Advanced Mitigation 2 solutions applied as per the 2013 Report. Capital costs were to be accounted for and the models were to be re-run in Farmax to validate technical feasibility, revised financial budgets prepared and revised Overseer nutrient budgets prepared.

6. There was only sufficient scope within the project to consider applying the full refinement methodology as discussed above to one dairy farm (Dairy 3), to update to current. It is assumed that thereafter, the existing Dairy 2 advanced mitigation models would apply.

4.3. On Farm Analysis

1. To enable analysis between the 2013 Report and this analysis, the farm system total areas have been maintained.

2. Leaching loss reductions were then measured against capital cost, and annual operating cash surplus reduction from the baseline (either 2012 figures in the 2013 report or 2018 in this report) per kg N loss reduced and expected capital value degradation.

4.4. Catchment Scale Modelling

1 Revise the proportions of farm types and amount of irrigation.

2 Catchment scale assessment of costs was then made at an on-farm level, and a community level. The on farm level assessment was calculated as the weighted average nutrient loss reduction costs as in On Farm Analysis above, multiplied by the proportion of farms in the catchment.

3 The Community scale assessment is calculated by multiplying the Farm Working Expenditure and 50% of NPAT by an a re-spend coefficient of 2.5 times. A multiplier of between 2 times and 4 times is considered representative of the contribution of on farm spending to the total regional spend.

4 The change in asset value was calculated as base value of land, less capital invested through mitigations, plus (or less if negative) change in EBIT capitalised at 4%.

5 Capital expenditure/investment in mitigations assumes that all borderdyke has been converted to spray irrigation for the new "current" and therefore is not included in any additional capital expenditure calculations.

4.5. Mitigations and Farm Management

4.5.1. Good Management Practice

- Reduction in fertiliser in crops following large winter depositions of nitrogen.
- Dairy to install 30+ days effluent storage and greater reduction in N use on effluent applied land.

4.5.2. Advanced Mitigations Level 1

- Installation of soil moisture monitoring gear and VRI on existing centre pivots.
- No May urea applications.
- Adjust cropping fertiliser rates and types to best suit plant requirements and timings.
- Use of yield maps to define an assumed 10% of the paddock which only yields half of the paddock average.
- Use variable rate fertiliser technology
- Limit each urea application to <140kg/ha
- Variable Rate Fertiliser
- Gibberellic Acid to substitute some Spring and Autumn Nitrogen on Pastures
- Nitrification Inhibitor use combined with nitrogen based fertiliser reductions to match.
- Mixed Pasture Sward (although no credit attained in Overseer)
- Short Rotation Ryegrass and White Clover Pasture.
- Modify existing centre pivot irrigators to Variable Rate Irrigation technology on 90% of area
- Optimise stocking rates.

4.5.3. Advanced Mitigations Level 2

- Modify 90% of irrigated area to include centre pivots/laterals fitted with Variable Rate Irrigation technology
- Employ NDVI sensing technology and consequent Variable Rate application of liquid urea.
- Dairy farms to install covered feed pads and required effluent systems.

4.5.4. Advanced Mitigations Level 3

- Reduce nitrogen fertiliser applications by 15% and model appropriate reductions in production.
- Reduce stocking rates by 10% (without increasing production to compensate).
- All cows wintered in barns and dairy farms grow sufficient winter feed (f. beet to lift).
- No winter feed crop yields over 14t/ha Kale or 22t/ha Fodder Beet.

5. Farm Systems

5.1. Farm Systems 2018

Please refer to the 2013 Report for details on farm systems in 2013. Detailed below are the farm programmes Bob Englebrecht and Mark Everest to be more representative of farm types in 2018.

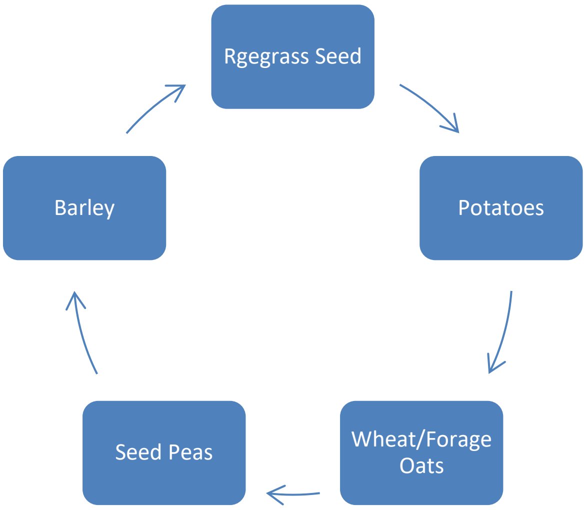
The two biggest changes that need consideration are:

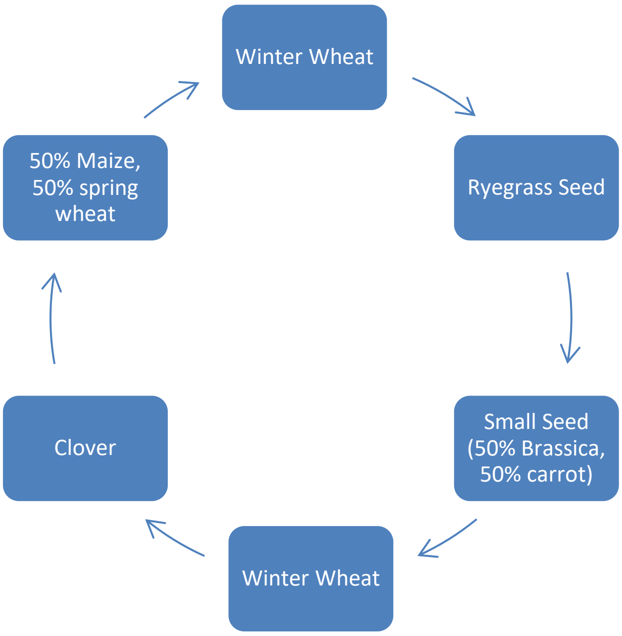
1. The 17,839ha of dryland Sheep, Beef and Deer farms that were modelled as carrying breeding ewes in 2013, that are now carrying more trading cattle, winter feed and trading lambs.
2. The 43,867ha of dairy farms in 2013, now increased to an estimated 49,107ha, and increased production by an estimated 225kgMS/ha from 1458kgMS/ha to 1713kgMS/ha in 2018. Over the same time period, out internal database indicates a 339kgMS/ha Lift and Dairybase indicates at 263kgMS/ha lift in productivity.

See details in the following sections as to how we view farm systems are now operated in 2018.

5.1.1. Arable 5 (A5)

Rotations:





Irrigation:
Mainly Centre Pivot or lateral irrigator. Modelled in overseer as 100% pivot as most remaining rotorainers or similar are on higher water holding capacity soils or are operating on a very short return period with suitable application depths.

Stock:
100% winter lambs
50% summer trade lambs
50% beef calf rearing for autumn sale.

5.1.2. Dairy 3 (D3)

System:

3.5 cows/ha.

1713kgMS/ha

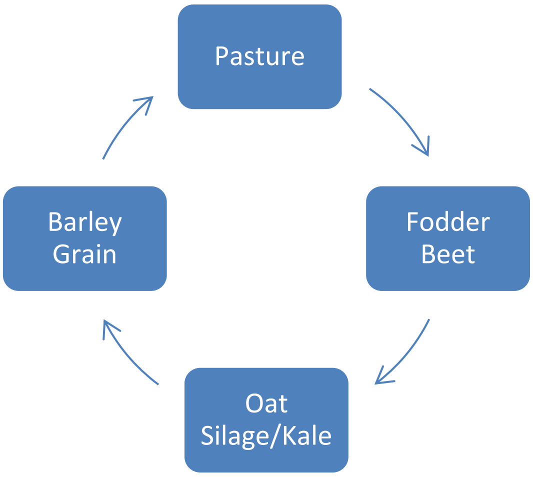
Feeding grain, PKE, small amount of maize and grass silage, fodder beet grown on platform for autumn feeding.

Irrigation:

All centre pivot.

5.1.3. Dairy Support 3 (DS3)

Rotation:



22% Kale

22% Fodder Beet

22% Barley

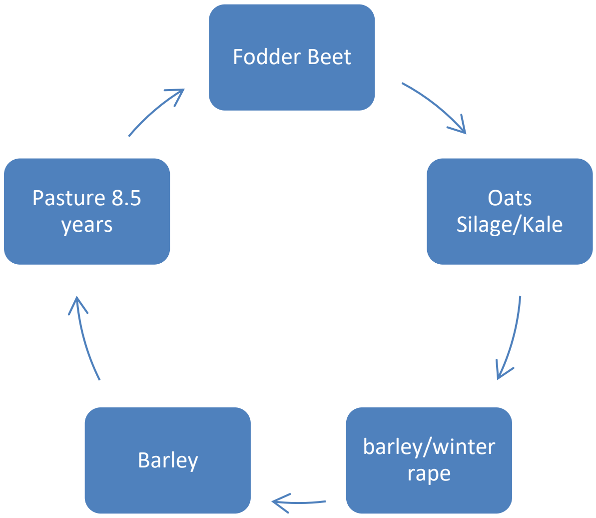
66% pasture (2 years grass)

Irrigation:

Centre Pivot or efficient traveling boom, other than in areas that are not efficient to or economically viable to irrigate with centre pivot.

5.1.4. Sheep, Beef and Deer 3 (SBD 3)

Rotation:



Stock:

70% cattle

2/3 Trading dairy cross calves to finish

1/3 Buying beef store cattle in May, sell to Five Star Beef in December-March following year.

30 sheep

Summer lambs for surplus

Winter trade lambs

5.2. Land Use Change from 2013 to 2018

To reflect change in land use and irrigation development since 2013, Bob Englebrecht and Mark Everest have made some land use change assumptions.

- 6,000ha increase in irrigated area
  - 45% (2,700ha) of increased irrigation to Dairy (ex: Sheep, Beef and Deer 1)
  - 25% (1,500ha) of increased irrigation to Dairy Support (ex: Sheep, Beef and Deer 1)
  - 10% (600ha) of increased irrigation to Arable (ex: Arable 4)
  - 20% (1,200) of increased irrigation to Sheep, Beef and Deer Irrigated (ex: SBD1)
- 5,240ha conversion to dairy (includes the 2,700 ha of Dairy conversion in Irrigation).
  - 4% of total area (131,411ha).
  - 2,540 converted from existing irrigated land (ex: Sheep, Beef and Deer 2)

Farm System	2013 Report	2018 Estimate
Arable 1	1,009	0
Arable 2	11,046	0
Arable 3	14,196	0
Arable 4 (dryland)	1,093	493
Arable 5	0	26,851
Dairy 1	7,050	0
Dairy 2	36,817	0
Dairy 3	0	49,107
Dairy Support 1	8,086	0
Dairy Support 2 (50% dryland)	2,730	0
Dairy Support 3	0	12,316
SBD 1 (dryland)	23,239	17,839
SBD 2 (irrigated)	20,271	18,931
Other	5,874	5,874
TOTAL	131,411	131,411

Figure 1: Land use area by date

6. Results – Water Quality

6.1. On Farm Analysis - Revised 2013 Report and Farm Systems

6.1.1. Nutrient Loss Modelling

The below figure reports the nitrogen losses as calculated in Overseer 6.0.3 and reported in the 2013 Report. PC2 stipulates that 36% reductions to on farm losses must be made by 2035. The grey boxes represent my understanding of what PC2 intended farmers to achieve in terms of loss reductions by farm type (despite the fact that Dairy and Dairy Support only had to migrate to AM1 to become compliant).

Overseer 6.0.3 (2013 Report)										
	2013 Current		GMP		AM1		AM2		AM3	
	kgN/ha	N ppm	kgN/ha	N ppm	kgN/ha	N ppm	kgN/ha	N ppm	kgN/ha	N ppm
Dairy 1	65	28.1	64	27.8	29	16.6	27	15.3	11	7.2
Dairy 2	71	23.7	71	23.8	40	14.5	26	14.9	14	7.4
Dairy Support 1	69	19.7	67	19.3	44	15.1	29	14.8	13	6.1
Dairy Support 2	43	17.6	41	17.1	33	14.3	22	14.1	10	5.7
Arable 1	18	4.6	18	4.6	10	5.3	8	5.7	8	5.8
Arable 2	27	5.0	27	5.0	18	6.0	14	6.6	13	6.5
Arable 3	16	4.3	16	4.3	14	3.8	8	4.4	7	3.5
Arable 4	5	3.6	5	3.6	4	3.4	5	3.6	5	3.5
SBD 1	10	4.4	10	4.4	9	3.8	9	3.8	8	3.4
SBD 2	19	8.4	19	8.4	16	7.2	11	7	10	6.6

Figure 2: Nitrogen Losses reported by Overseer v 6.0.3 in 2013

The weighted average reduction in N loss and concentration of N lost from root zone to ground water is estimated at 19kgN/ha and 3.6ppm across the 131,411ha catchment.

When modelled in the current version of Overseer (v6.3.0), the loss reductions achieved through the varying levels of advanced mitigations saw markedly less reductions in N lost to water (6kgN/ha, and 1.9ppm reduction). See Figure 3 for revised nitrogen losses calculated in Overseer v6.3.0.

Overseer 6.3.0 (2013 Report Updated)										
	2013 Current		GMP		AM1		AM2		AM3	
	kgN/ha	N ppm	kgN/ha	N ppm	kgN/ha	N ppm	kgN/ha	N ppm	kgN/ha	N ppm
Dairy 1	67	28	67	28	65	20	59	19	51	16
Dairy 2	71	24	71	24	59	18	62	19	48	15
Dairy Support 1	81	20	77	19	62	17	44	14	32	10
Dairy Support 2	45	17	40	16	34	15	27	13	19	8
Arable 1	35	11	35	9	37	8	18	9	18	9
Arable 2	67	13	67	13	66	16	59	17	56	26
Arable 3	29	4	29	8	29	8	24	9	7	4
Arable 4	12	8	12	8	11	7	11	7	11	7
SBD 1	15	4	15	4	13	4	13	4	12	5
SBD 2	29	12	29	12	26	7	27	14	21	11

Figure 3: Nitrogen Losses reported by Overseer v 6.3.0 in 2018 for 2013 assumptions

6.1. On Farm Analysis - Target 36% reductions in N losses as per PC2 rules

When individual farm systems are pushed to achieve 36% on farm reductions (or 20kgN/ha) individually as per PC2, the farms would have to adopt management practices as per the relevant mitigations for them as outlined by the grey boxes below. You will note that some farm systems must employ AM3 tools and some make no changes from GMP.

The results suggest that the best the community could achieve with current mitigation tools is 29% reduction in losses. This equates to 15kgN/ha loss reduction and 3.1ppm reduction. Please see **Representative reported figures in red for corrupt files are calculated based on loss rates from similar crop rotations in the AM1 file.**

Figure 4 for more details.

Overseer 6.3.0 (2018 Report)										
	2013 Current		GMP		AM1		AM2		AM3	
	kgN/ha	N ppm	kgN/ha	N ppm	kgN/ha	N ppm	kgN/ha	N ppm	kgN/ha	N ppm
Dairy 1	67	28.0	67	27.9	65	20.4	59	19.4	51	15.6
Dairy 2	71	23.5	71	23.7	59	17.8	62	19.4	48	15.0
Dairy 3	-	-	72	24	-	-	62	19	48	15
Dairy Support 1	81	20.3	77	19.2	62	17.1	**44**	**13.6**	**32**	**9.7**
Dairy Support 2	45	17.4	40	16.2	34	15.0	27	13.0	19	8.1
Arable 1	35	11.1	35	9.2	37	8.3	18	8.9	18	8.9
Arable 2	67	13.3	67	13.3	66	15.8	59	17.1	56	26.1
Arable 3	29	4.3	29	8.2	29	8.2	24	8.8	7	3.5
Arable 4	12	7.6	12	7.5	11	6.9	11	7.1	11	6.7
SBD 1	15	4.2	15	4.2	13	3.6	13	3.6	12	4.9
SBD 2	29	12.5	29	11.7	26	7.2	27	13.6	21	10.8

Corrupt files, unable to be updated by Overseer at this stage, results are a 2013 coefficient of operating AM1 models.
Representative reported figures in red for corrupt files are calculated based on loss rates from similar crop rotations in the AM1 file.

Figure 4: Nitrogen Losses reported by Overseer v6.3.0 for 2018 to target 36% nitrogen loss reductions

6.2. On Farm Analysis - 36% reductions in N losses attained ("with MAR")

In order for the community to achieve the targeted 36% losses for PC2, this modelling suggests that all irrigated farms would need to adopt AM3 mitigations, and all dryland properties would need to adopt AM2 mitigations. Please see Figure 5 below.

Overseer 6.3.0 (2018 Report)										
	2013 Current		GMP		AM1		AM2		AM3	
	kgN/ha	N ppm	kgN/ha	N ppm	kgN/ha	N ppm	kgN/ha	N ppm	kgN/ha	N ppm
Dairy 1	67	28.0	67	27.9	65	20.4	59	19.4	51	15.6
Dairy 2	71	23.5	71	23.7	59	17.8	62	19.4	48	15.0
Dairy 3	-	-	72	24	-	-	62	19	48	15
Dairy Support 1	81	20.3	77	19.2	62	17.1	**44**	**13.6**	**32**	**9.7**
Dairy Support 2	45	17.4	40	16.2	34	15.0	27	13.0	19	8.1
Arable 1	35	11.1	35	9.2	37	8.3	18	8.9	18	8.9
Arable 2	67	13.3	67	13.3	66	15.8	59	17.1	56	26.1
Arable 3	29	4.3	29	8.2	29	8.2	24	8.8	7	3.5
Arable 4	12	7.6	12	7.5	11	6.9	11	7.1	11	6.7
SBD 1	15	4.2	15	4.2	13	3.6	13	3.6	12	4.9
SBD 2	29	12.5	29	11.7	26	7.2	27	13.6	21	10.8

Corrupt files, unable to be updated by Overseer at this stage, results are a 2013 coefficient of operating AM1 models.

Representative reported figures in red for corrupt files are calculated based on loss rates from similar crop rotations in the AM1 file.

Figure 5: Nitrogen Losses reported by Overseer v6.3.0 for 2018 to reduce nitrogen loss by 36%

6.3. On Farm Analysis - 48% reductions in N losses attained ("without MAR")

If MAR is not available in the catchment, the required reductions are increased to 48% to meet agreed water quality targets (WGA, 2018). To achieve 36% reductions, farm programmes were pushed as far as possible within the currently modelled mitigation strategies. To attain a 48% reduction, land use change would be required.

Assuming the farm systems are only required to make the same mitigations as detailed in Figure 5 above, the land use change required to meet reduction would be:

- 33% reduction in Dairy Farm area
- 33% reduction in Dairy Support Farm area
- 33% reduction in Arable 2 (small seed production) area
- 194% increase in Arable 1 (process vegetables) area
- 83% increase in Arable 4 (livestock and grain) area
- 53% increase in Sheep, Beef and Deer (finishing livestock) area.

See Figure 6 below for a summary of the area changes between the base land use assumptions ("2018 Estimate – model") and the area assumed given the above changes in land use ("2018 LUC for 48%").

Farm System	2013 Report	2018 Estimate - model	2018 LUC for 48%
Dairy 1	7,050		
Dairy 2	36,817		
Dairy 3	0	49,107	32,902
Dairy Support 1	8,086	9207	6,169
Dairy Support 2 (50% dryland)	2,730	3109	2,083
Arable 1	1,009	1,032	3,032
Arable 2	11,046	11,298	7,570
Arable 3	14,196	14,520	26,518
Arable 4 (dryland)	1,093	493	493
SBD 1 (dryland)	23,239	17,839	17,839
SBD 2 (irrigated)	20,271	18,931	28,931
Other	5,874	5,874	5,874
TOTAL	131,411	131,411	131,411

Figure 6: Land Use Area by Model

6.4. On Farm Financial Breakdown Summary

Farm Type	2013 Current			GMP			AM1			AM2			AM3		
	Expenses	EBIT	NPAT	Expenses	EBIT	NPAT	Expenses	EBIT	NPAT	Expenses	EBIT	NPAT	Expenses	EBIT	NPAT
Dairy 1	$7,957	$4,289	$884	$7,941	$4,305	$849	$7,777	$4,694	$1,055	$7,792	$4,694	$983	$7,095	$4,103	$163
Dairy 2	$5,712	$3,686	$835	$5,646	$3,748	$844	$5,867	$3,781	$785	$6,729	$4,436	$640	$5,760	$4,019	$131
Dairy 3	-	-	-	$7,131	$4,397	$783	-	-	-	$6,729	$4,436	$640	$5,760	$4,019	$131
Dairy Support 1	$2,210	$1,140	$319	$2,187	$1,164	$336	$2,312	$1,039	$179	$2,337	$1,160	$113	$2,293	$1,070	$30
Dairy Support 2	$2,086	$1,167	$492	$2,074	$1,180	$500	$2,182	$1,071	$399	$2,178	$1,153	$326	$2,054	$679	-$45
Arable 1	$5,229	$1,983	$419	$5,229	$1,983	$419	$5,236	$1,952	$315	$5,301	$2,020	$226	$5,268	$2,029	$234
Arable 2	$3,684	$1,914	$530	$3,684	$1,914	$530	$3,643	$1,932	$491	$3,684	$2,020	$428	$3,661	$1,996	$414
Arable 3	$2,281	$1,078	$263	$2,281	$1,078	$263	$2,295	$961	$169	$2,482	$1,324	$3	$2,361	$1,025	-$293
Arable 4	$1,724	$561	$170	$1,724	$561	$170	$1,739	$499	$102	$1,887	$351	-$4	$1,837	$401	$32
SBD 1	$1,119	$495	$171	$1,119	$495	$171	$1,331	$370	$76	$1,331	$370	$76	$1,249	$309	$39
SBD 2	$1,433	$326	$7	$1,417	$343	$19	$1,543	$344	$7	$1,583	$590	$78	$1,558	$509	$20

Figure 7: Farm System Financial Summary

Figure 7 above is based on the original 2013 Report cost structures, EBIT and NPAT figures for the varying farm enterprises as reported on a per hectare basis. Dairy 3 is a newly formed representative model for this 2018 analysis. This table is the basis for all on farm financial analysis contained in this report.

6.5. Stakeholder impacts of meeting reduction targets.

6.5.1. 2013 Report - plan

When modelled under Overseer v6.0.3 (2013), to achieve the prescribed loss reduction targets as set in PC2, the farm gate cost was $4.82/kg N saved, however due to the forecasted increase in spend to achieve the reductions, the community could potentially benefit by $86,341,810 p/a.

This economic assessment notes that with development of irrigation infrastructure and improvements in farm programme efficiency, farms could become more profitable while making reductions to nitrogen losses, and therefore add value to the farm asset. Figure 8 shows that modelling indicates $3,687/ha of asset value grain through productivity return could have been possible.

While 36% reductions were the target in the 2013 Report, with a more accurate Overseer engine, the achievable reductions are now only 12% from that strategy.

Farm Gate NPAT Change from GMP		-$11,454,286
Farm Gate EBIT Change from GMP		$27,211,332
Regional Spend Change from GMP		$86,341,810
	Farm Gate	Community
Cost per kgN saved	-$4.82	$36.34
Cost per ppm N saved	-$25.49	$192.16
	Farm Gate	Community
Change in Land Asset Value from GMP	$3,687/ha	$484,447,706

Figure 8: 2013 Models Cost of Nutrient Saved - Overseer v6.0.3

6.5.2. 2013 plan - revised to 2018 (29% reduction attained)

When modelled under Overseer v6.3.0 (2018), if individual enterprises operate within the PC2 rules to make 36% reduction from their GMP loss (with a 20kgN/ha loss minimum cap), the greatest reductions attainable are likely to be a 29% catchment wide.

The cost of attaining the 29% reduction at the farm gate is estimated at -$21.56/kgN saved. Current modelling suggests that some farms would have to employ AM3 mitigations (greater lengths than initially planned) to reduce N losses, and as a result spend less in the community. Modelling indicates that this would cost the community -$200,395,050 in regional spending.

Modelling also indicates that there may be a decrease in asset value of -$6,553/ha (-$2,093/ha in excess of capital expenditure).

As discussed earlier, if the original 2013 plan is still implemented, it is likely only a 12% reduction in N loss to water would be achievable using only the AM1 and AM2 mitigations used in MRB 2013 to achieve 36%. A summary of the estimated costs and benefits of making the discussed 29% N loss reductions are outlined in Figure 9.

Farm Gate NPAT Change from GMP				-$39,878,111
Farm Gate EBIT Change from GMP				-$11,003,966
Regional Spend Change from GMP				-$200,395,050
			Farm Gate	Community
Cost per kgN saved			-$21.56	-$108.37
Cost per ppm N saved			-$101.94	-$512.25
			Farm Gate	Community
Change in Land Asset Value from GMP			-$6,553/ha	-$861,112,677

Figure 9: 2018 Revision of 2013 Models Cost of Nutrient Saved - Overseer v6.3.0

6.5.3. 36% reduction plan (meet targets with MAR).

To achieve a 36% reduction in N loss to water, a very aggressive strategy to mitigation must be employed.

To achieve a 36% reduction, a significant investment in infrastructure will be required, and with a reduction in EBIT/ha, it is possible that regional asset values could be reduced by -$8,271/ha ($1,086,950,214 for the community). The flow on effect of meeting the 36% target with current mitigation tools, is that the community would likely see a reduction in spending of -$207,178,294 (-$293,520,104 more than the original 2013 plan). A summary is outlined in Figure 10 below.

Farm Gate NPAT Change from GMP				-$47,865,907
Farm Gate EBIT Change from GMP				-$19,971,847
Regional Spend Change from GMP				-$207,178,294
			Farm Gate	Community
Cost per kgN saved			-$25.88	-$112.03
Cost per ppm N saved			-$122.36	-$529.59
			Farm Gate	Community
Change in Land Asset Value from GMP			-$8,271/ha	-$1,086,950,214

Figure 10: Cost of nutrient saved to achieve 36% reduction in N loss

6.5.4. 48% reduction plan (meet targets without MAR).

If MAR is not approved as a viable mitigation tool, then to achieve groundwater quality targets as set out in PC2, a 48% reduction from 2013 GMP would be required.

As outlined in 6.3 above, to achieve a 48% reduction in N loss to water, significant changes in land use would be required if other on farm technologies are not developed.

In order to determine which land uses would be changed, I have indiscriminately selected the highest emitters at AM3, which are Dairy (48kgN/ha/year); Dairy Support (because with less dairy area, there is a lesser demand for dairy support); Arable (small seed) (56kgN/ha/year). The areas were then applied to the lower emitting enterprises remaining in an arbitrary manner we saw likely. The result was a small increase in process arable (due to the fact that the local process vegetable contracts are in large occupied), and a large increase in grain based arable and mixed livestock finishing.

To assess land use change cost to the community, there would be a considerable capital asset value loss. Due to the fact that farmers are forever optimistic, Andy Macfarlane recommended that an assumption be made around capital expenditure before land use change which is:

- That 50% of the properties that would have to change land use in time, would invest in enterprise-specific infrastructure developments as per AM3, but then write that investment off when land use change was undertaken.
- And, 50% of properties that would have to change land use would not invest in any enterprise-specific infrastructure developments as per AM3, rather they would operate their existing assets and depreciate them to a $0 value, before changing land use.

With regard to debt on enterprises, I have made a simple assumption that if land use change was to occur, the changed enterprise would adopt all the financial characteristics of an established farm operating that enterprise.

The cost of achieving 48% reductions in excess of the 36% reductions, with land use change would cost the on farm component -$55/ha NPAT (-$7,268,221 on a catchment basis). This is not significantly more than 36% reductions due to the fact that when a farm operates at AM3, no NPAT exceeds $450/ha whereas at GMP 45% of properties operated with an NPAT above $450/ha.

The community cost of reduction in spending -$56,135,574 less than 36% reductions with MAR, because with change in land use, land has been changed from high cost input and high revenue output to modest inputs and modest outputs.

The greatest cost however, as outlined in Figure 11 below, is the land asset value degradation of $20,077/ha from current 2018 value, or -$11,806/ha more loss in asset value than 36% reductions with MAR.

Farm Gate NPAT Change from GMP			-$55,134,128
Farm Gate EBIT Change from GMP			-$76,107,421
Regional Spend Change from GMP			-$370,319,858
		Farm Gate	Community
Cost per kgN saved		-$17.71	-$118.95
Cost per ppm N saved		-$79.85	-$536.35
		Farm Gate	Community
Change in Land Asset Value from GMP		-$20,077/ha	-$2,638,350,971

Figure 11: Cost of nutrient saved to achieve 48% reduction in N loss

7. Results – Water Quantity (Valetta)

7.1. Introduction

Valetta Groundwater Zone is overallocated by 75% (allocated at 175%). MAR is currently used to help increase groundwater storage offsetting this overallocation. While the take volume may not be as high as the consented volume in every year, to understand what would be the costs without MAR for groundwater supplies, Bob Bower (WGA) has asked the potential economic implications to the community of to reduce the water allocation back by 43%, so that the resource if 100% allocated and no more.

7.2. Method

1. Current land value was estimated by land use.
    a. Dairy $58,000/ha irrigated
    b. Dairy Support $45,000/ha irrigated
       $28,000/ha dryland
    c. Process Arable $48,000/ha irrigated
    d. Seed Arable $48,000/ha irrigated
    e. Seed and Stock Arable $45,000/ha irrigated
       $32,000/ha dryland
    f. Sheep and Beef $45,000/ha irrigated
       $28,000/ha dryland

2. Assumption was made that if farms were to have water allocation reduced, it would be on an equal basis, and all farm enterprises would reduce their irrigated land uses by 43%.
3. The land that was changed from irrigated to dryland was assumed to be allocated to:
    a. 13% (5,823ha) dryland cattle finishing (using dryland dairy support as the proxy)
    b. 2% (1,052ha) dryland arable grain and livestock.
    c. 85% (38,050ha) dryland sheep and beef breeding and finishing.
4. Asset value change was calculated on the basis of the above values multiplied by the attributable areas before and after water cut backs.
5. It is assumed that the Valetta GWAZ is occupied by the same proportion of farm systems as in the whole Hinds Catchment.

7.3. Results

A re-allocation of the water resource may see some properties revert to dryland farm systems.

The on farm economic impact of cutting back 43% of the allocated water is likely to have a negative net impact on farm gate returns of -$121/ha NPAT, assuming that the farm will somehow be able to repay debt to a sustainable level (unlikely without full asset sale).

The asset value implications of withdrawing water resources are than there will likely be a re-valuation of the assets that will be reverted to dryland. It is estimated that this would be at a cost of $7,588/ha ($425,580,986 for the community).

The flow on effect of the change in spending in the community resulting from land use change is an estimated $133,080,274 p/a as seen in Figure 12 below.

Farm Gate NPAT Change from Current				$6,535,903
Regional Spend Change from Current				$133,080,274
			Farm Gate	Community
Change in Land Asset Value from Current			$7,588/ha	$425,580,986

Figure 12: Valetta GWAZ water cut backs community impact.

8. Discussion

8.1. Results

Compounded by soaking up good management practice nitrogen savings with improved performance, and in lieu of agronomic nitrogen loss reducing tools proven and available (e.g. Italian pastures and plantain based pastures), modelling of the cost of reducing nitrogen loss indicates that the magnitude of the tasks required to achieve PC 2 targets could cost the community as much as $207,178,294 annually with MAR or $370,319,858 without MAR as a mitigation tool. Farmer farm gate returns would also reduce, by as much as $55,134,128 ($420/ha) annually without MAR.

Economic Indicator	Type	With MAR	Without MAR	Difference (- is degradation; + is improvement)
Farm Asset Value Change (from Current)	One time	-$8,271/ha	-$20,077/ha	-$11,806/ha
		-$1,086,950,214 total	-$2,638,350,971 total	-$1,551,400,756 total
Farm NPAT Change	Annually	-$364/ha	-$420/ha	-$55/ha
		-$47,865,907 total	-$55,134,128 total	-$7,268,221 total
Cost to Regional Spend	Annually	-$207,178,294 total	-$370,319,858 total	-$163,141,563 total

Figure 13: Economic comparison with and without MAR

Figure 13 above illustrates the difference in regional spend, farm profitability (NPAT) and asset value change likely as a result in agricultural practice change required to achieve PC2 water quality standards with MAR (36% reduction required) and without MAR (48% reduction in N loss required).

Without MAR, farmers will lose an additional $11,806/ha in asset value ($1,551,400,756 community wide), will see a reduction in NPAT of $55/ha/year and through less spending on farm working expenses, the community economy could shrink by $163,141,563 p/a.

In Figure 14 below, a sensitivity of ± 10% in the accuracy of the above numbers might be impacted.

Economic Indicator	Type	With MAR		Without MAR		Difference (- is degradation; + is improvement)	
Farm Asset Value Change (from Current)	One time	-$7,200/ha to	-$8,800/ha	-$18,000/ha to	-$22,000/ha	-$14,800/ha to	-$9,200/ha
		-$981,000,000 total to	-$1,199,000,000 total	-$2,376,000,000 total to	-$2,904,000,000 total	-$1,923,000,000 total to	-$1,177,000,000 total
Farm NPAT Change	Annually	-$360/ha to	-$440/ha	-$360/ha to	-$440/ha	-$80/ha to	$80/ha
		-$45,000,000 total to	-$55,000,000 total	-$54,000,000 total to	-$66,000,000 total	-$21,000,000 total to	$1,000,000 total
Cost to Regional Spend	Annually	-$189,000,000 total to	-$231,000,000 total	-$333,000,000 total to	-$407,000,000 total	-$218,000,000 total to	-$102,000,000 total

Figure 14: Range table for economic comparison with and without MAR

The over allocation of Valetta GWAZ by 75% could be addressed by cutting all water allocations back by 43%. The impact on the community of doing this would be reduced regional flow on spending of $133,080,274 p/a and underlying land asset value erosion of $7,588/ha ($425,580,986).

8.2. Considerations

Further things to consider that this report does not cover are the impact of reduced productivity on land values, underlying equity, stability in the land market and then following on to rating income adjustments with lower land values.

If Ecotain, Italian pastures and DCD were made available as mitigation tools, the metrics discussed here could change considerably. If we consider the catchment as 61% pasture, 12% forage and 27% arable; assuming we adopt 30% pasture as Italians that save 20% of losses (4% saving in the catchment); assuming we adopt 70% of pastures with Ecotain that save 30% of losses (13% savings in the catchment) and perhaps we get a nitrification inhibitor for winter feed that can save 40% of losses (5% saving in the catchment), this would give a 22% N loss to water saving, making PC2 water quality standards more economically feasible, leaving only a 14% saving to be made in system changes.

This report does not consider alternatives to managing water quality, rather is intended to outline potential costs of making reductions all the responsibility of the farming community.

The wider community and farming community both stand to lose a considerable amount, therefore we recommend that the cost of Managed Aquifer Recharge as a mitigating tool be shared between farmers and wider community.

9. References

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