OVERSEER Nutrient Budget review

For: Environment Southland – Cashmere Dairy

Prepared by: Nicky Watt, CNMA

Introduction

1. Regarding the consent application for Cashmere Dairy, I have reviewed the following OVERSEER ® Nutrient Budget (OVERSEER) files:
   a) Cashmere Bay – 1516 Dairy + Runoff
   b) Cashmere Bay – 1617 Dairy + Runoff
   c) Cashmere Bay – 1718 Dairy + Runoff + Sheep Blocks
   d) Cashmere Bay-Pro-posed scenario

2. Along with the files I have reviewed the following accompany reports:
   - 20190411 18106 Cashmere Bay Dairy land addition lodgment package 12 April prepared by: Mike Freeman, Senior Scientist/Planner Landpro. In particular, Attachment A: Overseer Nutrient budget Technical Report by Brain Goodger, Fonterra (pages 65 to 93).

3. I have completed a robustness check on the files for sensibility based on data available and checked to ensure the modelling aligns with the OVERSEER Best Practice Data Input Standards for v6.3.0. Ideally the sheep block should have been modelled separately for the 2017 2018 season, but the sheep block area is clearly identified in the 2017 2018 model and in the proposed model to be able to make comparisons.

4. It must be assumed that the information provided in the OVERSEER files that the current farming system as modelled is a viable farming system, using actual stock and fertiliser inputs. Therefore, the actual and proposed scenario is also assumed to be appropriate for the location and climate.

5. A 'sensibility test' has been undertaken on the Cashmere Dairy nutrient budgets with the following five output screens from OVERSEER forming the basis of the determination of the robustness of the nutrient budget:
   a) Is the nutrient loss consistent with what you would expect for an operation of this type and soils in this location?
   b) Does the summary of inputs and outputs make sense? Especially clover fixation and change in block pools?
   c) Check the 'Other values' block reports for rainfall, drainage, and PAW
   d) Select the Scenario reports other values and check the production and stocking rate
   e) Select the pasture production in the scenario report and check pasture growth.

6. Answers to each of these five points will be provided further in this report and then a final determination of the robustness of the nutrient loss to water will be provided at the end of this report.

OVERSEER AUDIT

Appropriateness of the Overseer inputs

1. The four XML files stated in paragraph 1 of this report have been reviewed for consistency between the files and appropriateness of the inputs regarding the farming systems and the Overseer Best Practice Data Input Standard (BPDIS).

2. I concur that there is no deviation from the BPDIS.

3. The models all have 442.6 ha of dairy and support total area with 434 ha effective. The 2017 2018 and proposed models have the 80-ha total are of the new sheep block of which 76.5 ha is considered effective. There has been little change in the peak stocking rate for the last 3 seasons but a shift to less cow's peak milked and more cows in the winter over the seasons. The proposed model shows a drop in the stocking rate which reflects the increase in area farmed with only a slight increase in cow numbers (still in line with consent conditions).

4. Reviewing the NZ Dairy statistics for the 2017/2018 season, shows the average milk solids production on this property (441 kgMS/cow) is greater than the Southland regional average of 408 kg MS/cow. The stocking rate is lower than the Southland average for the 2017/2018 season of 2.64 cows/ha. The Proposed per cow production is 6% higher than the average of the last 3 season and the per hectare production is proposed to decrease from the average of 1026 kgMS/ha by 10% which is due to the increase in land area with similar stock numbers. Lactation length has remained the same.

Table 1: Summary of Production and stocking rate

	2015/2016[1]	2016/2017[2]	20172018 D[3]	20172018 S#	Proposed D*	Proposed S**
Total Ha	442.6	442.6	442.6	80	442.6	80
Effective Area (ha)	434	434	434	76.5	434	76.5
KgMS	407656	437215	437028	-	470000	
MS kg/ha grazed	966	1035	1076	-	920	920
MS kg MS/cow	407.7	460.2	455.2	-	470	470
Dairy RSU	9736	10160	10199	-	8637	1562
Lactation Length	278	278	278	-	278	278
Cows/ha	2.4	2.2	2.4	-	2.0	2.0
Cows October	1000	950	960	-	847	153
Cows June	400	720	730	-	678	122
Cows July	400	720	730	-	678	122
R1yr Heifers Support Oct	220	209	211	-	220	-
R2Yr Heifers Support Oct	220	209	211	-	220	-
Replacement Support RSU	1738	1649	1665	-	1737	-
Sheep RSU	-	-	-	115	-	-
Beef RSU	-	-	-	125	-	-
N lost kg/ha/yr	43	38	45	16	39	30

[1]Cashmere Bay – 1516 Dairy + Runoff -**2015/2016**
[2]Cashmere Bay – 1617 Dairy + Runoff – **2016/2017**
[3]Cashmere Bay – 1718 Dairy + Runoff + Sheep Blocks- **2017/2018 D** (dairy +support no sheep)
Cashmere Bay – 1718 Dairy + Runoff + Sheep Blocks- **2017/2018 S** (sheep only)
Cashmere Bay-Pro-posed scenario--Proposed S** (sheep only)
*Cashmere Bay-Pro-posed scenario -**Proposed D** (dairy only)

5. The crop area has changed between the years as can be seen in Table 2 below. The average crop area for the last 3 seasons is 35 ha and the proposed is in line with this. May be in error but there are 2 blocks missed off the fodder rotation in the proposed model (see table 2 below). Please note in fodder beet fertiliser in the proposed model has differing application of fertiliser but the same crop yields (runoff has application in Dec and Mar but not the dairy fodder crops).

Table 2: Crop Details

	2015/2016	2016/2017	20172018 D	20172018 S	Proposed D	Proposed S
Dairy Fodder Ha	5	32	34	-	34 - FB rotates through all blocks*	34 - FB rotates through all blocks*
Dairy Fodder Yield (tDM/ha)	26	26	26	-	26	26
Dairy Kale Ha	14	-	-	-	-	-
Dairy Kale Yield (tDM/ha)	12	-	-	-	-	
Support Fodder Ha	8	7.5	7	-	4 - FB rotates through all blocks*	4 – FB rotates through all blocks*
Support Fodder Yield (tDM/ha)	26	26	25	-	26	-
Sheep Swede Ha	-	-	-	4	-	-
Sheep Swede Yield (tDM/ha)	-	-	-	12	-	-

*Except Main Past Flat Selw 50a.1 and Runoff Selw50a.1

6. Supplements imported have varied over the years to meet cow demand (see Table 3). Pasture silage has been made where there was a surplus of pasture.

Table 3: Supplements imported and Harvested

	2015/2016	2016/2017	20172018 D	20172018 S	Proposed D	Proposed S
Supplements Imported (tDM)	1085	1135	1185	-	750	-
Supplements Imported (tDM/ha)	2.45	2.56	2.68	-	1.69	
Total Area (ha)	442.6	442.6	442.6	80	442.6	80
Effective Area (ha)	434	434	434	76.5	434	76.5
Peak Cows/ha	2.4	2.2	2.4	-	2.0	2.0
N Fertiliser applied (kgN/ha)	176	166	197	2	156	156
Pasture Growth Dairy Irrigated and Effluent (TDM/ha)	18.75	18.09	19.23	-	17.68	-
Pasture Growth Dairy Dryland (TDM/ha)	14.06	13.57	14.42	-	13.26	-
Pasture Growth runoff Dryland (TDM/ha)	16.32	16.76	15.68	-	14.37	-
Pasture Growth Sheep Dryland (TDM/ha)	-	-	-	12.2	-	13.26
Silage Harvested to storage (tDM) -Dairy	290	339	126	-	350	-
Silage Harvested to storage (tDM) - Support	150	162	250	-	63	-
Silage Harvested to storage (tDM) - Sheep	-	-	-	20	-	67

7. The proposed Overseer model shows the average pasture production for the last 3 seasons is 18.7 tDM/ha for irrigated/effluent land, 14 tDM/ha for dryland, and 16.3 ha for the runoff dryland. This is all greater than the proposed scenario. The sheep pasture growth at 12.2 tDM/ha seems high allowing it was an organic sheep farm. The average N used over the last 3 seasons has been 180 kgN/ha and the proposed is predicting using 156 kgN/ha. The supplement used for the last 3 seasons has averaged 2.56 tDM/ha and the proposed is predicting using 1.69 tDM/ha or 0.87 tDM/ha decrease in supplement used. Based on this information, the proposed scenarios decrease in pasture harvested has been justified by the increase in land area and similar stock numbers (see Table 3 above).

8. The N lost to water has been relatively steady over the last 3 seasons for the dairy plus support modelling (see Table 4a below). The average N loss for the last 3 seasons has averaged 42 kgN/ha. The N loss of the sheep block has increased from 16 kgN/ha to 30 kgN/ha. When the sheep block has been included in the calculations for each year (as in Table 4b below) the average N loss for the last 3 seasons has averaged 38 kgN/ha which is the same as the proposed scenario. The P loss has remained relatively steady across the dairy plus runoff models. The sheep block P loss has increased from 0.2 kgP in the 2017 2018 season to 0.5 kgP for the proposed but the when added to the dairy models each year and compared to the proposed scenario the P loss remains the same. It must be assumed that the information provided in the 2015/16 to 2017/18 seasons farming systems are modelled as a viable farming system, using actual stock and fertiliser inputs. Therefore, the future scenario is also assumed to be appropriate for the location and climate.

Overseer Outputs

Table 4b: OVERSEER outputs

Overseer v6.3.0	2015/2016	2016/2017	20172018 D	20172018 S	Proposed D	Proposed S
N lost to water kg/ha/yr	43	38	45	16	39	30
Total N lost kg/farm	19121	16615	19801	1286	17267	2401
P lost kg/ha/yr	0.6	0.6	0.7	0.2	0.6	0.5
Total P lost kg/farm	282	275	295	15	274	43
Other sources – N	449	381	363	65	367	65
Other sources – P	174	157	140	25	155	28

Table 4b: Adding Sheep Block to each Year

Overseer v6.3.0	2015/2016 + Sheep	2016/2017 + Sheep	20172018 + Sheep	Proposed + Sheep
N lost to water kg/ha/yr	39	34	40	38
Total N lost kg/farm	20407	17901	21087	19668
P lost kg/ha/yr	0.6	0.6	0.6	0.6
Total P lost kg/farm	297	310	310	317
Other sources – N	514	446	428	432
Other sources – P	199	182	165	183

Change in block pools

9. Overall there is no significant difference in the change in block pool values between the 3 years and the proposed scenario for both N and P.

10. It appears N is potentially being immobilized. This is observed with a positive value in the Organic pool for N. This value remains reasonably constant in all 4 models.

11. Slightly above maintenance P was applied to the 2016 2017, 2017 2018 and proposed models and below maintenance requirements for the 2015 2016 model which is seen by the respective slight increase and decrease in Inorganic Soil Pool levels.

Table 5: Change in block pool (N)

	2015/2016	2016/2017	20172018	Proposed
Plant Material	20	21	14	12
Organic Pool	110	86	84	88
Inorganic Material	0	0	0	0
Inorganic Soil Pool	5	10	9	5

Table 6: Change in block pool (P)

	2015/2016	2016/2017	20172018	Proposed
Plant Material	3	4	3	2
Organic Pool	14	12	9	13
Inorganic Material	2	2	2	2
Inorganic Soil Pool	-7	12	27	7

Rain/clover N Fixation

12. The average Biological fixation for the last 3 seasons has averaged 76 compared to the proposed 95 or a 20% increase (see table 7 below).

13. Average N added to the proposed scenario is 13% less than average of 180kg N/ha/yr for the last 3 seasons.

14. The large increase in biological fixation mostly due to the decrease in average N applied to the proposed scenario. This is deemed to be an acceptable variance and within the limitations of the model due to the increase in area farmed with little change in stocking rate.

Table 7: Biological fixation

	2015/2016	2016/2017	20172018	Proposed
Biological Fixation	96	84	49	95
Average N applied to whole farm kg/ha/yr	176	166	197	156

15. It is not known if the decrease in N applied and increase in biological fixation will be able to maintain the pasture production modelled.

Pasture Production

16. The effluent N inputs remain constant across the 2015 2016 season but increases by 30% in the 2017 2018 season due to a possible error in the modelling - only 100 ha has been modelled in the 2017 2018 season. The proposed scenario shows a decrease in the N from effluent due to the increase in area effluent is to be applied (see table 8 below).

17. Fertiliser inputs of N vary across the scenarios with the highest inputs in the 2017/2018 file.

18. Pond solids are applied mainly to the effluent area in almost all the models. Liquid effluent is only applied to the effluent block in all models using a low application method.

19. Long term pasture growth in Southland between 1979 and 2012 indicated that average pasture growth for newer pastures was 12.7T DM/ha/yr. Average growth data for Tapanui, from Dairy NZ data sheets, showed 10.2 tDM/ha excluding N applications on dryland (adding 267 kgN/ha of nitrogen at a 10:1 response will give pasture growth of 12.9 tDM/ha). The pasture production on this property, for dryland, is much higher than the long-term growth. An explanation should be given for why the average annual pasture growth for the last 3 seasons for dairy dryland at 14 tDM/ha is 8.5% higher than the Southland average. Also, an explanation of why the average of the last 3 seasons for the runoff dryland at 16.2 tDM/ha is 21% higher than the Southland long term pasture growth. An explanation of why the pasture growth for the irrigated land is also higher than would be expected. Pasture growth for the sheep block also needs to be addressed as the growth of 12.2 tDM/ha should be closer to 10.2 tDM/ha (allowing that the stocking rate and fertiliser inputs are estimated and was an organic sheep farm).

20. The proposed pasture production is more in line with pasture growth expectations for dryland and irrigated pastures but still on the high side.

21. The animal distribution is modelled the same in all scenarios.

Table 8: Pasture production and N inputs (fertiliser and effluent)

	2015/2016	2016/2017	20172018	Proposed
Effluent Area (ha)*	150	147**	100**	170
Pasture Growth (tDM/ha/yr)				
Effluent	18.75	18.09	19.23	17.6
Non-Effluent	14.06	13.57	14.42	13.58
N Fertiliser inputs (kg/ha/yr)				
Effluent	215	217	355	156
Non-Effluent	246	215	355	222
N Effluent Inputs (kg/ha/yr)				
Effluent	66	62	88	60
Non-effluent (includes solids)	1	1	-	0
Total N Inputs (kgN/ha/yr)				
Effluent	281	279	443	216
Non-Effluent	247	216	355	222

**Effluent area is area that receives liquid effluent*
***Possible errors? The reporting indicated 158 ha for current and 186 for proposed and 2017 2018*

Mitigations Modelled

22. As described in the appended nutrient budget analysis of the Cashmere Dairy application (page 66), there are several mitigation measures to mitigate N loss that have been included in the proposed scenario. The below table details if the mitigation measures have been included in the proposed scenario and if they are accurately modelled.

Table 9: Mitigation option for proposed

Farm system strategies	Included in Proposed OVERSEER scenario
Increased Effluent area	Yes and No (the area has increased from 132 ha to 170 ha), report indicated an increase in effluent area from 158.6 ha to 186.4ha
No change in farm area for 2017 2018 to Proposed	Yes, farm area has remained at a total of 522.6 ha, 510.5 ha effective.
Peak cows will be less than the average of the last 3 season	Yes. The stocking rate has dropped from 2.3 cows/ha to 2.0 cows/ha
Annual rotation of fodder beet 34 ha Dairy and 4 ha support	Yes. Note here the fodder beet is rotated through every block except two blocks noted in table 2 above. Also note fertiliser application vary between the 2 fodder crop rotations with the same yield
Supplement in the proposed model is reduced	Yes, supplement imported has dropped from 2.56 tDM/ha average for the last 3 seasons to 1.69 tDM/ha (when comparing the same dairy area)

23. Most of the mitigation measures are robust, however there are a few areas in the modelling that may need to be addressed.

24. It is important that these mitigation measures are measured and monitored as if they are not adhered to the N loss reductions proposed may not occur.

CONCLUDING COMMENTS

Determination of the robustness of the nutrient loss to water

25. The questions below were described at Paragraph five of this report. Whilst these have been answered throughput this report, this section summarizes the answer to each question to make an overall conclusion about the robustness of the nutrient budgets.

Is the N loss consistent with what you would expect for an operation of this type and soils in this location?

26. Based on my experience, the N loss estimates are reasonably consistent with an operation of this scale and soil types present.

Does the summary of inputs and outputs make sense? Especially clover fixation and change in block pools?

27. There is no significant difference in the change in block pool values between 4 models presented for both N and P.

28. There is a 20% increase in biological fixation in the future scenario and a 13% decrease in applied N. Clover and pasture inputs are the same across all 4 scenarios.

29. It is not apparent from reviewing the Overseer technical manuals or the nutrient budgets if the difference in pasture production and N fertiliser use accounts for all the increase in biological fixation.

Check the 'Other values' block reports for rainfall, drainage, and PAW

30. The rainfall and soil information have been entered based on protocols for the location and soil type selected.

Production and stocking rate

31. Based on my experience as well as reviewing NZ Dairy statistics for the 2017/2018 season the stocking rate is lower than the Southland Region average in the 2017/2018 season. The milk production per cow is higher than the Southland Region average in the 2017/2018 season

32. The average milk solids production per cow on this property for the last 3 seasons is 441kg MS/cow/year which is higher than the Southland regional average of 408kg MS/cow. The target of 470 kgMS/cow is a 6% increase over the last 3 season and if not achieved is likely to result in a lowered N loss.

33. The stocking rate at 2.3 cows/ha for the last 3 season and 2.0 cows/ha for the proposed model is also lower than the Southland average for the 2017/2018 season of 2.64 cows/ha.

34. It is assumed that since the 4 seasons worth of actual scenarios are based on year end information that all scenarios represent viable production and stocking rate.

Select the pasture production in the scenario report and check pasture growth.

35. A detailed explanation of the pasture production has been outlined in the above sections.

36. There is a decrease in pasture growth between the proposed scenario and the average of the last 3 seasons of actual scenarios and a corresponding decrease in N applied and decrease in supplement being imported. This is as a result of the addition of the 80 ha of land with no corresponding increase in stock.

37. Average growth data for Tapanui, from Dairy NZ data sheets, showed a pasture growth of 12.9 tDM/ha (including N application). The pasture production on this property, for dryland, is much higher than average growth for the area. An explanation should be given for why the average annual pasture growth for the last 3 seasons for dairy dryland at 14 tDM/ha is 8.5% higher than the Southland average. Also, an explanation of why the average of the last 3 seasons for the runoff dryland at 16.2 tDM/ha is 21% higher than the Southland long term pasture growth and why the pasture growth for the irrigated land is also higher than would be expected. Pasture growth for the sheep block also needs to be addressed as the growth of 12.2 tDM/ha should be closer to 10.2 tDM/ha (allowing that the stocking rate and fertiliser inputs are estimated and was an organic sheep farm).

38. I have assumed an adequate level of robustness around the 4 seasons of actual Overseer Modelling as it is based on an actual farming system, and with that, I have assumed actual stock and fertiliser inputs used.

39. Check that the area the effluent is applied occurs (the area effluent is applied varies between the 3 actual models and is not inline with the information provided in Attachment A: Overseer Nutrient Budget Technical Report by Brain Goodger, Fonterra (pages 65 to 93)

40. The data input protocols have been followed for all scenarios with no deviations. This leads to a high level of robustness for the relevant input data for example, climate, soils, and pasture type.

41. Based on the concerns raised regarding some of the inputs and outputs in the Overseer models, I consider that the robustness of the nutrient loss estimates for the Proposed scenario are **medium,** this id due to the robustness of the nutrient loss estimates for the actual scenarios is **medium**.

42. The area of concern in all the models is: the high pasture production for all blocks needs to be addressed. Also, the variance in effluent area, to what is reported, needs to be addressed.

43. The area of concern In the proposed model is: The difference in the fertiliser applied to the 2 fodder crop rotations and the 2 blocks possibly missed in the fodder rotation needs to be addressed.

44. It is vital that the proposed changes to the future farm system are effectively measured and monitored as if these are not adhered to then the reductions in N loss proposed may not occur.

References:

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https://www.dairynz.co.nz/media/5790451/nz-dairy-statistics-2017-18.pdf
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Smith. L. C. 2012. Proceedings of the New Zealand Grassland Association 74: 147-152 (2012) *Long Term pasture growth patterns for Southland New Zealand: 1978-2012*. www.grassland.org.nz/publications/nzgrassland_publication_2284.pdf

https://www.dairynz.co.nz/media/5790163/average-pasture-growth-data-south-island-2018.pdf