BEFORE THE HEARING PANEL OF SOUTHLAND REGIONAL COUNCIL

In the matter of sections 88 to 115 of the Resource Management Act 1991

And

In the matter Applications for resource consents by:

WOLDWIDE FOUR LIMITED, WOLDWIDE FIVE LIMITED,
Applicants

BRIEF OF EVIDENCE OF MARK ANTHONY CRAWFORD

16 September 2019

STATEMENT OF EVIDENCE OF MARK ANTHONY CRAWFORD

1 My full name is Mark Anthony Crawford.

2 I graduated from Massey University with a Bachelor of Agricultural Science in 1982.

3 I achieved Certificates of Completion with an A- grade from Massey University in 2007 for satisfying the course requirements for the Advanced Certificate in Sustainable Nutrient Management, part of the training required for understanding and using OVERSEER®.

4 I am a current Certified Nutrient Management Adviser having satisfied criteria initially in November 2013 under the Nutrient Management Adviser Certification Programme managed by the Fertiliser Association of NZ, and every year subsequent to this.

5 I have had over 15 years in the fertiliser industry advising farmers on nutrient management and have extensively used OVERSEER® and other decision support software to provide nutrient management advice to clients of Ravensdown.

6 I have extensive experience in farm systems and nutrient management plans having provided these plans for key clients in past years.

7 I am qualified to complete farm systems appraisals with over 37 years' experience in the Agriculture industry, helping advise and educate farmers and their staff, with various roles in the Ministry of Agriculture, Telford Rural Polytechnic, Farm Source and Ravensdown and am a member of the New Zealand Institute of Primary Industry Management (NZIPIM)

8 I am currently employed as a Senior Farm Environmental consultant and have been providing detailed reports of OVERSEER® modelling of proposals being submitted to Regional Councils in Southland, Otago and Canterbury for the last 5.5 years.

9 Although this is a Council hearing I note that in preparing my evidence I have reviewed the code of conduct for expert witnesses contained in part 5 of the consolidated Environment Court Practice Note 2011. I have complied with it in preparing my evidence. I confirm that the issues addressed in this statement of evidence are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

SCOPE OF EVIDENCE

10 My evidence provides:

10.1 OVERSEER® FM v6.3.1 modelling for the current farm system, averaged 2012-17 seasons, and the proposed farm system.

10.2 For the consent applications I modelled an initial proposal and a further two subsequent proposals; namely a proposed budget with an adjusted area (Proposed consent adj area) and a budget for the initial winter barn proposal (Proposed winter barn 2019). These were completed for Woldwide 4. For Worldwide 5 I completed a current season effluent extra 2014/15-17/18 season averaged, an initial proposal (Proposed consent extra effluent) and a budget for the proposed Woldwide 5 barn example farm system.

11 Overseer modelling:

11.1 OVERSEER® FM is an agricultural management tool which assists farmers and their advisers to assess nutrient use and movements within a farm to identify nutrient surpluses and deficits whilst seeking to optimise farming outcomes. The computer model calculates and estimates the nutrient flows in a productive farming system and identifies risk for environmental impacts through nutrient loss, including through both run off and leaching.

11.2 There are 4 main assumptions underpinning the use of OVERSEER® FM as a modelling tool. They are:

(a) Annual Average – model uses annual average inputs (e.g. averaged over a number of years), particularly with respect to climate inputs, and therefore produces annual average outputs.

(b) Near equilibrium conditions – model assumes that the farm is at a state where there is minimal change each year, particularly with respect to soil processes involving nutrient movement between soil pools.

(c) Actual and reasonable inputs –a practical tool which relies on input data easily obtainable and assumes that this data, including animal productivity, are correct.

(d) Good management practices– it models the management practices within the farm boundary as if they are at accepted industry good management practices

A fifth assumption is that with quasi equilibrium assumptions means that management or mitigation changes must also include changes in animal productivity.

11.3 OVERSEER® FM uses animal stocking rate and productivity to estimate animal requirements (MJME) which is then in turn used to estimate pasture production which in turn drives an important part of both the nitrogen and phosphorous cycle. It is an animal driven model, rather than a soil/pasture based one.

11.4 OVERSEER® FM modelling following on from above does not;

(a) consider transformations, attenuation or dilution of nutrients between the root zone or farm boundary and the eventual receiving water body.

(b) calculate outcomes from extreme events (floods and droughts) but provides a typical year's result based on a long-term average.

(c) represent the farm beyond the level of defined blocks. It models the sum of the blocks as the farm boundary (does not need to be spatially contiguous) and the bottom of the root zone.

(d) represent all farm systems across all environments within New Zealand. More calibration and/or validation is required for certain systems, and thus estimates of whole farm nutrient losses undertaken for those situations significantly beyond the calibration/validation range used to develop Overseer need to be considered extremely cautiously.

11.5 Give the above limitations, Overseer and the Fertiliser Industry has put in place the following to minimise the uncertainty;

(a) Development of nationally agreed protocols for model inputs, namely adhering to Best Practice Data Input standards (BPDIS).

(b) It is an expert use system which the outputs are dependent on many inputs that rely on expert judgement. The CNMA qualification is the industry quality assurance system for this and the budgets and reports have been completed by, reviewed both internally (Ravensdown) and externally (Environment Southland) by CNMA qualified persons.

(c) Certainty relies on consistency in modelling across all budgets (see above), and that the farm system modelled is within the model parameters. The soils, climate and farm systems are within the model's parameters reported (dairy farm system, 700mm to 1200 mm annual rainfall and pallic soils).

(d) Certainty also relies on ensuring a consistent approach, with blocking of the farm system consistent with land use, soils, topography and that the farm system is valid and transparent. A standard approach is used by the modeller to verify information (farm visit and records), block accordingly (BPDIS and review) and detail inputs and outputs to ensure farm system validity and transparency (Report and review).

10.6 Any 'work arounds' that have been developed specifically for these nutrient budgets have been discussed within the report. In addition, the farm outputs were reviewed against other outcomes of past work and reported results, with identified risks driving environmental losses highlighted for the farm system (report and peer reviews) and any mitigations used within the scenarios identified and explained for transparency.

MY INVOLVEMENT WITH WOLDWIDE4 & 5 FARM LTD

12 The initial request was from Tanya Copeland (Landpro) and Abe de Wolde on the 16th April 2018 to carry out a baseline Nutrient Budget and scenario budget for Woldwide 4 & 5. A contract was signed at the farm visit on May 8th, 2018.

WOLDWIDE4 LTD

13 The initial engagement was to collect the farm data for both properties. This included past fertiliser budgets; the Sheep unit budget, which was obtained from Fonterra and reviewed; and additional farm data collected. Supporting detail was drawn from summaries provided from the Woldwide consultant, Ivan Lines. The property modelling was split into the one key soil type (Braxton) for Woldwide 4 which was obtained from S Maps (Landcare) and reflected the drainage, water holding capacity, topography and soil type of the farm. Artificial drainage, effluent and non-effluent blocks plus minor holding paddocks (used for calf grazing given pastoral blocks but not primarily dairy cow grazing) reflected the main management blocks. My recommendation was to include the Gladfield support block within the budget as it was an integral feature where the dry cattle wintered, and where supplement was imported from onto the dairy platform. Also. the support block is comprised of the same soils and is located 3.34 km south west of the farm. Other blocks added included riparian areas and a block representing the non-productive areas of the farm. Climate settings were obtained from the Overseer climate station tool. The total GIS mapped area was 349.3 ha (including the 78.8 ha support block) and of this 337.5 ha was calculated to be effective area. The farms are modelled as entities in their own right, with any shared resource (e.g. supplement, slurry effluent and when young stock are on and off the property) being accounted for

13.1 The current system was based on stock numbers of 810 cows calved and 775 cows peak milked producing 410,452 kg Milk solids total, equating to 510 kg MS/cow or 1574 kg MS/total grazed ha. The overall stocking rate was 9,578 revised stock units (rsu.), equating to 27.4/total grazed ha or 2.3 cows/total grazed ha (Crawford M. , Woldwide 4 Current Farm system and Winter barn Proposal 163(a2v6.2.3), 2019). Replacement heifer numbers were 180. These heifers moved off-farm from weaning as R1 heifers until their second winter, when they were wintered on the Gladfield Support block, together with the dairy herd.

These wintered first calving heifers and cows were modelled to start milking from late July.

13.2 The farm system required 24 ha of crop, all grown on the Gladfield block. This was modelled as a two-year cropping rotation (third year as young grass) with averaged yields of 25 T DM/ha. The rest of the support block was cut and carried (12.2 T DM/ha or 480 T DM used, and 50 T DM stored) to the dairy block. A further 995 Tonnes (T) of Dry Matter (DM) in supplement were imported (grain, brewers distilled grain, molasses and PKE) and fed to the dairy cows through the milking shed and on the pastoral blocks, together with 223 T DM of purchased baleage and 30 T DM in stored silage also fed to the dairy cows on the pastoral blocks as well.

13.3 Fertiliser amounts were modelled from farmer comments on normal practice and past sales records. The total fertiliser nitrogen modelled averaged 195 kg N/ha/year, and the sales record for the past 3 years to the 16/17 season averaged at 212 kg N/ha/year (With spreader and weighbridge error plus paddock area error and variation, less than a 10 % variation is well acceptable)

PURCHASED SHEEP BLOCK (COCHRANS FARM)

14 A neighbouring sheep farm has been recently purchased and is proposed to be split between the Woldwide 4 (63.3 ha) and Woldwide 5 (73.0 ha) dairy farms. A completed budget, which I reviewed and amended, for this neighbouring property was obtained from C Duncan (Fonterra) and the inputs used were verified and/or amended by a phone call to the owner. The key soils on this property are Braxton (77 ha), Tuatapere (55.5 ha) and a smaller area of Upukeroroa (3.8 ha). The management blocks used in the modelling were flat dry land sheep with a fodder cop of swedes which rotated through the two key soil types.

14.1 The stocking in the system was based on 1550 ewes (65 kg Live weight (LW) at mating and lambing at 155 % survival to sale (STS), weaning 33 kg LW lambs. Replacement lambs (390) are kept entering the winter at 48 kg LW and are not mated with the remaining lambs sold at 19 kg carcass to works. There are also 20 breeding rams and a total of 12,000 kg wool/year is shorn (4.5 kg wool/rsu), The overall stock rate is 2,490 rsu, or 19.4 rsu/ha effective.

14.2 No supplements are imported, however 15 T DM of baleage is made and stored, with 8 T DM fed to sheep on the pastoral blocks and 7 T DM fed to sheep on the crops. A 9 ha swede crop is sown each year (14 T DM/ha).

14.3 Fertiliser was modelled as per the owner’s comments, with some areas receiving a urea application at varying rates each spring, this was deemed to average 60 kg/ha of Sustain N across all pastoral blocks.

WW4 COMBINED RESULTS OF CURRENT SYSTEMS (DAIRY AND SHEEP)

15

Current Farm System		Area	N loss	N loss/ha		P loss
Brax_4a.1 Effluent	Pastoral	25.6	991	38		12
Brax_4a.1 Eff Tile	Pastoral	36.1	1493	41		27
Brax_4a.1 Non Eff	Pastoral	120.8	3947	32		47
Brax_4a.1 Non Eff Tile	Pastoral	71.5	2342	32		37
Brax_4a.1 Non Eff Grzng	Pastoral	5.2	146	28		2
Brax_4a.1 Cut&Carry	Cut and Ca	40.8	204	5		7
Brax_4a.1 Past>FBt	Crop	12	426	35		7
Brax_4a.1 FBt>FBt	Crop	12	617	51		7
Brax_4a.1 FBt>Past	Crop	12	231	19		5
Brax_4a.1 RO	Pastoral	1.5	24	15		0
Riparian 1	Riparian	3.7	11			0
Non prod		8.1	428			165
			10860			318
Total		349.3	**10860**	**31.1**		316
Dairy platform effective	192.3	259.2	**8919**	**34.4**		125

Current Sheep Block							
Sheep Block		Area	N loss	P loss	WW4 adj	N loss	P loss
Sheep Block (Brax_4a.1)	Pastoral	72.8	667	30	38.5	353	16
Sheep Block (Tuap_6b.2)	Pastoral	55.5	758	6	23.5	321	3
Swedes	Fodder Cro	-	890	2		430	1
Sheep Block Upuk_8a.1	Pastoral	3.8	143	1		0	0
Non prod		4.2	45	18	1.3	14	6
Total		136.3	2503	56	63.3	1118	25
Total		136.3	2503	56	63.3	1118	25
Sum total blocks		136.3	2503	57	63.3	1118	25

Combined Situation			
	Area	**N loss**	**P loss**
Brax_4a.1 Effluent	**25.6**	**991**	**12**
Brax_4a.1 Eff Tile	**36.1**	**1493**	**27**
Brax_4a.1 Non Eff	**120.8**	**3947**	**47**
Brax_4a.1 Non Eff Tile	**110**	**2695**	**53**
Brax_4a.1 Non Eff Grzng	**5.2**	**146**	**2**
Brax_4a.1 Cut&Carry	**40.8**	**204**	**7**
Brax_4a.1 Past>FBt	**12**	**426**	**7**
Brax_4a.1 FBt>FBt	**12**	**617**	**7**
Brax_4a.1 FBt>Past	**12**	**231**	**5**
Tuap_6b.2 Non Eff	**23.5**	**321**	**3**
Brax_4a.1 RO	**1.5**	**24**	**0**
Riparian 1	**4.1**	**15.3**	**1.8**
Non prod	**9**	**437.7**	**169.2**
incl crop portion	**0**	**430**	**1**
Total	**412.6**	**11978**	**343**
Sum total blocks	**412.6**	**11978**	**341**

15.1 The above tables show how the combined losses are calculated, with the first two tables setting out the associated nitrogen and phosphorus losses for each of Worldwide 4 Farm and the Sheep Farm. I have then combined these in the third table. This shows how each block is changed (block detail) with the addition of land a total loss of 11,978 kg N/year or 29 kg N/ha/year and 343 kg P /year and 0.9 kg P/ha/year is achieved. The addition of each the losses into a combined loss to then compare the subsequent effect from a proposed change across all the land is an acceptable way to represent the sum change.

15.2 The results show a key driver of losses is the cropping blocks for both current systems (1274+430=1704 kg N/ha, including young grass phase equating to 14.4% of total losses from 8 % of the total area), as well as the higher productivity from both systems (higher stocking rates than average). Losses from other sources is the key risk to P loss (169 kg/year equating to 49 % of 343 kg/year total) followed by optimal P levels and fertiliser rate on heavy silt loam soils.

WW4 INITIAL PROPOSAL (PHASE 1)

16 The initial scenario asked for by Tanya Copland was for a transitional stage whereby the cow numbers were increased to the maximum specified (850) in existing resource consents, to account for the additional land.

16.1 The initial scenario I modelled involved swapping 18.6 ha of land with Woldwide 3 (WW3) through a re-alignment of paddocks. The applicant's planner had checked with Council staff if these paddocks could be transferred and following email advice, I was informed it was alright to do so. I did not in my initial report make an adjustment to the result. This was picked up by the review process. Regardless of this error this modelling had become superfluous as a subsequent decision was made to no longer swap land with WW3.

16.2 The transitional stage thus settled on increasing the platform by the 63.3 ha part parcel of Cochrans block as per point 13 (by adding 23.5 ha of Tuatapere soils as well as more Braxton), thereby giving a total area 412.6 ha with 399.5 ha effective.

16.3 The stock system modelled was based on 850 cows calved with 830 cows peak milked, producing 421,000 kg Milk solids equating to 507 kg milk solids/cow or 1,305 kg MS/total grazed. ha. The overall stocking rate was 10,096 rsu equating to 24.5 rsu/total grazed. ha or 2.1 cows/total grazed ha (Crawford M. , Woldwide 4 Current Farm system and Winter barn Proposal 163(a2v6.2.3), 2019). Replacement heifers (190) are grazed off-farm from weaning until they come back to winter on the support block as explained in 12.1. The dairy cows are also wintered on crop on the support block as set out in 12.1 above.

16.4 This modelled system still has a requirement for 24 ha of crop, all on the Gladfield block, modelled as a two-year cropping rotation (third year as young grass) with average yields of 25 T DM/ha. The rest of the support block was cut and carried to the dairy block (12.2 T DM/ha, 480 T DM used, and 50 T DM stored). A further 775 Tonnes (T) of Dry Matter (DM) in supplement were imported (grain, brewers distilled grain, molasses and PKE) to be fed to dairy cows through the milking shed and on the pastoral blocks with 30 T DM in stored silage fed to the dairy cows on the pastoral blocks as well. In this model there was no baleage purchased as more pasture was available.

16.5 The fertiliser amounts modelled were reduced to total fertiliser nitrogen modelled averaged at 176 kg N/ha/year. This was due to the lowered pastoral productivity and with a lower application across the effluent area due to the greater amount of nutrients from effluent to the same area.

16.6 Key differences between the two systems are;

(a) Fertiliser use

Tables 1:

Fertiliser use (kg/ha/year)	Current System	Initial Proposed (Consent) System.
Effluent	Total N applied 169 kg.	Total N applied 137 kg.
Non-Effluent	Total N applied 222 kg.	Total N applied 194 kg.
Fodder Crop	same	same
Support block	same	same
Annual N use (kg N/ha)	195	176

(b) Supplement use

Supplement use	Current System	Proposed (Consent) System.
Pastoral	1248 T DM in total imported or 4,815 effective platform. Note also 395 T DM silage is made on the support block and fed out on dairy pastoral blocks including 30 T DM from storage included in above imported figure.	805 T DM in total imported or 2,660 effective platform. Note also 395 T DM silage is made on the support block and fed out on dairy pastoral blocks including 30 T DM from storage included in above imported figure
Fodder Crop	same	same

(c) Wintering system and pasture production

Wintering System	Current System	Proposed (Consent) System.
Pastoral	The dairy cows are on farm platform on Gladfield support block on crop plus in calf heifers wintered on Gladfield support block	The dairy cows are on farm on Gladfield support block on crop plus in calf heifers wintered on support block
Fodder Crop	same	same
Pasture Production (kg DM/ha/year) *	15456	14462 (reduced due to lower stocking over greater areas as described below.
Productivity: Stocking SU/ha	9,578 s.u* equivalent to 28.4 s.u/ha effective or 3.1 cows/ha milking platform (27.4 s.u/ha total or 2.3 cows/ha total)	10,096 s.u* equivalent to 31.4 s.u/ha effective or 2.8 cows/ha milking platform (24.5 s.u/ha total or 2.1 cows/ha total)
Milk solid sold (kg/ha effective)	1,583/ha effective milking platform (1,574/ha total grazed)	1,417/ha effective platform (1,305/ha total grazed)

* Estimated by OVERSEER FM®

(d) Effluent System

Effluent System	Current System	Proposed (Consent) System.
Modelled input	Holding Pond system after stone trap and applied via K Line pods. Application depth at < 10 mm per application (modelled < 12 mm) from August to May (spray infrequently as not modelling June or July to receive effluent 119 kg N/ha/year liquid over 57 ha (61.7 @ 92%)	Same system, over the same area, however with greater numbers of cows the volume has increased leading to the higher figure below; 124 kg N/ha/year liquid over 57 ha (61.7 ha@92%)

* Estimated by OVERSEER FM®

16.7 All soil information, climate and topography are the same between the two different scenarios

Table 2: The outputs generated by OVERSEER FM® for the two systems

System type	Current System (combined)	Proposed (Consent) System.
Nitrogen leaching loss to water (kg N/ha) Total N lost kg/farm (before wetland removal)	29 11,978	28 11,898(0.7% reduction)
Nitrogen Conversion efficiency % (N in products/N inputs) *	28	28
Phosphorus run off to water (kg P/ha) Total P lost kg/farm	0.8 343	0.8 349(1.7% increase)

* Dairy farm only

16.8 The Nitrogen loss is maintained with the proposed scenario when compared to the current system, a similar level from 29 kg N/ha/year (11,978/412.6=29.0) to 29 kg /N/ha/year rounded (11,898/412.6=28.8). This is largely due to the decreased pastoral productivity and reduced risk of urine patch losses.

16.9 The Phosphorus loss from run off is maintained at 0.8 kg P/ha/year, reflecting a similar level of P loss risk between the two systems.

16.10 Nitrogen efficiency is the same at 28 % from both systems, reflecting little change in risk from the various Nitrogen sources/inputs into the farm system.

16.11 The proposed system is being managed less intensively when comparing the amount of product sold per ha and the amount of pasture required supporting each venture (Table 1c). The risks associated with both farming systems arise from the cropping programme, the high animal productivity and artificial drainage systems.

WW4 FINAL PROPOSAL (WINTER BARN)

17 The winter barn proposal poses its own issues such as creating a representative farm system and all its associated farm inputs, and so, in my opinion, the most accurate solution was to model the current farm system and model the winter barn structure with the current farm system's detail and relevant model data. As I noted in my report ((Crawford M. , Woldwide 4 Current Farm system and Winter barn Proposal 163(a2v6.2.3), 2019), the situation for Woldwide 4, in my opinion, would be an exemplar for a good deal of Southland dairy farms. Subsequent to modelling this, a further request from the applicant's planner was made to consider and apply further mitigations (Crawford M. , 2019)(see last section in table paragraph 18) for both N and P to reduced their losses further to below a threshold that was considered necessary to show a reduced impact upon the receiving environment.

17.1 The winter barn stocking system (Final barn consent) is based on 1032 cows calved, with 1000 cows peak milked, producing 570,000 kg Milk solids equating to 570 kg milk solids/cow or 1708 kg MS/effective. ha. The overall stocking rate was 12,570 rsu. equating to 30.5 rsu/total grazed. ha or 2.5 cows/total grazed. ha A total of 260 replacement heifers are grazed off-farm from weaning until they come back to winter in the barn. Neither the heifers nor the dairy cows are now wintered on crop.

17.2 This proposed system models a covered wintering barn to be used as both a winter feed pad (24 hours) and as a feeding stand-off area for milking cows when conditions dictate. It is required by Overseer modelling to be modelled separately for each class of stock which uses the facility, namely the wintered cows (Dry cattle), replacement heifers and milking cows, to direct differing amounts of feed plus the amount of time within the barn to each stock class. It is based on an unlined concrete and rubber bedding surface and a concrete feeding apron. Effluent material would be scrapped into an effluent holding facility which can then be taken and spread via a slurry tanker on-farm. The materials nutrient concentration was measured differently to Overseer defaults and I used the same effluent nutrient concentrations as for WW1 and WW2. The effluent was modelled as exported and then re-imported as organic dairy effluent fertiliser.

17.3 Cattle numbers in the barn were initially modelled as per the table below but were altered in response to the further mitigation request and are shown below.

Initial Model Herd		Apr	May	Jun	Jul	Aug
Milking herd	% of cows		100	100	100	100
	Hours/ day grazing		10	0	0	10
Dry cows	% of cows			100	100	99
	Hours/ day grazing			0	0	0

Final Model; Herd		Apr	May	Jun	Jul	Aug
Milking herd	% of cows	50	100	100	100	100
	Hours/ day grazing	10	10	0	0	10
Dry cows	% of cows			100	100	99*
	Hours/ day grazing			0	0	0
Repl. In calf Heifers	% of cows		99*	100	100	100
	Hours/ day grazing		0	0	0	0

* Note the Overseer limitation where it requires animal enterprise to be grazing a pastoral block

17.4 There was no crop required given the winter barn, with 1374 Tonnes (T) of Dry Matter (DM) in supplement imported (grain, molasses and PKE) being fed to dairy cows in the barn milking shed and pastoral blocks, with 1280 T DM silage and baleage made from the support block and fed into the barn and pastoral blocks. No supplement are made on the milking platform. With additional mitigations as noted in 16.3 above in the final example and with more cattle in the barn, the final figures used were; 1514 T DM supplement imported (grain, PKE and molasses), with 1280 T DM silage and baleage made from the support block and a further 115 T DM silage purchased and fed into the barn to the heifers.

17.5 The fertiliser amounts modelled were reduced and adjusted for the addition of the barn slurry giving an averaged total fertiliser nitrogen modelled of 216 kg N/ha/year (initial) and 205 kg N/ha/year (final). This was also possible because of the altered pastoral productivity from the proposal, especially on the Gladfield support block, and the adjustments after effluent and barn slurry is applied to the various blocks. There was also lower application rates accordingly due to the greater amount of nutrients from the effluent being applied to the same area (see Crawford Report)

17.6 Key differences between the two systems (Current and Final Winter Barn)

(a) Table 1: Fertiliser use

Fertiliser use (kg/ha/year)	Current System	Proposed Final Winter Barn System.
Effluent	Total N applied 169 kg.	Total N applied (varying) 171 to 194 kg.
Non-Effluent	Total N applied 222 kg.	Total N applied (varying) 176 to 279 kg.
Fodder Crop	Total N applied 94 kg.	n/a
Support block	Total N applied 219 kg.	Total N applied 172 kg.
Annual N use (kg N/ha)	195	205

(b) Supplement use

Supplement use	Current System	Proposed (Winter Barn Final) System.
Pastoral	1248 T DM in total imported or 4,815 kgDM/ effective platform. Note also 395 T DM silage is made on the support block and fed out on dairy pastoral blocks including 30 T DM from storage included in above imported figure.	2,869 T DM in total or 8,582 kgDM/ effective platform. Note also 1,280 T DM silage is made on the support block and fed out on dairy pastoral blocks and wintering barn, included in above imported figure
Fodder Crop	115 T DM baleage fed on crop	Nil

(c) Wintering system and pasture production

Wintering System	Current System	Proposed (Winter Barn Final) System.
Pastoral	Dairy cows on farm platform on Gladfield support block on crop plus in calf heifers wintered on Gladfield support block	All stock in winter barns and off pasture
Fodder Crop	Used for wintering	n/a
Pasture Production (kg DM/ha/year) *	15456	16001
Productivity: Stocking SU/ha Milk solid sold (kg/ha effective)	9,578 s.u* equating to 28.4 s.u/ha effective or 3.1 cows/ha effective platform (27.4 s.u/ha total or 2.3 cows/ha total) 1,583/ha effective platform (1,574/ha total grazed)	12,570 s.u* equating to 31.5 s.u/ha effective or 3.1 cows/ha effective platform (30.5 s.u/ha total or 2.5 cows/ha total) 1,774/ha effective platform (1,775/ha total farm)

* Estimated by OVERSEER®

(d) Effluent System

Effluent System	Current System	Proposed (Winter Barn Final) System.
Modelled input	Holding Pond system after stone trap and applied via K Line pods. Application depth at < 10 mm per application (modelled < 12 mm) from August to May (spray infrequently as not modelling June or July to receive effluent 119 kg N/ha/year liquid over 57 ha (61.7 @ 92%)	Same system, over a greater area, however with greater numbers of cows the volume has increased leading to the higher figure below, the variation due to the differing volumes applied to tiled and non-tiled blocks. Note the barn has a separate system for its effluent 136 and 91 kg N/ha/year liquid over 78 ha (84.8 @ 92%)

* Estimated by OVERSEER®

17.7 All soil information, climate and topography are the same between the two different scenarios.

Table 2: The outputs generated by OVERSEER® for the two systems

System type	Current System (combined)	Proposed (Winter barn final) System.
Nitrogen leaching loss to water (kg N/ha) Total N lost kg/farm (before wetland removal)	29 11,978	24 (18.8 % decrease) 9,727
Nitrogen Conversion efficiency % (N in products/N inputs)	28	48
Phosphorus run off to water (kg P/ha) Total P lost kg/farm Recalculated P lost (kgP/year/farm)	0.8 343	0.9 (recalculated to 0.8) 371 (8.2 % increase) 342 (0.3 % decrease)

* The Recalculation is explained in the last section in table in paragraph 19 plus 25 and 26

Calculations obtained from (Crawford M. , 2019).

17.8 The Nitrogen loss is decreased with the proposed winter barn scenario when compared to the current system, decreasing from 29 kg N/ha/year to 24 kg /N/ha/year. This is largely due to the addition of the winter barn and no intensive winter grazing on crop.

17.9 The Phosphorus loss from run off is increased to 0.9 kg P/ha/year, reflecting an increased level of P loss risk between the two systems. The further mitigations reduced this loss to 0.8, a similar level of associated risk of P loss.

17.10 Nitrogen efficiency is increased from 28 % to 48 % reflecting the better productivity gained from the nitrogen inputs into the farm system and from the feeding efficiency within the winter barn.

17.11 The proposed system is being managed more intensively when comparing the amount of product sold per ha and the amount of pasture required supporting each venture (Table 1c). However, this is being largely mitigated by the use of a wintering barn and the increased supplement use whilst the stock are in the barn. The risks associated with both farming systems relate to the physical features of the farm, being the artificial drainage systems and the free draining soil, which have a severe rating for nutrient leaching.

18 A summary of the mitigations that are contained in the Winter barn scenario and how they relate to reducing losses are set out below.

	Mitigations modelled:	**Reason/Rationale:**	**Effect:**
Winter Barn Farm System	Effluent mitigations (disposal area increased and targeted applications)	Ensure effluent only applied to appropriate areas and spread as widely as possible, with Nitrogen applications taking into account the additional effluent nutrients.	Increase effluent area by 23.1 ha ensuring this is not within the tiled area. Increase Nitrogen applications over October - January period on effluent spray blocks and annually apply the imported slurry to Braxton non effluent area, meaning reduced additional fertiliser will be required for this block. The Cut and Carry block have two applications of the winter barn slurry. This in effect returns nutrients to the block where they are being taken from.
	Alter cropping regime with the Winter Barn	With the winter barn, no crop area is required.	No crop area over winter reduces Nitrogen losses in cut and carry block from 1,542 to 449 kg N/ha, plus the risk of P losses is also reduced from overland flow from exposed soils with no vegetation cover.
	Winter Barn	With the additional milking cows, the use of the barn over May and August gives the farm system an ability to reduce risk of pugging to pastures over spring and at autumn as required.	Using the barn removes the cattle from the paddocks thereby reducing the risk of pugging which reduces infiltration of soils and increases overland flow of nutrients. Also nutrients are held and spread onto soil by effluent applications when pastures more able to receive the nutrients and thus lowers the associated risk of losses.
	Supplementary feed	Additional feed is able to be used for the extended lactation and for the wintering of cattle, with an ability to lower losses and ensure higher utilisation	Higher amounts of grain and PKE provide for a reduction in pastoral productivity further. With a lower pastoral productivity and higher supplement use overall N losses will reduce.

19 The additional mitigations that further reduced the N and P losses are contained in the Further clarifications and P mitigation requests of Scenario report as explained in point 16. This is summarised in the table below;

	Mitigations modelled:	**Reason/Rationale:**	**Effect:**
Winter Barn Farm System Additional N & P mitigations	Effluent mitigations (targeted applications)	Ensure effluent only applied to appropriate areas and spread as widely as possible, with Nitrogen applications taking into account the additional effluent nutrients Target imported slurry to the more appropriate soil (Tuatapere), and reduce organic effluent on Braxton soils, together with adjusting the amounts of nutrients being applied on tiled areas.	Tiled areas and Braxton soils have higher P losses given the higher risk of overland flow. By targeting slurry at the appropriate soil this will reduce the risk of P loss and by timing fertiliser applications more appropriately N and P losses can be slightly reduced further. The Cut and Carry block is an area where increased slurry applications can occur, thereby returning nutrients to the block where the nutrients are being taken from.
	Winter Barn	Increase the utilisation of the barn, by wintering more cattle within it, this includes the replacement heifers. Also increase utilisation of the barn by using it over the shoulders of the season more with milking cows (April).	Using the barn removes the cattle from the paddocks thereby reducing the risk of pugging. This reduces infiltration of soils and increases overland flow of nutrients. Also nutrients are held and spread onto soil by effluent applications when pastures are more able to receive the nutrients and thus lowers the associated risk of losses, especially at the high risk time in autumn for this environment.
	Supplementary feed	Additional feed is able to be used for the extended lactation and for the wintering of cattle, with an ability to lower losses and ensure higher utilisation	Higher amounts of grain and PKE provide for a further reduction in pastoral productivity. With a lower pastoral productivity and higher supplement use overall N losses will reduce.
	Re construct lane ways, fence 4 Critical Source Areas (CSA's)*	Other source of P loss is key influence on on farm P loss and is not modelled well in Overseer The farmer and I have identified some areas where these losses could be reduced and calculated these losses as a means to show the added benefits of further identified P mitigations.	Such mitigations will have positive effects by reducing risk of overland flow, or slowing overland flows to water ways and lowering losses from other sources within the farm boundary

Please note calculations are obtained in Report titled, Crawford, M. (2019). *Further clarifications and P mitigation requests of Scenario reports.* Ravesndown.

WOLDWIDE 5 LTD

20 The initial engagement was as per description in Woldwide 4 point 12. The property modelling was split into the three key soil types (Braxton, Tuatapere and Upukeroroa) for Woldwide 5 which was obtained from S Maps (Landcare) and reflected the drainage, water holding capacity, topography and soil type of the farm. Artificial drainage, effluent and non-effluent blocks plus developing and cropped paddocks (Upukeroroa) reflected the main management blocks. A key decision made was to include the Collies block, a consented block of land which was surrounded by WW5 but not yet being grazed by the dairy herd (yet converted). This was raised at the very first meeting I attended, and a decision was sought from Environment Southland by Tanya Copland. In modelling this situation, one modelled the current system and then pro-rated the additional area, as agreed by the regulatory authority. Other blocks added included riparian areas and a block representing the non-productive areas of the farm. Climate settings were obtained from the Overseer climate station tool. The total GIS mapped area was 262.6 ha (including the 44.3 ha consented block) and of this 241.2 ha was calculated to be effective area. The farms are modelled as entities in their own right, with any shared resource (e.g. supplement, WW3 effluent and when young stock are on and off the property) being accounted for.

20.1 The current system was based on stock numbers of 680 cows calved and 665 cows peak milked producing 314,081 kg Milk solids total, equating to 465 kg MS/cow or 1513 kg MS/total grazed ha. The overall stocking rate was 7,841 revised stock units (rsu.) or 32.5/effective. ha or 2.8 cows/effective ha (Crawford M. , Woldwide 5 Current and Proposed System Nutrient Budgets 164(a2)v6.3.2, 2019). Replacement heifer numbers were 170. These heifers moved off farm from weaning as R1 heifers until their second winter, when they were wintered on the developing Upukeroroa block, together with the dairy herd. These wintered first calving heifers and cows wee modelled to start milking from late July. Note that during the past two years of this recently converted dairy farm, it has wintered additional cattle other than the WW5 dairy cows and heifers in these recent years of conversion, leading to an additional 200 dairy grazers wintered on the crop area.

20.2 The farm system required 28.1 ha of crop, all grown on the Upukeroroa block. This was modelled as a three-year cropping rotation (third or fourth year as young grass) with averaged yields of 25 T DM/ha. A further 772 Tonnes (T) of Dry Matter (DM) in supplement were imported (grain, brewers distilled grain, molasses and PKE) and fed to the dairy cows through the milking shed, together with 380 T DM of silage purchased and fed on pastoral blocks, which includes 80 T DM which should be fed on crop, but given the model would not report with this additional feed, was fed on pastoral blocks also.

20.3 Fertiliser amounts were modelled from farmer comments on normal practice and past sales records and follow a similar pattern as Woldwide 4 applications. The total fertiliser nitrogen modelled averaged 172 kg N/ha/year, and the sales record for the past 2 years to the 16/17 season averaged at 175 kg N/ha/year. It has to be noted that a further directive was to model an additional effluent application from WW3, which is explained in page 11 of the Crawford report (Crawford M. , Woldwide 5 Current and Proposed System Nutrient Budgets 164(a2)v6.3.2, 2019), and reduces the fertiliser N for 172 to 153 (a modelled variation from actual)

PURCHASED SHEEP BLOCK (COCHRANS FARM)

21 Please refer to points 13 to 13.3 for explanation. The key point here is that the Upukeroroa soils are only added to the WW5 block, and are not added to the WW4.

COMBINED RESULTS OF CURRENT SYSTEMS (DAIRY AND SHEEP)

22

Current Scenario WW5	effIntadj	Area	N loss	P loss	Sheep Block		Area	N loss	P loss	WW5 adj	N loss	P loss
Brax_4a.1 Effluent	Pastoral	18.4	614	6	Sheep Block (Brax_4a.1)	Pastoral	72.8	667	30	34.3	314	14
Brax_4a.1 Eff Tile	Pastoral	52.5	1808	32	Sheep Block (Tuap_6b.2)	Pastoral	55.5	758	6	32	437	3
Tuap_6b.2 Effluent	Pastoral	59.2	3542	9	Swedes	Fodder Cr	-	890	2		460	1
Brax_4a.1 Non Eff	Pastoral	2.4	75	1	Sheep Block Upuk_8a.1	Pastoral	3.8	143	1		143	1
Tuap_6b.2 Non Eff	Pastoral	69.7	3983	9	Non prod		4.2	45	18	2.9	31	12
Upuk_8a.1 Non Eff	Pastoral	4.3	540	2	Total		136.3	2503	56	73	1385.3	31.6
Upuk_8a.1 Non Eff dev	Pastoral	1.1	138	0								
Riparian 1	Riparian	12.9	39	1								
Upuk_8a.1 FBt>FBt	Crop	22.3	2460	17								
Upuk_8a.1 Past>FBt	Crop	5.8	725	4								
Upuk_8a.1 FBt>YG	Crop	5.5	579	3								
Non prod		8.5	359	127								
Total		262.6	14862	211	Total		136.3	2503	56	73	1385	32
Sum total blocks		262.6	14862	211	Sum total blocks		136.3	2503	57	73	1385	32

Combined Situation				
		Area	**N loss**	**P loss**
Brax_4a.1 Effluent		**18.4**	**614**	**6**
Brax_4a.1 Eff Tile		**52.5**	**1808**	**32**
Tuap_6b.2 Effluent		**59.2**	**3542**	**9**
Brax_4a.1 Non Eff		**36.7**	**651**	**16**
Tuap_6b.2 Non Eff		**101.7**	**4618**	**13**
Upuk_8a.1 Non Eff		**8.1**	**683**	**3**
Upuk_8a.1 Non Eff dev		**1.1**	**138**	**0**
Riparian 1		**12.9**	**39**	**1**
Upuk_8a.1 FBt>FBt		**22.3**	**2460**	**17**
Upuk_8a.1 Past>FBt		**5.8**	**725**	**4**
Upuk_8a.1 FBt>YG		**5.5**	**579**	**3**
Non prod		**11.4**	**390**	**139**
incl crop portion			**460**	**1**
Total		**335.6**	**16247**	**243**
Sum total blocks		**335.6**	**16247**	**243**

22.1 The above tables show how the combined losses are calculated, with the first two tables setting out the associated nitrogen and phosphorus losses for each of Worldwide5 Farm and the Sheep Farm. I have then combined these in the third table. This shows how each block is changed (block detail) with the addition of land a loss of 16,247 kg N/year or 48 kg N/ha/year and 243 kg P /year and 0.7 kg P/ha/year. The addition of each of the losses into a combined loss to then compare the subsequent effect from a proposed change across all the land is an acceptable way to represent the sum change.

22.2 The results show a key driver of losses is the cropping blocks for both current systems (3,356+460=3,816 kg N/ha including young grass phase equating to 23.5 % of total losses from 10.7 % of the total area), as well as the higher productivity from both systems (higher stocking rates than average). In addition, the well-drained Upukeroroa soil increases the risk of N loss as can be seen from the table below;

Current System Soil type and Management Block	Loss indices	WW4	WW5	Sheep Farm
Braxton Non effluent pasture or sheep pasture	N loss (kg N/ha/year)	33	31	9
	P loss (kg P/ha/year)	0.4	0.4	0.4
Upukeroroa Non effluent pasture or sheep pasture	N loss (kg N/ha/year)	n/a	126	38
	P loss (kg P/ha/year)	n/a	0.5	0.3

22.3 Losses from other sources is the key risk to P loss (139 kg/year equating to 57 % of 243 kg/year total) followed by optimal P levels and effluent applications plus fertiliser rate on heavy silt loam soils.

INITIAL PROPOSAL (PHASE 1)

22.4 The initial scenario asked for by Tanya Copland was for a transitional stage whereby the cow numbers were increased, to account for the additional land from the Cochran's Block (73 ha). The transitional stage thus added 34.3 ha of Braxton soils and 32.0 ha of Tuatapere soils as well as 3.8 ha of Upukeroroa soils and non-productive area of 2.9 ha, thereby giving a total area 335.6 ha with 311.3 ha effective.

22.5 The stocking system modelled was based on a slight reduced number of 780 cows calved with 770 cows peak milked, producing 354,000 kg Milk solids equating to 454 kg milk solids/cow or 1,137 kg MS/effective. ha. The overall stocking rate was 8,594 rsu equating to 27.6 rsu/effective ha or 2.6 cows/effective ha (Crawford M. , Woldwide 5 Current and Proposed System Nutrient Budgets 164(a2)v6.3.2, 2019). Replacement heifers (190) are grazed off farm from weaning until they come back to winter on the crop block together with the dairy herd as set out in 19.1 above.

22.6 The modelled system has a reduced requirement for 23 ha of crop due to no longer wintering additional cattle. A key decision made by the modeller was to crop on the more resilient soils to N loss, these being the Tuatapere and Braxton soils on the two additional blocks (Cochran's and Collie's) rather than the original dairy platform. It was modelled as a two-year cropping rotation (third year as young grass) with averaged yields of 25 T DM/ha.

A work around in modelling, detailing different crops and % crop grazed between milking cows and dry cattle was noted on page 23 of the Report (Crawford M. , Woldwide 5 Current and Proposed System Nutrient Budgets 164(a2)v6.3.2, 2019) A further 691 Tonnes (T) of Dry Matter (DM) in supplement were imported (grain, brewers distilled grain, molasses and PKE) to be fed to dairy cows through the milking shed, with a further 85 T DM of baleage purchased and fed either on the wintering/calving pad (65 T DM) or fed on crop (20 T DM). A further 100 T DM Cereal silage (Lower N feed) was fed to dairy cows on pastoral blocks in spring and autumn as an additional mitigation.

22.7 A further mitigation was modelled, with the three wintering pad structures used by the previous owner, would now be used over autumn and calving to reduce N loss. I have modelled these as uncovered wintering pads, with ad lib baleage feeding being fed in ring feeders. In this scenario the effluent is not stored and is spread by a muck spreader in October once the cows have left the pads. I have modelled the stock numbers as an estimated 100 cows (25 % April and September, 50 % May and August) over the shoulders of the season.

22.8 The fertiliser amounts modelled were similar, with the averaged total fertiliser nitrogen modelled as 164 kg N/ha/year (includes WW3 effluent), with the WW3 effluent plus farm effluent being spread across a greater area, and the sensitive Upukeroroa soils being targeted with slightly less fertiliser.

22.9 Key differences between the two systems are;

(a) Fertiliser use

Tables 1:

Fertiliser use (kg/ha/year)	Current System	Initial Proposed (Consent) System.
Effluent	Total N applied 192 kg.	Total N applied 174 kg.
Non-Effluent	Total N applied 219 kg.	Total N applied 206 kg.
Fodder Crop	same	same
WW3 effluent	14-10-8-3 (NPKS rating)	11-8-7-3 (NPKS rating)
Annual N use (kg N/ha)	172	164

(b) Supplement use

Supplement use	Current System	Proposed (Consent) System.
Pastoral	1,152 T DM in total or 4,776 kg DM per effective ha. 772 T DM plus 380 T DM silage	876 T DM in total or 2,815 kg DM per effective ha. 691 T DM plus 185 T DM cereal silage and baleage
Fodder Crop	Nil (work around, fed to dry cattle on pasture)	20 T DM to crop

(c) Wintering system and pasture production

Wintering System	Current System	Proposed (Consent) System.
Pastoral	The dairy cows are on farm on developing Upukeroroa soils on crop plus in calf heifers wintered on crop block also and additional dairy grazers	The dairy cows are on farm on Tuatapere and Braxton soils on crop plus in calf heifers wintered on crop block also with a winter feed pad available for milking cows spring and autumns
Fodder Crop	Used for wintering	Used for wintering
Pasture Production (kg DM/ha/year) *	15680	15247
Productivity: Stocking SU/ha Milk solid sold (kg/ha effective)	7,841 s.u* equating to 32.5 s.u/ha effective or 2.8 cows/ha effective 1,302/ha effective platform (1,513/ha total grazed)	8,594 s.u* equating to 27.6 s.u/ha effective or 2.6 cows/ha effective 1,137/ha effective platform (1,300/ha total grazed)

* Estimated by OVERSEER FM®

(d) Effluent System

Effluent System	Current System	Proposed (Consent) System.
Modelled input	Holding tanks system after stone trap and sump, then applied via K Line pods. Application depth at < 10 mm per application (modelled < 12 mm) from August to May (spray infrequently as not modelling June or July to receive effluent 46 kg N/ha/year liquid plus 11 kg N/ha/year sludge over 112 ha (130.1 @ 86%)	Same system, over the same area, however with greater numbers of cows the volume has increased leading to the higher figure below, 56 kg N/ha/year liquid plus 12 kg N/ha/year sludge over 107 ha (130.1 @ 86% less crop area 5 ha)

* Estimated by OVERSEER FM®

22.10 All soil information, climate and topography are the same between the two different scenarios

Table 2: The outputs generated by OVERSEER FM® for the two systems

System type	Current System (combined)	Proposed (Consent) System.
Nitrogen leaching loss to water (kg N/ha) Total N lost kg/farm (before wetland removal)	48 16,247	48 16,047 (1.2% decrease)
Nitrogen Conversion efficiency % (N in products/N inputs) *	27	27
Phosphorus run off to water (kg P/ha) Total P lost kg/farm	0.7 243	0.7 233(4% reduction)

* Dairy farm only

22.11 The Nitrogen loss is similar with the proposed scenario when compared to the current system, remaining at 48 kg N/ha/year (minor total decrease of 200 kg N/year divided by 335.6 ha is 0.6 kg N/ha/year). This is largely due to the added productivity increases on the additional land with associated increased risk of urine patch losses which are not fully mitigated by the mitigations used.

22.12 The Phosphorus loss from run off is maintained at 0.7 kg P/ha/year, reflecting a similar level of P loss risk between the two systems, with a slight reduction in total P loss/year of 10 kg or a 4 % reduction.

22.13 Nitrogen efficiency is the same at 27 % from both systems, reflecting little change in risk from the various Nitrogen sources/inputs into the farm system.

22.14 The proposed system is being managed less intensively when comparing the amount of product sold per ha and similar intensity when comparing the amount of pasture required supporting each venture (Table 1c). The risks associated with both farming systems arise from the cropping programme, the high animal productivity and artificial drainage systems, plus the sensitive Upukeroroa soils.

FINAL PROPOSAL (WINTER BARN)

23 After the initial modelling, reports and reviews, a further request was made by the applicant’s planner to model a third scenario for the business, which was to primarily winter indoors. This proposed system is the subject of this consent application. Specifically, it was requested by Environment Southland to model a winter barn example, but this poses its own issues as pointed out in point 16, and so the most accurate solution was to model the current farm system and model the winter barn structure with these set of inputs. As noted in the report (Crawford M. , Woldwide 5 Current and Proposed System Nutrient Budgets 164(a2)v6.3.2, 2019), the situation for both Woldwide farms would, in my opinion, be an exemplar for a good deal of Southland dairy farms. Subsequent to modelling this, a further request from the applicant’s planner was made to consider and apply further mitigations for both N and P to reduce their losses further to below a threshold that was considered as necessary to show a reduced impact upon the receiving environment.

23.1 The winter barn stocking system (Final barn consent) is based on 960 cows calved, with 930 cows peak milked, producing 535,000 kg Milk solids equating to 575 kg milk solids/cow or 1719 kg MS/effective. ha. The overall stocking rate was 11,510 rsu, equating to 36.9 rsu/effective. ha or 3.1 cows/effective Ha. A total of 248 replacement heifers are grazed off farm from weaning until they come back to winter in the barn. Neither the heifers nor the dairy cows are wintered on crop as explained in 16.1.

23.2 The proposed system models a covered wintering barn to be used as both a winter feed pad (24 hours) and as a feeding stand-off area for milking cows when conditions dictate. It is required by Overseer modelling to be modelled separately for each class of stock which uses the facility, as per point 16.2, namely the wintered cows (Dry cattle), replacement heifers and milking cows. It is based on an unlined concrete and rubber bedding surface and a concrete feeding apron. Effluent material would be scrapped into an effluent holding facility which can then be taken and spread via a slurry tanker on farm The materials nutrient concentration was measured differently to Overseer defaults and I used the same effluent nutrient concentrations as for WW1 and WW2 and also WW4. Thus, the effluent was modelled as exported and then re imported as organic dairy effluent fertiliser.

23.3 Cattle numbers in the barn were initially modelled as per the table below, but were altered in response to the further request, and are shown below.

Initial Model Herd		Apr	May	Jun	Jul	Aug
Milking herd	% of cows		100	100	100	100
	Hours/ day grazing		10	0	0	10
Dry cows	% of cows			100	100	99
	Hours/ day grazing			0	0	0

Final Model; Herd		Apr	May	Jun	Jul	Aug
Milking herd	% of cows	50	100	100	100	100
	Hours/ day grazing	10	10	0	0	10
Dry cows	% of cows			100	100	99*
	Hours/ day grazing			0	0	0
Repl. In calf Heifers	% of cows		99*	100	100	100
	Hours/ day grazing		0	0	0	0

* Note the Overseer limitation where it requires animal enterprise to be grazing a pastoral block

23.4 There was no crop required given the winter barn, with 1274 Tonnes (T) of Dry Matter (DM) in supplement imported (grain, molasses and PKE) being to be fed to dairy cows in both the barn, milking shed and pastoral blocks, with 1250 T DM silage and baleage made from the support blocks and fed into the barn and pastoral blocks. No supplement are made on the milking platform. With additional mitigations as noted in 16.3 and 21.3 above in the final example and with more cattle in the barn, a further 105 T DM silage was purchased and fed into the barn to the heifers.

23.5 The fertiliser amounts modelled were reduced and adjusted for the addition of the barn slurry giving an averaged total fertiliser nitrogen modelled of 194 kg N/ha/year (final). This was also possible because of the altered pastoral productivity from the proposal, and the adjustments after effluent and barn slurry is applied to the various blocks. There was also lower application rates accordingly due to the greater amount of nutrients from the effluent being applied to the same area (see Crawford Report)

23.6 Key differences between the two systems (Current and Final Winter Barn)

(a) Table 1: Fertiliser use

Fertiliser use (kg/ha/year)	Current System	Proposed Final Winter Barn System.
Effluent	Total N applied 192 kg.	Total N applied 121 to 201 kg.
Non-Effluent	Total N applied 219 kg.	Total N applied 169 (Upukeroroa) & 190 to 202 kg.
Fodder Crop	same	n/a
WW3 Effluent	14-10-8-3 (NPKS rating)	32-13-19-17 and 18-12-11-4 (NPKS rating)
Annual N use (kg N/ha)	172	161 (plus 58)

(b) Supplement use

Supplement use	Current System	Proposed (Winter Barn Final) System.
Pastoral	1,152 T DM in total or 4,776 kg DM per effective platform ha. 772 T DM plus 380 T DM silage	2,629 T DM in total or 8,445 kg DM per effective platform ha. Note also 1,355 T DM silage is made on the support blocks and fed out on dairy pastoral blocks and wintering barn, included in above imported figure
Fodder Crop	Nil (work around, fed to dry cattle on pasture)	n/a (Nil)l

(c) Wintering system and pasture production

Wintering System	Current System	Proposed (Winter Barn Final) System.
Pastoral	All dairy cows on farm platform on developing Upukeroroa soils on crop plus in calf heifers wintered on crop block also and additional dairy grazers	All stock in winter barns and off pasture
Fodder Crop	same	n/a
Pasture Production (kg DM/ha/year) *	15680	16044
Productivity: Stocking SU/ha Milk solid sold (kg/ha effective)	7,841 s.u* equating to 32.5 s.u/ha effective or 2.8 cows/ha platform (3.3 cows/total ha grazed) 1,302/ha effective platform (1,513/ha total grazed	11,510 s.u* equating to 36.9 su/ha effective or 3.1 cows/ha platform (34.3 s.u/ha total or 3.1 cows/ha total grazed) 1,719/ha effective platform (1,594/ha total farm)

* Estimated by OVERSEER®

(d) Effluent System

Effluent System	Current System	Proposed (Winter Barn Final) System.
Modelled input	Holding tanks system after stone trap and sump, then applied via K Line pods. Application depth at < 10 mm per application (modelled < 12 mm) from August to May (spray infrequently as not modelling June or July to receive effluent 46 kg N/ha/year liquid plus 11 kg N/ha/year sludge over 112 ha (130.1 @ 86%)	Same system, over a greater area, however with greater numbers of cows the volume has increased leading to the higher figure below, the variation due to the differing volumes applied to tiled and non-tiled blocks. Note the barn has a separate system for its effluent 75 and 60 kg N/ha/year liquid plus 12 kg sludge over 112 ha (130.1 @ 86%)

* Estimated by OVERSEER®

23.7 All soil information, climate and topography are the same between the two different scenarios.

Table 2: The outputs generated by OVERSEER® for the two systems

System type	Current System (combined)	Proposed (Winter barn final) System. (% reduction)
Nitrogen leaching loss to water (kg N/ha) Total N lost kg/farm (before wetland removal)	48 16,247	44 (10 % reduction) 14,678
Nitrogen Conversion efficiency % (N in products/N inputs)	27	47
Phosphorus run off to water (kg P/ha) Total P lost kg/farm Recalculated P lost kg/farm*	0.7 243	0.7 248 (2 % increase) 236 kg/year (3 % decrease)

* The Recalculation is explained in the last section in table in paragraph 24 plus 25 and 26.

23.8 The Nitrogen loss is decreased with the proposed winter barn scenario when compared to the current system, decreasing from 48 kg N/ha/year to 44 kg /N/ha/year. This is largely due to the addition of the winter barn and no intensive winter grazing on crop.

23.9 The Phosphorus loss from run off is maintained at 0.7 kg P/ha/year, reflecting a similar level of P loss risk between the two systems. The further mitigations further reduced this associated risk of P loss by a 3 % reduction.

23.10 Nitrogen efficiency is increased from 27 % to 47 % reflecting the better productivity gained from the nitrogen inputs into the farm system, and from the feeding efficiency within the winter barn.

23.11 The proposed system is being managed more intensively when comparing the amount of product sold per ha and the amount of pasture required supporting each venture (Table 1c). However, this is being largely mitigated by the use of a wintering barn and the increased supplement use whilst the stock are in the barn. The risks associated with both farming systems relate to the physical features of the farm, being the artificial drainage systems and the free draining soil, which have a severe rating for nutrient leaching.

24 A summary of the mitigations that are contained in the Winter barn scenario and how they relate to reducing losses are set out below;.

	Mitigations modelled:	**Reason/Rationale:**	**Effect:**
Winter Barn Farm System	Effluent mitigations (disposal area maintained and targeted fertiliser applications)	Ensure effluent only applied to appropriate areas, with Nitrogen applications taking into account the additional effluent nutrients from barn slurry.	Effluent area are maintained. Decrease Nitrogen applications to account for the application of the imported slurry on the Non effluent and effluent areas, ensuring the slurry is not applied on the Upukeroroa and tiled effluent areas. The fertiliser applications will be adjusted to account for this and the required pastoral productivity. Other blocks will have adjusted fertiliser applied including those blocks which have effluent solids applied.
	Alter cropping regime with the Winter Barn	With the winter barn, no crop area is required.	No crop area over winter reduces Nitrogen losses, especially on the more vulnerable Upukeroroa blocks (higher nutrient leaching risk) The current scenario losses reduce from 4,550 to 3,481 kg N/ha and the risk of P losses is also reduced(see point 17 in table). Note the interim stage showed cropping on the Braxton would also lower losses to 2,453 kg N/year. Both reduction in losses can be used to counter the increase in urine patch losses from pastures on the more vulnerable Upukeroroa soils due to intensification.
	Winter Barn	With the additional milking cows, the use of the barn over May and August gives the farm system an ability to reduce risk of pugging to pastures over spring and at autumn as required.	Using the barn removes the cattle from the paddocks thereby reducing the risk of pugging which leads to reduced infiltration of soils and increased overland flow of nutrients. Also nutrients are held and spread onto soil by effluent applications when pastures more able to receive the nutrients and thus lowers the associated risk of losses.
	Supplementary feed	Additional feed is able to be used for the extended lactation and for the wintering of cattle, with an ability to lower losses and ensure higher utilisation	Higher amounts of grain and PKE provide for a reduction in pastoral productivity further, With a lower pastoral productivity and higher supplement use overall N losses will reduce.
	Mitigate stocking on more vulnerable Upukeroroa soils	Higher stocking on the dairy platform could lead to increased urine patch losses on the free draining river soils	Mitigate this by not grazing milking cows on these soils over autumn, and the lower productivity will mean reduced fertiliser (nitrogen) applications on these soils (lower pastoral nutrient need). In addition, the numbers wintered, calved and peak milked are lowered to account for this as well.

25 The additional mitigations that further reduced the N and P losses are summarised in the table below;

	Mitigations modelled:	Reason/Rationale:	Effect:
Winter Barn Farm System Additional N & P mitigations	Effluent mitigations (targeted applications)	Ensure effluent only applied to appropriate areas with Nitrogen applications taking into account the additional effluent nutrients Target imported slurry to the more appropriate soil (Tuatapere), and reduce organic effluent on Braxton soils together with adjusting the amounts of nutrients being applied on tiled areas.	Tiled areas and Braxton soils have higher P losses given the higher risk of overland flow, and by targeting slurry at the appropriate soil this will reduce the risk of P loss and by timing fertiliser applications more appropriately N and P losses can be slightly reduced further.
	Winter Barn	Increase the utilisation of the barn, by wintering more cattle within it, this includes the replacement heifers. Also increase the utilisation of the barn by using it over the shoulders of the season more with milking cows (April).	Using the barn removes the cattle from the paddocks thereby reducing the risk of pugging. This reduces infiltration of soils and increases overland flow of nutrients. Also nutrients are held and spread onto soil by effluent applications when pastures are more able to receive the nutrients and thus lowers the associated risk of losses, especially at the high risk time in autumn for this environment.
	Fence water way and lengthen and plant riparian areas, fence 4 Critical Source Areas (CSA's)	Other source of P loss is key influence on on farm P loss and is not modelled well in Overseer The farmer and I have identified some areas where these losses could be reduced and calculated these losses as a means to show the added benefits of further identified P mitigations.	Such mitigations will have positive effects by reducing risk of overland flow, or slowing overland flows to water ways and lowering losses from other sources within the farm boundary

Please note calculations are obtained in Report titled, Crawford, M. (2019). *Further clarifications and P mitigation requests of Scenario reports.* Ravesndown.

SENSITIVITY ANALYSIS (WINTER BARN EFFECT ON P LOSS)

26 When modelling the winter barn option and the additional mitigations with added milking cows fed in the barns on the shoulders of the season, I became aware that the Nitrogen loss figures were responsive as one would expect, but the P loss figures were unresponsive to any modelled changes. I therefore decided to do a sensitivity analysis, by removing the barn structures for the proposals, and model all animals and feed supplements onto pastoral blocks, all other inputs are unchanged. From this I would expect an increase in N and P losses.

26.1 It has been noted that farm scale P losses from farm infrastructure which includes feed pads and wintering barns are reported cumulatively as other sources and other losses, and a review has been highlighted to see if the current loss factor is reasonable. In addition, the original calibration studies do require investigation as to whether their temporal scale was appropriate for the tactical mitigations used in this modelling. As well "*the P loss from dung is not considered separately and given that animals can be off blocks, then a monthly risk of P loss from dung could be considered*" (C W Gray & McDowell, September 2016)

27 I have set out the two results of this modelling in the Table below;

Management details and Information: Modelled changes in P loss reductions No Barns or Winter Barns Woldwide Four & Five:

Losses	WW 4 N loss kg N	WW4 P loss kg P	WW5 N Loss kg.N	WW5 P loss kg P.
Barn	9727/year or 24/ha/yr.	371/yr. or 0.9/ha/yr.	14678/yr. or 44/ha/yr.	248/yr. or 0.7/ha/yr.
No Barn	13896/yr. or 34/ha/yr.	376/yr. or 0.9/ha/yr.	22592/yr. or 67/ha/yr.	249/yr. or .07/ha/yr.

27.1 As I expected, Nitrogen losses increase by a factor of 43% and 53 % for the Woldwide 4 and 5 farms respectively; whilst the P loss risk increased only 1.3 % and 0.4 % respectively.

27.2 More importantly it was the Other losses which changed and not the block P losses, confirming the commentary from the Gray report cited in paragraph 26.1.

27.3 This indicated a limitation in Overseer's ability to take account of the likely P loss that would accompany a winter barn, which I have logged with both my organisation (Dr Ants Roberts and Alister Metherell) to clarify and with OVERSEER® Ltd (Carly Sluys directly) to provide a confirmation.

27.4 I then proceeded to estimate P losses by calculating the effect of reduced time on lanes from milking cows being fed indoors, noting that the effluent in barn slurry will have been accounted for in OVERSEER FM® reasonably. These are contained in the report titled, Crawford, M. (2019). Further clarifications and P mitigation requests of Scenario reports. Ravesndown.

CONCLUSIONS

28 The OVERSEER FM® modelling endeavours to describe two different farm systems for two different farms (Woldwide 4 & 5), which in the proposed scenarios have each applicant incorporate into its dairy platform its own part of newly acquired block of land. The modelling describes these farms as entities, with any shared resource such as additional effluent from Woldwide 3 being accounted for as well as when young stock are on and off the property.

28.1 The current farming system is modelled on data for 2 to 4 seasons including the 17/18 season. The system is best described as a seasonal dairy farm with changes to numbers wintered and crops grown as the farmer responded to various signals in the marketplace. To contend that additional budgets would give greater certainty downplays the fact that this is an acceptable rationale for modelling, the 3 years were considered representative, one farm is a consented recent conversion and any recent seasons will have had increased cow number leading to further increases in N loss for that current farm system.

28.2 The two final scenarios are seasonal dairy farm systems with a wintering barn and extended effluent area modelled on the expected level of productivity and inputs required to recover the outlay of capital over a period. The expectation is that the wintering barn should be able mitigate all the potential N and P loss risks due to the intensification of the purchased sheep farm which is incorporated as part of the dairy farm.

28.3 The modelling of the farm systems has been consistent with the information provided, BPDIS have been used and both external and internal reviews have been done. Therefore, the results should not be inconsistent with the output scenarios shown. The reviews carried out by Ms Phillips concludes that the modelling was of medium to high robustness and any issues identified were items for clarification and *not issues of concern* as detailed in an Environmental Southland file note dated 27th September from Courtney Guise APP-20181619

28.4 The use of OVERESEER FM® has enabled people to;

(a) See the predicted change from a current farming system, to a proposed system, with the overall effect being one of reduced environmental effect given that N losses are reduced by 18.8 % and 10 % for WW4 & 5 as modelled by OVERSEER® FM, and slightly reduced risk of P loss (0.4 % and 3 % respectively) with additional mitigations which highlight the limitations of the P loss sub model in OVERSEER® FM.

(b) The scenario analysis strongly indicates that the proposed land use change results in a lower to significantly lower estimate of the annual average, long term equilibrium N loss to water and marginally lower P loss risks.

(c) The reduced N loss is due to the reduction of the cropped area, and the mitigating features of the winter barn, along with the extended effluent area and adjusted fertiliser to accommodate the organic effluent

(d) The block losses need to consider the effects from all the blocks, not just focusing on certain ones. This is evidenced from the table produced by Ms Phillips in her review on page 7, summarised in point 126 of her review, and shown below with additional figures inputted by me *(my additions in italics)*;

WW4 - N lossv6.3.1	**Current Sheep**		***Current Dairy***		**Proposed Dairy**	
Kg/ha/year	N	P	*N*	*P*	N	P
Brax_4a.1	10 *or 16#*	0.4	*30*	*0.4*	27 (21**)	0.5
Tuap_6b.2	15 *or 21#*	0.1	*56*	*0.4*	49	0.2
Upuk_8a.1	38	0.3	*113**	*0.5*	*81**	0.4

This data includes the fodder crop losses which need to be included given they rotate through these blocks and are not accounted for in Ms Phillips analysis.*These figures are for the WW4 and for the Upukeroroa I have used an averaged figure from WW5, appropriate given the block losses on the Braxton and Tuatapere for WW4 & 5 are very similar.** Figure for WW4 only

Ms Phillips' focus on the sheep block as a determinant of contaminant losses is incorrect, as it fails to account for the reduced losses on the original dairy block. The fodder crop on the sheep block is also required to be accounted for in the losses. Using the simple table below for Woldwide 4 calculated from the table above, illustrates this;

WW4 - N lossv6.3.1	**Current Sheep**		***Proposed Dairy***	
Kg/year total	N	P	*N*	*P*
Before	1,110 (16*38.5+21*23.5)	18 (0.4*38.5+0.1*23.5)	*10,125 (30*337.5 ha)*	*135 (337.5 ha*0.4)*
After	2,192 (27*38.5+49*23.5)	24 (0.2*23.5+0.5*38.5)	*9,112 (27*337.5 ha)*	*169 (337.5 ha*0.5)*
Difference	-1,082	-6	*+1,013*	*-34*

This illustrate the effects can either be magnified or minimised if you don't include the other blocks.

It needs to be noted that the overall block losses on the current dairy pastures are decreased and given their portion of the total area is by far greater for these blocks, the overall effect is reduced as seen in the reports provided and summarised here in paragraphs 17.7 and23..7 table 2.

27 In my opinion a wintering barn and the other proposed measures in this application can provide a high level of certainty that N and P losses would be reduced compared to the current losses provided that farm system and mitigation measures are all implemented as described.

Dated: 16 September 2019

Mark Crawford

WORKS CITED

C W Gray, D. W., & McDowell, R. (September 2016). *Review of the Phosphorous loss sub model in OVERSEER.* Agresearch.

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Crawford, M. (2019). *Woldwide 4 Current Farm system and Winter barn Proposal 163(a2v6.2.3).*

Crawford, M. (2019). *Woldwide 5 Current and Proposed System Nutrient Budgets 164(a1).*