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 CRAWFORD
Addendum – 2018/19 Season Modelling

2 October 2019

PURPOSE OF REPORT

1 This addendum has been prepared to anticipate a response to a request by commissioners to provide a 2018/19 nutrient budget in a minute issued on 26 September 2019:

> *"The lack of this budget has been raised as an issue in the s42A Report. We request that the nutrient budget for 2018/19 is provided so that up to date data is available to determine the issue of nutrient loss changes, or alternatively a more complete explanation of why it cannot be provided.*

WOLDWIDE 4 LTD 18/19 YEAR END BUDGET

1 The total GIS mapped area remains at 349.3 ha (including the 78.8 ha support block) and of this 337.5 ha was calculated to be effective area. The farm is still modelled as an entity in its own right, with any shared resource (e.g. supplement, slurry effluent and when young stock are on and off the property) being accounted for.

1.1 The 18/19 system (averaged numbers used in brackets) was based on stock numbers of 794 (810) cows calved and 771 (775) cows peak milked producing 415,192 (410,452) kg Milk solids total, equating to 523 (510) kg MS/cow or 1593 (1574) kg MS/total grazed ha. The overall stocking rate was 9,624 (9,578) revised stock units (rsu.), equating to 27.5 (27.4)/total ha or 2.3 cows/total ha (Crawford M. , Woldwide 4 Current Farm system and Winter barn Proposal 163(a2v6.2.3), 2019). Replacement heifer numbers are 170 (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.2018.

1.2 The farm system required 26 (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 (12.9 T DM/ha or 480 T DM used, and 50 T DM stored) to the dairy block. A further 965 (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 171 (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.

1.3 Fertiliser amounts were modelled from past sales records. The total fertiliser nitrogen modelled averaged 213 (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.

1.4 Key differences between the two systems are;

(a) Fertiliser use

Tables 1:

Fertiliser use (kg/ha/year)	Current System	Year End 18/19 System.
Effluent	Total N applied 169 kg.	Total N applied 177 kg.
Non-Effluent	Total N applied 222 kg.	Total N applied 241kg.
Fodder Crop	same	same
Support block	Total N applied 219 kg.	Total N applied 294 kg.
Annual N use (kg N/ha)	195	213

(b) Supplement use

Supplement use	Current System	Year End 18/19 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.	1167 T DM in total imported or 4,502 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	Year End 18/19 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	15816 (increased due to higher productivity as described below.
Productivity: Stocking SU/ha Milk solid sold (kg/ha effective)	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) 1,583/ha effective milking platform (1,574/ha total grazed)	9,624 s.u* equivalent to 28.5 s.u/ha effective or 3.0 cows/ha milking platform (27.5 s.u/ha total or 2.2 cows/ha total) 1,,602/ha effective platform (1,593/ha total grazed)

* Estimated by OVERSEER FM®

(d) Effluent System

Effluent System	Current System	Year End 18/19 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 productivity the volume has increased leading to the slightly higher figure below; 121kg N/ha/year liquid over 57 ha (61.7 ha@92%)

* Estimated by OVERSEER FM®

1.5 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 with sheep block))	Year End 18/19 System. (combined with sheep block)
Nitrogen leaching loss to water (kg N/ha)	31 (29)	32 (29)
Total N lost kg/farm (before wetland removal)	10,860 (11,978)	11,058 (12,018) (0.3% increase)
Nitrogen Conversion efficiency % (N in products/N inputs) *	28	27
Phosphorus run off to water (kg P/ha)	0.7 (0.8)	0.9 (0.8)
Total P lost kg/farm	318 (343)	325 (344) (0.3% increase)

* Dairy farm only

1.6 The Nitrogen loss has increased for the 18/19-year end and when the new average is combined with the sheep block and compared to the current system, a similar level is achieved at 29 kg N/ha/year (11,978/412.6=29.0) and (12,018/412.6=29.1). This is largely due to the slightly increased pastoral productivity and higher risk of urine patch losses.

1.7 The Phosphorus loss from run off is increased for the 18/19 year end but maintained at 0.8 kg P/ha/year when the new average is calculated, reflecting a similar level of P loss risk between the two systems, with a similar increase of 0.3 % in total P lost per year between the two systems modelled, due to the same factors as mentioned in 1.6.

1.8 Nitrogen efficiency is similar at 28 % and 27 % from both systems, reflecting little change in risk from the various Nitrogen sources/inputs into the farm system.

1.9 The 18/19-year end system was managed more 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.

WOLDWIDE 5 LTD YEAR END 18/19.

2 The total GIS mapped area remains as 262.6 ha (including the 44.3 ha consented block) and of this 241.2 ha was calculated to be effective area. The farm is still modelled as an entity in its own right, with any shared resource (e.g. supplement, slurry effluent, WW3 effluent and when young stock are on and off the property) being accounted for.

2.1 The 18/19-year end season (current system in brackets) was based on stock numbers of 747 (680) cows calved and 698 (665) cows peak milked producing 390,655 (314,081) kg Milk solids total, equating to 523 (465) kg MS/cow or 1882 (1513) kg MS/total grazed ha. The overall stocking rate was 9,046 (7,841) revised stock units (rsu.) or 37.5/effective. ha or 3.1 cows/effective ha (Crawford M. , Woldwide 5 Current and Proposed System Nutrient Budgets 164(a2)v6.3.2, 2019). Replacement heifer numbers were still 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 were modelled to start milking from late July. An additional 200 dairy grazing cows were still wintered on the crop area.

2.2 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 1908 (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 80 T DM of silage purchased and fed on pastoral blocks, and a further 80 T DM fed on crop blocks to beef/dairy grazers.

2.3 Fertiliser amounts were modelled on past sales records and follow a similar pattern as both Woldwide 4 and 5 current system applications. The total fertiliser nitrogen modelled averaged 165 (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. The 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), is still included (rating of 14-10-8-3 NPKS/ha/year) and thus still reduces the fertiliser N from 165 to 154 (a modelled variation from actual)

2.4 Key differences between the two systems are;

(a) Fertiliser use

Tables 1:

Fertiliser use (kg/ha/year)	Current System	Year End 18/19 System.
Effluent	Total N applied 192kg.	Total N applied 171 kg.
Non-Effluent	Total N applied 219 kg.	Total N applied 186kg.
Fodder Crop	same	same
WW 3 Effluent	14-10-8-3 (NPKS rating)	14-10-8-3 (NPKS rating)
Annual N use (kg N/ha)	172	154

(b) Supplement use

Supplement use	Current System	Year End 18/19 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. 1136 T DM plus 380 T DM silage
Fodder Crop	Nil (work around, fed to dry cattle on pasture)	80 T DM to crop

(c) Wintering system and pasture production

Wintering System	Current System	Year End 18/19 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 developing Upukeroroa soils on crop plus in calf heifers wintered on crop block also and additional dairy grazers
Fodder Crop	Used for wintering	Used for wintering
Pasture Production (kg DM/ha/year) *	15680	17409
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)	9,046 s.u* equating to 37.5 s.u/ha effective or 3.1 cows/ha effective 1,620/ha effective platform (1,882/ha total grazed)

* Estimated by OVERSEER FM®

(d) Effluent System

Effluent System	Current System	Year End 18/19 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, 55 kg N/ha/year liquid plus 13 kg N/ha/year sludge over 112 ha (130.1 @ 86%)

* Estimated by OVERSEER FM®

2.5 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 with sheep block))	Year End 18/19 System. (combined with sheep block)
Nitrogen leaching loss to water (kg N/ha)	57 (48)	61 (49)
Total N lost kg/farm (before wetland removal)	14,862 (16,247)	15,902 (16,590) (2.1 % increase)
Nitrogen Conversion efficiency % (N in products/N inputs) *	27	29
Phosphorus run off to water (kg P/ha)	0.8 (0.7)	0.9 (0.7)
Total P lost kg/farm	211 (243)	228 (249) (2.5 % increase)

* Dairy farm only

2.6 The Nitrogen loss has increased for the 18/19 year end and when the new average is combined with the sheep block and compared to the current system, a higher level is achieved, up from 48 kg N/ha/year (16,247/335.6=48) to 49 kg /N/ha/year rounded (16,590/335.6=49). This is largely due to the increased animal and thus pastoral productivity and therefore the higher risk of urine patch losses.

2.7 The Phosphorus loss from run off is maintained to 0.7 kg P/ha/year, reflecting a similar level of P loss risk between the two systems, with a slight increase of 2.5 % in total P lost per year between the two systems modelled, due to the same factors as mentioned in 2.6.

2.8 Nitrogen efficiency is increased slightly at 29 % from 27 % from both systems, reflecting improved Nitrogen in outputs from the various Nitrogen sources/inputs into the farm system.

2.9 The 18/19-year end system was managed more 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 plus the sensitive Upukeroroa soils.

CONCLUSIONS

3 The OVERSEER FM® (6.3.2/2.8.1.0) modelling endeavours to describe the 18/19-year end farm systems for two different farms (Woldwide 4 & 5) and compare to the current averaged baseline years to demonstrate the level of certainty in the modelled figures. 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.

3.1 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.

3.2 The 18/19 season results show that the current figures reported were both a reasonable reflection of the averaged system in use and show the conservative approach used in modelling. Both 18/19 season budgets showed higher losses given the favourable conditions that led to the improved pastoral production for that season.

3.3 One farm (Woldwide 5) showed much higher productivity and this is well explained by the developing nature of this recent conversion, as opposed to the more stable farming system for Woldwide 4. More recent conversions show increasing productivity as newly improved fertility and pasture renewed takes effect. In addition, the farmer improves herd productivity through more culling on productivity and less retention of cows to build herd numbers, as the herd builds towards a stable calving number.

3.4 These additional budgets give greater certainty that the current averaged scenarios were an acceptable rationale for modelling, the 2 and 4 years were considered representative, and the contention made that any recent seasons added will have meant increased cow numbers leading to further increases in N loss for that current averaged farm system.

3.5 The contention that the budgets made were based on fanciful input data (paragraph 5.13.15) shows a misrepresentation and misunderstanding of the detail in the budgets modelled.

4 I would like to further expand on paragraph 28.4 (d) in my evidence with the attached table. This outlines how each block changes between the current average system and the proposed system for both farms. It shows that the Nitrogen losses do increase on the sheep block, for both Woldwide farms, but the P losses on one farm reduces substantially (from 19 to 11) thus the information about what happens to the nutrient concentrations on the sheep block is not fully explained. In addition, as noted, the N loss on the dairy blocks decrease providing an overall decline, this being the more complete picture in explaining effects.

5 I also note in Mr and Mrs de Wolde's evidence they use the metric Nutrient loss/kg Milk solid (paragraph 5) In using the figures already provided, I have demonstrated that this occurs by dividing the kg milk solids produced to the nutrient lost and so, for example, for Woldwide 4 it takes 37.4 kg milk solids for every 1 kg N lost in the current scenario , but in the proposal, this becomes 56.4 kg milk solid per kg N lost (a 51 % improvement).

6 Finally, it is noted in 1.17 of the hearing report that; "*the increased stocking rate and associated feed demand through pasture or supplementation has the potential to increase the nitrogen surplus in the soil…".* The third table provided shows that this is not true and that both N surplus decreases and N efficiency increases, measures which allow one to surmise that the risk of N loss is reduced with the addition of the winter barns. This is evidential information that has not been considered.

Mark Crawford

Dated 2 October 2019

Block Comparison between Dairy and Sheep Blocks for Current and Proposed Scenarios (Pre additional P mitigation):

Woldwide Four

Blocks	Current Scenario N loss (kg N/year)	Proposed Scenario N loss (kg N/year)	Difference (kg N/year)	Current Scenario P loss (kg N/year)	Proposed Scenario P loss (kg N/year)	Difference (kg P/year)
Dairy Blocks	8,079	5,398	**2,681**	114	100	**14**
Dairy Blocks integrated with Sheep Blocks	2,432	1,735	**607**	37	37	0
Sheep Blocks	1,104	934+1,092=2,026	922	20	20+3=23	3
Total	**11,525**	**9,159**	**2,366**	**171**	**160**	**11**
Other Losses	Dairy 439 Sheep 14 Total 453	568	115	Dairy 165 Sheep 6	210	39
Total	**11,978**	**9,727**	**2,251**	**342**	**370**	**28**
Overseer Check	11,978	9,727	9,727-11,978=**2,251**	343	371	371-343=28

Woldwide Five

Blocks	Current Scenario N loss (kg N/year)	Proposed Scenario N loss (kg N/year)	Difference (kg N/year)	Current Scenario P loss (kg N/year)	Proposed Scenario P loss (kg N/year)	Difference (kg P/year)
Dairy Blocks	9,866	7,112	**2,754**	71	51	**20**
Dairy Blocks integrated with Sheep Blocks	4,598	62+3381+811=4,254	**344**	12	0.5+6.9+3.6= 11	**1**
Sheep Blocks	1,354	879+1552+315=2,746	1,392	19	6.5+3.1+1.4=11	**8**
Total	**15,878**	**14,112**	**1,706**	**102**	**73**	**29**
Other Losses	Dairy 398 Sheep 31 Total 429	566	137	Dairy 128 Sheep 12 Total 140	175	35
Total	**16,247**	**14,678**	**1,569**	**242**	**248**	**6**
Overseer Check	16,247	14,678	14,678-16,247=**1,569**	243	248	248-243=5(rounding error)

Note: Red is decrease, black increase. Sheep losses in isolation don't account for changes in dairy blocks, nor does looking at N give a true picture of all losses. Totals for P do not include further P mitigation calculations.

Nutrient Losses /kg Milk solid

Metric	WW4: Current Scenario	WW4: Proposed Scenario	WW5: Current Scenario	WW5: Proposed Scenario
N loss	10,672	9,727	14,862	14,678
P loss	315	371	211	248
Milk solids produced	410452	570,000	314,081	535000
Cows peak milked:	775	1000	665	930
Kg Nutrient lost/peak cow	14.2/cow	10.1/cow	22.7/cow	16.0/cow
Kg MS/kg nutrient lost	37.4 kg MS/kg nutrient	56.4/kg MS/kg nutrient	20.8 kg MS/kg nutrient lost	35.8 kg MS/kg nutrient lost
Kg MS/kg N lost	38.5 /kg N lost	58.6/kg MS/kg N lost	21.1/kg N lost	36.4/ kg N lost
Kg MS/kg P lost	1303.0/kg P lost	1536.4/kg MS/kg P lost	1488.5/ kg P lost	2157.3/kg P lost

Note: Efficiency of production per nutrient lost does improve, for both farms.

Metrics for Nitrogen surplus:

Metric	WW4: Current (and combined)	18/19 season	Proposed	Sheep Current Year	WW5: Current (and combined)	18/19 season	Proposed
N Surplus (kg/ha)	232 (284)	243	217 (23.6 % reduction)	113	244 (305)	268	259 (15.1 % reduction)
Nitrogen conversion efficiency (%)	28	27	48	17	26	29	47

Metrics for additional Nutrient Budget (18/19): Likely Effect in relation to current scenario/baseline average.

Woldwide Four & Five:

Metric	WW4: Current Scenario	Average incl 18/19 season	Likely Effect	WW5: Current Scenario actual average	Average incl 18/19 season Actual average	Likely Effect
No of cows wintered	810	805	Dec.	533	601	Inc
No of cows peak milked	775	778	Inc	513	573	Inc
Milk solids produced	410452	411242	Inc	249340	296445	Inc
Nitrogen used	195	200	Inc	212	207	Dec
Silage used	253 plus 480 Gladfield	220	Inc	330	90 plus	Dec
Molasses	66	59	Inc	49	68	Inc/Same
Barkley	520	530	Dec	402	401	Inc/Same
PKE	409 (total 995)	402 (total 991)	Inc	161 (total 612)	159 (total 608)	Inc/Similar

Note: Additional budgets would not provide any further clarity to aid in decision making, given they do not change the metrics significantly. Note also, for WW5 the numbers used were extrapolated from this actual data with the addition of the Collies block. However given the similarities between the averaging figures the figures used in the current scenario for WW5 would have resulted in a similar picture to which has been modelled.

Metrics for Average N loss 18/19 season included

Metric	WW4: Current Scenario averaged	WW4: Year End 18/19 actual	WW4: Current Scenario averaged (combined)	WW4: Current Scenario averaged 18/19 (combined)	WW4: Proposed Scenario
N loss	10,860	10,900	11,978	12,018	9,727
P loss	318	319	343	344	371
Milk solids produced	410,452	415,192	n/a	n/a	570,000
Cows peak milked:	775	771	n/a	n/a	1000

Metric	WW5: Current Scenario averaged incl. Collies	WW5: Year End 18/19 actual incl. Collies	WW5: Current Scenario averaged (combined)	WW5: Current Scenario averaged 18/19 (combined)	WW5: Proposed Scenario
N loss	14,862	15,205	16,247	16,590	14,678
P loss	211	217	243	249	248
Milk solids produced	314,081	390655	n/a	n/a	535000
Cows peak milked:	665	698	n/a	n/a	930

* Includes non OverseerFM modelling of P loss mitigation. Refer to Cain Duncan evidence

Woldwide Four Phase 1			
	Current Farm System	**Proposed Farm system**	**Reduction**
N (kg/yr)	12,018	11,898	1.0 %
P (kg/yr)	344	349	-1.5 % (increase)
Woldwide Four Final			
	Current Total Farm System	**Proposed Total Farm system**	**Reduction**
N (kg/yr)	12,018	9,727	18.8
P (kg/yr)	344	342* (371)	0.6
Woldwide Five Phase 1			
	Current Farm System	**Proposed Farm system**	**Reduction**
N (kg/yr)	16,590	16,047	3.3 %
P (kg/yr)	249	233	6.4 %
Woldwide Five Final			
	Current Total Farm System	**Proposed Total Farm system**	**Reduction**
N (kg/yr)	16,590	14,678	11.5 %
P (kg/yr)	249	227*(248)	8.8%

* Includes non OverseerFM modelling of P loss mitigation. Refer to Cain Duncan evidence

Mark Crawford Senior Farm Environmental Consultant, Ravensdown