ADDENDUM to: Pareora Meat Processing Plant Land Discharge

Technical Support Document

for Assessment of Environmental Effects

Prepared for

Silver Fern Farms

Prepared by

Lowe Environmental Impact

April 2021

Addendum to: Pareora Meat Processing Plant Land Discharge Technical Support Document for Application and Assessment of Environmental Effects

Silver Fern Farms

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Ref: RE-10688-SFF_Tech_Support-200415-BP_Addendum.docx

Job No.: 10668

Date: April 2021

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1 EXECUTIVE SUMMARY

This addendum report has been prepared in response to a request for further information by Environment Canterbury on Silver Fern Farms resource consent application relodged in January 2020. The report incorporates monitoring data from 2016 along with an updated commentary and updated conclusions to that reported in 2017 (LEI 10448). The report includes an evaluation of annual nitrogen leaching with Overseer modelling.

There have been no changes to the discharge area, soils and the way the land discharge has been managed. Therefore, the description of site activities and the receiving environment contained in the 2017 report prepared by Lowe Environmental Impact (attached in Appendix 1 to the AEE) continues to apply.

Flows of WW to land from 2016 - 2020 were a daily average of 1,530 m^3/d and a 95-percentile peak of 3,234 m^3/d. The daily average flow is lower than the previously reported daily average from 2012 – 2016 of 1,982 m^3/d.

Irrigation application depths ranged from 0 – 6 mm/day with an average 1.3 mm/d.

Pasture dry matter (DM) removed from the blocks averaged in the order of 13.5 – 15 t DM/ha/yr. Specific blocks cut and carry removal of DM ranged from 3 to 22 t DM/ha/yr depending on the number of harvests made each season.

Annual N application ranged from 59 to 1,095 kg N/ha/yr. The report also incorporates the updated Overseer model. The Overseer modelling gives three-year average annual leaching of nitrate-N of around 75 kg N/ha/yr on the irrigated blocks. A simple mass balance shows N removal of 384 kg N/ha/yr from pasture harvesting and atmosphere loss resulting in leaching from the irrigation blocks of 77 – 231 kg N/ha/yr (three-year average of 150 kg N/ha/yr).

The average leaching is in the order of 75 kg N/ha/yr due to harvesting of high yielding ryegrass from the blocks. Further N reduction occurs in soil, central gully and the constructed rock filter wetlands, giving an N concentration that is very similar in the ephemeral stream leaving the property to that arriving at the property. This shows that the impact from the wastewater application to the site is minimal and not having large downstream effects. The system has a high (>95%) amount of nutrient removal. This is not fully represented in the predicted drainage concentrations reported by Overseer and is indicative of additional treatment and nutrient capture process attenuating nitrogen between the root zone and the receiving environment.

A proposed cap to the winter application rate of wastewater when soil is nearing field capacity is also discussed. The purpose of the cap is to reduce the potential for winter drainage and N loss, and to ensure soil structure is maintained.

Overall, the effects on soils from the land application system are considered to be manageable and less than minor. The land treatment system has been in operation for many years with the application and soil management producing a sustainable system. There is significant reduction in nitrogen between what is applied to the land and that measured downstream of the land treatment area.

2 INTRODUCTION

2.1 Purpose

Silver Fern Farms Ltd (SFF) relodged an application in January 2020 to discharge contaminants to land and sea from wastewater associated with the Pareroa meat processing plant. After further review, SFF identified that a physico-chemical DAF (PCDAF) is the preferred option to treat the wastewater and this option has been incorporated into the relodged application.

This addendum report has been prepared in response to a request for further information (RFI) by Environment Canterbury on the relodged application. The RFI asks that Lowe Environmental Impact provide an addendum to its technical report that incorporates the more recent monitoring data from 2016 along with an updated commentary and updated conclusions.

This addendum provides data from 2016 - 2020 and reassesses the evaluation of annual nitrogen leaching with Overseer modelling. This addendum accompanies the LEI 2017 report "*Pareora Meat Processing Plant Land Discharge Technical Support Document for Assessment of Environmental Effects Feb 2017*".

2.2 Background

The Silver Fern Farms Pareora meat processing plant is located at Pareora just south of Timaru between State Highway 1 and the coastline. The site includes stockyards, meat processing operations, fellmongery, composting, land-based irrigation areas and other farmland. Pareora township adjoins the plant, which includes residential housing, a hostel, and a sports field.

The meat processing wastewater (WW), defined as treated meat processing waste and associated stormwater and freshwater, is discharged to land via centre pivot and K-line irrigation and to sea via an ocean outfall. The land discharge is onto land referred to as the Pareora Farm and has operated since 2008.

SFF engaged Lowe Environmental Impact (LEI) in 2017 to prepare a technical evaluation of the soil and land condition, and potential movement of nutrients through the soil (nutrient leaching losses). That report is contained in Appendix 1 to the Assessment of Environmental Effects (Part A) for the discharge to land of the WW.

The technical report prepared in 2017 contained information from 2012 - 2016.

3 DESCRIPTION OF ACTIVITY

3.1 WW Flow andQuality

Table 3.1 below outlines the volumes of wastewater applied to land during the 2016 – 2019 period. Table 3.2 and Table 3.3 give details about the quality of the wastewater discharged to the sea and discharged to land.

2016/17: The total volume of wastewater discharged to either land or sea in the 2016/2017 season was 979,178 m^3. In total, 534,367 m^3 was applied to land (55%), with a range of <100 – 4,264 m^3/d.

2017/18: The total volume of wastewater discharge to land and sea was 1,198,578 m^3 in the 2017/2018 season. In total, 556,581 m^3 was applied to land (46%), with a range of <100 – 4,273 m^3/d. In this season the total volume discharge to sea and land was 219,400 m^3 more than the previous year. However, there was only a 22,214 m^3 increase in volume applied to land. In this year, a higher proportion of the wastewater was discharged to sea.

2018/19: The total volume of wastewater discharged to land and sea was 1,043,037 m^3 in the 2018/2019 season. In total, 543,715 m^3 was applied to land (52%), with a range of <100 – 4,334 m^3/d.

2019/2020: During this reporting period (up to March 2020) the total volume of wastewater discharged (Land and Sea) was 864,840 m^3. In total, 473,554 m^3 had been applied to land (55%), with a range of <100 – 4,095 m^3/d.

Between 2016 - 2020 the percentage of wastewater that was applied to land ranged between 46.4% - 54.7%, with the lowest % being applied to land in 2017 - 2018. This is a much more even range in percentages than the 2012 - 2016 period, were the % applied to land ranged from 38% in 2012/2013 to 68% in 2014/2015. The range of daily volumes applied (<100 m^3 – 4,334 m^3/d) to land is generally lower than the 2012 - 2016 period. In 2012/2013 the maximum discharged in one day was up to 6,938 m^3.

Table 3.1: WW Flows Applied to Land

Flow statistics	Volumes 2016/17 (m^3)	Volumes 2017/18 (m^3)	Volumes 2018/19 (m^3)	Volumes 2019/20 (m^3)
Annual total	534,367	556,581	543,715	600,537
Daily average	1,466	1,527	1,493	1,641
Daily minimum	28	0	0	0
Daily maximum	4,264	4,273	4,334	4,095

Table 3.2: Quality of the Wastewater Discharged to Sea (2016 - 2019)

Parameter	2016 - 2017			2017 - 2018			2018/2019			2019/2020		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
pH	6.4	8.8	7.4	6.5	8.1	7.1	5.8	7.8	7.2	6.8	10.4	7.6
Biochemical Oxygen Demand (g/m^3)	150	2,156	833	140	2,480	791	130	2,130	1,040	200	1830	1100
Total Suspended Solids (g/m^3)	118	5,510	920	114	4,040	860	190	6,510	1,350	277	3350	1188
Ammoniacal Nitrogen (g/m^3)	0.2	46.1	17	5.69	57	21	2.3	47.7	21	4.4	44.2	22.2
Dissolved Reactive Phosphorus (g/m^3)	1.2	23.2	9.9	1.1	36.1	11.9	0.5	27.8	10.7	0.8	23	12
Oil and Grease (g/m^3)	11	4,960	604	39	2,450	523	76	4,820	1,046	109	2370	720
Total Kjeldahl Nitrogen (g/m^3)	14	141	67.1	20	199	68.2	10	279	75	17	128	77.6
Total Phosphorus (g/m^3)	2.1	33.7	13.1	2.6	44.5	15	0.92	34.4	14.3	2.7	28.5	16
Faecal Coliforms (cfu/100 ml)	$4x10^3$	$1.8x10^7$	$3.9x10^6$	$1.4x10^5$	$1.1x10^7$	$1.5x10^6$	$3.3x10^4$	$4.2x10^7$	$4.8x10^6$	$1.8x10^5$	$1.6x10^7$	$4.4x10^6$
Enterococci (cfu/100ml)	$8x10^3$	$1.4x10^7$	$3.2x10^6$	$4.4x10^4$	$2.7x10^7$	$7.8x10^6$	$3x10^4$	$1.1x10^7$	$3.3x10^6$	$1.7x10^4$	$1.3x10^7$	$2.2x10^6$

Table 3.3: Quality of the Wastewater Discharged to Land (2016-2019)

Parameter	2016/2017			2017/2018			2018/2019			2019/2020		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
pH	3.6	6.5	7.2	8.9	7.2	8	7.2	8.9	7.2	6.7	7.8	7.16
Total Kjeldahl Nitrogen (g/m^3)	23	305	110	14	342	111	37	575	179	20	419	139

Note: During the 2016–2017 and 2017-2018 seasons, the wastewater quality discharged to land for most parameters was similar to the previous season. The mean in the 2018-2019 season was slightly higher.

3.2 Land Treatment

3.2.1 System Description

As described in the AEE and 2017 technical report, the Pareora farm area consists of 273 ha of which currently 141.6 ha are irrigated with wastewater generated by the meat processing plant. The wastewater streams from the plant are kept in two general categories: (1) Containing blood – Red Line (or "Blood Stream"), and (2) Low in blood – Green Line (or "Work Stream").

The Red waste stream is the wastewater from blood-bearing departments including primary butchery and blood handling activities, and can include water storage overflow and stormwater.

Note: Of the 141.6 ha that are irrigated with the Pareora Plant wastewater, 140.6 ha are considered as "productive land", and 1 ha is occupied by the Terrace gully.

Land Treatment is currently carried out on two of the Pareora Farm blocks: the "Terrace Block" and the "Village Block".

The Terrace Block is irrigated with five centre pivots and K-Line irrigation pods. The Village Block is irrigated with K-Line pods only. No irrigation with Pareora Plant wastewater is currently carried out on the River Block. The majority of the Terrace Block area drains to a constructed wetland.

The areas irrigated with wastewater are managed under Cut and Carry operations to limit nutrient leaching.

3.2.2 Land Application and Management

The land to which WW is applied is owned and managed by Silver Fern Farms Pareora. The way the land to which WW is applied and managed is described within the following tables. Table 3.4 outlines the effective irrigated areas for the different irrigation blocks and types of irrigators.

Table 3.4: Types of Management and Effective Irrigated Areas

Block Name		Management	Effective Area (ha)
Terrace Block	Pivot 1	Cut and Carry	26.6
	Pivot 2	Cut and Carry	13.3
	Pivot 3	Cut and Carry	23.2
	Pivot 4	Cut and Carry	16.1
	Pivot 5	Cut and Carry	14.8
	Hill Top K Line	Cut and Carry	32.6
Village Block	Village K Line	Cut and Carry	14
Total			140.6

The irrigation systems have been set up to apply less than 5 mm/hour. The pivots and K-Line systems are generally applying 2 – 3 mm/hr.

The Terrace and Village Blocks are generally irrigated using a non-deficit management regime, i.e. irrigation can occur even if there is no, or minimal, soil moisture deficit. Parts of the Terrace Block that do not drain to the central gully, are managed using a deficit regime, i.e. irrigation can only occur if the application will not result in the soil moisture exceeding field capacity. The River Block, although not currently irrigated, also must be managed under a deficit regime under the existing consent conditions.

Monthly wastewater depths applied on land over the 2016 - 2017, 2017 – 2018, 2018 – 2019 and 2019 – 2020 years are reported in Table 3.5.

Table 3.5: Monthly and Annual Application Depths (mm)

		Blocks						
Year	Date	Pivot 1	Pivot 2	Pivot 3	Pivot 4	Pivot 5	Top K line	Village K line
16_17	Jan	63.3	41.3	66.7	71.3	52.6	16.1	20.06
	Feb	37.1	94.1	109.5	88.8	45.0	13.2	6.9
	Mar	38.0	65.6	129.6	71.6	54.3	22.4	19.3
	Apr	-	18.4	49.8	80.5	-	5.04	10.6
	May	31.7	35.9	129.0	66.9	24.3	10.8	13.9
	Jun	34.6	62.6	31.6	18.0	24.6	4.2	5.5
	Jul	38.7	17.8	31.5	49.4	15.3	3.02	2.7
	Aug	58.8	36.1	43.3	84.8	36.6	1.4	1.7
	Sep	66.3	88.1	0.09	25.7	54.6	0.3	4.2
	Oct	81.7	99.3	3.5	0.5	48.1	-	14.9
	Nov	7.7	5.3	96.8	61.2	13.7	14.9	0.8
	Dec	35.5	27.1	58.2	48.9	53.7	7.9	12.5
Total irrigation applied (mm/yr)		**493**	**591**	**799**	**667**	**422**	**99**	**112**
17_18	Jan	20.2	141.6	105.7	59.9	35.8	3.6	51.4
	Feb	40.6	17.6	64.4	130.9	92.5	8.8	0.1
	Mar	13.1	86.9	93.6	72.5	0.1	4.3	22.8
	Apr	40.3	20.7	96.5	39.8	168.5	12.4	-
	May	19.0	25.8	-	21.0	144	11.9	-
	Jun	10.7	4.4	0.2	16.5	28.8	5.48	0.4
	Jul	29.0	59.7	29.2	22.4	72.7	8.3	9.8
	Aug	15.2	58.3	45.1	18.2	130.1	8.	54.1
	Sep	13.4	78.5	45.9	0.3	16.9	0.17	19.1
	Oct	35.6	3.0	17.5	56.5	182.9	6.9	0.2
	Nov	11.8	102.6	161.5	27.2	54.9	1.9	20.3
	Dec	25.0	31.8	64.8	45.1	155.3	4.4	4.9
Total irrigation applied (mm/yr)		**273**	**631**	**803**	**510**	**1,082**	**183**	**76**
18_19	Jan	86.5	46.3	82.2	92.0	34.9	2.5	2.7
	Feb	36.2	171.6	97.6	18.7	62.1	5.6	1.8
	Mar	90.7	91.4	49.7	40.1	3.1	10.3	-
	Apr	39.2	52.2	61.7	36.6	58.0	9.6	28.2
	May	37.1	89.9	69.4	24.3	44.6	6.2	7.7
	Jun	10.4	47.4	11.3	5.5	1.3	4.1	0.2
	Jul	25.9	45.0	62.9	37.2	29.2	2.9	37.5
	Aug	62.9	-	28.0	54.6	8.7	0.9	34.6
	Sep	28.4	1.5	0.9	36.1	1.3	1.8	12.0
	Oct	13.7	86.0	74.9	20.1	56.8	6.8	17.3
	Nov	92.2	18.8	2.4	66.0	-	11.7	14.0
	Dec	56.8	48.0	29.9	24.1	8.3	7.5	4.4
Total irrigation applied (mm/yr)		**580**	**698**	**571**	**455**	**308**	**70**	**160**

Blocks								
Year	Date	Pivot 1	Pivot 2	Pivot 3	Pivot 4	Pivot 5	Top K line	Village K line
19_20	Jan	54.0	85.8	98.9	32.2	18.6	6.5	101.3
	Feb	44.5	71.7	30.2	34.1	8.5	10.5	112.0
	Mar	19.1	41.8	94.5	104.5	8.4	8.2	70.7
	Apr	36.0	63.5	10.9	9.5	44.5	12.8	107.3
	May	0.1	1.3	95.0	54.7	46.4	4.6	64.1
	Jun	33.4	45.1	9.2	22.2	25.6	7.8	16.2
	Jul	34.0	61.6	23.5	28.4	16.3	35.3	19.9
	Aug	25.0	63.8	39.0	43.0	32.2	20.0	46.1
	Sep	61.4	28.9	78.0	0.9	20.6	11.3	108.8
	Oct	7.8	27.9	20.5	0.0	25.2	9.6	66.6
	Nov	21.7	5.5	111.2	0.0	1.3	7.5	60.6
	Dec	54.6	29.9	57.9	26.9	44.0	7.8	72.3
Total irrigation applied (mm/yr)		**392**	**527**	**669**	**356**	**291**	**142**	**846**

Application of wastewater nitrogen was modelled as monthly fertiliser applications. The amount of applied nitrogen (kg N/ha) via wastewater irrigation is represented as NH_4-N in fertiliser form as follows in Table 3.6.

Table 3.6: Nitrogen Applied to Irrigation Areas (kg/ha/month, kg/ha/yr)

Sum of N applied (N kg/ha)		Block						
Year	Date	Pivot 1	Pivot 2	Pivot 3	Pivot 4	Pivot 5	Top K line	Village K line
16_17	Jan	69.5	42.0	72.2	56.6	51.6	12.8	30.4
	Feb	66.2	162.4	129.4	182.9	79.9	4.1	63.5
	Mar	27.8	49.0	68.4	64.1	42.9	7.0	50.6
	Apr	0.0	14.1	51.2	111.8	0.0	3.2	23.4
	May	66.6	56.6	127.7	107.9	36.0	9.6	40.8
	Jun	60.8	110.6	32.7	25.5	45.4	4.5	17.6
	Jul	46.5	26.1	11.8	55.4	9.8	1.5	9.0
	Aug	46.7	27.9	24.5	60.2	27.6	0.4	3.0
	Sep	41.5	53.2	0.0	20.3	27.6	1.0	0.5
	Oct	42.0	73.0	1.4	0.1	31.5	4.6	0.0
	Nov	7.0	4.8	48.2	37.1	12.4	0.3	24.3
	Dec	67.2	49.7	42.6	62.3	100.7	10.3	28.3
Total N applied		**541**	**669**	**610**	**784**	**465**	**59**	**291.3**

Sum of N applied (N kg/ha)		Block						
Year	Date	Pivot 1	Pivot 2	Pivot 3	Pivot 4	Pivot 5	Top K line	Village K line
17_18	Jan	24.9	95.5	114.4	135.4	57.8	3.8	52.1
	Feb	79.3	226.7	52.8	22.2	108.8	12.5	0.1
	Mar	0.1	110.8	75.8	91.5	32.2	5.2	32.6
	Apr	137.3	79.4	74.7	24.8	97.3	17.1	0.0
	May	173.2	66.5	0.0	40.4	72.3	27.4	0.0
	Jun	22.9	47.4	0.1	4.8	21.5	9.6	1.0
	Jul	36.1	28.0	17.6	50.4	61.6	6.4	5.6
	Aug	22.9	6.2	7.0	10.8	7.6	4.4	15.5
	Sep	1.8	0.1	14.2	32.7	3.4	0.0	11.0
	Oct	49.9	26.1	1.9	0.8	23.8	3.7	0.0
	Nov	23.9	23.2	93.4	104.7	14.8	1.3	24.8
	Dec	144.9	136.1	50.0	36.6	93.6	8.3	4.5
Total N applied		**717**	**846**	**502**	**555**	**595**	**100**	**147**
18_19	Jan	127.3	142.6	127.6	147.2	81.6	3.3	3.4
	Feb	44.0	291.6	31.1	12.5	156.8	8.2	5.9
	Mar	138.1	157.6	122.9	130.3	72.1	17.4	0.0
	Apr	115.7	124.6	134.3	29.9	223.8	39.1	73.6
	May	63.0	68.7	0.0	67.5	98.7	22.9	13.6
	Jun	17.1	51.2	0.3	7.2	41.3	9.0	0.5
	Jul	46.5	57.6	67.0	186.8	99.2	6.8	46.7
	Aug	55.0	25.6	34.1	60.0	35.1	0.9	31.8
	Sep	52.7	0.3	56.5	130.7	54.8	3.4	32.1
	Oct	13.6	67.1	10.6	2.4	48.3	7.7	20.3
	Nov	102.8	37.0	99.0	93.4	23.3	11.2	12.9
	Dec	71.3	70.6	39.5	27.6	56.9	9.2	5.4
Total N applied		**847**	**1094**	**723**	**895**	**992**	**139**	**246**
19-20	Jan	62.1	90.0	141.9	44.9	27.9	10.2	50.1
	Feb	49.4	72.0	31.7	34.3	8.3	26.1	51.4
	Mar	25.7	65.2	153.9	157.6	10.5	28.0	48.2
	Apr	47.3	53.0	21.3	9.1	47.1	16.2	41.2
	May	0.1	0.3	151.3	92.1	53.6	12.6	36.4
	Jun	33.7	44.6	10.6	22.0	23.8	17.5	6.0
	Jul	79.8	123.4	28.5	108.8	29.6	150.7	19.6
	Aug	28.3	29.1	58.6	41.1	19.6	44.0	25.9
	Sep	108.7	39.9	146.0	0.4	31.7	50.8	98.2
	Oct	2.4	45.7	13.4	0.0	36.7	35.6	21.5
	Nov	13.1	10.0	95.9	0.0	0.2	12.3	15.3
	Dec	89.8	43.0	59.9	31.5	58.3	24.8	31.9
Total N applied		**541**	**616**	**913**	**542**	**347**	**429**	**446**

Pareora Farm data was modelled in Overseer and compared to the Silver Fern Farms Limited nitrogen mass balance of N via uptake and losses. Losses of Nitrogen (N) for the irrigation areas only (140.6 ha) from Overseer are presented in Table 3.7 and Table 3.8 below. Appendix A includes the Overseer summary reports.

Note:

- The data used for the Overseer model are those reported as being applied to the soil surface; no reduction has been applied to the volume applied for distribution or evaporation losses.
- All N was added via fertiliser in the form of soluble N based on measured TKN content of the wastewater prior to application. Assuming the nitrogen form as 100% soluble is conservative as volatilisation losses in the spray application and ammonification process are minimised.
- N exported as forage via cut and carry is shown in Table 3.9.

Table 3.7: Nitrogen Losses (Leaching) over the Last four years (Overseer)

Year	Irrigation Only Blocks N Loss to Water (kg N/ha/year)
2019/20	87
2018/19	120
2017/18	55
2016/17	38
Average	75

Table 3.8: Nitrogen Mass Balance for Irrigated Areas (Overseer)

Year	Total N applied as Fertiliser (kg N/ha/year)	N removed in products (kg N/ha/year)	N Lost to atmosphere (kg N/ha/year)	Irrigation Blocks N Loss to water (kg N/ha/year)	Change in Soil N (kg N/ha/year)
2019/20	549	299	55	90	118
2018/19	643	339	88	120	108
2017/18	459	338	47	55	42
2016/17	446	384	33	38	22
Average	524	340	56	73	73

Table 3.9: Herbage Removed from the Irrigated Areas (in kg Dry Weight)

	Pivot 1	Pivot 2	Pivot 3	Pivot 4	Pivot 5	Hill Top	Village	Total
2019/20	390,355	214,139	451,703	142,907	162,429	50,273	80,671	1,492,457
2018/19	217,815	215,043	527,958	192,865	223,649	122,472	239,732	1,739,533
2017/18	491,535	207,928	346,934	268,653	138,968	148,862	167,345	1,770,225
2016/17	451,040	279,884	475,575	341,977	198,082	143,595	141,956	2,032,109

The simple mass balance undertaken by Silver Fern Farms Limited using the herbage dry matter harvested, the concentration of N in the dry matter and assumptions regarding ammonia volatilisation and denitrification is shown in Table 3.10.

Table 3.10: Nitrogen Mass Balance for Irrigated Areas (Simple Mass Balance)

Year	Total N applied as Fertiliser (kg N/ha/year)	N removed in cut and carry (kg N/ha/year)	N Lost to atmosphere (kgN/ha/year)	Irrigation Blocks N Loss to water (kg N/ha/year)
2019/20	548	249	113	186
2018/19	676	303	140	231
2017/18	467	264	97	105
2016/17	427	261	88	77
Average	507	276	108	150

Note: The N lost to water in the Overseer model and via the mass balance does not take into account the additional N removal in the wetland and rock filter system.

4 ASSESSMENT OF ENVIRONMENTAL EFFECTS

4.1 Summary of Discharge Effects

The application to land has the potential to cause the following effects:

- Nutrient leaching to groundwater or drainage system;
- Ponding and runoff; and
- Air quality via aerosols, spray drift and odour.

This addendum provides additional assessment to that contained in LEI 2017 report concerning nutrient leaching, ponding and runoff. An assessment of air quality has been provided by others.

4.1.1 Nutrient Leaching

(1) Nitrogen

Section 3.2.2 above identifies that N leaching from the irrigation area using the Overseer Model has averaged around 75 kg N/ha/yr over the four years. The simple mass balance model shows an average of about 150 kg N/ha/yr leaching. There is some seasonal variability due to when harvesting occurs, how many cuts occur in the reporting year.

The majority of the loading is onto the Terrace Block (127 ha of 141 ha). This area is dissected by a gully that collects the soil drainage water (leachate) via subsurface drains and passes it into a wetland and rock filter treatment system. Nitrogen species sampling at the irrigator, along the gully and at the rock filter shows very low concentration with an average concentration of nitrate being 0.3 g/m^3 measured at the outlet. The majority of the nitrogen >95% has been removed from the wastewater via the land treatment system harvest activities, volatilisation, denitrification and immobilisation.

Further sampling of nitrogen species was undertaken in September 2020. sampling the irrigation water, several locations along the central gully of the Terrace LTA area, the rock filter wetland and the coastal pond.

The nitrogen quality sampling found significantly lower concentrations of nitrogen that predicted by the rootzone loss and drainage concentrations reported using Overseer. This is a consequence of the Overseer model being unable to account for attenuation of nitrogen beyond the root zone.

The water sample analysis is present in Table 4.1.

Table 4.1: Nitrogen Species Analysis LTA

Sample location	Nitrite – N (g/m^3)	Nitrate – N (g/m^3)	Ammonia (g/m^3)	TKN (g/m^3)
Land Treatment Storage tank	<0.002	0.08	25.6	156
After Irrigation under Pivot 4	<0.003	0.26	25.3	154
Top of Gully (upstream of LTA)	<0.003	<0.04	0.37	2.4
Midpoint of Gully	0.024	0.32	1.96	9.9
Rock filter inlet	0.063	0.85	0.09	6.5
Rock filter Mid Point	0.055	0.50	1.52	6.4
Rock filter discharge	<0.003	0.25	0.02	3
Coastal Pond	0.042	0.32	2.78	5.8

Overall, the land treatment area utilising a cut and carry system is removing a significant mass of nitrogen from the wastewater discharge and demonstrated by the sample analysis for the gully and rock filter.

(2) Phosphorus

Olsen P is generally between 15 and 30 mg/L and are relatively stable as shown in Figure 4.1. This is likely due to the cut and carry regime and irrigation application being relatively closely matched. The harvested material is generally removing around 100 kg/ha/yr compared to an application load in the order of 80 kg/ha/yr.

Phosphorus levels are likely to remain stable with the cut and carry management regime.

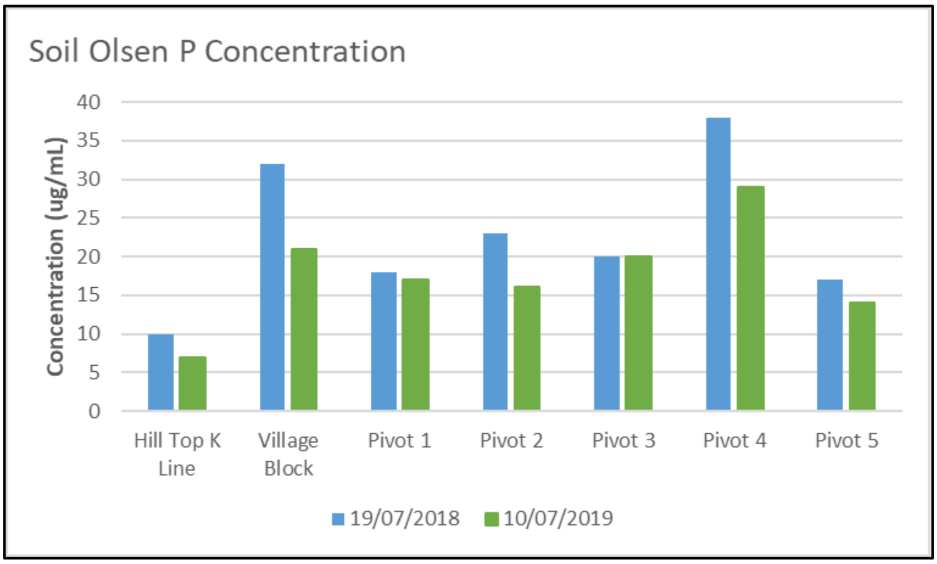

Figure 4.1 Olsen-P Soil Test results (2018 -19)

4.1.2 Ponding and Runoff

The Operation Management Plan outlined in the AEE and Technical Report has not changed. Wastewater application rates and depths are low and there have been no reported cases of ponding and runoff occurring as a result of wastewater applications.

5 MITIGATION OF ENVIRONMENTAL EFFECTS

5.1 Current Mitigation Measures

The land treatment system, as currently set-up and managed, mitigates the potential for effects to occur. For example, the following is undertaken:

1. Soil moisture is monitored real-time and irrigation decisions based on soil moisture deficits for application of Green line wastewater, in addition to Red line wastewater;
2. Low application rate systems to avoid ponding and runoff;
3. Low application depth per pass and sufficient return periods between applications to allow the soil to recover and aerate;
4. Installation of subsurface drainage to ensure Terrace Block soils do not remain saturated and are allowed to aerate between doses;
5. Annual monitoring of soils and addition of lime, gypsum, or dolomite to counteract the high Na;
6. Soil amelioration and ripping as required;
7. Application of wastewater chemicals at rates generally suited for agricultural production and addition of other chemicals as required to account for imbalances;
8. The addition of the wetland and rock filter system to further reduce N inputs into the environment;
9. Appropriate system management and monitoring; and
10. Fresh water flushing of irrigation lines at the cessation of daily irrigation.

5.2 Proposed Future Irrigation Regime

It is proposed that the future operation of the irrigation depth to the Land Treatment Area (LTA) be constrained during the winter months when soil moisture levels are above 96% of field capacity.

The moisture trigger of 96% field capacity is chosen so that the soils have capacity to receive the applied wastewater without ponding or surface runoff.

13. Any non-deficit discharge to land on the Terrace Block discharge area shall only occur onto land that drains to the constructed wetland established in the central gully of the Terrace Block discharge area, as shown on CRCXXX-Figure 1A attached to this consent. The rate of irrigation shall not exceed:

a) During the winter months of June to August

i. When Soil Moisture Level is greater than 96% of Field Capacity the irrigation application depth shall not exceed an average application depth of 2.5 mm per day with a minimum return period 3 days;

ii. When Soil Moisture Level is less than 96% of Field Capacity the irrigation application rate shall not exceed an average application depth of 7.5 mm per day; and *iii. Notwithstanding Clauses (i) and (ii) the peak irrigation application rate shall not exceed 20 mm per day;*

b) During the months September to May

i. The irrigation application rate shall not exceed an average application depth of 7.5 mm per day;

ii. The peak irrigation application rate shall not exceed 20 mm per day.

Climate data and historical daily wastewater volumes were used to model the soil moisture status and the potential irrigation depths.

Figure 5.1 below shows the theoretical soil moisture balance for the period 2009 to 2019 with the LTA fully utilising the proposed conditions.

In the soil moisture balance, Red and Green line wastewater volumes were applied to the land treatment area based on the volume of water available and the previous days soil moisture status. When soil moisture exceeded 96% the applications were limited to 2.5 mm.

The soil moisture balance calculates the daily soil moisture level by using the climate data for the addition of rainfall, and losses due to evapotranspiration, coupled with the irrigation added. The balance is added to the soil reservoir up to field capacity, with the surplus lost to drainage so that the soil maximum moisture level is not exceeded.

The blue line in Figure 5.1 shows the soil moisture deficit, with field capacity at around 115mm. The blue line decreases when a soil deficit is present. At times when the blue line is at 115 additional irrigation applied will cause drainage beneath the soil profile. The soil assessment undertaken by Soil Works has measured the Claremont soils hydraulic conductivity to be less than 0.4 mm/hr or 9.6 mm/day. Limiting the application depth to 2.5 mm/day means that these soils have the capacity to absorb the water without ponding or runoff. This low rate of application avoids bypass flows channels allow soil contact for adsorption of nutrients.

The purple and black lines are the rainfall and irrigation that are added into the system. The soil moisture increased (less any deficit) directly after an irrigation or rainfall event.

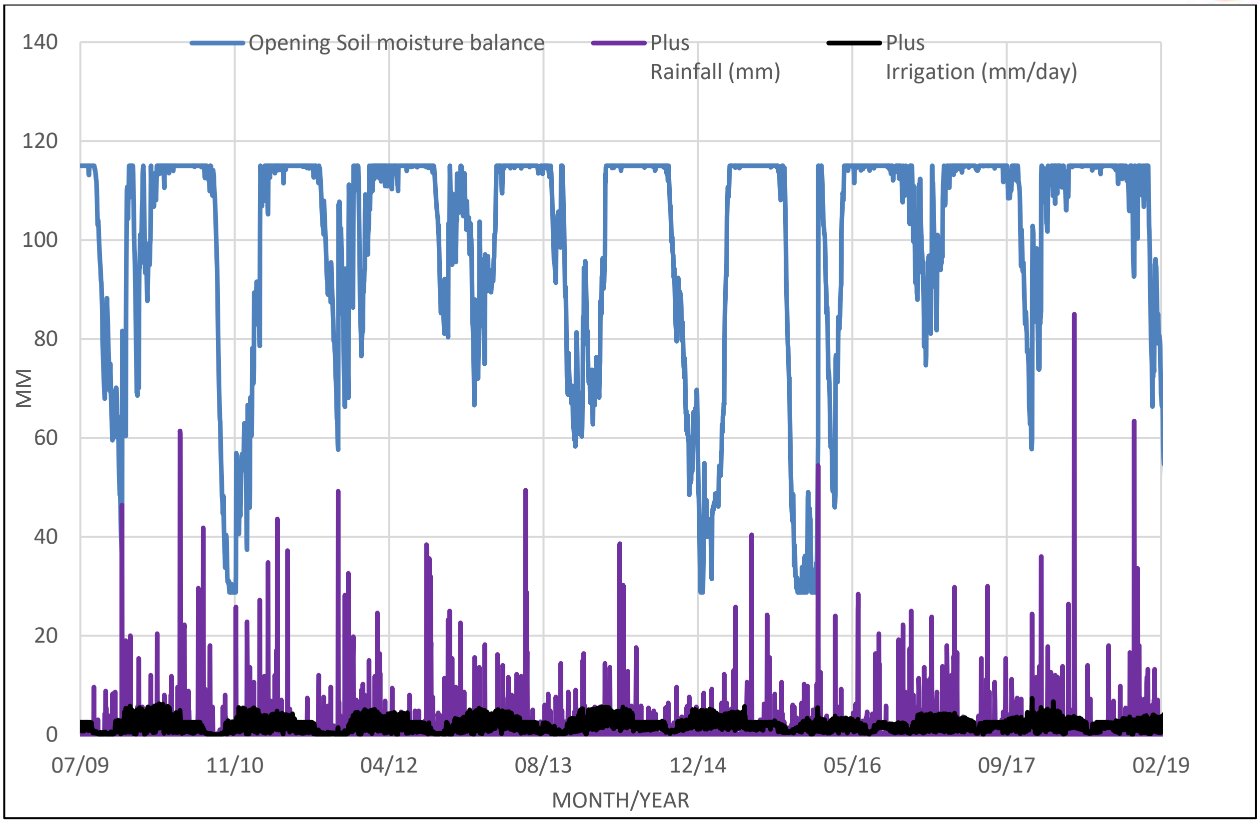

Figure 5.1 Theoretical Soil Moisture Balance

The graph above shows that there are significant periods when the soils are at field capacity during winter (the flat sections of the blue line). By limiting the application rate to the soil to 2.5mm when the soil is nearing or at field capacity, the amount of drainage and nitrogen loss that occurs during wet conditions is limited. When the soil is less than 96% field the soil has the capacity to receive a larger irrigation application depths.

The aim of this condition is to reduce N loss and soil drainage by restricting the potential for over irrigation during winter period and high soil moisture times. This condition prevents overloading the land and provides irrigation water at a rate that the soil can adsorb the nutrients.

The current operation does not limit the application of red line wastewater to the land treatment area at any time during the year. While the soil structure assessments and nutrient sampling of the gully and wetlands shows system is sustainable and removing >95% of the applied nitrogen, there is a desire for conditions to provided certainty that the soils at times of high moisture are not being over loaded.

The implications of introducing a soil moisture cap following the condition described earlier are:

- Irrigation application depth will be limited to 2.5mm per three day return as the soil near field capacity during the winter;
- Potential to increase the volume of water discharged to the sea when daily wastewater volume exceeds 3,175 m^3/day and soils are near field capacity during the winter; and
- Prevention of prolonged saturation of the soil.

The addition of soil moisture cap during winter will provide direction for the operator on how to avoid the potential for overloading of the land treatment areas during the winter.

6 CONCLUSIONS

As discussed in the 2017 technical report, the Pareora Farm WW irrigation system has been designed and is operated to meet the constraints of the soil types encountered across the blocks. This addendum gives a summary of the 2016 - 2020 seasons.

Modelled Nitrogen leaching is in the order of 75 kg N/ha/yr due to harvesting of high yielding ryegrass from the blocks. Further N reduction occurs in soil, central gully and the constructed rock filter wetlands, giving an N concentration that is very similar in the ephemeral stream leaving the property to that arriving at the property. The application of wastewater is having very little downstream effect due to the high removal of N in the system.

Mitigations are also proposed such as reducing winter irrigation application rates when soil conditions are nearing field capacity. This will further reduce the environmental impact and the potential for the overloading of the LTA causing damage to the soil structure and hydraulic performance of the system.

Effects on soils and air from the land application system are considered to be manageable and overall less than minor. This is reflected by the maintenance of the soil structure and high nitrogen removal rates, as evidenced by the low nitrate and ammoniacal forms of nitrogen measured in the gully wetland and coastal pond downstream of the majority of the LTA.

7 REFERENCES

Soilworks, 2004. Soil Assessment for Wastewater Irrigation.

Silver Fern Farms, 2017. Pareora Annual Monitoring Report: July 2016 - June 2017

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8 APPENDIX

Appendix A Updated OVERSEER Report

APPENDIX A

Updated Overseer Reports