PATTLE DELAMORE PARTNERS LTD

Technical assessment of environmental effects of discharging wastewater, stormwater and solid organic waste to land - Silver Fern Farms Takapau

Silver Fern Farms Management Limited

Technical assessment of environmental effects of discharging wastewater, stormwater and solid organic waste to land - Silver Fern Farms Takapau

Prepared for

Silver Fern Farms Management Limited

June 2018

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Limitations:

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1.0 Introduction

1.1 Background

This technical assessment of environmental effects (AEE) has been prepared by Pattle Delamore Partners Limited (PDP) for the purpose of supporting Silver Fern Farms' (*Silver Fern Farms* or the *Company*) application to replace expiring discharge consents related to wastewater, stormwater and solid organic waste at the Silver Fern Farms Takapau site (*Silver Fern Farms Takapau*, or the *Site*, or the *Plant*).

1.2 Summary of the Activity

It is proposed by Silver Fern Farms that the same discharge conditions be retained, including weekly and annual volumes as well as irrigated area. The term of the replacement consent being sought is 10 years.

The work undertaken by PDP involved an assessment of the effects of the existing land discharges on:

- Groundwater quality;
- Surface water quality and ecology of surface water features;
- Soil quality and plants; and
- Air quality.

Changes to the discharge methodology were previously planned to occur under the Ruataniwha Water Storage Scheme (RWSS), where the scheme would provide supplementary water for summer irrigation. In the event that the storage scheme proceeds in the future, any proposed change will be applied for and implemented at a subsequent date. Whilst PDP has not included the RWSS opportunity as part of assessments, the effect of available water on plant health has nevertheless been assessed.

2.0 Proposed Activity

2.1 Replacement consent activities

The existing discharge permits to be replaced, and resultant activities, that are assessed in this report are summarised in Table 1. A more detailed description of these discharges is provided below.

Table 1: Existing resource consents and activity

Existing Consent Ref.	Activity
DP981043Ld & DP981044Ad	Discharge of 35,000 m^3/7 day period and 1,365,000 m^3/year of treated meat processing wastewater onto land and associated discharges of odour and aerosols to air
DP981039Lb	Discharge of solid organic waste material (principally stockyard scrapings) to land[1] at a total nitrogen (TN) rate not exceeding: - 600kg/ha/yr on any cropped pastoral area - 650 kg/ha/yr on any cropped lucerne area
DP981041L	Discharge of stormwater from a catchment area of 9.6 ha (approximately 4.8 ha of which is impervious), defrost water, untreated groundwater, water filter backwash and cooling water (collectively 'other water') to land after passing through a detention pond
DP981040L	Discharge domestic wastewater from an oxidation pond at a rate of 750 m^3 during any 21 day period onto 1.6 ha of land through a border dyke system

Notes:

1. *Note that Silver Fern Farms also holds a certificate of compliance (CC120130L) to discharge solid organic waste material (principally stockyard scrapings) to land on a separate part of the land-holdings (Blocks F and G). These rates are the total for all wastewater, solid organic waste material and fertiliser.*

2.2 Location of Discharge Land

Table 2 contains a summary of the discharge blocks used by the plant and Figure 1 shows a map of the site including the discharge blocks. This map also shows the groundwater bores that supply water to the plant.

Table 2: Land discharge blocks

Block ID	Area (ha)	Discharge type
S1	8.5	• Solid organic waste (DP981039Lb)
S2	5.0	
A	70.88	• Meat processing wastewater (DP981043Ld & DP981044Ad) • Stormwater, defrost water, untreated groundwater, water filter backwash and cooling water (DP981041L)
B	22.23	
C	30.56	
D	25.92	
E	69.12	
F	39.4	• Solid organic waste (CC12013L)[1]
G	77.4	

Notes:
1. *CC120130L is a certificate of compliance (Permitted Activity)*

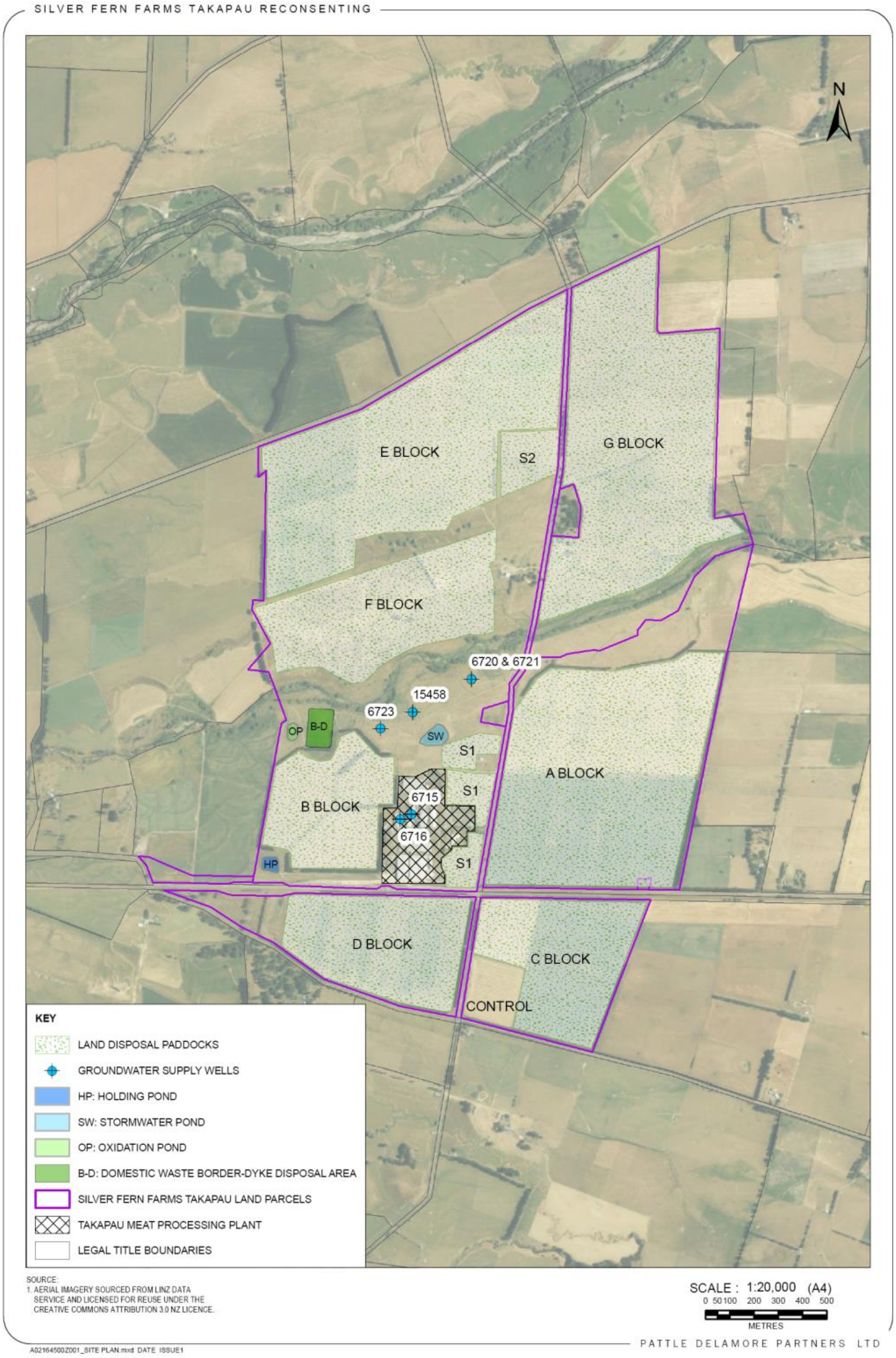

Figure 1: Silver Fern Farms Takapau site plan

The nearest registered community drinking water source is the Takapau township supply bore located at Meta St in Takapau. This source is shown in Figure 2 and is approximately 2 km up-gradient from the nearest Silver Fern Farms Takapau site boundary in terms of groundwater flow direction. It is listed on the on the Ministry of Health's Drinking Water register as follows:

Community:	TAK001	Takapau	Size:	Minor
Volume Capability:		1,598 m^3/day	Category:	Networked Supply
└ Source:	G00056	Meta Street Bore		

This supply is sourced from bore 1762 (150 mm diameter) and is consented under WP140534T from HBRC. The HBRC bore information shows that the bore is 48.9 m deep, with a screen from 31.08 to 33.48 m deep. The water has a relatively high manganese content which requires treating to remove. Central Hawke's Bay District Council also disinfects the water by the addition of chlorine gas to the water at the pump station.

Given the distance to this drinking water source and the fact it is located up-gradient of the site, no further consideration is deemed required.

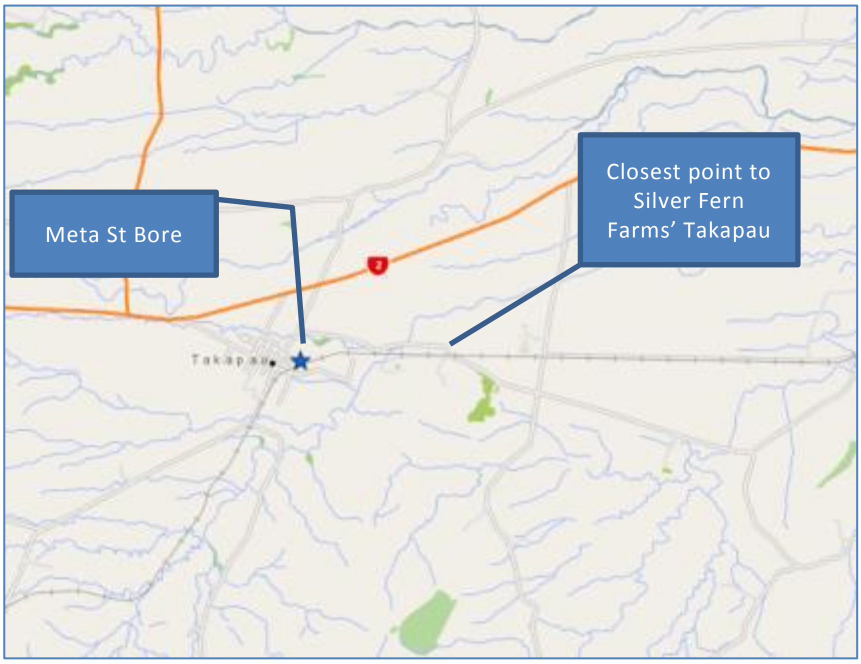

Figure 2: Nearest Registered Community Drinking Water Source (HBRC)

2.3 Overview

The discharges all originate at the meat processing plant. The plant is shown in an aerial image in Figure 3. Also visible in Figure 3 is irrigated Block B to the west of the plant (left of image), the wastewater holding pond to the west, the domestic oxidation pond to the north-west and the stormwater pond to the north.

No changes to the discharges are proposed to occur under the replacement consents sought.

Figure 3: Takapau plant (Google Earth image)

2.4 Meat Processing Wastewater Discharge

Silver Fern Farms Takapau is a mixed species processing operation. There are no fellmongery or rendering operations onsite. All blood, skins / hides and renderable material is sent offsite for further processing.

All wastewater generated from the Takapau plant, including Animal Assembly, Primary Butchery, Secondary Butchery and other processing areas is treated in a non-chemical Dissolved Air Flotation (DAF) treatment device and then irrigated to company owned land surrounding the plant. The DAF treatment system involves the clarification of wastewater via flotation of suspended matter. This dissolved air adheres to and then floats suspended matter to the surface of the treatment device before being skimmed off. The treated wastewater is then diverted to a holding pond where it is stored prior to being discharged to land via irrigation. The holding pond is located west of the plant facility, as shown on Figure 1.

The consent to discharge meat processing wastewater (DP981043Ld & DP981044Ad) allows the irrigation of treated wastewater from the plant onto land which may result in contaminants entering water, and to discharge odorous compounds and aerosols into the air associated with the wastewater irrigation. The consent permits irrigation of Blocks A, B, C, D, and E (as shown in Figure 1), which cover a total area of approximately 218 ha. The 5 ha Control Block (C3) at the south-eastern corner of Block C does not receive irrigation.

The volume of the wastewater discharge is limited to 35,000 m^3/7 day period and 1,365,000 m^3/year (between 1 October and 30 September). Maximum application depths based on the return period of the irrigation event are set as shown in Table 3.

Table 3: Allowable meat processing wastewater application rates

Max. application depth (mm)	Min. return period (days)
≤ 30	7
31 – 45	10
46 – 65	14

Irrigation is via a travelling irrigator system, currently consisting of around twelve irrigators, irrigating multiple rows at a time. Six of the irrigators are currently operated with telemetry monitoring. Daily irrigation records are recorded by run. In the 2015/2016 reporting period, Silver Fern Farms upgraded the irrigation reporting system for all irrigators based on in-line flow meters. The records now reflect the actual recorded volume applied per run versus manufacturers' specifications as previously reported.

Irrigation occurs year round and the application area shifts daily to spread the treated wastewater evenly across the irrigable areas. Block A is the preferred block utilised for wastewater irrigation due to its large irrigable area. Plant growth is harvested and exported from site via a cut-and-carry operation. The restrictive nature of the low permeability soil types on Block E means the irrigation scheduling of this block is based on soil moisture levels, with the majority of wastewater applied there during summer.

The total nitrogen (TN) loading applied to the land is limited to 600 kg N/ha/year on cropped pastoral areas and 650 kg N/ha/year on cropped lucerne areas. This is the combined loading limit applied via the meat processing wastewater discharge and the solid waste discharge described in Section 2.5.

The data provided to us by Silver Fern Farms shows the peak total nitrogen (TN) loading in the wastewater irrigated blocks since 2011 have been well within consented limits.

Similarly, the volume of wastewater discharged has been well within consented limits, both on a 7-day rolling total and annual total (1 Oct-30 Sep) as highlighted in Figure 4 and Figure 5.

A detailed assessment of the process wastewater discharge including a nutrient assessment is provided in Appendix C.

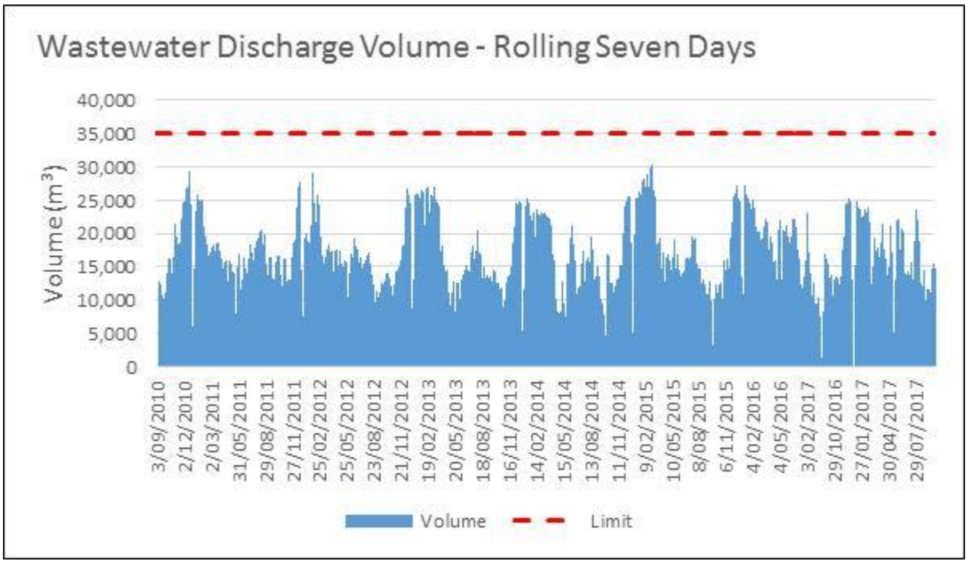

Figure 4: Volume Discharged – Rolling 7-Day Total 2009-2017 (DP981043Ld & DP981044Ad)

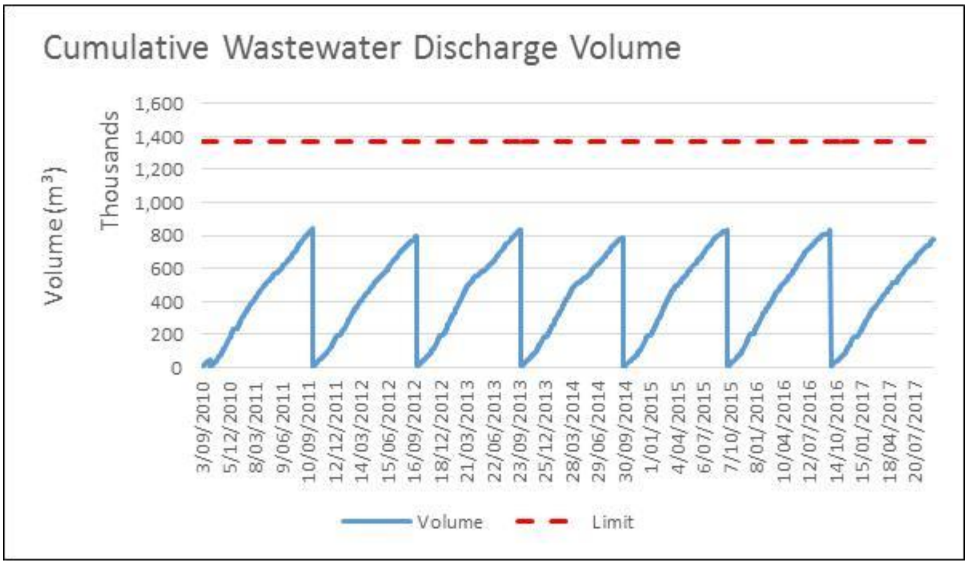

Figure 5: Volume Discharged – Annual 2009-2017 (DP981043Ld & DP981044Ad)

2.5 Solid Waste Discharge

Sampling of this solid waste indicates the composition varies but it is typically between 10 and 11% solids and between 1 and 3% Total Kjeldahl Nitrogen (TKN) by dry weight.

Consent DP981039Lb permits the discharge of solid organic waste material (principally stockyard scrapings) to land (Blocks S1, S2, A, B, C, D, and E, as shown in Figure 1).

Silver Fern Farms also holds a certificate of compliance (CC120130L) recognising permitted activity status to discharge solid organic waste material (principally stockyard scrapings) to land on a separate part of the land-holdings (Blocks F and G).

The organic solids are loaded into a tractor-drawn agricultural spreader before being applied to the land. Grazing occurs across Blocks S1, S2, F and G with short-term low stocking ratios to manage grass growth.

The total nitrogen authorised for the discharge of solids is combined with the discharge of meat processing water (DP981043Ld & DP981044Ad). The nitrogen applied via solids is typically low compared to the consent limits has only been applied to non-irrigated blocks. For Blocks F and G, the peak average loading rate calculated from the data provided is 84.53 kg/ha/year, which is well within the permitted activity limit of 150 kg/ha/year.

A map provided by Silver Fern Farms showing the different sub-blocks is included as Figure 6. This also shows grazed areas.

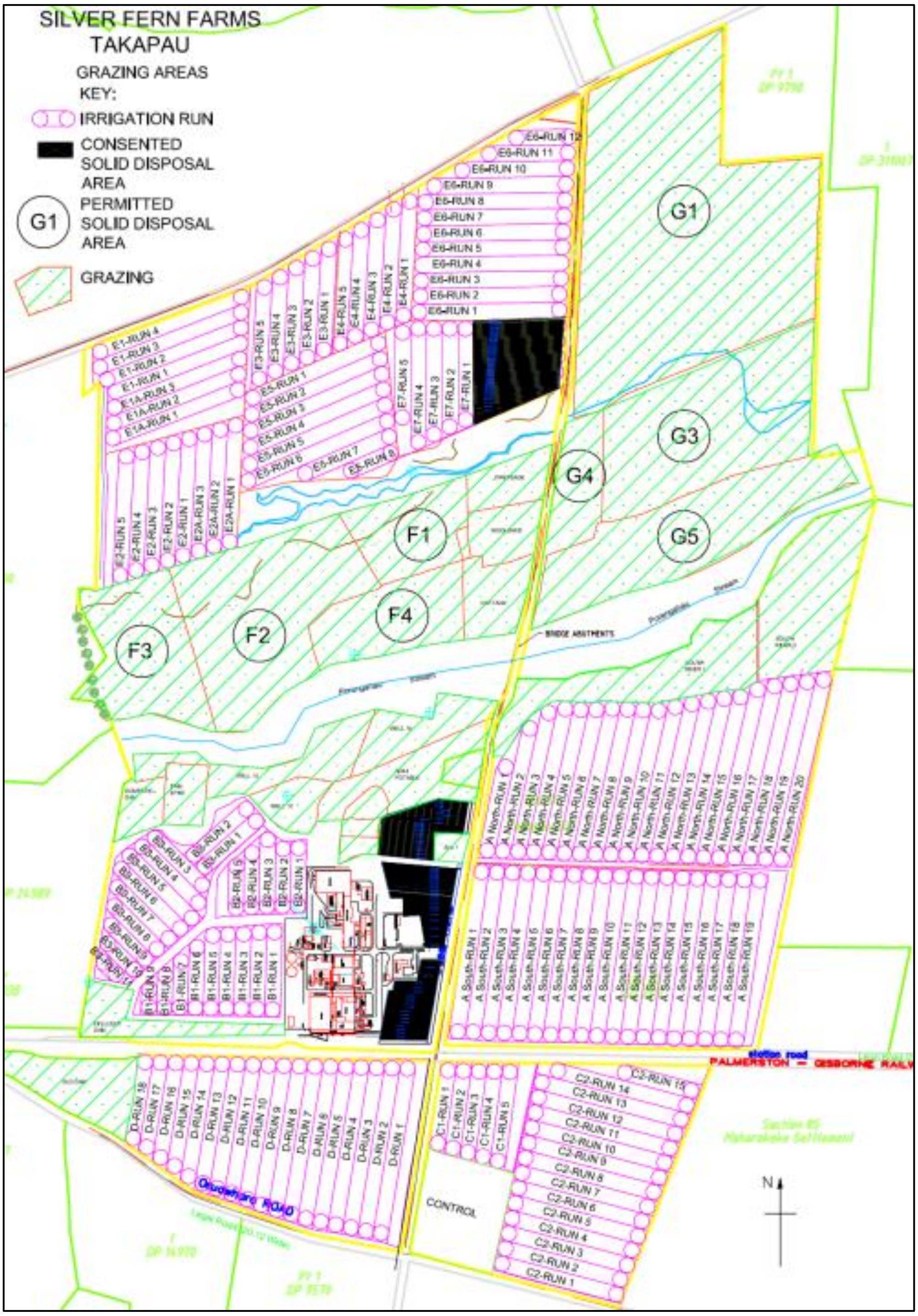

Figure 6: Grazing areas and sub-blocks

2.6 Stormwater and Other Water Discharge

Stormwater and a number of other sources of water generated at the plant are routed to a stormwater detention pond that stores the collected water. The pond is roughly oval in shape and is around 3.4 m deep with a surface area of 5,250 m^2 when full. The sources of water are as follows:

- Stormwater collected from a catchment area of 10 ha, of which approximately 6 ha is impervious rooftops and hardstand surfaces.
- Cooling plant defrost water
- Water sourced from the water supply bores
- Backwash water used to clean drinking water filters. The potable water supply is filtered to remove iron and manganese. The sand filter is back-washed with water containing low levels of chlorine which then drains into the stormwater pond.

Consent DP981041L permits these discharges to land.

To supplement the supply from the water supply bores and to reduce the volume required for discharge to land, where possible, water from the detention pond is recycled and used for:

- Stock washing
- Animal assembly yard cleaning
- Screen washing
- Flushing wastewater lines
- Emergency water for firefighting purposes

Virtually all stormwater is reused across the plant and discharges from the pond are infrequent. This means that almost all stormwater is eventually discharged to land through the wastewater network. Infrequently, overflow/discharge from the pond may occur through a concrete pipe into a natural grassed area. Discharges are anecdotally infrequent and not recorded or metered.

The pond is kept up to three quarters full to provide a buffer should there be a substantial rainfall event. This buffer also enables it to protect the Porangahau Stream should there be a spill in the factory.

Note that stormwater collected from the DAF concrete pad is directed into the DAF treatment device which is part of the wastewater treatment system before being directed into the wastewater storage pond. Details on the DAF treatment device can be found in Section 2.4.

There are no limits imposed on resource consent DP981041L that limit the quantity or quality of discharge. Accordingly, no monitoring data exists or is presented.

CPG (1998) assessed the effects of the discharge and concluded that there is rarely any discharge from the pond and, if there was, the pond has a high retention time which allows any sediment, metal oxides etc to settle out prior to discharge. They noted that any stormwater overflow from the pond would be further treated as it flowed overland towards the Porangahau Stream.

HBRC have noted on the consent documents for DP981041L that the actual and potential effects of this activity are considered minor because the pond has a large retention time, a discharge rarely occurs, and the contaminants in the discharge will have no adverse effect. It was also noted that the activity has been occurring for many years and no adverse effects have become apparent.

Given the infrequent nature of the discharge via overflow and the low level of contaminants expected, the effects of this activity are assessed in this report as part of the wastewater discharge, which is the usual method of discharge for the stormwater given its reuse.

2.7 Domestic Wastewater Discharge

Wastewater at the plant is also generated from the domestic facilities onsite. These include waste streams from ablution blocks and kitchens (tearooms). The waste is diverted to an oxidation pond for treatment.

Consent DP981040L covers the discharge of treated sewage from the oxidation pond to 1.6 ha of land through a border dyke irrigation system. The locations of the oxidation pond and border dyke disposal area are shown in Figure 1.

The discharge is limited to a total volume of 750 m^3 during any 21 day period. The monitoring shows this occurs as a bulk discharge of up to 750 m^3 every three weeks and is alternated between two 0.8 ha discharge areas, in accordance with condition 3 of the consent. The volume limit has been met with the exception of some regular exceedances from 2007 to 2009 (see Figure 7). However, the consented limits have been met since that time.

A detailed review of the domestic system is provided in Appendix B.

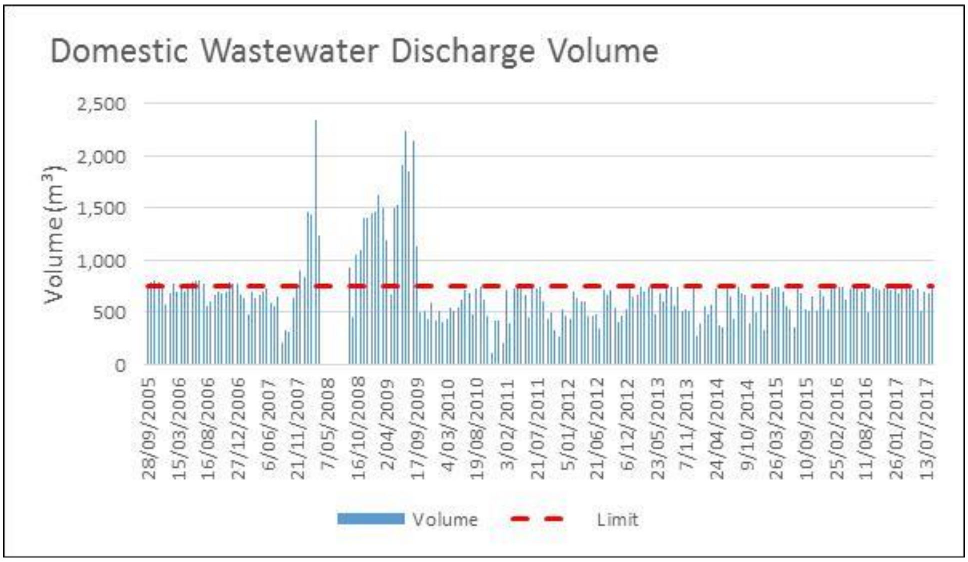

Figure 7: Volume Discharged in 21 day period 2005-17 (DP981040L)

The discharge quality results of the domestic wastewater disposal indicate that TN has fluctuated over the years, peaking at 60 g/m^3 in 2010, but has trended downwards since that time to recent readings of less than 40 g/m^3 (Figure 8).

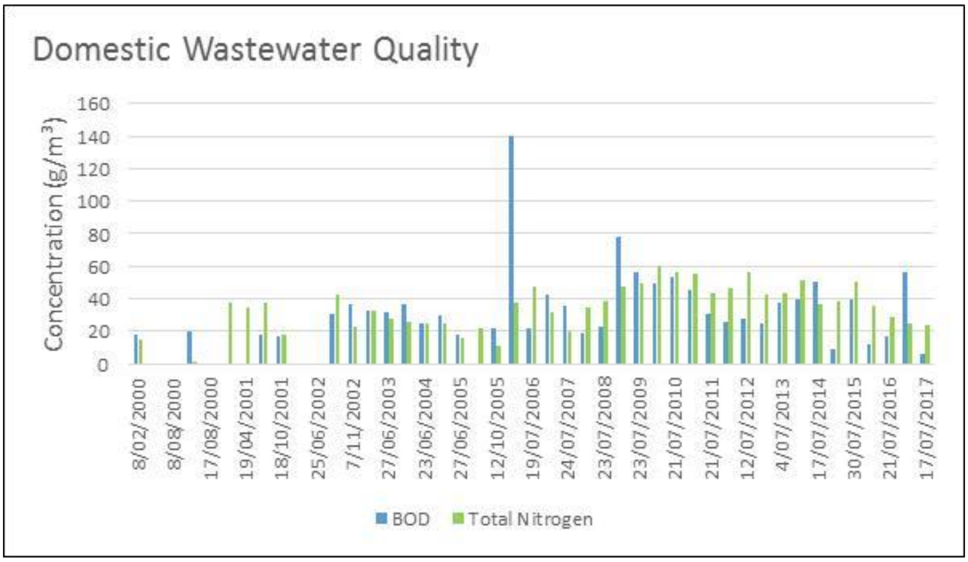

Figure 8: TN Discharged in period 2000-17 (DP981040L)

As outlined in Appendix B, the existing domestic wastewater management system is considered to be operating well, with the oxidation pond of suitable size and providing sufficient treatment for the following irrigation system. Some recommendations are made to optimise treatment. These are discussed later in this report.

3.0 The Existing Environment

3.1 Site Description

Silver Fern Farms Takapau is located on the Ruataniwha Plains, on Fraser Road approximately 3.5 km east of Takapau Township.

The blocks of land currently used for the discharges of wastewater, stormwater and waste solids generated by the plant are pastoral land located within 2.5 km of the plant, as shown Figure 1. The current groundwater supply bores are located at the plant or to the north of the plant, south of Porangahau Stream. These are also shown in Figure 1.

3.2 Surrounding Properties and Activities

The site and wider area are zoned for rural use under the Central Hawkes Bay District Plan (CHBDC, 2003). The land neighbouring the plant is currently used for pastoral/grazing activities, including dairy farms and intensive cropping operations. The wider area of the Ruataniwha Plains is also highly intensified, with large-scale dairying and cropping operations being carried out.

Nearby businesses and operations include Takapau Golf Course, Oruawharo Homestead Limited and Kintail Honey Limited.

Figure 9 shows the current resource consents recorded on HBRC's database within 2 km of Silver Fern Farms land at Takapau. These include a number of bore permits. There are three discharges to land shown. HBRC may wish to update their records, as two of these are Silver Fern Farms consents which are shown outside of their land holdings. These are the discharge permit for solid organic waste (DP981039Lb) and a consent to discharge contaminants from a disued offal pit (DP940241L). The remaining discharge to land (DP030565La), to the northeast of the site, is for discharge of effluent from a farm dairy and piggery. The one discharge to air is also from the piggery (DP100580A). There surface water takes shown to the northwest, refer to the same consent (WP170060T), which authorises the abstraction of water from the Makaretu Stream to fill an off stream reservoir for subsequent irrigation, when flows in the Tukituki and Tukipo Rivers are above median flows.

Figure 9 indicates that there are three other groundwater takes in the vicinity of the plant, all of which are for irrigation. These consents were first granted in 2005, 2012 and 2015.

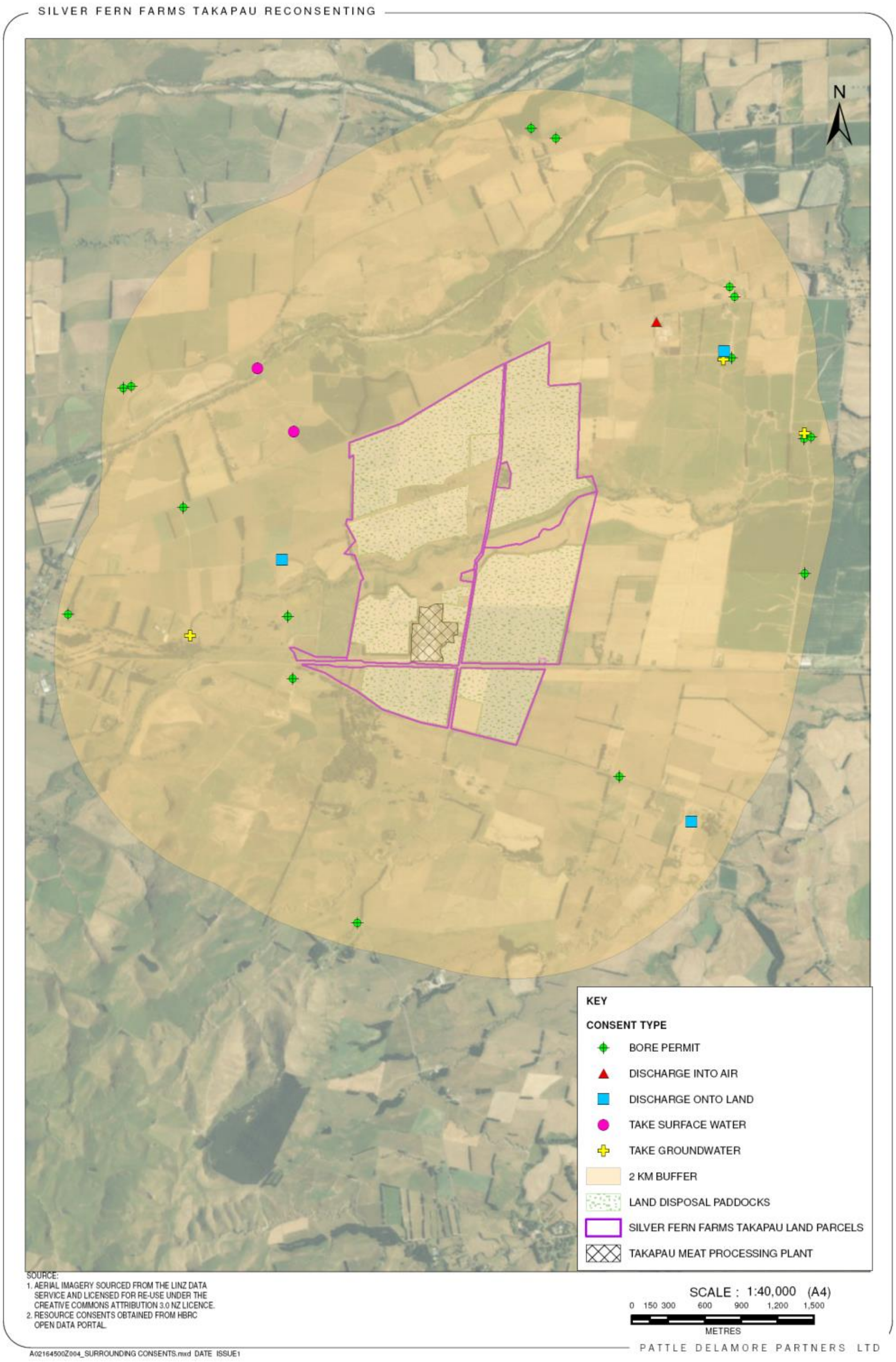

Figure 9: Current resource consents within 2 km of Silver Fern Farms' land

3.3 Climate and Meteorology

Long term data for the Kopua climate station (1962 to 2016) indicates that there is approximately 1,000 mm/year of rainfall at the site, with monthly rainfall varying between roughly 65 mm in February and 120 mm in July.

Silver Fern Farms also has a weather station located at the plant which provides daily records of precipitation and temperature extending back to 2010. This weather station also records wind speed and direction. In addition, Central Hawke's Bay District Council (CHBDC) has a weather station (No. 33) located near the Waipukurau Airfield, approximately 12 km from the Silver Fern Farms Takapau Plant. That weather station has recorded potential evapotranspiration (PET) from December 2013 to present. This gives an annual PET of 1,304 mm with moderate variation over the monitoring period.

The Silver Fern Farms data shows that mean annual rainfall over the monitoring period is 774 mm at the plant. The mean annual temperature is 12.6 °C. Monthly maximum temperatures have varied between roughly 24.1 ^{o}C (January) and 11.2 ^{o}C (July).

Daily average temperature and precipitation data from Silver Fern Farms and PET data from CHBDC weather station is presented in Figure 10.

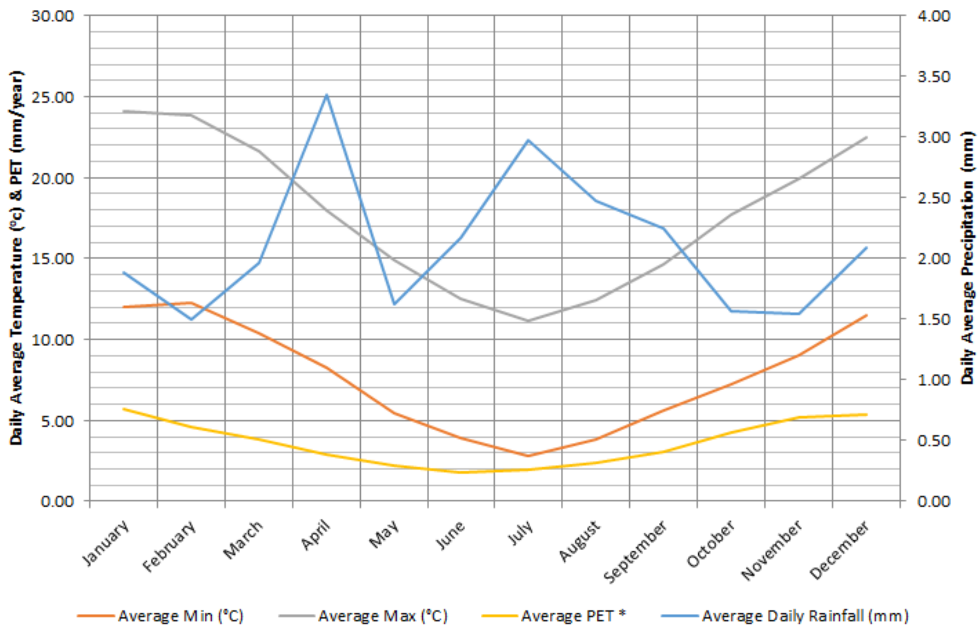

Figure 10: Precipitation and temperature and PET for Takapau Plains 2009 – 2017

The nearest weather station with hourly wind data is the Takapau Plains automatic weather station (AWS), which is located approximately 11 km west of the plant. Data from 2008 to 2012 inclusive was imported into AERMET View and analysed with WRPLOT View. The resultant wind rose is presented in Figure 11. The prevailing wind direction is from the south-west, with the second prevailing wind from the west, i.e., along the Ruataniwha Plains. This suggests that wind conditions at the plant are likely to be similar to those at the weather station, as there are no significant changes in the surrounding topography between the two areas.

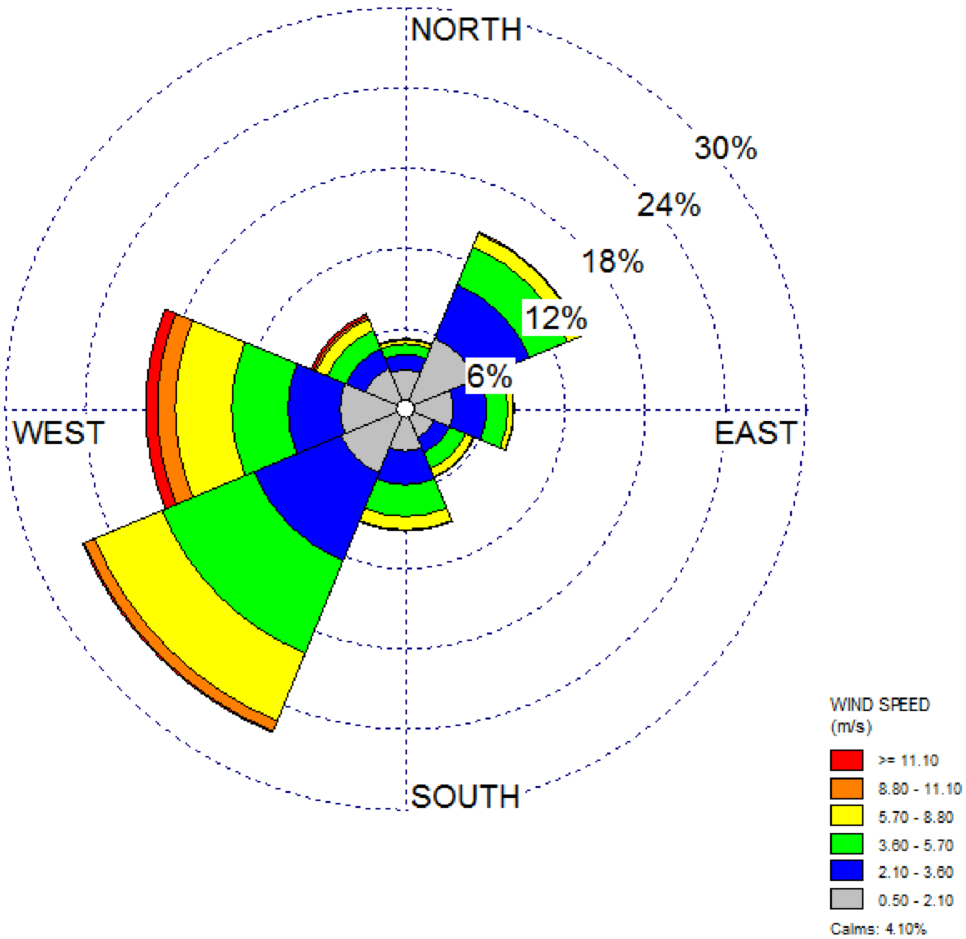

Figure 11: Wind rose for Takapau Plains AWS 2008 – 2012

Figure 12 shows that the wind speeds are generally low, with wind speeds less than 5.7 m/s approximately 82% of the time. Calm conditions occur 4.1% of the time.

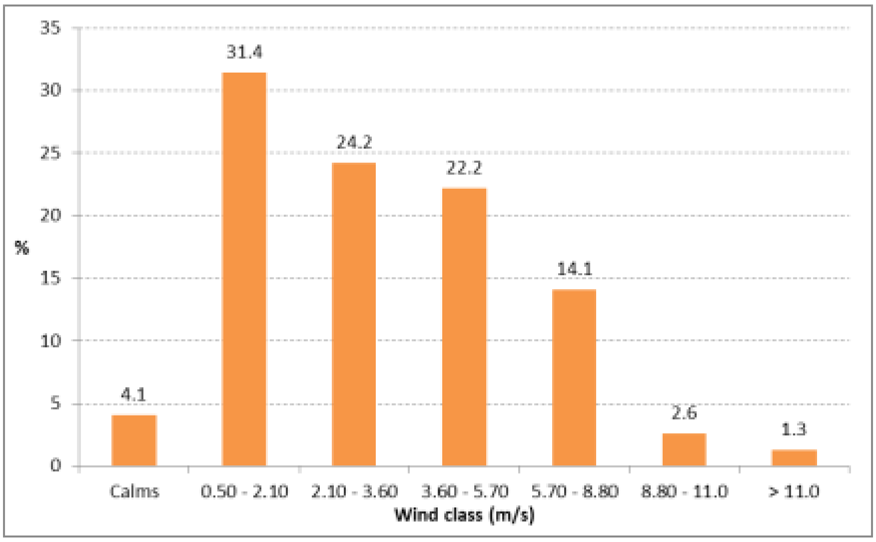

Figure 12: Wind class frequency distribution for Takapau Plains AWS 2008 – 2012

3.4 Topography

The entire Silver Fern Farms site is considered to be flat at an elevation of approximately 200 m above mean sea level with very little variation in topography (see Figure 13). The flat topography is ideal for wastewater discharge via irrigation.

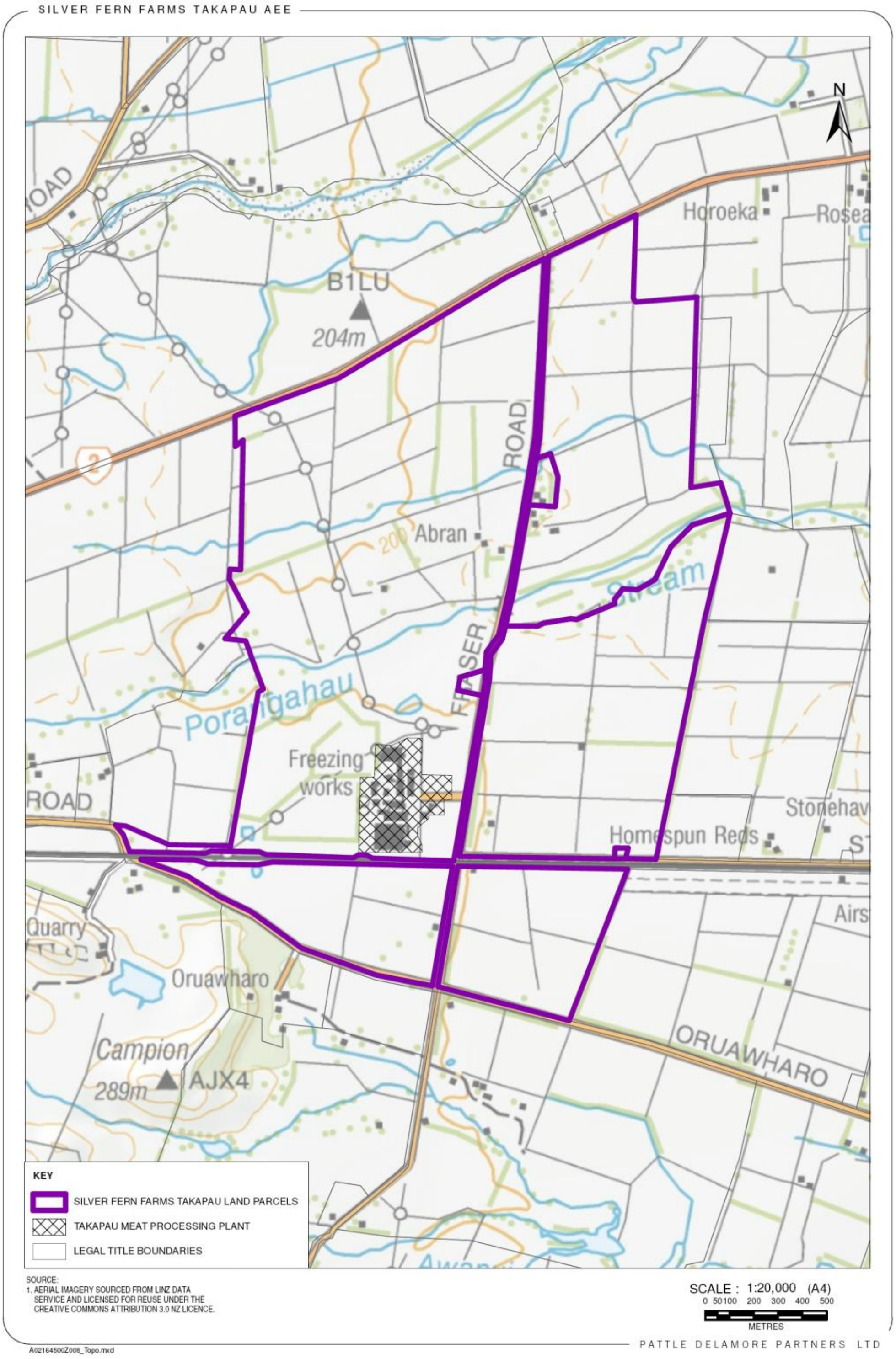

Figure 13: Silver Fern Farms' Site Topography

3.5 Geology

The Takapau Plains are located on the south edge of a depression trending north-east which underlies the larger Ruataniwha Plains. Basement rocks comprise highly folded and faulted Triassic and Jurassic greywacke and argillite, overlain with Pleistocene sandstones, mudstones, and limestones. Covering this is a mantle of mid/late Pleistocene fan gravels and sands ranging from 50 to 120 m in thickness.

The subsurface geology of the area is comprised of young gravel and silt, known as the Ruataniwha Alluvium (Kingma, 1962). This layer is up to 100 m thick in the vicinity of the site. An Upper Pliocene sandstone and siltstone layer underlies the gravel. This layer is up to 260 m thick in the vicinity of the site. This is underlain by an Upper Pliocene limestone layer, with a maximum thickness of approximately 50 m around the site. This in turn is underlain by a series of alternating sedimentary and limestone layers to the greywacke basement at an estimated approximate depth of 10 km.

The geology of the irrigation blocks (Blocks A – E) has been described as being located on aggradational river terraces covered in alluvium derived from fluvially redistributed tephra and loess over aggradational gravels. Block F is composed of two small non-floodable degradational terraces related to the aggradational terrace above, and an infrequently flooded degradation terrace covered in alluvium (CPG, 2009). From this the geology of Block G can be inferred, and it is assumed that the southern section of the block is geologically similar to Block F, and the northern part is similar to Blocks A – E.

There are a number of faults in the area, including the Oruawharo Fault Zone (also known as the Makuri Fault) situated east of the Takapau Range, which strikes from south of Takapau in a north-easterly direction towards the intersection of Fraser Road and Oruawharo Road. Another fault zone, the Takapau Fault Zone, is located approximately 700 m west of the Oruawharo Fault Zone. According to the available geological information, the faults do not appear to have significantly affected the overlying young gravel and silt deposits.

3.6 Soils

3.6.1 General

The main objective of wastewater or solids discharge to land is to apply it in a manner that allows treatment of the waste, via re-use as a source of water and nutrients for the soil and plants and attenuation of microbes. The amount of water that can enter and be retained by a soil depends on a range of properties including depth, texture, and structure, as these affect water balances, internal drainage, and susceptibility to structural damage. The application of discharges should therefore be managed based on these properties.

PDP have undertaken a detailed soils investigation and this is described in Appendix C. The following sections on soils are based on the information in that memo.

3.6.2 Soil types

Several different soil types are identified by Landcare's S-map online soil database on the land holdings; however, many of these soil types are relatively similar. During site investigations, the land holdings were observed to have three groups of soils that demonstrate differing characteristics when irrigated. A soils map is provided in Figure 14. The three groups are:

- Allophanic and Orthic Brown soils.
- Perch-gley Pallic soils.
- Fluvial Raw soils.

The Allophanic Brown and Orthic Brown soils underlie the majority of the process water irrigation blocks. Orthic Brown soils are moderately well drained, with medium phosphorus retention. The Allophanic Brown soils are Brown soils that contain an Allophanic soil horizon. This horizon typically increases the phosphorus retention and drainage class to high phosphorus retention and well drained respectively.

The Perch-gley Pallic soil extends across approximately half of Block E. This soil contains a confining clay layer that forms a rooting and hydraulic barrier. This soil is typically associated with poor drainage and low phosphorus retention. This was supported by PDP observations of highly saturated soil in this area (*site walkover*, 18 October 2017), and by a reduced irrigation loading rate to this area.

The Fluvial Raw soils are found underlying streams, which run through the land holdings. This soil is very young due to sedimentation processes occurring from stream flow. Consequently; it lacks a significant topsoil layer. This soil is typically well drained, with low to moderate profile available water and very low phosphorus retention.

A visual soil assessment was conducted during a site visit by PDP on different blocks. This showed that the irrigation blocks containing allophanic/brown soils (Blocks A, B, C, D and parts of E) all have soils in moderate to good condition. The gley soils in parts of Block E were in poor condition, but this is attributed to the soil type and not as a result of wastewater irrigation.

Soil permeability testing undertaken indicates that the allophanic/brown soils have good particle distribution and are suitable for the existing irrigation rate. Permeability testing of the gley soils and visual observation, confirms that wastewater irrigation of this soil type is unsuitable except for deficit irrigation during summer and early autumn.

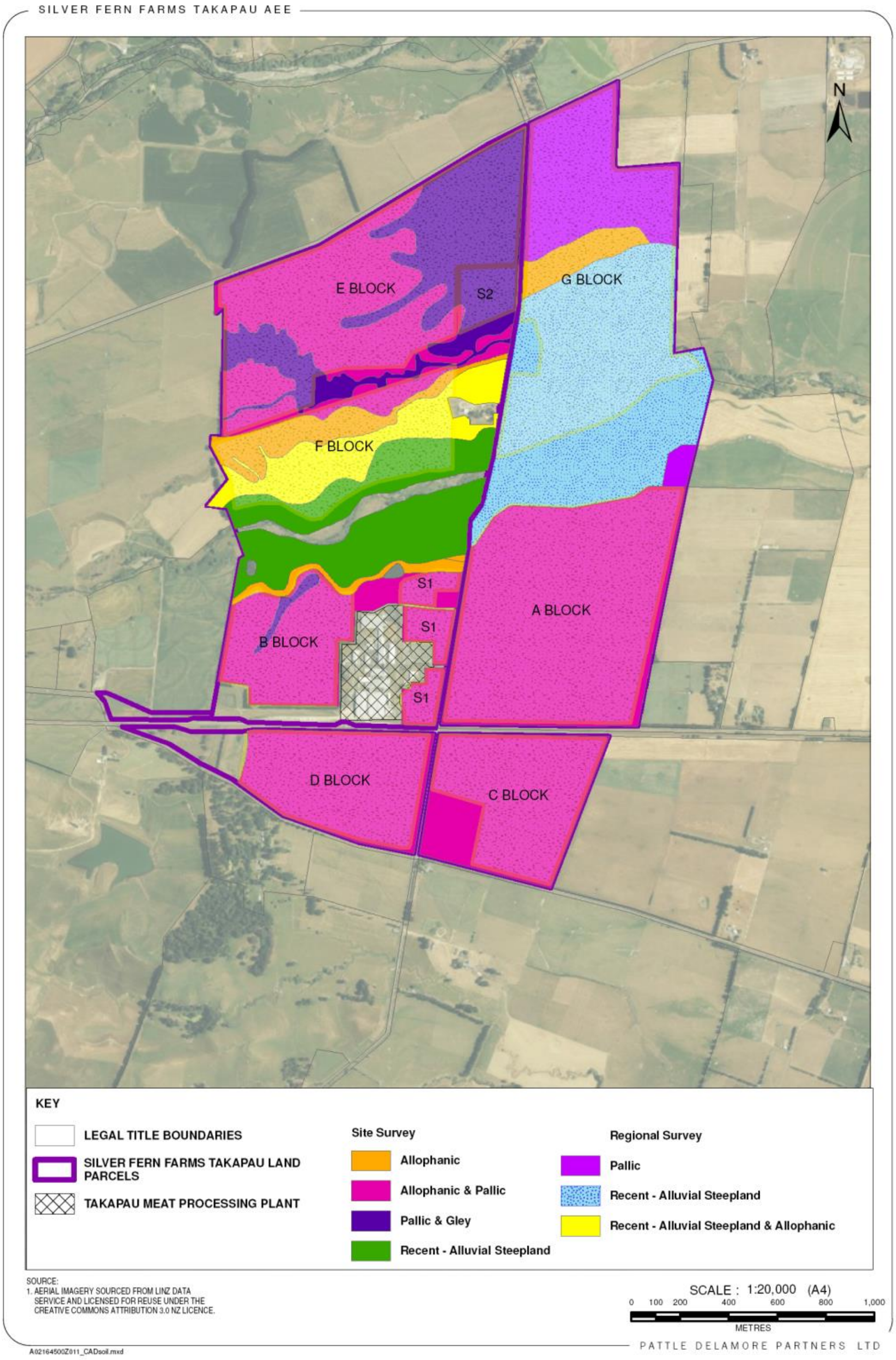

Figure 14: Soils map

3.6.3 Soil monitoring

Monitoring of soil nutrient levels is conducted by Silver Fern Farms annually for the process wastewater irrigation blocks (Blocks A, B, C, D and E) and the solid spreading blocks (Blocks F and G). The last soil sampling event provided was undertaken on 30 August 2017. The results are summarised in Table 3 in the memorandum in Appendix C for the process water irrigation blocks, and in Table 4 below for the solid spreading blocks.

Monitoring has been conducted to a depth of 75 mm. Block C3 is utilised as a control block and this is appropriate for comparison of nutrient levels as irrigation has not occurred on this block.

Monitoring data indicates elevated Olsen P levels (plant available phosphorus) in the main irrigated blocks, A, B, C and D. The optimum Olsen P level for the land use is 30 – 40 mg/L (Dairy NZ, 2012). The technical memorandum in Appendix C shows that the average phosphorus loading rates across all blocks are slightly in excess of crop uptake rates, which is primarily associated with the blocks receiving irrigated process wastewater.

Sodium levels are elevated for all irrigated blocks, in comparison to the control block; however, the exchangeable sodium percentages remain relatively low. At the monitored ESP levels, it is not expected that the soils will be experiencing impaired permeability as a result of elevated sodium. The ESP levels will require ongoing monitoring to identify if there is an increasing trend and whether lime or gypsum addition is required to offset sodium addition. pH levels in the soil remain at optimum levels (DairyNZ, 2012).

Table 4: Soil Monitoring Results for Solids Spreading Blocks

Monitoring Parameter	F	G	Control (C3)
pH	6.2	5.8	5.9
Olsen P (mg/L)	34	37	14
Sodium (me/100g)	0.1	0.1	0.10
Potassium (me/100g)	0.6	0.4	0.6
Calcium (me/100g)	11.5	5.3	9
Magnesium (me/100g)	1.4	0.9	0.7
CEC (me/100g) [3]	17	12	17
ESP (%) [3]	0.9	1.2	0.6
ASC [3 4]	28	25	82
TOC (% w/w) [3 4]	4.8	3.5	9.0

Notes:

1. *Based on the blocks average of soil monitoring results from 30 August 2017 sampling event.*
2. *CEC = cation exchange capacity, ESP = exchangeable sodium percentage, ASC = anion storage capacity, TOC = total organic carbon.*
3. *Results not available for the 30 August 2017 sampling event, so the block average 29 July 2016 sampling event results were used.*

The soil monitoring data for Blocks F and G indicates Olsen P is elevated when compared with Block C (control), but within the optimum level for the land use 30 – 40 mg/L (DairyNZ, 2012). All other monitored parameters indicate no significant change relative to Block C (control), except for a reduction in the anion storage capacity (ASC) and the total organic carbon (TOC). pH levels in the soil remain at optimum levels (DairyNZ, 2012).

Soil samples for heavy metal analysis were also collected in October 2017 from Blocks A and D (process wastewater irrigation blocks only) for assessment against a selected control site, Block G, which has received no historic irrigation and has the same gley soils as parts of Block E. Because gley soils would generally score lower under a visual soil assessment, a gley soil control block was selected for comparison with Block E, to assess whether or not wastewater irrigation was contributing to the lower scoring of Block E or whether it was solely associated with soil type.

Monitoring of the irrigation blocks indicates that there is minimal increase in heavy metal concentrations in comparison to the background levels and all results are well below guideline limits. A slight increase in zinc concentrations in comparison to the background levels may be occurring, however, given the number of years that irrigation has been occurring at the site, the rate of increase is considered negligible.

Soil core sampling was conducted in October, 2017 to test soil permeability from all process water irrigation blocks but Block B, which is stony and did not allow for core collection. Infiltration testing results indicate the allophanic/brown soils are suitable for wastewater irrigation under most annual conditions, however, the gley soils are unsuitable for wastewater irrigation other than under deficit conditions (which generally occur in summer and early autumn).

3.6.4 Nutrient Modelling and Monitored Soil Water Nitrogen

The whole Takapau land holdings (including process and domestic wastewater irrigation, and stockyard solids spreading activities and un-irrigated areas) has been modelled using the OVERSEER nutrient modelling program (Version 6.3.0, released May 2018). This model is used to identify nutrient utilisation and losses based on the 2015-2016 processing season. This record year was chosen as the most recent full year of records without significant discrepancies. The nutrient model developed for the process wastewater irrigation system is provided in detail in the memorandum in Appendix C.

The results of this modelling show that process wastewater irrigation, domestic wastewater irrigation and solids spreading account for 85 % of nitrogen entering the land-holding and 100 % of phosphorus. These activities contribute 120 kg/ha/yr of nitrogen and 19 kg/ha/yr of phosphorus. The nutrient load is almost entirely utilised by the cut-and-carry operations, with 119 kg/ha/yr of nitrogen and 15 kg/ha/yr of phosphorus exported as supplements.

There is some nutrient loss is via leaching through the soil column, and to the atmosphere via denitrification and volatilisation. Nitrogen leaching has been modelled at a rate of 17 kg/ha/yr, and denitrification and volatilisation is at a rate of 11 kg/ha/yr.

While the model shows that phosphorus is accumulating in the soil, due to the flat nature of the land, the model suggests that there is minimal loss of phosphorus to water.

There are significant differences between the blocks, as detailed in the report, but overall the modelled nitrogen leaching rates are low for this type of wastewater management system.

The OVERSEER model output was compared with lysimeter monitoring data collected onsite. Lysimeter data is sampled approximately twice monthly (deep and shallow) within 10 blocks. However, the failure rate of samples due to insufficient volume is high (approximately 65 %). A comparison of the OVERSEER data and 2015/2016 monitored lysimeter data is provided in the memorandum in Appendix C.

The lysimeter data shows higher concentrations of nitrogen in the soil water than would be expected from the cut-and-carry operation, as shown with the OVERSEER results.

While OVERSEER predicts the nitrogen leaching to be low, in light of the lysimeter results and in line with good practice, it is recommended that some consideration be given to further optimising management to minimise nitrogen leaching. This could include options for increasing pasture yield, for example re-sowing some irrigation areas with high-yield ryegrass species, particularly where pasture has become patchy, and considering irrigation with clean water to prevent grass die-off, if a small amount of water becomes available under the groundwater abstraction consent.

3.7 Land Use Capability

Land use capability (LUC) maps have been sourced from the HBRC GIS database. These are shown in Figure 15.

Blocks A, B, C and D are entirely classified as LUC 3. Around half of Block E to the west and north, and a quarter of block G to the north is also LUC 3. This LUC is defined as '*Land with moderate limitations for arable use but suitable for cultivated crops, pasture or forestry*'.

Most of Block F and around half of Block G are classified as LUC 4. LUC 4 is defined as '*Land with moderate limitations for arable use but suitable for occasional cropping, pasture or forestry*'.

The remaining half of Block E and quarter of Block G are classified as LUC 6 which is defined as '*Non-arable land with moderate limitations for use under perennial vegetation such as pasture or forest*'.

These maps provide a general indication of land use suitability. On this Silver Fern Farms' site, the specific investigations on soil type, land use suitability and management practices that have been undertaken provide accurate site-specific information. This includes the recent soils investigation by PDP that is detailed in Appendix C.

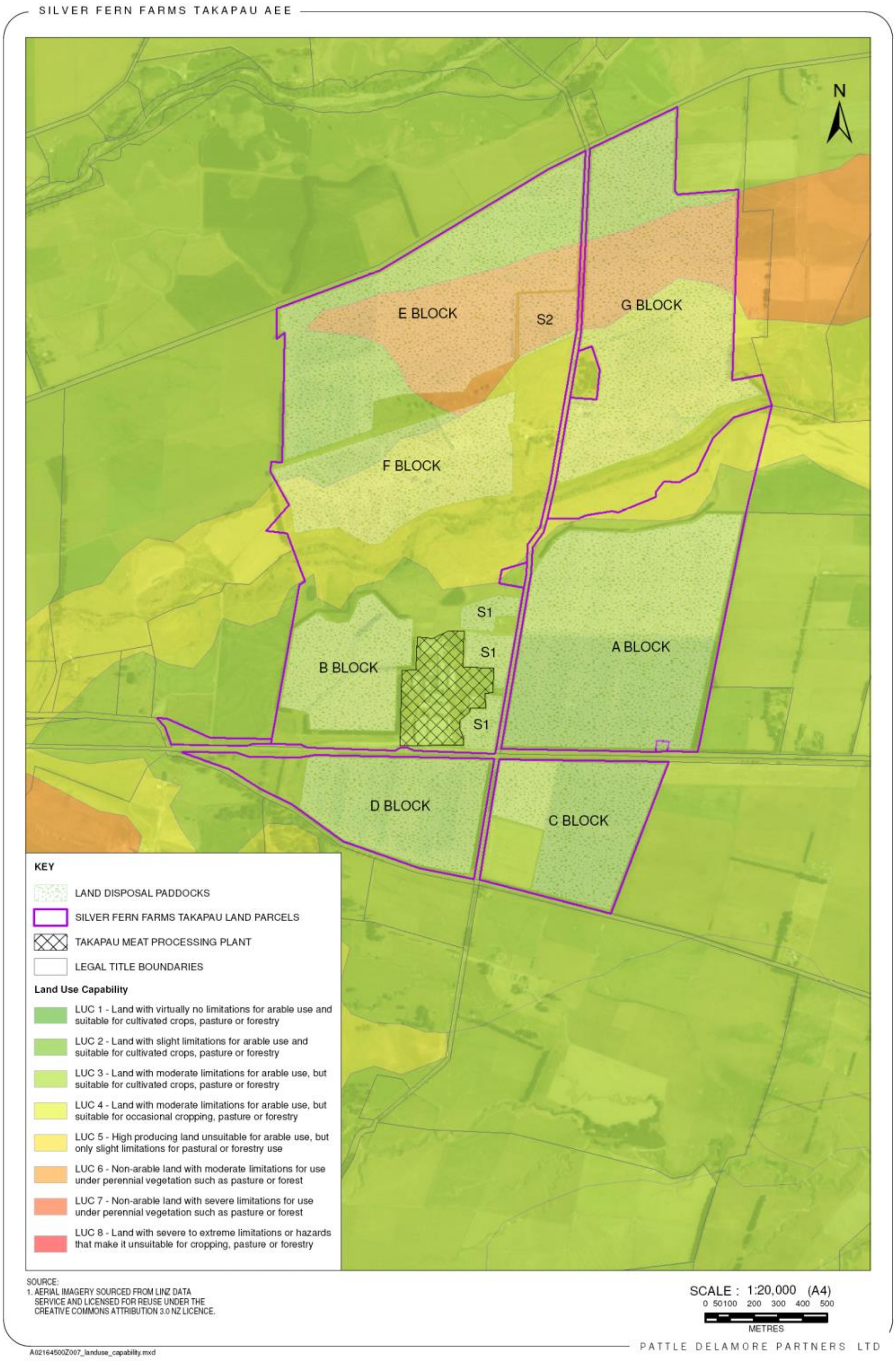

Figure 15: Land Use Capability Map (HBRC)

3.8 Groundwater

3.8.1 Hydrogeological Setting

The hydrogeology of the Ruataniwha Basin is described here based on previous reports including PDP (1999). At a broad scale, the geology of the Ruataniwha Basin can be split into two overall intervals, with a younger gravel formation overlying the older Salisbury Gravel formation to a maximum depth of around 200 m below ground surface (Weir, 2013). However, the depth and thickness of the younger gravels is not well defined, and it is likely that the younger gravels grade into the deeper gravel formation without a distinct intervening surface.

Groundwater in the basin is recharged through rainfall, less any evapotranspiration, together with river seepage from the main Tukituki and Waipawa Rivers, with a lesser component of seepage from other, smaller streams that occur across the basin. Some irrigation recharge also occurs. The groundwater flow direction is generally to the south-east. Locally, PDP (2010) showed the general flow direction across the site to tend more towards the north-east. The Ruataniwha Basin is effectively enclosed by lower permeability strata and, as a result, groundwater discharges from the basin principally via upwards seepage into the main rivers and also through groundwater abstraction.

The Ruataniwha Basin contains a number of confined and unconfined aquifers which provide about 70% of the water used for irrigation, industry, rural, and domestic water supply in the area.

Information from bore logs, geological mapping, aquifer monitoring and testing indicates a multi-layered alluvial aquifer system in this area that is part of the wider groundwater resource of the Ruataniwha Basin. The system consists of alternating water-bearing gravel strata and lower permeability strata comprised of sand, silt, and clay.

As outlined in Good Earth Matters (1998), the main aquifers capable of supplying sufficient water from abstractive use have been identified across the following depths beneath the site.

- **A shallow unconfined gravel aquifer, 5 – 15 m deep:** There are currently no supply bores to the Takapau plant in this aquifer.
- **An intermediate semi-confined gravel aquifer, 25 – 45 m deep:** Two of the Takapau plant supply bores are located in this aquifer (bores 5 and 9).
- **A deep semi-confined gravel aquifer, 55 – 80 m deep:** Four of the Takapau plant supply bores are located in this aquifer (bores 4, 10, 12, and 15). It is proposed that the additional bore will be located within this zone, or deeper if there is sufficient yield at a greater depth.

3.8.2 Groundwater levels

The presence of faults in the area is understood to influence the depths at which water-bearing zones occur and groundwater flow patterns. Groundwater levels are monitored at weekly intervals by Silver Fern Farms in two bores, 6713 (bore 2) and 6715 (bore 4). The locations of these bores are shown in Figure 10 and the measured water levels are shown in Figure 11 and Figure 12.

With a screened depth of 25 to 28 m, 6713 (bore 2) is considered to be screened in the intermediate aquifer. With a screened depth of 68 to 73 m, 6715 (bore 4) is considered to be screened in the deep aquifer. The difference in water levels between the two bores indicates that a strong downwards gradient exists between the intermediate and the deep aquifer at this location.

Although these two bores are in different locations, a downwards gradient is also evident in other nearby water level monitoring data. For example, bores 9 and 10 are at the same location, but recent water level monitoring data shows a difference in static water levels of more than 20 m between the two bores. There is also a large difference in two of the monitoring bores - bores 15954 (7A) and 15957 (7B). The measured water levels in these bores are shown in Figure 19 and Figure 20 and their locations are shown in Figure 21. The levels in the deeper bore (45 m deep) are typically around 10 m below those in the shallow bore (6.6 m deep). This same downwards gradient is observed for monitoring bores 15958 (2B) and 15871 (2A).

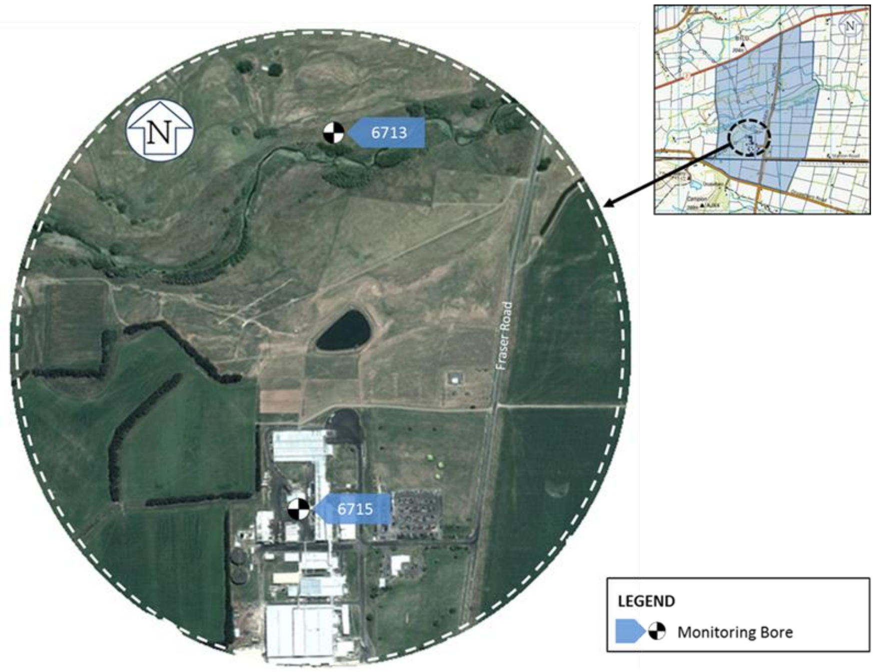

Figure 16: Indicative location of bores 6713 (bore 2) and 6715 (bore 4)

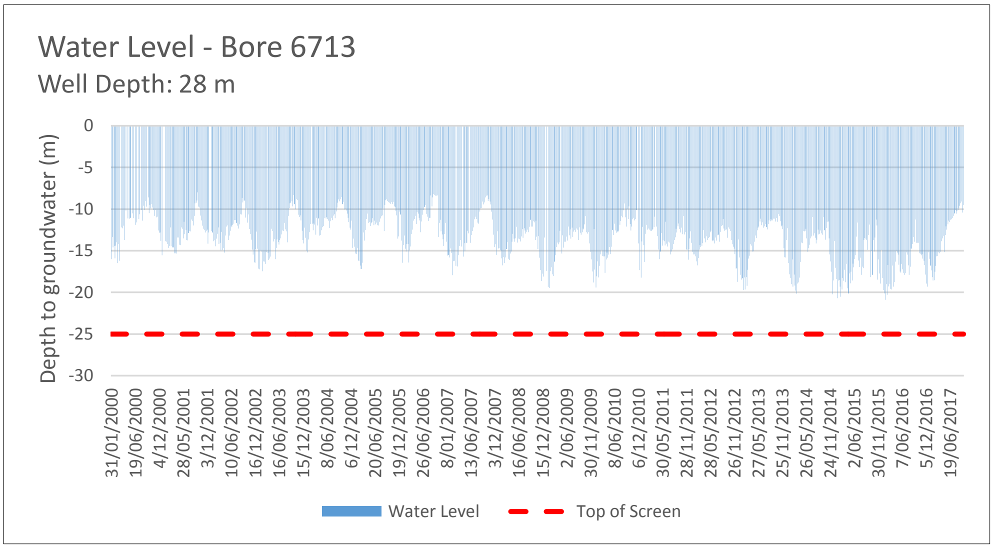

Figure 17: Weekly measured water levels in 6713 (bore 2)

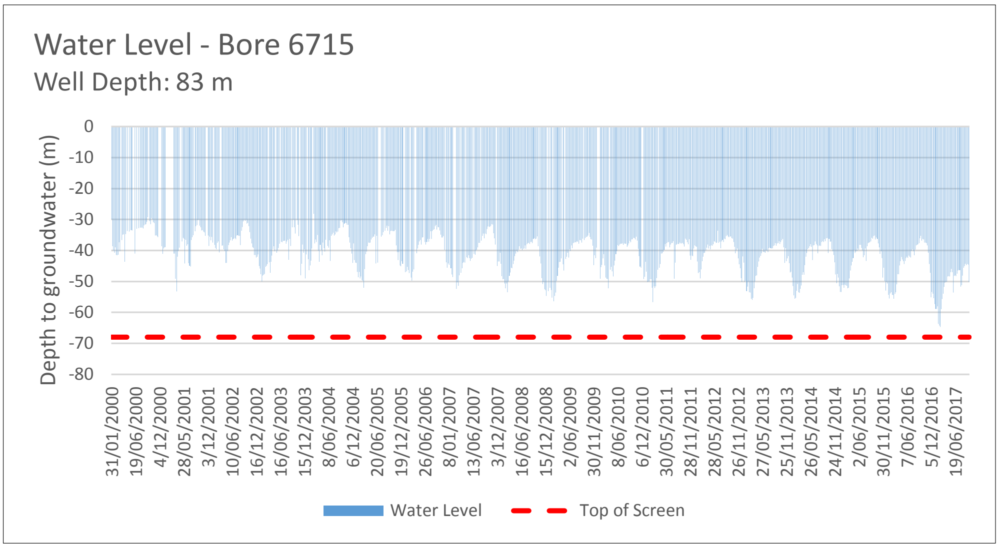

Figure 18: Weekly measured water levels in 6715 (bore 4)

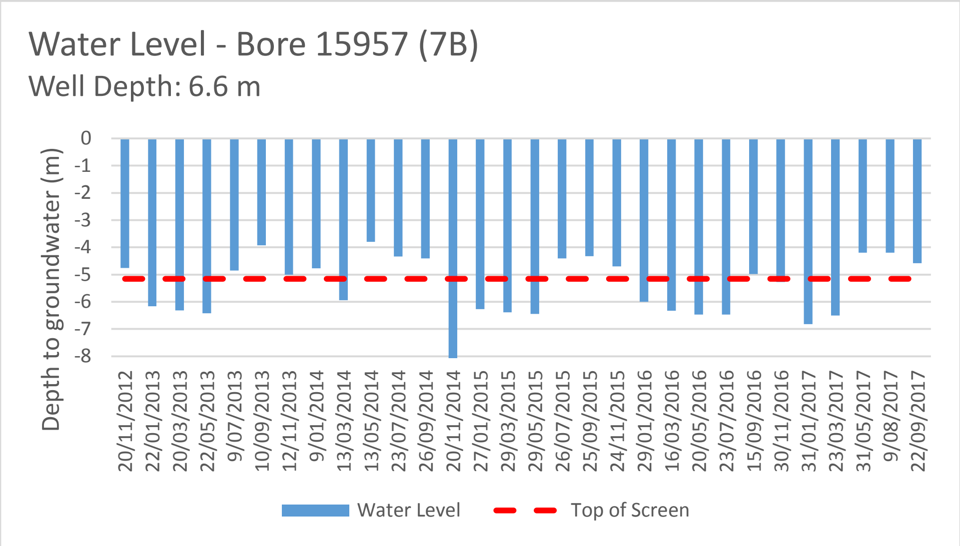

Figure 19: Measured water levels in 15957 (bore 7B)

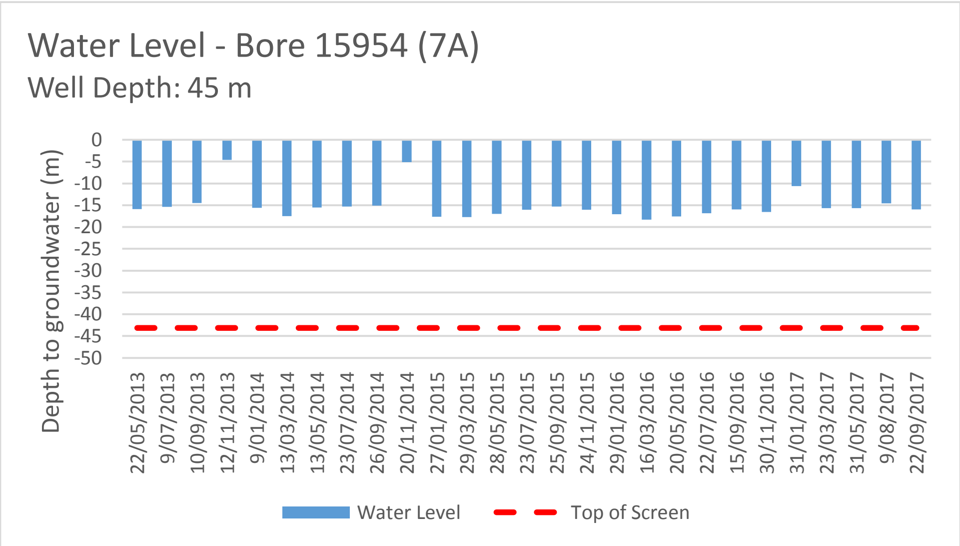

Figure 20: Measured water levels in 15954 (bore 7A)

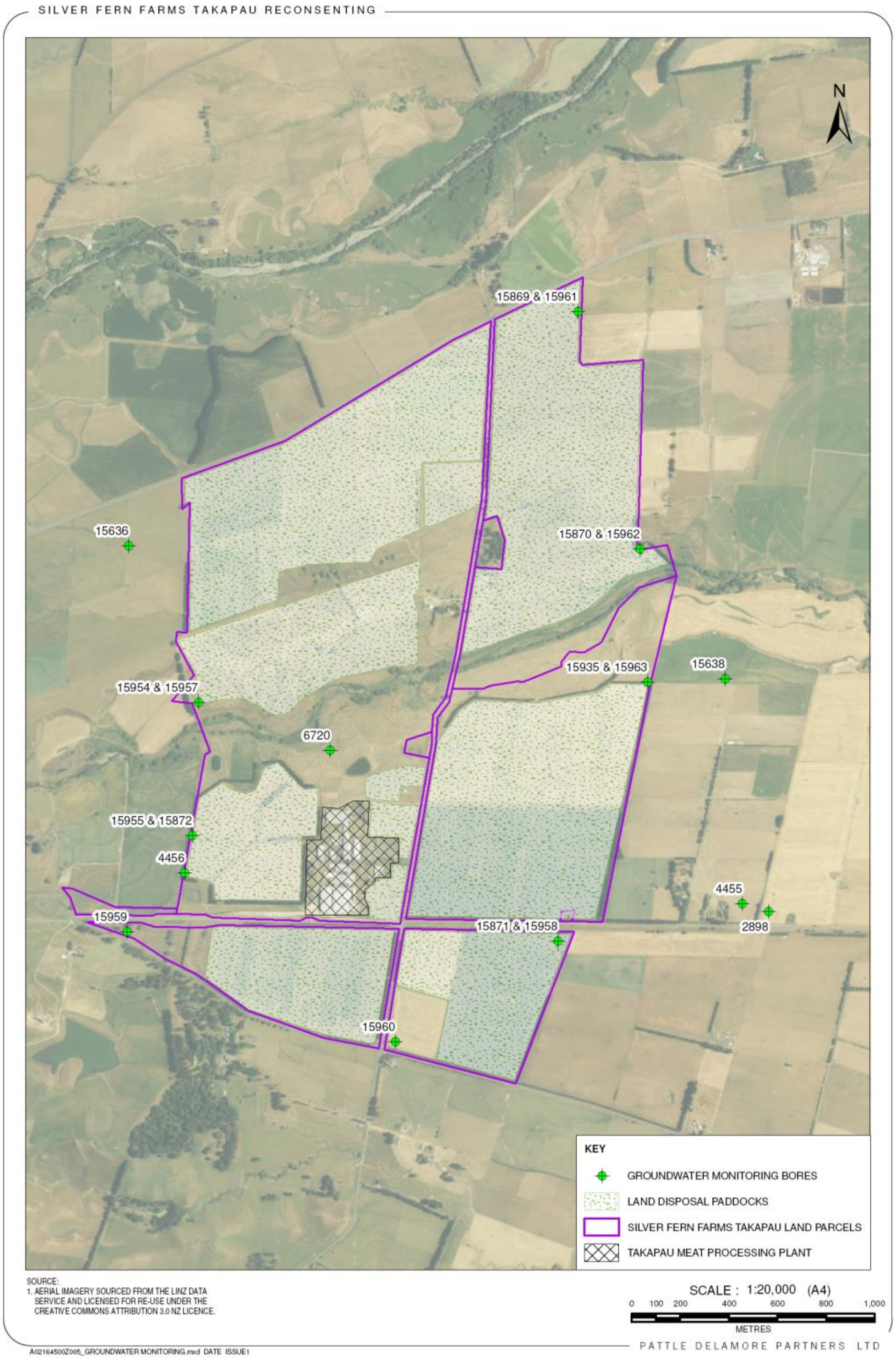

Figure 21: Silver Fern Farms groundwater monitoring bores

Although there will always be variation from year to year, the measurements shown indicate that groundwater levels have generally been lowering in recent years, with reductions evident in both the summer lows and winter highs.

A review of neighbouring consents in Section 20 indicates that a number of new groundwater consents have been granted in the area over the last decade. As such, it is considered likely that an increase in groundwater abstraction may have contributed to the decline in water levels, although climate changes will also influence water levels. A number of other monitoring bore records available on the HBRC website for the area display a similar pattern of water level declines in the deeper aquifer and the intermediate aquifer.

3.8.3 Neighbouring Bores

There are a number of bores in the area that are not owned by Silver Fern Farms or included in the monitoring programme that are recorded on HBRC's database. These bores are shown in Figure 22. The bores access water from a range of depths.

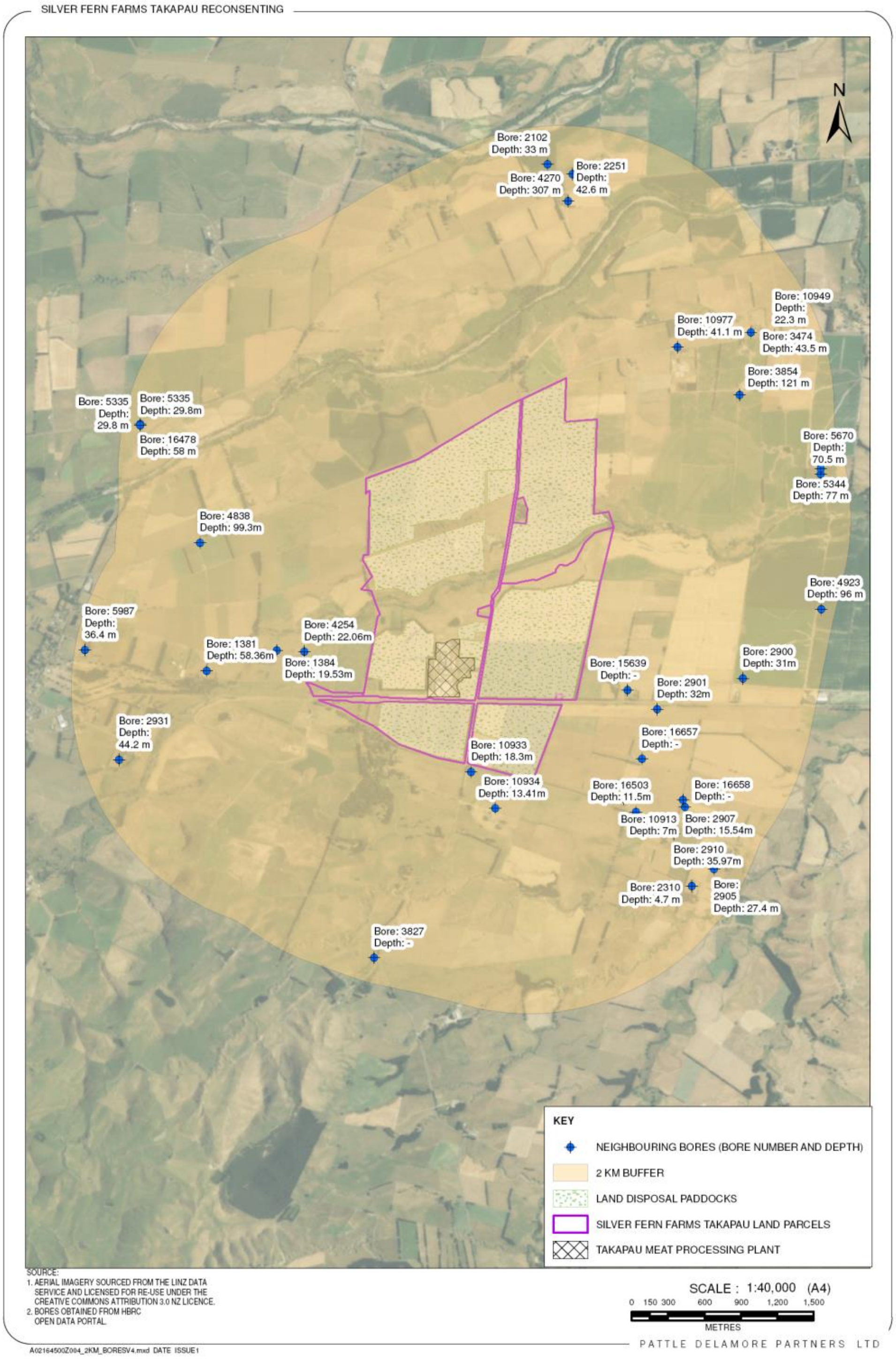

Figure 22: Recorded bores within 2 km of Silver Fern Farms' land not owned by Silver Fern Farms

3.8.4 Groundwater Quality

Groundwater quality in the vicinity of the Takapau site is monitored by Silver Fern Farms at twenty groundwater bores on a bimonthly basis. Some bores have monitoring data available from 2000 onwards; however others have only been monitored since 2012/13. The locations of the monitored bores are shown in Figure 21, in Section 3.8.2. Table 5 provides a summary of the bore information.

In addition to the bores in Table 5, monitoring is also undertaken in one of the plant water supply bores, which is 6720 (Bore 9). This bore does not have specific screen information, but is recorded as being screened within the *"28 to 43 m zone"*.

A summary of groundwater quality from the Takapau groundwater monitoring bores is provided in Table 6 and Table 7. Results are split into shallow groundwater upstream (6 bores) and downstream (6 bores) and deep groundwater upstream (2 bores) and downstream (5 bores) to represent likelihood of land based wastewater disposal impacts. Full plots of groundwater quality trends are presented in Appendix C.

Table 5: Groundwater monitoring bores

Bore Group	HBRC[1]/Silver Fern Farms Bore ID	Screened Depth (m)	Start of Monitoring
Upstream Shallow	4456 (Y)	12.6-15.6	2000
	15636 (W)	N/A -14 m deep	2000
	15872 (8B)	11.2-12.5	2013
	15957 (7B)	5.1-6.6	2012
	15959 (4B)	7-45	2012
	15960 (3B) [2]	13.2-14.2	2013
Downstream Shallow	4455 (Z)	6.6-9.6	2000
	15638 (I)	13.0-16.0	2000
	15958 (2B)	5.0-6.0	2012
	15961 (6B)	9.6-10.5	2012
	15962 (5B)	6.3-7.3	2012
	15963 (1B)	14-45	2012
Upstream Deep	15954 (7A)	43.2-44.2	2013
	15955 (8A)	42.9-44.2	2013
Downstream Deep	2898 (Layers)	N/A -28 m deep	2000
	15869 (6A)	44.2-45.1	2012
	15870 (5A)	44-45	2012
	15871 (2A)	26.2-27.2	2012
	15935 (1A)	44-45	2013

1. Some HBRC bores have a separate water quality ID
2. This is classified as an upstream bore. However, while it is located within the unirrigated control Block C3, it is located down-gradient of block D.

Table 6: Shallow groundwater water quality	
pH	pH has remained within a range of 6.5-8 in the upstream bores with a couple of exceptions, mainly in historic data. All downstream bores appear reasonably stable, although 15962 has been more variable, and has exceeded a pH of 8 on one occasion. Overall, there are no significant differences upstream and downstream.
Conductivity	Most upstream bores have remained fairly stable over time with the exception of bores 15960 and 15872. Bore 15960 has shown a steady reduction from elevated levels and bore 15872 experienced a two-fold increase in 2014 and has since remained at elevated but stable levels. As identified in Table 5, 15960 is technically a down-gradient/downstream bore relative to Block D. Other downstream bores are generally at similar levels to most upstream bores, with bore 15958 the exception which is around three times higher than other bores, but showing an improving trend. 15638 and 15961 are the only bores to show an increasing trend. Bore 4455 had historically high levels, but steadily declined since 2001.
Chloride	All upstream bores have remained stable with the exception of bore 15960 which is elevated but improving. All downstream bores are generally lower than upstream bores with the exception of bore 15958 and 15638. Concentrations in bore 15958 have steadily reduced. The only bore to show signs of increasing chloride levels is 15638.
Sodium	Upstream bores are variable with some showing slight increases in sodium, while others show slight improvements. Bore 15872 has higher concentrations. Downstream bores are similarly variable. Bore 15958 is at an elevated level compared to the others.
Nitrate-N	Most upstream bores have generally remained stable, expect for bore 15960 which has shown a steady reduction since 2012. As identified in Table 5, 15960 is technically a down-gradient/downstream bore relative to Block D. The downstream bores generally reflect the same patterns as upstream, with bore 4455 showing significant improvements since 2000. The only significantly elevated bore is 15958, although this shows a gradual reduction from elevated levels since 2012. Levels in bore 15638 have increased over time.
Ammoniacal-	Ammoniacal-N has been generally low but variable. Upstream

N	bore 15872 is slightly elevated. Downstream bores generally reflect upstream bore patterns with low levels since 2013.
Total Kjeldahl Nitrogen	TKN level have a similar pattern to ammoniacal-N, which is expected given TKN is a measure of ammoniacal and organic nitrogen. Both upstream and downstream bores show similar patterns as upstream. The TKN levels compared to Nitrate-N indicate that most nitrogen leached has been converted to nitrate.
Escherichia coli (E. coli)	Both upstream and downstream bores have E.Coli detections, as expected for shallow groundwater in a rural area. There is no clear difference in upstream and downstream bores.

A detailed assessment of the historic elevated nitrate-nitrogen concentrations in bore 4455 was undertaken by PDP (2010). This was attributed to the historic high nitrogen loadings via border dyke irrigation of the wastewater, which had occurred on blocks B, C and D.

Overall, the more recent data information indicates that the effects are generally less, although elevated levels of nitrate-nitrogen are still occurring, albeit improving in some bores, particularly 15960 and 15958. The levels in these two bores are well above the Maximum Acceptable Value (MAV) in the Drinking-water Standards for New Zealand 2005 (revised 2008) (DWSNZ). Conductivity, sodium and chloride are also elevated in these two bores.

Bore 15960 is down-gradient of Block D, and may be affected from the historic high loadings that occurred on that block. Continued monitoring of this bore to ensure that the declining trends continue, together with on-going good management wastewater irrigation practices in Block D will be important.

Bore 15958 is within Block C and down-gradient of Block D. This bore is may still be affected from the historic high loadings that occurred on those blocks. As with bore 15960, continued monitoring of this bore to ensure that the declining trends continue, together with on-going good management wastewater irrigation practices will be important.

Bore 15638 is the only downstream bore that has had an increasing trend in conductivity, chloride and nitrate-nitrogen, although the levels have stabilised over the last few years. This bore is located down-gradient of Block A, and generally down-gradient from the other irrigation blocks. This bore is located on neighbouring land and it is understood that this land has been used to grow potatoes and other crops in between harvest. This land use may be contributing to the change in water quality, which means it is difficult to isolate any effects due to Silver Fern Farms activities.

The other shallow downstream bores do not indicate clear impacts from Silver Fern Farms operations.

It is possible that the close proximity to the discharge areas for some upstream bores, including bore 15872, means they may experience some effects from the discharge. It is also understood that bore 15872 is located near a feedlot.

Table 7: Deep groundwater water quality

pH	Upstream bores are very stable. Early data for downstream bores show variable, slightly basic conditions in a few bores, with bore 15871 recently increasing in 2016 to a pH of around 9.5.
Conductivity	Conductivity has remained stable in both upstream bores since 2014. Downstream bores 15870, 15935 and 15869 have remained stable. Downstream bore 2898 has steadily increased since 2000, with bore 15871 reflecting the same pattern since 2012, except recently where it has significantly decreased.
Chloride	Both upstream bores have remained stable. Three downstream bores reflect this stability at even lower levels, however bores 15871 and 2898 have both steadily increased in chloride levels.
Sodium	The upstream bores are distinctly different from each other, both being stable, but one showing the highest and one showing the lowest sodium reading of all deep bores. All downstream bores are stable.
Nitrate-N	Both upstream bores have only returned detections sporadically. In contrast, downstream bore 15871 has remained elevated for most of its monitoring period, while bore 2898 showed an increasing trend and is now more stable.
Ammoniacal-N	Levels in both upstream bores have been low and steady. Most downstream bores reflect the same pattern, with the odd spike in levels.
Total Kjeldahl Nitrogen	A similar pattern to ammoniacal-N occurs in upstream and downstream bores.
E. coli	Sporadic detections have occurred in both upstream bores, at up to 21 cfu/100ml. Apart from some historic high levels in bore 2898, detections are generally low, at up to 16 cfu/100 ml.

Bores 2898 and 15871 are also downgradient of the blocks where historic high nitrogen loadings via border dyke irrigation occurred. Modelling undertaken by PDP (2010) theorised lag times of up to 43 years for the plume to fully pass.

In general, both bores 2898 and 15871 appear to be experiencing the on-going effects of the historic loadings, with elevated conductivity, chloride and nitrate-nitrogen. The levels in these two bores still exceed the MAV of 11.3 g/m^3 in the DWSNZ. Bore 2898 has increased to above 20 g/m^3. Most other bores appear to have a stable temporal trend.

For bores 2898 and 15871, continued monitoring is important together with on-going good wastewater irrigation practices to minimise leaching from these blocks. The other deep downstream bores do not indicate clear impacts from Silver Fern Farms operations.

Bore 2898 is a drinking water supply bore. Silver Fern Farms have provided a nitrate filter for this bore. Samples were taken in May 2017 and this showed that the filter was reducing concentrations from 21.5 g/m^3 to 0.57 g/m^3, which is well within the MAV of 11.3 g/m^3.

It is also noted that the plots included in Appendix E for one of Silver Fern Farms' supply bores, bore 6720, indicate a rising trend in nitrate-nitrogen, chloride and conductivity. This suggests some impacts from land use. No E.Coli have been detected. Nitrate-nitrogen concentrations are still well below the MAV of 11.3 g/m^3, but it will be important to continue monitoring for any further changes.

3.9 Surface Water

3.9.1 General

The site is located within the Porangahau Stream sub catchment, which is part of the Tukituki Catchment (Figure 23). The site is not located within a catchment sensitive to animal effluent discharges, as defined in Schedule 6(b) of the HBRC Regional Resource Management Plan (RRMP) (HBRC, 2006).

There are a number of surface waterbodies in the vicinity of Silver Fern Farms Takapau (Figure 24). These include:

- Porangahau Stream, which flows from west to east across the site;
- an un-named ephemeral tributary to Porangahau Stream that flows west to east across the site;
- the Maharakeke Stream to the east, including some small tributaries
- the Awanui Stream to the south, which is a tributary of Maharakeke Stream

- the Makaretu River further north (just visible in in north-west corner of Figure 24)

As described in Section 3.8.1, the rivers and streams that flow across the Ruataniwha Plains lose water to groundwater in their upper recharges and gain water from groundwater at the eastern margin of the basin, where outcropping bedrock forces groundwater upwards and into the rivers. The groundwater flow direction is generally to the south-east. Locally, PDP (2010) showed the general flow direction across the site to tend more towards the north-east. At Silver Fern Farms Takapau, a downwards groundwater gradient is also evident.

Porangahau Stream is the nearest water course that could potentially be affected by the land discharge. It is located approximately 100 m north of Block B, 150 m north of Block A, and 500 m south of Block E. Blocks F and G are located directly to the north of the stream (Figure 24)

Porangahau Stream runs through pastoral farming land upstream and downstream of the site and has a catchment area of 850 km^2. It is thought to be spring-fed further to the west from relatively deep aquifers 30 to 70 m below ground level (Willoughby, 1992). The mean annual flow at Oruawharo Road is estimated at 183 L/s, with low flows during January of approximately 50 L/s (GPG, 1998).

Porangahau Stream has historically had little or no riparian vegetation to prevent surface runoff from occurring. Silver Fern Farms Takapau has fenced and established a significant riparian buffer either side of the Porangahau Stream for the entire two kilometre length within its property. However, margins have not been fenced on neighbouring land. Riparian planting offers multiple benefits to the health of the stream, including interception of runoff, restoration of instream habitat, shading to regulate water temperatures, and stabilisation of stream banks to reduce sedimentation and bank slumping.

An ephemeral stream, which discharges seasonally into Porangahau Stream, runs through the site from west to east, between Blocks E and F (Figure 24). An interception ditch constructed along the western edges of Blocks E and F leads towards the ephemeral stream.

Porangahau Stream flows into Maharakeke Stream, located east of the Silver Fern Farms Takapau land disposal areas (Figure 24). A tributary of the Maharakeke Stream (Awanui Stream) is located approximately 500 m south of irrigation Block C. Maharakeke Stream is thought to originate from a southern limestone catchment (Dravid, 1992) and has also been suggested to be from a deep aquifer discharge via the Oruawharo Fault (Willoughby, 1992). It has also been suggested that the shallow aquifer may contribute to the stream. The mean annual flow (measured at Station Road) is estimated at 482 L/s, with low flows of approximately 153 L/s during January (GPG, 1998).

PDP (2010) indicate that the flow of groundwater is to the north east, towards the Porangahau Stream rather than the Maharakeke Stream, therefore the Porangahau Stream is considered most relevant for monitoring.

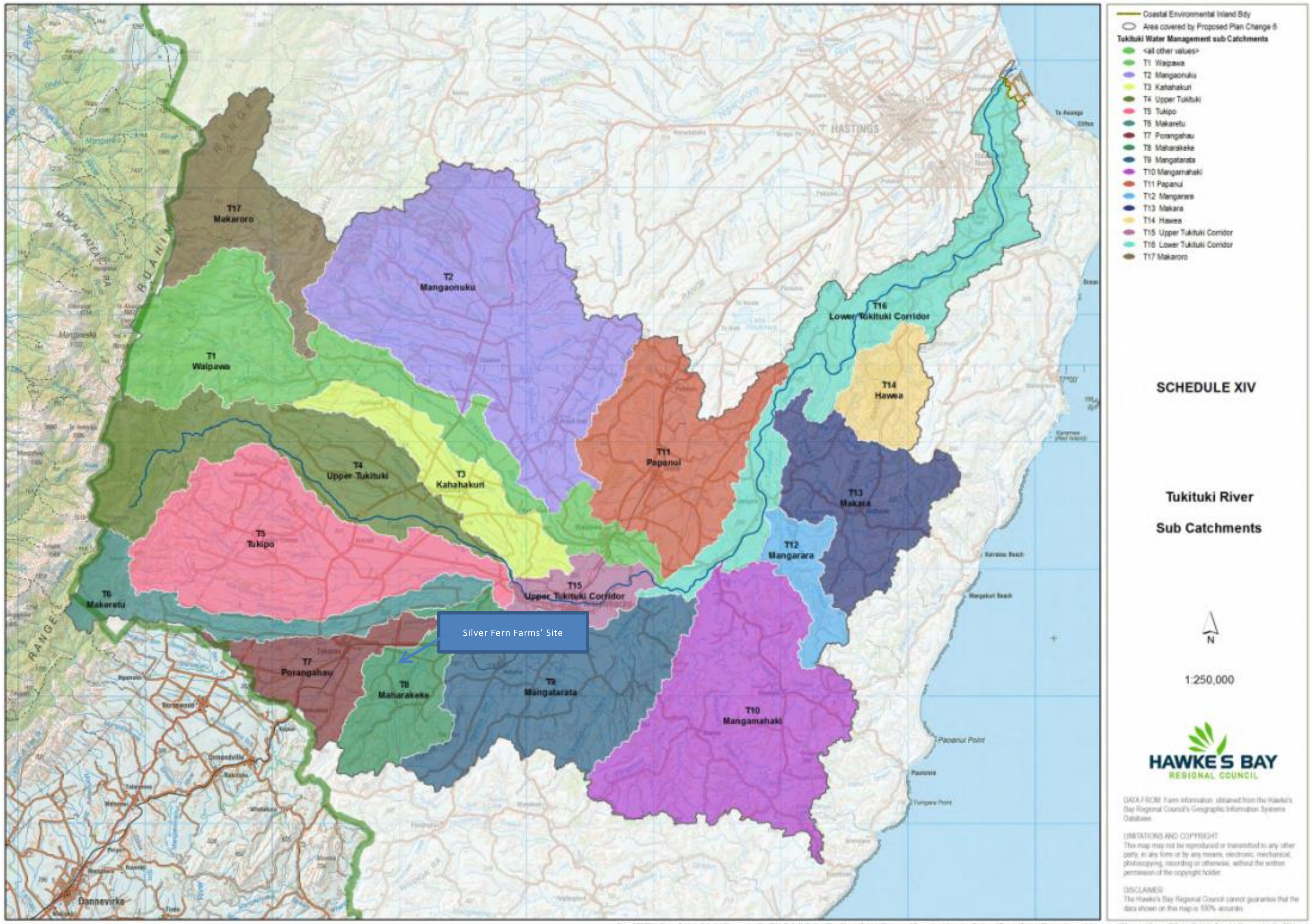

Figure 23: Tukituki Surface Water Zone Map (HBRC)

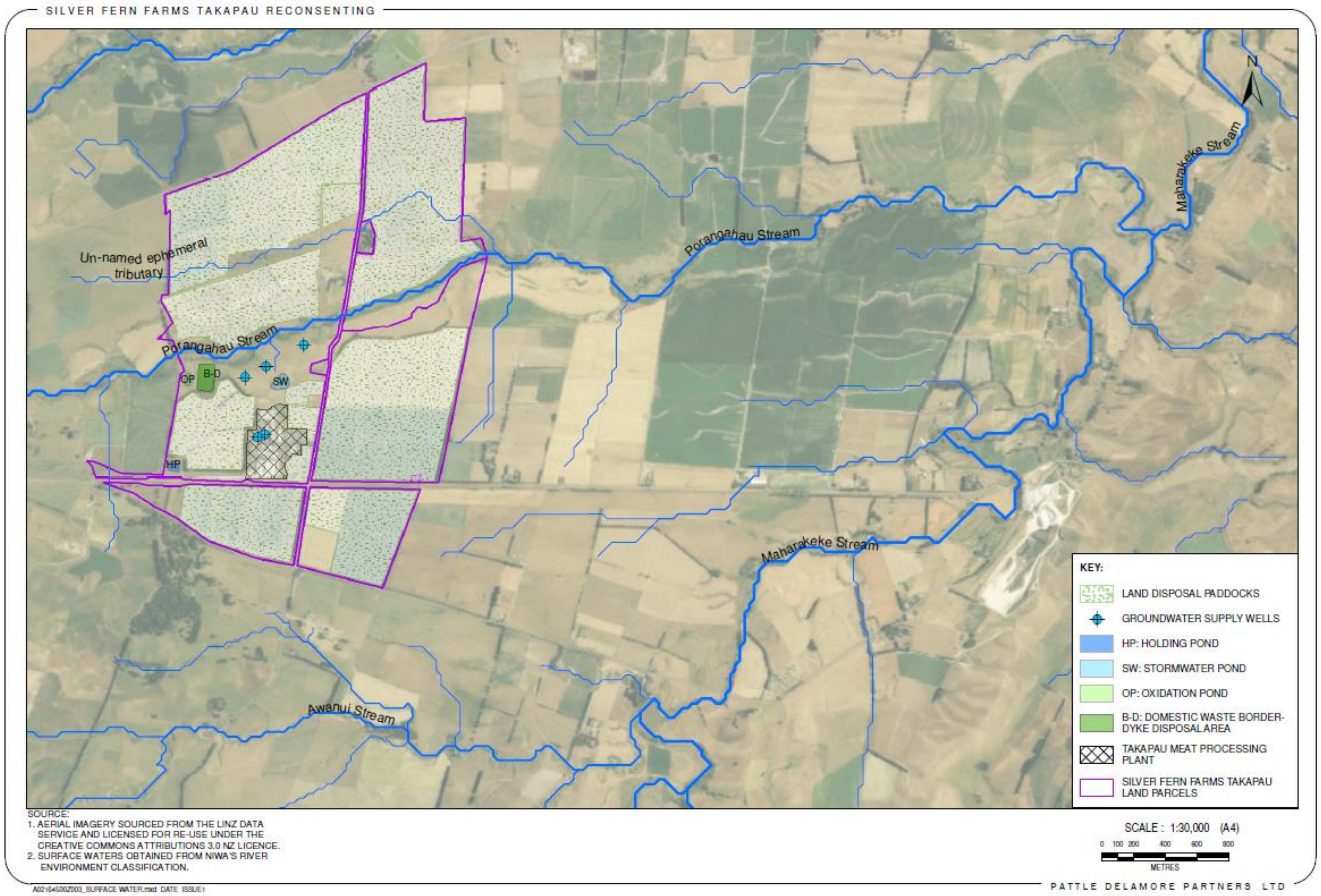

Figure 24: Nearby surface water features

3.9.2 Site Improvements

Silver Fern Farms undertook a wetland development project that led to the establishment of extensive wetlands at the ephemeral tributary to Porangahau Stream in 2010. The site has also established a significant riparian buffer either side of the Porangahau Stream. Pest control of these areas is undertaken on an annual basis and replanting occurs when required.

3.9.3 Stream Flows

The closest HBRC flow gauging site is the Porangahau Stream at Oruawharo Road, located approximately 1.5 km upstream of the site. Routine spot gauging measurements are available for this site from 1976-2016, with some gaps in collected data. Although data is limited, base flow appears to be approximately 50 L/s, with maximum high flow levels of up to 3500 L/s recorded.

3.9.4 Surface Water Quality

Silver Fern Farms Takapau monitors surface water quality at two locations (Figure 25); one upstream and one downstream of the land disposal fields, at monthly intervals. Monitoring data collected at the Silver Fern Farms Takapau is summarised in Table 8.

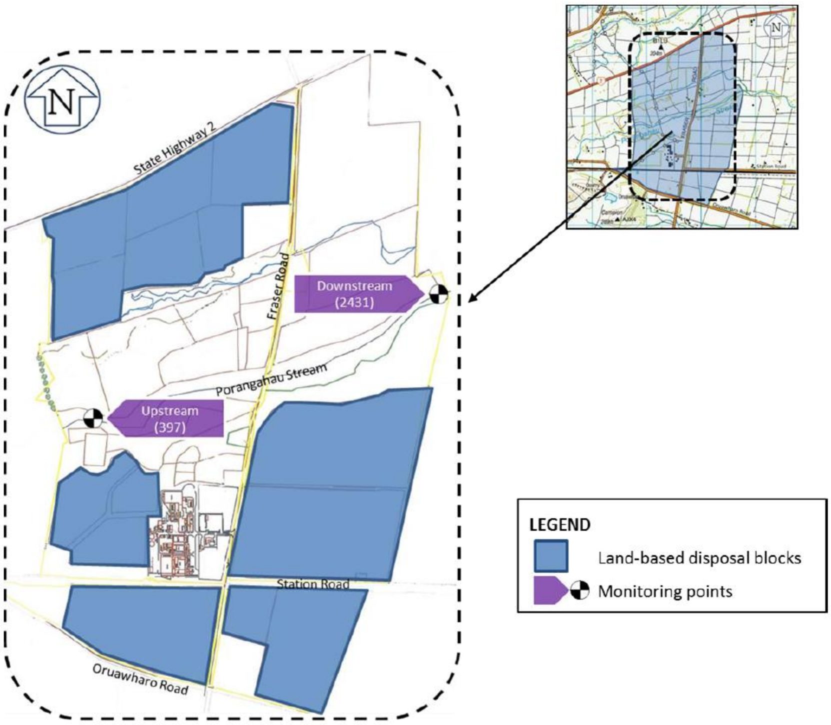

Figure 25: Surface water monitoring sites

Table 8 : Surface Water Quality Monitoring Data

	Median		Minimum		Maximum	
	U/S	D/S	U/S	D/S	U/S	D/S
Temperature (^{o}c)	13.5	14.1	7.4	7.3	24.1	23.4
pH	7.9	7.8	5.9	2.3	9.4	8.9
Chloride (g/m^3)	16.6	17.0	9.0	8.2	29.0	40.0
Nitrate-N (g/m^3)	1.65	1.64	0.01	0.01	5.71	6.90
Total Kjeldahl Nitrogen (g/m^3)	0.8	0.8	0.8	0.8	8.6	8.6
Ammoniacal-N	0.02	0.02	0.01	0.01	0.50	0.11
Dissolved Oxygen (DO) (g/m^3)	10.3	10.1	5.4	3.8	15.6	31.0
Dissolved Reactive Phosphorus (DRP) (g/m^3)	0.03	0.02	0.00	0.00	0.17	0.12
E. *coli* (cfu/100ml)	100	76	13	3	800	700

HBRC has routinely monitored the Porangahau Stream water quality at the Oruawharo Road, approximately 1.5 km upstream of the site and data is available on the LAWA website. Many parameters sampled at this site cannot be compared to the Silver Ferns Farms Takapau data, due to differences in analysed parameters. However, the two upstream monitoring datasets support each other fairly well in the readings for DRP and *E. coli*.

The following is a temporal assessment of monitored water parameters, presented in full in Appendix D.

Since 2010, water temperature measured at the upstream and downstream sampling locations has been comparable. With the exception of some very acidic readings at the downstream site in the early 2000's, pH has remained stable (between 7 and 8.5) at both the upstream and downstream sites. Chloride, Nitrate-N and Ammoniacal-N at the upstream and downstream sampling locations have been comparable. DO generally trends in a similar pattern, with the exception of some downstream readings of very high DO in 2011/12, which may be attributed to a meter error. DRP is highly variable at both the upstream and downstream sites, but this variability has improved, with only two spikes since 2006 and only one reading at the downstream site in exceedance of the upstream level. *E. coli* levels at the downstream site generally follow the same temporal trend as the upstream site, with the upstream site generally presenting more elevated levels on occasion.

3.9.5 Ecology

Consent conditions require surveys of the macroinvertebrate community at monitoring sites in the Porangahau Stream. For the purpose of comparatively assessing effects of the discharge to land, one upstream and one downstream site are monitored, with an additional downstream site being added in 2014 for better matching of site habitat characteristics upstream (see Figure 26). The most recent results are summarised below, referenced from the report "*Macroinvertebrate Monitoring at Sites in the Porangahau Stream Adjacent to Silver Fern Farms Takapau: 2018 Survey*" (Triplefin, 2018). The full report is included in Appendix D.

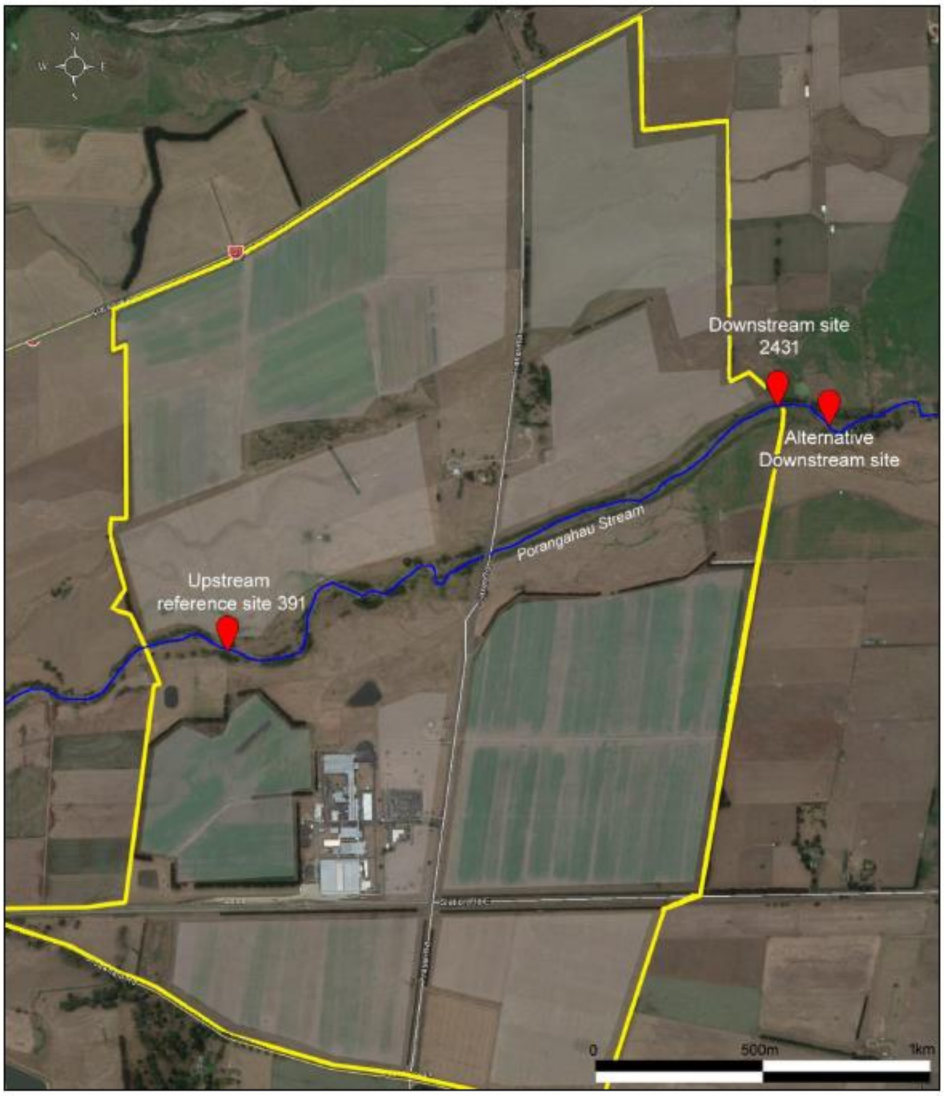

Figure 26: Macroinvertebrate Monitoring Sites (Triplefin, 2016)

The sampling sites were assessed in February, 2018 under summer low flow conditions. All sites were flowing at the time of assessment, had some shading, and extensive emergent macrophyte growth.

The upstream site is described as riffle run reach leading to a pool, and had a wetted width and average depth of 3.7 m and 15 cm, respectively. The stream bed was hard bottomed embedded substrate composed of small cobbles (6-13 cm, 60%), gravels (0.2 – 6cm, 20%), large cobbles (13-26cm, 20%) and silt/sand (<0.2cm, 0%). Algae cover was extensive, with approximately 60% cover composed of a mixture of thick brown mats of periphyton and short green filamentous algae strands, with longer strands in deeper areas.

The downstream site was described as a glide/run reach with a lower gradient than the upstream site. Wetted width was around 7 m and average depth 10 cm. The stream bed was not as well armoured as the upstream site and was easily disturbed, with patches of softer sediment observed. Substrate was composed of approximately 75% gravels, 15% sand/silt and 10% small cobbles. Extensive periphyton was present, with approximately 90% cover of long green filamentous algae.

The alternative downstream site is considered a riffle/run habitat, which is more comparable with the upstream site. Wetted width and water depth were also more comparable at 3.5 m and 14 cm, respectively. Substrate comprised of 50% small cobbles, 40% large cobbles and 10% gravels. Algae growth was patchy, with some sections having extensive cover of long green filamentous algae. Minimal thin brown periphyton mats were observed on cobbles in the thalweg, with approximately 60% coverage.

Benthic macroinvertebrate monitoring results from 2013 to 2018 indicate varied taxa composition between the upstream and downstream sites, dependant on sample year. This variation was determined likely due to the differences in hydrology and substrate and is the reason the alternative downstream site was added. Examining benthic macroinvertebrate taxa temporally is important to understand any potential changes in water quality over time, as benthic macroinvertebrates are an indicator of stream health.

The upstream site has remained fairly stable in terms of taxa abundance, whereas the original downstream site shows variation over time. Stress can increase variability and the increased variability at the downstream site could suggest higher stress levels than the upstream reference site. In comparison, the alternative downstream site shows less variability between the sampling events, with comparable taxa composition to the upstream site. Figure 27 provides a comparison of major macroinvertebrate taxa groups since 2013.

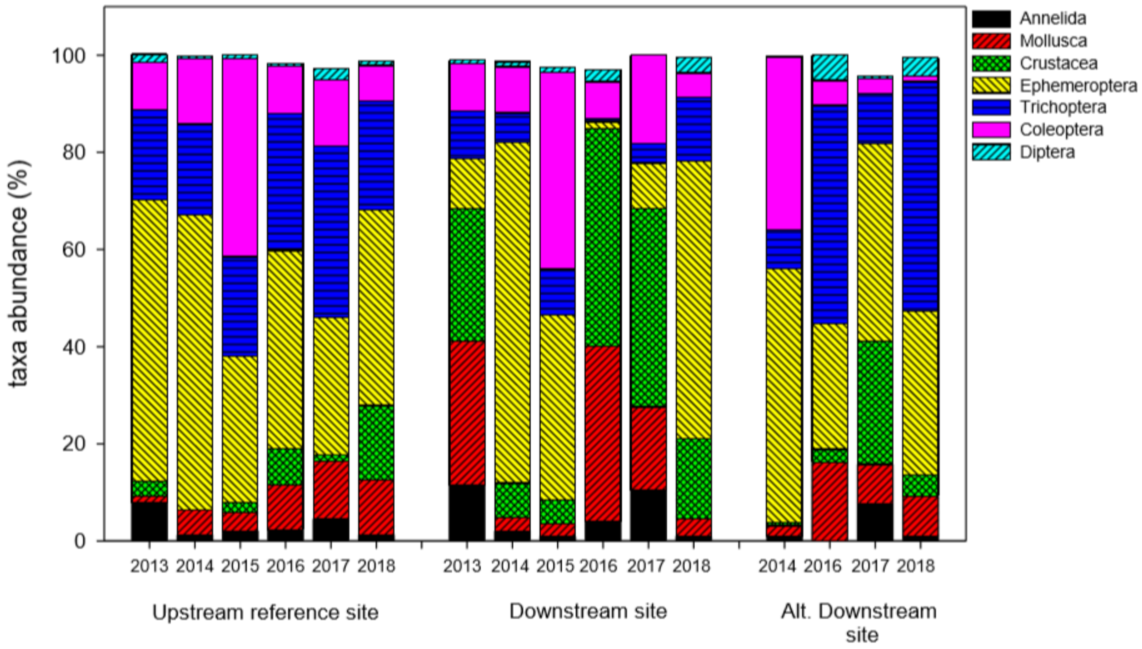

Figure 27: Macroinvertebrate Sampling Results 2013-2018 (Triplefin, 2018)

It is considered that the overall taxa diversity in this part of the Porangahau is moderate and indicative of a fair-moderately healthy stream. All three sites had moderately high abundance and diversity of Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa, which is an indication for stream degradation. The original downstream showed an improvement in abundance and diversity of taxa, after several years of lower abundance dominated by Diptera and Coleoptera taxa, EPT levels in 2018 are similar to the upstream and alternate downstream sites. It should be noted however, that the most frequently occurring Ephemeropteran at the downstream site (*Oxyethira*) is regarded as tolerant of organic pollution and is common in soft sediment areas or degraded stream environments.

Macroinvertebrate Community Index (MCI) scores at the upstream reference site and downstream site rated stream health to be on the lower end of the “good” category, while the alternative downstream was within the upper range of the “fair” category. The QMCI scores for these sites for the upstream reference site and alternate downstream site rated “good” and “excellent” for the downstream site.

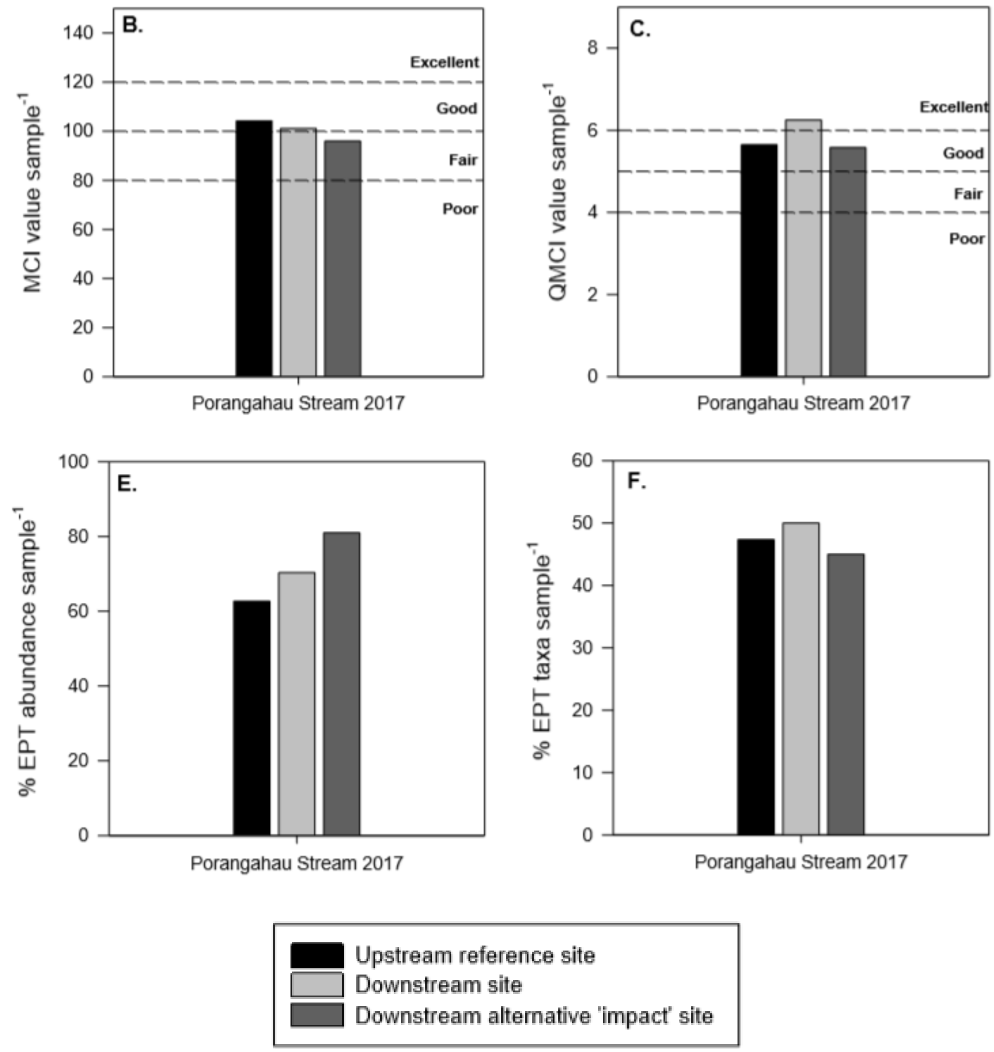

Figure 28: Comparison of MCI, QMCI, % EPT abundance, % EPT taxa from 2018 survey (not 2017 as shown) (Triplefin, 2018)

A comparison of biometric indices between years was also completed (Triplefin, 2018) to undertake trend testing. One significant trend was observed through trend testing, a negative/decreasing trend (estimated at 4.9 % per year) at the upstream site for QMCI (p=0.008). A pattern of higher variability was also observed at the downstream and alternate downstream sites (Triplefin, 2018).

Overall, the macroinvertebrate results provide evidence of mild-moderate organic enrichment occurring in the stream, with the macroinvertebrate community typical of a middle reach stream of moderate flow that drains farmland (Triplefin, 2018). Interannual data, in particular the declining QMCI scores at the upstream reference site, indicate that the Porangahau Stream is deteriorating in health, however there is no evidence of significant adverse effects from the Silver Fern Farms discharge (Triplefin, 2018).

3.10 Air Quality

The air quality in the Ruataniwha Plains is relatively good; the region has a low population density and few significant industrial emissions. The area surrounding the plant is currently used for agricultural activities, and as such related air quality issues are expected to occur in the area (e.g. agrichemical spray drift, odour, and dust).

Silver Fern Farms has maintained a detailed complaints register since 2002. While there have been no complaints about dust from the property, there has been a total of nine complaints received about odour between 2003 and present. Four of those were received in 2003, one in 2006, two in 2010, one in 2012 and the last received in March 2016.

For the four more recent complaints (since 2006) the rendering of animal products appeared to be the source for three of these, with the process ceasing immediately upon receiving the complaints. The 2012 complaint was from a residence 10 km away, the odour was short-lived and was considered to be from other possible sources, including a commercial operation (piggery), located closer to the complainant. Silver Fern Farms investigated and took preventive measures nonetheless. The final complaint (in 2016) related to wastewater during night time irrigation. In response, Silver Fern Farms ceased irrigation of D Block immediately. This complaint was received from the Oruawharo Homestead. The Oruawharo Homestead hosts events, including weddings, and Silver Fern Farms work proactively with Oruawharo Homestead to avoid irrigation in the blocks near the Homestead when events are taking place.

Importantly of the complaints, since 2006 only one appears to be related to discharge of wastewater, as opposed to others which relate to processing operations. Accordingly, the discharge of wastewater appears to be generating very little odour of a nature that warrants complaint from neighbouring properties. Silver Fern Farms work proactively with neighbouring properties to prevent issues arising, and are very responsive in taking action on receipt of complaints, even when their operation may not be the cause of the odour.

4.0 Assessment of Environmental Effects

4.1 Effects on Soils

As outlined in the memorandum in Appendix C, the process wastewater irrigation does not appear to be having an effect on the soil condition within the irrigation blocks, as shown by low ESP levels. At the monitored ESP levels, it is not expected that the soils will be experiencing impaired permeability (as a result of elevated sodium). The ESP levels will require on going monitoring identifying if there is an increasing trend and if lime or gypsum addition is required to offset sodium addition. Instead, soil condition appears to be more affected by soil type than wastewater application.

The wastewater irrigation activity is resulting in insignificant increases in heavy metals in the soils. The low levels also indicate that the small component of stormwater that is reused prior to discharge in the wastewater is not contributing significantly to heavy metals, as expected.

Soil permeability testing indicates that the allophanic/brown soils have good particle distribution and are suitable for the existing irrigation rate. Permeability testing of the gley soils and visual observation, confirms that wastewater irrigation of this soil type is unsuitable except for deficit irrigation during summer and early autumn. Irrigation on these soils should continue to occur via deficit irrigation.

The nutrient load across the site is generally well utilised by the cut and carry operations. However, elevated Olsen P levels in all main irrigated blocks (Blocks A, B, C and D) are attributed to a higher loading rate of phosphorus in the wastewater than what is currently being removed from these blocks through harvest. Overseer nutrient modelling also shows that phosphorus is accumulating in the soil. Due to the flat nature of the land, the modelling suggests minimal loss of phosphorus to water. It will be important to maintain good harvest rates in all years to assist in phosphorus removal.

Lysimeter data shows higher concentrations of nitrogen in the soil water than would be expected from the land-based operation, as shown with the OVERSEER results.

While OVERSEER predicts the nitrogen leaching to be low, in light of the lysimeter results and in line with good practice, it is recommended that some consideration be given to further optimising management to minimise nitrogen leaching. This could include options for increasing pasture yield, for example re-sowing some irrigation areas with high-yield ryegrass species, particularly where pasture has become patchy, and considering irrigation with clean water to prevent grass die-off, if a small amount of water becomes available under the groundwater abstraction consent.

Overall, the effects on soils are being managed well, but maintaining optimum harvest is important to minimise nutrient leaching. If this is not practical, some changes to the wastewater treatment to reduce the nutrient concentrations in the effluent could occur.

It is recommended that the current monitoring that occurs should continue, with continued good record of solids and wastewater applications.

As outlined in Appendix C, pasture cover was good for all blocks, with the exception of Block A where the pasture was clumpy, likely as a result of extended years of cropping without grazing or resowing and/or the grass height being allowed to grow too long between cropping events. It is recommended that Block A is resown for better pasture distribution. Consideration could also be given to grazing of residuals, which involves periodically grazing stock on the pasture to encourage lower level pasture removal and scuffing of soil surfaces Sufficient stand-down time between wastewater application, grazing and stock processing would be required.

As outlined in Appendix B, the domestic border dyke irrigation system is providing for disposal of the treated wastewater, and while the soils appear to be in moderate to good condition, there is evidence of ponding occurring at the south east corner of the southern irrigation field. The nitrogen leaching rate that has been modelled is also relatively high and there is potential for improvement to reduce the nitrogen leaching rate.

As a minimum, the irrigation areas should be scarified to break up any silt sealing layer that may be occurring. This needs to be a regular practice (annually at minimum) with particular focus in the south eastern corner.

Operating the irrigation system approximately every two weeks, results in an instantaneous application rate of 50 mm per event. While this is not an excessive depth, it occurs very rapidly. It may be possible to decrease the potential for ponding by increasing the frequency of application or installing an alternative irrigation method, such as spray irrigation (such as solid set). A more frequent lower volume discharge to the border dyke area should result in less run-off accumulating in the area that currently experiences ponding.

A stand-down period between irrigation of the wastewater and the intermittent grazing of the border dyke areas is applied to minimise potential effects for stock/human health. Sheep are grazed on the area for one week prior to a discharge occurring and these stock also have a 21 day withholding period before processing.

As described above, heavy metal concentrations in the soil in the disposal area are well within guideline limits and a stand-down period is applied for grazing on the domestic border-dyke area. Based on this and the irrigation management practices across the property, no adverse effects on soils, or stock or plant growth are expected.

4.2 Effects on Groundwater Quantity

The year round irrigation of wastewater on some blocks will increase drainage to groundwater. Based on the low irrigation rates, no significant increase is expected to occur. This is supported by the levels monitored in the monitoring bores.

Overall, the effects on groundwater quantity, in terms of mounding, are expected to be minimal and specific monitoring is not required.

4.3 Effects on Groundwater Quality

Nutrient modelling indicates rates of nitrogen leaching across the solids and process water discharge areas are low for this type of wastewater management system; while the monitored lysimeters show higher leaching rates occurring. Overall, downstream concentrations in most bores are similar to upstream concentrations in monitoring bores, indicating impacts are minimal from the plant.

Bore 15638 is the only downstream bore that has had an increasing trend in conductivity, chloride and nitrate-nitrogen, although the levels have stabilised over the last few years. This bore is located down-gradient of Block A, and generally down-gradient from the other irrigation blocks. Continued monitoring of this bore is important to assess long term trends.

Historical impacts are still observed in some bores downgradient of the old border dyke irrigation areas, which are shallow bores 15960 and 15958 and deep bores 2898 and 15871. These show elevated levels of nitrate nitrogen, conductivity and chloride. Smaller elevations are also observed in the shallow groundwater bores at the sample location (bores 4455 and 15958). Prior modelling in PDP (2010) theorised lag times of up to 43 years for the plume to fully pass through the groundwater, so this is not unexpected. The ongoing impacts observed mean that it is important to continue monitoring.

No new bores are identified on HBRC’s database as being used for drinking water down-gradient of the site, but it would be important for Silver Fern Farms to maintain good communication with neighbouring properties to ensure they are not impacted by the elevated nitrate-nitrogen concentrations down-gradient of the site. Microbial impacts from the activities are not discernible from background concentrations.

No effect on the community drinking water supply identified in Section 2.2 is expected, given its up-gradient location.

Overall, the land management changes that have occurred at the site have reduced nitrogen loadings, so groundwater concentrations should trend downwards over time with on-going good management.

It is recommended that on-going monitoring of all current monitoring bores continue. To minimise impacts on groundwater, nutrient leaching should be minimised via good management, including maximising harvest from the site.

In terms of the domestic wastewater, some additional monitoring bores in the site vicinity have been recommended. This would enable better characterisation of the local environmental effects of that activity, particularly potential effects on the Silver Fern Farms supply bores and the Porangahau Stream. However, as is discussed in the following section, impacts from this system and the other discharges on the Porangahau Stream are not evident in the regular consent monitoring undertaken. It is possible that the Porangahau Stream is losing water to groundwater in this section, which could be confirmed by a period of surface water level and groundwater level monitoring in the vicinity of the plant.

4.4 Effects on Surface Water

The water quality in the Porangahau Stream upstream and downstream of wastewater discharge land has been monitored consistently as part of compliance monitoring by Silver Ferns Farms. Median water quality results show no significant changes in measured parameters between the upstream and downstream sites, indicating no adverse effects on Porangahau Stream water quality from the wastewater discharges.

Benthic macroinvertebrate data can be used as an indicator for instream health and has been collected in the Porangahau Stream upstream and downstream of the wastewater discharge land since 2013. Data collected from the downstream site shows high temporal variability, which was attributed to differences in physical site characteristics, including hydrology and substrate. Therefore, an alternative downstream site was chosen and is recommended to be continued as a sampling site for more useful comparison with the upstream site. This is outside the property boundary, so there is some potential to be influenced by other land use.

Benthic macroinvertebrate results, including MCI and EPT levels between the upstream reference site and the alternative downstream site, and the close proximity of the alternative downstream site to the Silver Fern Farms boundary suggests that the Silver Fern Farms Takapau discharge to land does not cause a significant adverse effect to the in-stream macroinvertebrate community of the Porangahau Stream.

It is recommended that on-going monitoring at the current sites required under the current process wastewater discharge consent (DP981043Ld + DP981044Ad) should continue.

DP981043Ld + DP981044Ad also contains conditions relating to no ponding of wastewater for more than 2 hours, no discharge to areas where there is already surface ponding, deficit only irrigation to the poorly drained soils on block E and no discharge within 20 m of a surface water body. These conditions are considered appropriate with respect to surface water quality effects and should be retained.

The discharge permit for solid organic waste (DP981039Lb) also includes a set-back distance of 20 m of a surface water body as well as 50 m during heavy rainfall, and 50 m at any time from the Porangahau Stream. These conditions are also considered appropriate with respect to surface water quality effects and should be retained.

Overall, the operation appears to be having limited impact on local surface water courses. Because all groundwater ultimately re-enters surface water to exit the Ruataniwha Basin, continuing to manage the operations with a view to maximising nutrient uptake via harvest will limit the site’s contribution to cumulative nutrient effects on down-gradient waterways.

4.5 Effects on Air Quality

The consent to discharge meat processing wastewater (DP981043Ld & DP981044Ad) allows the discharge of odorous compounds and aerosols into the air associated with the wastewater irrigation.

Silver Fern Farms maintains a complaints register, to track complaints made on odour at nearby properties. There has been one odour complaint since 2006 that appears to be related to wastewater discharge, with no complaints since early 2016. Accordingly, the discharge of wastewater appears to be generating very little odour of a nature that warrant complaints from neighbouring properties.

Silver Fern Farms work proactively with neighbouring properties to prevent issues arising, and are very responsive in taking action on receipt of complaints, even when their operation may not be the cause of the odour.

The environmental effects on air quality are determined to low, due to the region’s low population density, low number of complaints and the surrounding agricultural land use activities.

It is not considered that any additional consent conditions related to air quality are required.

5.0 Conclusion

Silver Fern Farms is applying for replacement resource consents from HBRC for the expiring discharge consents related to wastewater, stormwater and solid organic waste.

The discharges have been assessed in terms of their environmental effects, and it is considered that the overall scheme is being managed well, and effects on the environment have reduced with management improvements.

Overall, the effects on soils are being managed well. The wastewater irrigation activities are resulting in insignificant increases in heavy metals in the soils. The low levels also indicate that the small component of stormwater that is reused prior to discharge in the wastewater is not contributing significantly to heavy metals, as expected. Maintaining optimum harvest is important to minimise nutrient leaching arising from wastewater.

The effects on groundwater levels are considered to be insignificant based on the application rates. For groundwater quality, a key issue is the impacts on nitrate-nitrogen concentrations in groundwater in some locations, attributed primarily to the historic activities at the site. It is important that ongoing groundwater monitoring takes place and any changes to drinking water supplies are monitored by Silver Fern Farms, to ensure no adverse effects occur on human health. Overall, the land management changes that have occurred at the site have reduced nitrogen loadings significantly, so groundwater concentrations should trend downwards over time with on-going good management.

The operation appears to be having limited impact on local surface water courses. Because all groundwater ultimately re-enters surface water to exit the Ruataniwha Basin, continuing to manage the operations with a view to maximising nutrient uptake via harvest will limit the site's contribution to cumulative nutrient effects on down-gradient waterways.

The discharge of wastewater appears to be generating very little odour of a nature that warrant complaints from neighbouring properties. Silver Fern Farms work proactively with neighbouring properties to prevent issues arising, and are very responsive in taking action on receipt of complaints, even when their operation may not be the cause of the odour.

Aside from the historic impacts from past activities at the site that are still observable in groundwater, overall, the effects of the current discharges are being well managed with limited observable impacts in the extensive monitoring data that has been collected.

6.0 References

CHBDC. (2003). *Operative Central Hawkes Bay District Plan.* Waipawa: Central Hawke's Bay District Council.

CPG. (1998). *Resource Consent Application and Assessment of Environmental Effects of the Discharge of Stormwater to Land. RICHMOND LTD - TAKAPAU.*

CPG. (2009). *Takapau Resource Report.* Palmerston North: CPG New Zealand Limited.

Dairy NZ. (2012). *Critical Nutrient Levels for Pasture (Farmfact No. 7-5). Dairy NZ.*

Dravid, P. N. (1992). *Takapau Geology and Groundwater.* Napier: Hawke's Bay Regional Council.

Good Earth Matters. (1998). *Resource Summary and Assessment of Environmental Effects: Richmond (Takapau) Ltd Groundwater Take.* Palmerston North: Good Earth Matters Consulting Limited.

GPG. (1998). *Resource Consent Application and Assessment of Environmental Effects for the Land Treatment of Meat Processing Wastewater.* Christchurch: Glasson Potts Group.

Griffiths, E. (2004). *Soils of the Ruataniwha Plains: A guide to their management.* Napier: Grifftech and Hawke's Bay Regional Council.

HBRC. (2006). *Regional Resource Management Plan (RRMP).* Napier: Hawke's Bay Regional Council.

Kingma, J. T. (1962). *Sheet 11, Dannevirke (1st Ed.) Geological Map of New Zealand 1:250,000.* Wellington: Department of Scientific and Industrial Research.

Pattle Delamore Partners Ltd. (1999). *Report on Conceptual Hydrogeological Model for the Ruataniwha Basin, Hawke's Bay.*

Pattle Delamore Partners Ltd. (2010). *Discharge to Land – Resource Consent Application & S127 Change Assessment of Environmental Effects. Prepared for Silver Fern Farms Limited, Takapau.*

Silver Fern Farms Ltd. (2016). *Silver Fern Farms – Takapau Plant Annual Monitoring Report 1 October 2015 – 30 September 2016.*

Triplefin. (2018). *Macroinvertebrate Monitoring atr Sites in the Porangahau Stream Adjacent to Silver Fern Farms Takapu: 2018 Survey.* Napier.

Weir, J. (2013). *Statement of Evidence of Julian James Weir for Ruataniwha Water Users Group (Groundwater Modelling). 7 October 2013.*

Willoughby, G. (1992). *Takapau Water Quality Monitoring.* Napier: Hawke's Bay Regional Council.

Appendix A

Existing Resource Consents

TRANSFER OF RESOURCE CONSENT:	DP981040L
DATE:	23rd November 2015
TO:	**Silver Fern Farms Management Limited** PO Box 941 Dunedin 9054
FROM:	Silver Fern Farms Limited
LOCATION:	Fraser Road, Takapau
LEGAL DESCRIPTION:	Site of activity: Pt Lot 1 DP 3357

Malcolm Miller
Manager - Consents
RESOURCE MANAGEMENT GROUP

Hawke's Bay Regional Council
Safeguarding Your Environment

TRANSFER OF RESOURCE CONSENT:	DP981040L
DATE:	16 June 2008
TO:	**Silver Fern Farms Limited** PO Box 941 Dunedin
FROM:	PPCS Limited
LOCATION:	Fraser Road, Takapau
LEGAL DESCRIPTION:	Pt Lot 1 DP 3357

TIM WAUGH
CONSENTS OFFICER ADMINISTRATION

Hawke's Bay Regional Council
Safeguarding Your Environment

TRANSFER OF RESOURCE CONSENT:	DP981040L
DATE:	26 October 2005
TO:	PPCS Limited PO Box 941 Dunedin
FROM:	Richmond Limited
LOCATION:	Fraser Road, Takapau
LEGAL DESCRIPTION:	Pt Lot 1 DP 3357

TIM WAUGH
CONSENTS OFFICER ADMINISTRATION

Hawke's Bay Regional Council
Safeguarding Your Environment

Resource Consent

DISCHARGE PERMIT

In accordance with Rule 6-1 of the *Proposed Regional Water Resources Plan (November 1996)* and the provisions of the *Resource Management Act 1991*, and subject to the attached conditions, the Hawke's Bay Regional Council (the Council) grants resource consents for a discretionary activity to:

Silver Fern Farms Limited
PO Box 941
Dunedin

to discharge secondary treated sewage from an oxidation pond onto 1.6 ha of land through a border dyke system.

LOCATION

Address of site:	Fraser Road, Takapau
Map Reference	U23:9900-2630
Legal description	Pt Lot 1 DP 3357

DETAILS OF RESOURCE CONSENT

Effluent to be discharged:	oxidation pond effluent
Maximum rate of discharge:	750 m^3 during any 21 day period
Consent duration:	Granted for a period expiring on 31 December 2018

Sue Twigg
GROUP MANAGER: ENVIRONMENTAL MANAGEMENT
Under authority delegated by the Hawke's Bay Regional Council
14 December 1999

CONDITIONS

1. All works and structures relating to this resource consent shall be designed and constructed to conform to the best engineering practices and at all times maintained to a safe and serviceable standard.

2. The consent holder shall undertake all operations in accordance with any drawings, specifications, statements of intent and other information supplied as part of the application for this resource consent. In the event that there is conflict between the information supplied with the application and any consent condition(s), the condition(s) shall prevail. Such information specifically includes *Richmond Ltd - Takapau. Resource consent application and assessment of environmental effects of discharge to land of domestic wastewater. RIC 04, June 1998.*

3. The effluent shall be applied as discrete discharges 3 weeks apart over 1.6 ha as described below;

   - one discharge not exceeding 750 m^3 to 0.8 ha (10 of the 20 borders) every 6 weeks, and

   - another discharge not exceeding 750 m^3 to the other 0.8 ha 3 weeks later.

4. The consent holder shall, during each calendar year, take a composite sample of the effluent over the period of discharge (the time interval between each subsample not exceeding 30 minutes). The sample shall be analysed for BOD_5 and Total Nitrogen.

5. All analyses, other than field measurements, required by the conditions of this consent shall be undertaken by an independent laboratory accredited to IANZ. All methodologies adopted shall be appropriate for water and wastewater analyses.

6. The consent holder shall record:

   i) the date and time of each discharge event;

   ii) the a specific borders into which each discharge occurs;

   iii) the volume of effluent discharged during each discharge event.

   Note: One means of complying with this condition is to calculate the volume from the surface area of the pond and the change in level during a discharge event.

7. All records and results of analyses collected in accordance with the conditions of this consent shall be provided to the Council (in electronic form) at monthly intervals, or at any other time that may be requested by the Council. Records shall be provided no more than seven days following the end of the month to which they relate.

8. Before 31 December 2000 and annually thereafter, the consent holder shall provide the Council with a 'monitoring report' for the 12 month period ending at the previous 30 September. The monitoring report shall include;

   i) A summary of analyses and records collected in accordance with the conditions of this consent; and

   ii) A comment on the extent that each consent condition has been complied with.

REVIEW OF CONSENT CONDITIONS BY THE COUNCIL

The Council may review conditions of this consent by serving notice of its intention to do so pursuant to section 128 and section 129 of the Resource Management Act 1991.

The Council may review conditions of this consent by serving notice of its intention to do so pursuant to section 128 and section 129 of the Resource Management Act 1991.

Times of service of notice of any review:	During the month of May in the years 2000, 2002, 2004, 2009 and 2014.
Purposes of review:	To ensure conditions are consistent with any policies and rules in regional plans that may be established after the commencement of the consent. Requiring the adoption of the best practicable option to remove or reduce any adverse effect on the environment. To deal with any adverse effect on the environment which may arise from the exercise of this consent, which it is appropriate to deal with at that time, or which became evident after the date of issue. To modify the monitoring programme if the record of monitoring to date indicates that it is inappropriate.

CHANGE OF CONSENT CONDITIONS ON APPLICATION BY THE CONSENT HOLDER

Pursuant to s.127 of the Resource Management Act, the consent holder may at any time, apply for a change to the conditions of this consent for purposes modifying the monitoring programme if the record of monitoring to date indicates that it is inappropriate.

REASONS FOR DECISION

1. Based on the comprehensive evaluation of resource provided with the application the Council is satisfied that it can sustain the activity.

2. The conditions of consent will ensure that the actual effects of the activity will be adequately monitored and any significant adverse affects that may occur are detected as early as possible.

3. The duration of the consent, and the provision to review conditions is sufficient to provide consent holder with appropriate security without significant risk to the environment or potentially affected parties.

4. The activity is consistent with relevant plans and policies and with the Resource Management Act.

MONITORING BY THE CONSENT HOLDER

The monitoring of ground and surface required to be undertaken by the consent holder pursuant to the consents authorising the discharge of meat works wastewater (Consent Nos.: DP981043L & DP981044A), is sufficient to also monitor the effects of this consent.

MONITORING BY THE COUNCIL

Routine inspections of the site of this consent will be undertaken by Council officers at a frequency of no more than four times per year. The costs of these routine inspections and any formal monitoring programme that may be established in consultation with the consent holder will be charged to the consent holder.

“Non routine” inspections will be made on other occasions if there is reason to believe (e.g. following a complaint from the public, or monitoring) that the consent holder is in breach of the conditions of this consent. The cost of non-routine inspections will be charged to the consent holder in the event that non-compliance with conditions is determined, or if the Consent holder is deemed not to be fulfilling the obligations specified in section 17(1) of the Resource Management Act (RMA) 1991 shown below.

Section 17(1) of the RMA 1991 states;

*Every person has a duty to avoid, remedy, or mitigate any adverse effect on the environment arising from an activity carried on, by or on behalf of that person, whether or not the activity is in accordance with a rule in a plan, a resource consent**,** section 10, section 10A, or section 20.*

HAWKE'S BAY
REGIONAL COUNCIL

TRANSFER OF RESOURCE CONSENT:	DP981039Lb
DATE:	23rd November 2015
TO:	**Silver Fern Farms Management Limited** PO Box 941 Dunedin 9054
FROM:	Silver Fern Farms Limited
LOCATION:	Fraser, Station & Oruawhara Roads, Takapau
LEGAL DESCRIPTION:	Site of activity: Pt Lot 1 DP 3357, Pt of Blk 120, Sec 1S Maharakeke Settlement and Lots 4 and 5 DP 6204

Malcolm Miller
Manager - Consents
RESOURCE MANAGEMENT GROUP

RESOURCE CONSENT
Discharge Permit

In accordance with the provisions of the Resource Management Act 1991(RMA), and subject to the attached conditions, the Hawke's Bay Regional Council (the Council) grants a resource consent for a discretionary activity to:

Silver Fern Farms Management Limited
PO Box 941
Dunedin 9054

to discharge solid organic waste material (principally stockyard scrapings) to land

LOCATION

Site ID (see Plan attached)	**Property Address**	**Legal Description**	**Map Reference (at centre of site)**
S1	Fraser Rd, Takapau	Pt Lot 1 DP 3357 Pt of Blk 120,	E1889606 N5564310
S2	Fraser Rd, Takapau	Pt Lot 1 DP 3357	E1889850 N5565750
A	Fraser Road, Takapau	Sec 1S Maharakeke Settlement	E1890195 N5564585
B	Station Road, Takapau	Pt Lot 1 DP 3357	E1889062 N55664355
C	Oruawhara Road, Takapau	Lot 5 DP 6204	E1889940 N5563729
D	Oruawhara Road, Takapau	Lot 4 DP 6204	E1889235 N5563824
E	Fraser Road, Takapau	Pt Lot 1 DP 3357	E1889399 N5565781

CONSENT DURATION: Granted for a period expiring on 31 December 2018

Malcolm Miller
Manager Consents
RESOURCE MANAGEMENT GROUP
Under authority delegated by Hawke's Bay Regional Council
8th May 2012

This consent was originally issued on 14 December 1999 and subsequently changed in accordance with s 127 of the RMA.

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CONDITIONS

1. All works and structures relating to this resource consent shall be designed and constructed to conform to the best engineering practices and at all times maintained to a safe and serviceable standard.

2. The consent holder shall undertake all operations in accordance with any drawings, specifications, statements of intent and other information supplied as part of the application for this resource consent. In the event that there is conflict between the information supplied with the application and any consent conditions, the conditions shall prevail. Such information specifically includes:

    a) Richmond Ltd - Takapau. Resource consent application and assessment of environmental effects of discharge of sheepyard wastes onto land. RIC 07, June 1998;

    b) Richmond Ltd Takapau. Application for variation of resource consent conditions for the abstraction of groundwater, the discharge of meat processing wastewater and discharge of yard solids. 6919RIC, November 2002.

    c) Application to Change Conditions of Discharge to Land Resource consents – Assessments of Environmental Effects, Silver Fern Farms Limited – Takapau. Prepared by Pattle Delamore Partners Limited, February 2010.

3. Deleted.

~~4.~~ Deleted.

5. The total nitrogen loading from solid organic waste material, fertiliser and wastewater discharged under DP981043Lb, to any discharge run in Blocks S1, S2 and Blocks A – E over any the period 1 October each year to 30 September the following year shall not exceed the following:

    a) 600 kg per hectare on any cropped pastoral area; nor

    b) 650 kg per hectare on any cropped lucerne area; nor

6. There shall be no discharge of waste solids within:

    a) 20 metres of any surface water body;

    b) 30 metres from any bore unless secure wellhead protection, to the satisfaction of the Council (Manager Compliance) is in place;

    c) 50 metres of any surface water body during heavy rainfall;

    d) 10 metres of any property boundary;

    e) 50 metres of the Porangahau Stream.

7. There shall be no offensive or objectionable odour beyond the boundary of the property. The ‘property’ is the outline area shown in Appendix 1 as the Takapau Plant Land Area.

8. Deleted.

9. For each of the discharge sites, the consent holder shall maintain a detailed record of the solid organic waste material discharged, including the following;

    a) The date and time of each application;

    b) The discharge run onto which each application was made;

    c) The volume of each application;

    d) The total volume applied during the period 1 October to 30 September each year.

    e) Deleted.

10. All records collected in accordance with the conditions of this consent shall be provided to the Council (in electronic form) at monthly intervals, or at any other time that may be requested by the Council. Records shall be provided no more than seven days following the month to which they relate. Raw laboratory data shall be provided to the Council (Manager Compliance) on request.

11. The Consent holder shall log all complaints received. The log shall include the date, time, and nature of the complaint and the name, telephone number, and address of the complainant, weather information (an estimate of wind speed and direction), details of key operating parameters at the time of the complaint and the remedial action taken to mitigate the effects of the incident and the steps taken to prevent further incidents. Complaints shall be reported to the Council within 24 hours of receipt and the log of complaints shall be made available to the Council on request.

12. Before 31 December 2000 and annually thereafter, the consent holder shall provide the Council with a monitoring report for the 12-month period ending at the previous 30 September. The format of the monitoring report shall be to the satisfaction of the Council (Manager Compliance) and shall include (but not be limited to);

    a) A summary of analyses and records collected in accordance with the conditions of this consent; and

    b) A comment on the extent that each consent condition has been complied with.

13. A representative sample of solid organic waste material shall be collected in August and February each year from the milliscreen and analysed for Total Kjeldahl Nitrogen and Total Solids. The sample collection point and methodology shall be specified in the Wastewater and Solids Management Plan required by condition 56 of DP981043Lb. The results of the analysis shall be provided to the Council in accordance with condition 10 of this consent.

14. The total nitrogen from solid organic waste material applied to each discharge run annually shall be included in the nutrient mass balance required under condition 47 of DP981043Lb.

REVIEW OF CONSENT CONDITIONS BY THE COUNCIL

The Council may review conditions of this consent by serving notice of its intention to do so pursuant to section 128 and section 129 of the Resource Management Act 1991.

Times of service of notice of any review: During the month of May of any year.

Purposes of review:

To ensure conditions are consistent with any policies and rules in regional plans that may be established after the commencement of the consent.

Requiring the adoption of the best practicable option to remove or reduce any adverse effect on the environment.

To deal with any adverse effect on the environment which may arise from the exercise of this consent, which it is appropriate to deal with at that time, or which became evident after the date of issue.

To modify the monitoring programme if the record of monitoring to date indicates that it is inappropriate.

ADVICE NOTES

1) Total nitrogen from all sources includes nitrogen from effluent **and** solid organic waste material **and** fertiliser.

MONITORING BY THE COUNCIL

Routine inspections of the site of this consent will be undertaken by Council officers at a frequency of no more than four times per year. The costs of these routine inspections and any formal monitoring programme that may be established in consultation with the consent holder will be charged to the consent holder.

“Non routine” inspections will be made on other occasions if there is reason to believe (e.g. following a complaint from the public, or monitoring) that the consent holder is in breach of the conditions of this consent. The cost of non-routine inspections will be charged to the consent holder in the event that non-compliance with conditions is determined, or if the Consent holder is deemed not to be fulfilling the obligations specified in section 17(1) of the Resource Management Act (RMA) 1991 shown below.

Section 17(1) of the RMA 1991 states;

> *Every person has a duty to avoid, remedy, or mitigate any adverse effect on the environment arising from an activity carried on by or on behalf of the person, whether or not the activity is carried on in accordance with*
>
> *a) any of sections 10, 10A, 10B, and 20A; or*
>
> *b) a national environmental standard, a rule, a resource consent, or a designation.*

REASONS FOR DECISION
[Original Decision – 4 December 2000]

1. Based on the comprehensive evaluation of resource provided with the application the Council is satisfied that it can sustain the activity.

2. The monitoring required to be undertaken by the consent holder in accordance with its consent to discharge meatworks wastewater (consent nos. DP981043L & DP981044A) will adequately monitor the effects of this activity. No specific environmental monitoring conditions are therefore included.

3. The duration of the consent, and the provision to review conditions is sufficient to provide consent holder with appropriate security without significant risk to the environment or potentially affected parties.

4. The activity is consistent with relevant plans and policies and with the Resource Management Act.

REASONS FOR DECISION
[Change Of Consent Conditions – 17 January 2003]

1. The potential effect of using the existing wastewater disposal area for solids disposal is mitigated by the condition ensuring that only solids or wastewater is disposed of over an area in any 12-month period.

1. The potential effects on the Porangahau Stream of disposing of solids on the two new areas for disposing of solids is mitigated by a 50 metre buffer between the stream and any area used for solids disposal.

2. The adverse effects of the activity as a result of the use of the new sites, in accordance with the amended conditions will be unchanged.

REASONS FOR DECISION
[Change Of Consent Conditions – 8 May 2012]

The activity will have minor actual or potential adverse effects on the environment and is not contrary to any relevant plans or policies. The activity is also consistent with the purpose and principles of the Resource Management Act 1991.

MONITORING BY THE COUNCIL

Routine inspections of the site of this consent will be undertaken by Council officers at a frequency of no more than four times per year. The costs of these routine inspections and any formal monitoring programme that may be established in consultation with the consent holder will be charged to the consent holder.

On request the consent holder shall advise the Council of sampling dates and times so that concurrent audit samples can be taken by Council officers. The audit samples will be analysed by an alternative laboratory independently accredited by IANZ, and the costs of sampling and analysis will be charged to the consent holder.

“Non-routine” inspections will be made on other occasions if there is reason to believe (e.g. following a complaint from the public, or monitoring) that the consent holder is in breach of the conditions of this consent. The cost of non-routine inspections will be charged to the consent holder in the event that non-compliance with conditions is determined, or if the Consent holder is deemed not to be fulfilling the obligations specified in section 17(1) of the Resource Management Act (RMA) 1991 shown below.

Section 17(1) of the RMA 1991 states;

> *Every person has a duty to avoid, remedy, or mitigate any adverse effect on the environment arising from an activity carried on by or on behalf of the person, whether or not the activity is carried on in accordance with*
>
> *a) any of sections 10, 10A, 10B, and 20A; or*
>
> *b) a national environmental standard, a rule, a resource consent, or a designation.*

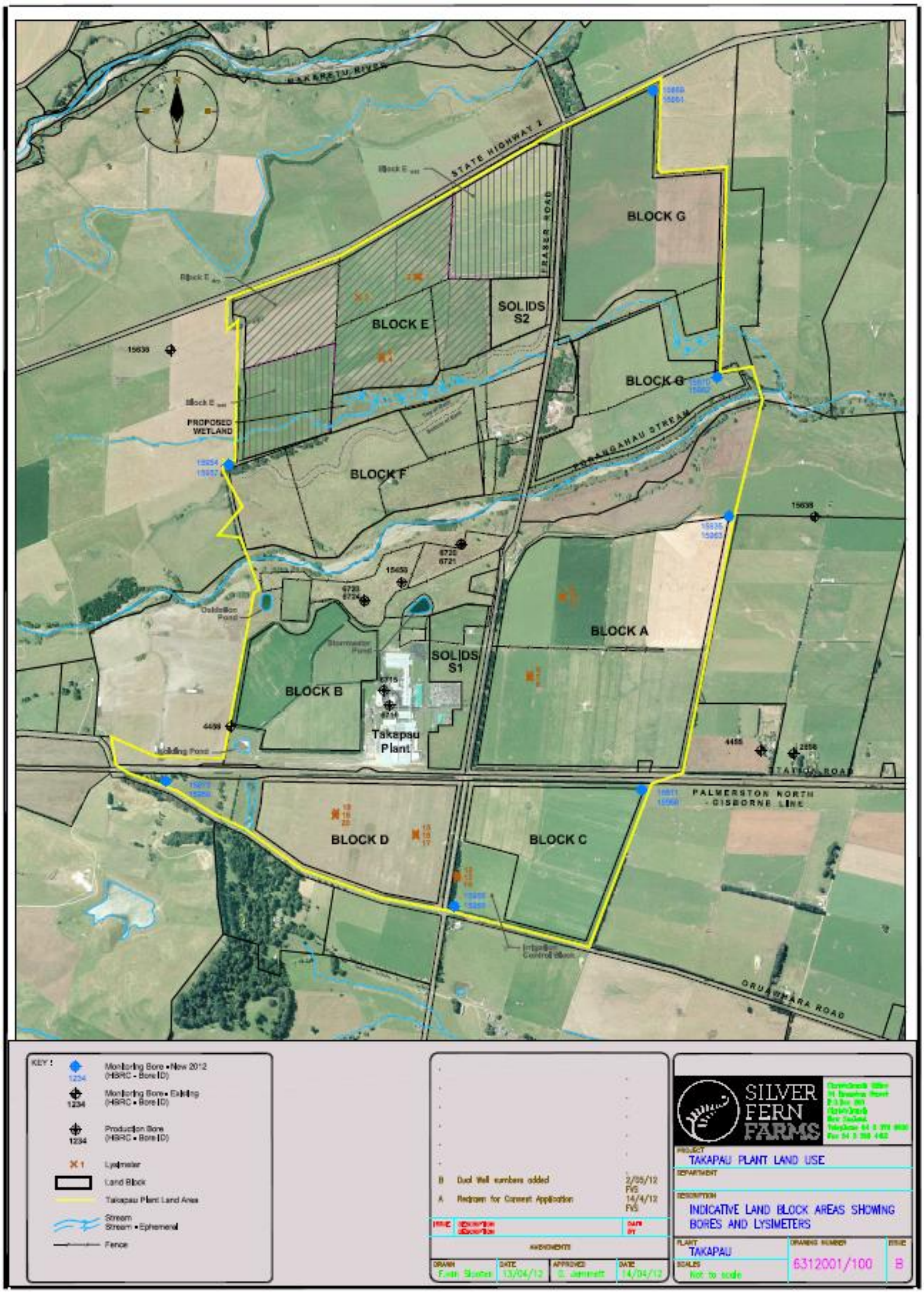
Consent Impact Monitoring

In accordance with section 36 of the RMA (which includes the requirement to consult with the consent holder) the Council may levy additional charges for the cost of monitoring the environmental effects of this consent, either in isolation or in combination with other nearby consents. Any such charge would generally be set through the Council’s Annual Plan process.

Debt Recovery

It is agreed by the consent holder that it is a term of the granting of this resource consent that all costs incurred by the Council for, and incidental to, the collection of any debt relating to the monitoring of this resource consent shall be borne by the consent holder as a debt due to the Council, and for that purpose the Council reserves the right to produce this document in support of any claim for recovery.

Appendix 1: Takapau Plant Land Area Showing Indicative Location of Land Blocks, Bores, Lysimeters, and Surrounding Area



HAWKE'S BAY
REGIONAL COUNCIL

TRANSFER OF RESOURCE CONSENT:	CC120130L
DATE:	23rd November 2015
TO:	**Silver Fern Farms Management Limited** PO Box 941 Dunedin 9054
FROM:	Silver Fern Farms Limited
LOCATION:	Fraser Road, Takapau
LEGAL DESCRIPTION:	Site of activity: Pt Lot 1 DP 3357 and Lot 1 DP 24978

Malcolm Miller
Manager - Consents
RESOURCE MANAGEMENT GROUP

HAWKE'S BAY REGIONAL COUNCIL

CERTIFICATE OF COMPLIANCE

Pursuant to Section 139 of the Resource Management Act 1991 the Hawke's Bay Regional Council issues a certificate of compliance to Silver Fern Farms Limited - Takapau for the activity described below, on the basis that as at 21 June 2012, the activity can lawfully be carried out without a resource consent from the Hawke's Bay Regional Council.

THE ACTIVITY

- To discharge solid organic waste material (principally stockyard scrapings) to land.

as described in the following document:

- Application For Certificate Of Compliance For Discharge Of Stockyard Solids Onto Land, 29 March 2011, Received by the Hawke's Bay Regional Council 4 April 2011.
- And amendments contained in Application for Certificate of Compliance for amendment to the wording of an existing certificate of compliance, 15 June 2012, received by the Hawke's Bay Regional Council 20 June 2012.

LOCATION OF ACTIVITY	**FRASER ROAD, TAKAPAU**
Map Reference:	(At or about) NZTM 1889752 5564809
Site of activity:	Blocks G and F as shown on the site map attached as Appendix 1 of this Certificate of Compliance.
Legal description:	Block F: Pt Lot 1 DP 3357 HB Land District Block G: Lot 1 DP 24978

Malcolm Miller
Manager Consents
RESOURCE MANAGEMENT GROUP
Under authority delegated by Hawke's Bay Regional Council
28th June 2012

Assessment of Proposed Activity under Rule 13 of the Regional Resource Management Plan (August 2006) (RRMP).

Rule 13	Conditions/Standards/Terms	Comment	Complies ?
a	Any area in the Heretaunga Plains unconfined aquifer (Schedule Va) or the Ruataniwha Plains unconfined aquifer (Schedule IV) which is used for storing organic material when there is potential for contamination of groundwater by seepage of contamininants, shall be managed in a manner that prevents such contamination.	Storage is undertaken on a hard surface and potential seepage is contained within the Silver Fern Farms Limited Takapau wastewater drainage network.	Yes
b	Any discharges to air shall not cause any offensive or objectionable odour, or noxious or dangerous levels of gases, beyond the boundary of the subject property.	The discharge of stockyard solid waste material has been occurring at the site for a number of years without issue and this is not expected to change. The Council has not received any complaints about offensive and objectionable odour arising from the Company's discharge of waste solids.	Yes
c	There shall be no visible discharge of any material, including dust, beyond the boundary of the subject property, unless written approval is obtained from the affected property owner.	The discharge of stockyard solid waste material has been occurring at the site for a number of years without issue and this is not expected to change. The Council has not received any complaints about particulate material including dust, arising from the Company's discharge of waste solids.	Yes
d	The discharge shall not result in any airborne liquid contaminant being carried beyond the boundary of the subject property.	The discharge of stockyard solid waste material has been occurring at the site for a number of years without issue and this is not expected to change. The Council has not received any complaints about airborne liquid contaminants arising from the Company's discharge of waste solids.	Yes
e	There shall be no surface ponding in the area used to store, mix or use the organic material, and no runoff of contaminants into any surface water body.	Storage is undertaken on a hard surface and potential seepage is contained within the Silver Fern Farms Limited Takapau wastewater drainage network.	Yes
f	There shall be no discharge within 30 m of any bore or well.	The Company have confirmed that there will be no discharge within 30 m of any bore or well.	Yes
g	The discharge shall occur no less than 600 mm above the winter groundwater table.	The Company have confirmed that there will be no discharge when the winter groundwater table is less than 600 mm from the ground surface.	Yes
h	Where material is discharged onto grazed pasture, the application rate shall not exceed 150 kg/ha/y of nitrogen.	The Company has confirmed that no more than 150 kg/ha/y of nitrogen from the waste solids shall be discharged onto grazed pasture. This will be monitored from within their systems.	Yes
i	Where material is discharged onto land used for a crop, the application rate shall not exceed the rate of nitrogen uptake by the crop.	The Company have confirmed that the application rate will be 150 kg N/ha/year.	Yes

ADVICE NOTES

This Certificate of Compliance is issued subject to the conditions, standards and terms of Rule 13 of the RRMP. Rule 13 of the RRMP (August 2006) is the use of compost, biosolids and other soil conditioners. Any activity that does not comply with the conditions of Rules 13 of the RRMP (August 2006) will require a resource consent.

Please note that the maximum application rate of **150 kg/ha/year of nitrogen** referred to in condition h. of Rule 13 does **not** relate to plant available nitrogen.

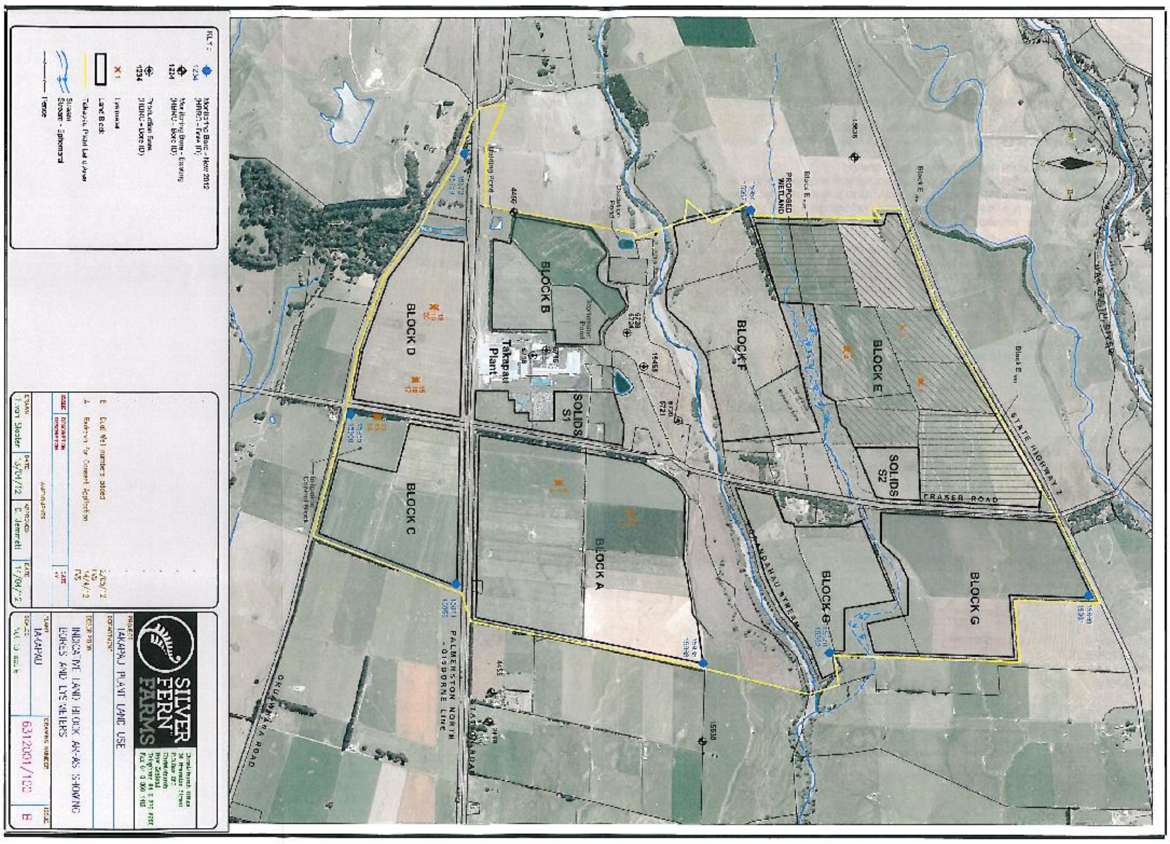
The Council may audit compliance with the conditions, standards and terms of Rule 13 and you are strongly advised to keep records of the each application of solid organic material to Blocks F and G, and prepare a nutrient balance for each block annually.

This Certificate of Compliance does not extend to activities which are authorised under resource consent DP981039L.

This certificate of compliance is subject to section 20A of the Resource Management Act 1991. The activity may require resource consent should relevant rules in the Hawke's Bay Regional Resource Plan or the Proposed Regional Coastal Environment Plan be modified.

This certificate of compliance supersedes certificate CC110136L.

Appendix 1: Location Of Blocks F and G



HAWKE'S BAY REGIONAL COUNCIL

TRANSFER OF RESOURCE CONSENT:	DP981041L
DATE:	23rd November 2015
TO:	**Silver Fern Farms Management Limited** PO Box 941 Dunedin 9054
FROM:	Silver Fern Farms Limited
LOCATION:	Fraser Road, Takapau
LEGAL DESCRIPTION:	Site of activity: Pt Lot 1 DP 3357

Malcolm Miller
Manager - Consents
RESOURCE MANAGEMENT GROUP

Hawke's Bay Regional Council
Safeguarding Your Environment

TRANSFER OF RESOURCE CONSENT:	DP981041L
DATE:	16 June 2008
TO:	**Silver Fern Farms Limited** PO Box 941 Dunedin
FROM:	PPCS Limited
LOCATION:	Fraser Road, Takapau
LEGAL DESCRIPTION:	Pt Lot 1 DP 3357

TIM WAUGH
CONSENTS OFFICER ADMINISTRATION

Hawke's Bay Regional Council
Safeguarding Your Environment

TRANSFER OF RESOURCE CONSENT:	DP981041L
DATE:	26 October 2005
TO:	PPCS Limited PO Box 941 Dunedin
FROM:	Richmond Limited
LOCATION:	Fraser Road, Takapau
LEGAL DESCRIPTION:	Pt Lot 1 DP 3357

TIM WAUGH
CONSENTS OFFICER ADMINISTRATION

Hawke's Bay Regional Council
Safeguarding Your Environment

Resource Consent

DISCHARGE PERMIT

In accordance with Rule 6-1 of the *Proposed Regional Water Resources Plan (November 1996)* and the provisions of the *Resource Management Act 1991*, and subject to the attached conditions, the Hawke's Bay Regional Council (the Council) grants resource consents for a discretionary activities to:

Silver Fern Farms Management Limited
PO Box 941
Dunedin 9054

to discharge;

a) stormwater from a catchment area of 9.6 ha (approximately 4.8 ha of which is impervious), and
b) water from other sources (potentially containing contaminants)

to land where it may enter water, after passing through a detention pond.

LOCATION

Address of site:	Fraser Road, Takapau
Legal description:	Pt Lot 1 DP 3357

DETAILS OF RESOURCE CONSENT

Effluent to be discharged:	stormwater, defrost water, untreated groundwater, water filter backwash, cooling water
Consent duration:	Granted for a period expiring on 31 December 2018
Lapsing of consent:	This consent shall lapse in accordance with s.125 on 31 December 2018.
Cancellation of consent:	In accordance with s.126(a), this consent shall not be cancelled in the event that it is not exercised for a period of 2 years.

Sue Twigg
GROUP MANAGER: ENVIRONMENTAL MANAGEMENT
Under authority delegated by the Hawke's Bay Regional Council
14 December 1999

CONDITIONS

Activity definition

1. The consent holder shall undertake all operations in accordance with any drawings, specifications, statements of intent and other information supplied as part of the application for this resource consent. In the event that there is conflict between the information supplied with the application and any consent condition(s), the condition(s) shall prevail. Such information specifically includes; *Richmond Ltd - Takapau. Resource consent application and assessment of environmental effects of the discharge of stormwater to land, RIC 05, June 1998.*

REVIEW OF CONSENT CONDITIONS BY THE COUNCIL

The Council may review conditions of this consent by serving notice of its intention to do so pursuant to section 128 and section 129 of the Resource Management Act 1991.

Times of service of notice of any review: During the month of May in the years 2000, 2002, 2004, 2009 and 2014.

Purposes of review:

To ensure conditions are consistent with any policies and rules in regional plans that may be established after the commencement of the consent.

Requiring the adoption of the best practicable option to remove or reduce any adverse effect on the environment.

To deal with any adverse effect on the environment which may arise from the exercise of this consent, which it is appropriate to deal with at that time, or which became evident after the date of issue.

REASONS FOR DECISION

1. The actual and potential effects of the activity are minor because
   i) the pond has a large retention time,
   ii) a discharge rarely occurs, and
   iii) the contaminants in the discharge will have no adverse effect.

2. The activity has been occurring for many years and no adverse effects have become apparent.

3. The activity is consistent with plans, policies and the Resource Management Act.

MONITORING BY THE COUNCIL

Routine inspections of the site of this consent will be undertaken by Council officers at a frequency of no more than four times per year. The costs of these routine inspections and any formal monitoring programme that may be established in consultation with the consent holder will be charged to the consent holder.

"Non routine" inspections will be made on other occasions if there is reason to believe (e.g. following a complaint from the public, or monitoring) that the consent holder is in breach of the conditions of this consent. The cost of non-routine inspections will be charged to the consent holder in the event that non-compliance with conditions is determined, or if the Consent holder is deemed not to be fulfilling the obligations specified in section 17(1) of the Resource Management Act (RMA) 1991 shown below.

Section 17(1) of the RMA 1991 states;

Every person has a duty to avoid, remedy, or mitigate any adverse effect on the environment arising from an activity carried on, by or on behalf of that person, whether or not the activity is in accordance with a rule in a plan, a resource consent, section 10, section 10A, or section 20.

HAWKE'S BAY
REGIONAL COUNCIL

Resource Consent

Discharge Permit

In accordance with the provisions of the Resource Management Act 1991(RMA), and subject to the attached conditions, the Hawke's Bay Regional Council (the Council) grants a resource consent for a discretionary activity to:

Silver Fern Farms Management Limited
PO Box 941
Dunedin 9054

to discharge partially treated meat processing plant wastewater onto land, in circumstances which may result in the contaminant (or any other contaminant emanating as a result of natural processes from that contaminant) entering water, and to discharge odorous compounds and aerosols into the air associated with the discharge of meat processing plant wastewater.

LOCATION

Block ID (see Appendix 1)	Legal Description	NZTM Reference (at centre of site)
A	Sec 1S Maharakeke Settlement	E1890195 N5564585
B	Pt Lot 1 DP 3357	E1889062 N5564355
C	Lot 5 DP 6204	E1889940 N5563729
D	Lot 4 DP 6204	E1889235 N5563824
E	Pt Lot 1 DP 3357	E1889399 N5565781

CONSENT DURATION
This consent is granted for a period expiring 31 December 2018.

Malcolm Miller
Manager Consents
Under authority delegated by the Hawke's Bay Regional Council
5th February 2016

This consent was originally issued on 14 December 1999 and subsequently changed in accordance with s 127 of the RMA, see consent history, page 18.

CONDITIONS

Activity definition

1. The consent holder shall undertake all operations in accordance with any drawings, specifications, statements of intent and other information supplied as part of the application for this resource consent. In the event that there is conflict between the information supplied with the application and any consent conditions, the conditions shall prevail. Such information specifically includes;

   a) *Richmond Ltd - Takapau. Resource consent application and assessment of environmental effects for the land treatment of meat processing effluent. RIC 08, June 1998.*

   b) Richmond Ltd - Takapau. Resource consent application and assessment of environmental effects for the emissions to air from the land application meat processing effluent. RIC 09, June 1998.

   c) Richmond Ltd - Takapau. Proposed Management plan for the land treatment of meat processing effluent. RIC 08-2, June 1998.

   d) Richmond Ltd – Takapau. Application for variation of resource consent conditions for the abstraction of groundwater, the discharge of meat processing waste water and discharge of yard solids. 6919RIC, November 2002

   e) Application to Change Conditions of Discharge to Land Resource Consents – Assessment of Environmental Effects, Silver Fern Farms Limited – Takapau. Prepared by Pattle Delamore Partners Ltd, February 2010.

   f) Application to Change Conditions of Discharge to Land Resource Consent application, dated 23 November 2015, received by the Council on 2 December 2015.

2. The volume of waste discharged shall not exceed 35,000 cubic metres during any 7 day period, nor 1,365,000 cubic metres during the period 1 October each year to 30 September the following year.

3. The wastewater shall be passed through screens having a maximum aperture of 1.5 mm before being discharged.

4. The wastewater shall contain no domestic sewage (excluding separated grey water), fellmongery waste, tannery waste nor chemical waste from the processing of casings (other than common salt (NaCl)). No imported wastewater other than truckwash and stock holding tank effluent shall be discharged.

4A. Cancelled.

Administrative

5. The consent holder shall appoint a person to be responsible for the day-to-day operation of the wastewater disposal system and to act as a contact for Regional Council staff. The name and phone number of this contact person shall be advised to the Council within 10 working days of the commencement of this consent and within 10 working days of any change.

Mitigation of effects

6. All works and structures relating to this resource consent shall be designed and constructed to conform to the best engineering practices and at all times maintained to a safe and serviceable standard.

7. Cancelled.

8. Cancelled.

9. Wastewater shall only be discharged using travelling irrigators operating at a pressure between 200 and 350 kPa.

9A. When operating during daylight hours during the working week, the consent holder shall regularly undertake visual observations of the irrigation network to ensure it is operating correctly. Written records of these observations shall be kept, and made available upon request to the Council (Manager Resource Use).

When operating during the hours of darkness, and over the weekend, all travelling irrigators fitted with an effective monitoring system that will shut down the pump to the irrigator should the pressure drop below 200kPa that are in working order, shall be used, spread across the irrigation network, to detect any significant pressure drop. The consent holder shall undertake regular maintenance on the travelling irrigators, and take all reasonable measures to ensure as many travelling irrigators fitted with monitoring systems are in operation during the hours of darkness, and weekends.

10. Irrigation blocks A - E shall be classified into one of the 'management classes' identified below. Before exercising this consent, and before 31 August each year, the consent holder shall provide the Council with a map identifying the management classification of each of the irrigation runs for the period 1 October each year to 30 September the following year. Any changes to the management classes after 31 August each year shall be submitted to the Council (Manager Resource Use) in writing.

<u>Management classes</u>

a) Cancelled;

b) *Managed cropped pastoral*: Standard pastoral cropping where hay, silage or other crops (including greenfeed) are removed off-site.

c) *Managed cropped lucerne*: Lucerne cropping. The crop is cut as frequently as is practicable and removed from the site.

d) Cancelled;

e) Cancelled.;

10A. Cancelled.

11. Cancelled.

12. Cancelled.

13. Cancelled.

14. The total nitrogen from wastewater, 'fertiliser', and solid organic waste material discharged under DP981039Lb, to any irrigation run in Blocks A - E over the period 1 October each year to 30 September the following year shall not exceed:

    a) Cancelled;

    b) 600 kg per hectare on any cropped pastoral area, nor;

    c) 650 kg per hectare on any cropped lucerne area;

    d) Cancelled;

    e) Cancelled;

    f) Cancelled.

15. Cancelled.

16. There shall be no surface runoff of wastewater to adjoining properties (including roads), or to water.

17. No ponding of wastewater for more than 6 hours shall occur up until 30 September 2014, and no ponding of wastewater for more than 2 hours shall occur after 30 September 2014. Nor shall any wastewater be applied to areas where there is surface ponding.

18. There shall be no discharge of wastewater within:

    a) 20 metres of a surface water body;

    b) 20 metres of any property boundary;

    c) 30 metres from any bore unless secure wellhead protection, to the satisfaction of the Council (Manager Resource Use), is in place.

    d) 150 metres of any occupied dwelling existing on 1 April 1999;

    e) 500 metres of any occupied downwind dwelling existing on 1 April 1999;

    f) 50 metres of any bore used for drinking water purposes existing on 1 April 1999.

19. No wastewater shall be discharged on to any part of the 'E-wet' irrigation area when the soil moisture deficit is less than 20 mm, i.e. when the soil moisture is greater than 45 mm.

20. Cancelled.

21. The wastewater 'storage' pond shall be emptied ('empty' is containing less than 500 m^3 of wastewater) at least once each operating day, unless soil moisture conditions are not conducive to irrigation.

21A. Within one year of the granting of this consent there shall be no more than minor visible deposition of particulate material, including fats, on the surface of the land application area after any discharge of wastewater.

(For the purpose of determining "more than minor visible deposition" refer to Advice Note 1.)

22. There shall be no offensive or objectionable odour beyond the boundary of the property. The 'property' is the outline area shown in Appendix 1 as the Takapau Plant Land Area.

Monitoring

23. All analyses, other than field measurements, required by the conditions of this consent shall be undertaken by a laboratory independently accredited by IANZ. All methodologies adopted shall be appropriate for water and effluent analyses.

24. Prior to 1 July 2012, the consent holder shall, fortnightly during each calendar month of operation, take a 24-hour proportional sample (maximum time interval of 1 hour) from within the discharge pipe at the wastewater storage pond, and analyse it for the following:

    a) pH

    b) COD

    c) Total suspended solids

    d) Chloride

    e) Ammoniacal Nitrogen

    f) Total Kjeldahl Nitrogen

    g) Total phosphorus

    h) Dissolved reactive phosphorus

    i) Total fat

    j) Potassium

    k) Calcium

    l) Magnesium

    m) Sodium

    n) E. coli

24A From 1 July 2012, the consent holder shall, fortnightly during each calendar month of operation, take a 24-hour time flow proportional sample (at intervals to be agreed upon with the Manager Resource Use) from within the discharge pipe at the wastewater storage pond, and analyse it for the analytes listed in condition 24 of this consent.

25. Soil water shall be sampled from at least three lysimeters installed and maintained on each of the blocks A, B, C, D and E-dry. At least three lysimeters shall also be located in a non-irrigated control block, and on the area known as E-wet. Relocation and installation of any existing lysimeters shall be completed within six months of the granting of this consent. The installation of all new lysimeters required by this consent shall be completed within 18 months of the granting of this consent. The location and installation details of any relocated or new lysimeters to be installed shall be agreed upon with Hawke's Bay Regional Council (Manager Resource Use), prior to their installation.

i. Cancelled.
ii. Cancelled.
iii. Cancelled.

Each sample shall be analysed for the analytes at the frequency shown in Table 1 below:

Table 1: Soil water monitoring programme

Analyte	Sampling frequency
Volume	Once every fortnight
Nitrate Nitrogen	Once every fortnight
Ammoniacal Nitrogen	Once every fortnight
Total Kjeldahl Nitrogen	Once every fortnight
Nitrite Nitrogen	Once every fortnight

26. The consent holder shall establish and maintain ground water monitoring bores, at the locations described in Table 2 (see Advice Note 2). The consent holder shall install any new bores in accordance with Hawke's Bay Regional Council guidelines and shall provide the bore logs to the Council. Any bores listed in Table 2 that are not drilled and operational at the time this consent is granted shall be drilled and operational within six months of the granting of this consent . Except that:
    - Bore **15958** need only be established if monitoring from bore **4455** is to be phased out.
    - Bore **15871** need only be established if monitoring from bore **2898** is to be phased out.
    - Bore **15963**, need only be established if bore **15638** is to be phased out
    - If weather is not conducive to establishing monitoring bores within six months, then establishment timing to be by agreement with the Hawkes Bay Regional Council and to be carried out by 31 Dec 2012.

Table 2: Groundwater monitoring bores

HBRC Bore ID [previous ref No(s).]	**Location & depth of bore**
HBRC Bore ID 15636 [2425]	**HBRC Bore ID 15636** – Immediately up-gradient of any potential effect on groundwater quality of the proposed discharge to Block E. Existing bore is 14m deep with its screen located in the shallow unconfined (or semi-confined) aquifer which occurs at a depth of 5 to 15 metres. Bore located at or about NZTM E1888522 N5565635.
HBRC Bore ID 4456 [2426]	**HBRC Bore ID 4456** – Immediately up-gradient of any potential effect to Area B. Screen to be located in the shallow unconfined (or semi-confined) aquifer which occurs at a depth of 5 to 15 metres. Bore located at or about NZTM E1888750 N5564196.
HBRC Bore ID 15954	**HBRC Bore ID 15954** – Just prior to the south west corner of Block E, up-gradient of any potential effect on groundwater quality of the proposed discharge to Block E. Bore is 45 m deep with its screen located in the intermediate (or 'main') semi-confined aquifer at a depth of 25 to 45 metres. Bore to be located at or about NZTM E1888755 N5565189.
HBRC Bore ID 15957	**HBRC Bore ID 15957** – Just prior to the south west corner of Block E, up-gradient of any potential effect on groundwater quality of the proposed discharge to Block E. Bore is 6.6 m deep with its screen located in the shallow unconfined or semi-confined aquifer at a depth of 5 to 15 metres. Bore to be located at or about NZTM E1888756 N5565193.

HBRC Bore ID 15871	**HBRC Bore ID 15871** – In the north east corner of Block C at a site where any effects on the groundwater quality of the proposed discharge are most likely to be detected. Bore is 45.5 m deep with its screen located in the intermediate (or 'main') semi-confined aquifer at a depth of 25 to 45 metres. Bore to be located at or about NZTM E1890351 N5565963.
HBRC Bore ID 15958	**HBRC Bore ID 15958** – In the north east corner of Block C at a site where any effects on the groundwater quality of the proposed discharge are most likely to be detected. Bore is 6.04 m deep with its screen located in the shallow unconfined or semi-confined aquifer at a depth of 5 to 15 metres. Bore to be located at or about NZTM E1890357 N5565964.
HBRC Bore ID 4455 [2429]	**HBRC Bore ID 4455** - Immediately down-gradient of Block C at a site where any effects on groundwater quality of the proposed discharge are most likely to be detected. Existing bore is 9.6m deep with its screen located in the shallow unconfined (or semi-confined) aquifer which occurs at a depth of 5 to 15 metres. If monitoring of this bore is to be phased out in favour of new bore **15958**, then transitional activities required: bore to be monitored until Bore **15958** has been monitored for 3 years. Bore located at or about NZTM E1890778 N5564102.
HBRC Bore ID 2898 [2433]	**HBRC Bore ID 2898** - Immediately down-gradient of Block C at a site where any effects on groundwater quality of the discharge are likely to be detected. Existing bore is 28m deep with its screen located in the intermediate (or 'main') semi-confined aquifer that occurs at a depth of 25 to 45 metres. If monitoring of this bore is to be phased out in favour of new bore **15871**, then transitional activities required: bore to be monitored until Bore **15871** has been monitored for 3 years. Bore located at or about E1890987 N5564064.
HBRC Bore ID 15872	**HBRC Bore ID 15872** – Immediately up-gradient of any potential effect to Block B, Bore is 12.51 m deep with its screen located in the shallow unconfined (or semi-confined) aquifer which occurs at a depth of 5 to 15 metres. Bore to be located at or about NZTM E1888777 N5564253.
HBRC Bore ID 15959	**HBRC Bore ID 15959** – On the terrace up-gradient of any potential effect to Block D. Bore is 45 m deep with its screen located in the shallow unconfined (or semi-confined) aquifer which occurs at a depth of 5 to 15 metres. Bore to be located at or about NZTM E1888586 N5563936.
HBRC Bore ID 15955	**HBRC Bore ID 15955** – Immediately up-gradient of any potential effect to Block B. Bore is 44.24 m deep and screened in the intermediate (or 'main') semi-confined aquifer at a depth of 25 to 45 metres. Bore to be located at or about NZTM E2798747 N5564254.
HBRC Bore ID 15960	**HBRC Bore ID 15960** – In the control quadrant of Block C, up-gradient of potential effects to Block C south of Oruawhara Road. Bore is 45 m deep with its screen in the shallow unconfined (or semi-confined) aquifer which occurs at a depth of 5 to 15. Bore to be located at or about NZTM E1889586 N5563502.
HBRC Bore ID 15869	**HBRC Bore ID 15869** – Immediately down gradient of Block E and G at a site where any effects on groundwater quality of the proposed discharge and any activities occurring on Block G are most likely to be detected. Bore is 45.13 m deep with its screen in the intermediate (or 'main') semi-confined aquifer at a depth of 25 to 45 metres. Bore to be located at or about NZTM E1890383 N5566653

HBRC Bore ID 15961	**HBRC Bore ID 15961** – Immediately down gradient of Block E and G at a site where any effects on groundwater quality of the proposed discharge and any activities occurring on Block G are most likely to be detected. Bore is 10.5 m deep with its screen in the shallow unconfined (or semi-confined) aquifer at a depth of 5 to 15 metres. Bore to be located at or about NZTM E1890381 N5566647.
HBRC Bore ID 15870	**HBRC Bore ID 15870** – Immediately down gradient of Block G where any effects on groundwater quality of the proposed discharge and any activities occurring on Block G are most likely to be detected. Bore is 45 m deep with its screen in the intermediate (or 'main') semi-confined aquifer at a depth of 25 to 45 metres. . Bore to be located at or about NZTM E1890608 N5565541.
HBRC Bore ID 15962	**HBRC Bore ID 15962** – Immediately down gradient of Block G where any effects on groundwater quality of the proposed discharge and any activities occurring on Block G are most likely to be detected. Bore is 7.35 m deep with its screen in the shallow unconfined (or semi-confined) aquifer at a depth of 5 to 15 metres. Bore to be located at or about NZTM E1890605 N5565541.
HBRC Bore ID 15935	**HBRC Bore ID 15935** - Immediately down-gradient of Block A at a site where any effects on groundwater quality of the proposed discharge are most likely to be detected. Bore is 45 m deep with its screen in the intermediate (or 'main') semi-confined aquifer at a depth of 25 to 45 metres. Bore to be located at or about NZTM E1890682 N5565038.
HBRC Bore ID 15963	**HBRC Bore ID 15963** - Immediately down-gradient of Block A at a site where any effects on groundwater quality of the proposed discharge are most likely to be detected. Bore is 14.2 m deep with its screen in the shallow unconfined (or semi-confined) aquifer which occurs at a depth of 5 to 15 metres. Bore to be located at or about NZTM E1890678 N5565026.
HBRC Bore ID 15638 [2428]	**HBRC Bore ID 15638** - Immediately down-gradient of Block A at a site where any effects on groundwater quality of the discharge are likely to be detected. Existing bore is 15.96m deep with its screen located in the shallow unconfined (or semi-confined) aquifer at a depth of 5 to 15 metres. If monitoring of this bore is to be phased out in favour of new bore **15963**, then transitional activities required: bore to be monitored until Bore **15963** has been monitored for 3 years. Bore located at or about NZTM E1890984 N5565635.
HBRC Bore ID 6720 [2430	**HBRC Bore ID 6720** - At a site where any effects on groundwater quality of parts of the discharge are likely to be detected. Existing bore is 45.7m deep with its screen located in the intermediate (or 'main') semi-confined aquifer that occurs at a depth of 25 to 45 metres. Bore located at or about NZTM E1889627 N5564898.

Previous Ref No(s). relate to Site ID superseded by HBRC Bore ID.

Note: *This consent does not authorise the drilling of any new monitoring bores – specific 'bore permits' must be obtained.*

27. The elevation (in metres above sea level) of the top of the casing of each monitoring bore shall be determined by the consent holder to an accuracy of ± 0.05m, and advised to the Council within 90 days of the drilling of the bore.

28. Samples shall be taken from the monitoring bores identified in condition 26 in accordance with "A National Protocol for State of the Environment Groundwater Sampling in New Zealand" (November 2006) and analysed, at the frequency shown in Table 3 below, for the analytes also shown. (Advice note 3)

Table 3: Groundwater monitoring programme

Analyte	Sampling frequency
pH	Once every 2 months
Conductivity	Once every 2 months
Sodium	Once every 2 months
Nitrate Nitrogen Ammoniacal Nitrogen	Once every 2 months Once every 2 months
Total Kjeldahl Nitrogen	Once every 2 months
Chloride	Once every 2 months
E. coli	Once every 2 months

29. Cancelled.

30. When samples are taken in accordance with condition 28, the consent holder shall measure and record the date, time and water level (before purging the bore), in each of the monitoring bores identified in condition 26. The water level shall be measured from the top of the casing, and shall be recorded to the nearest 0.01 metres.

31. Water shall be sampled at the sites detailed in Table 4 at a frequency of once every month and analysed for the following;

    a) pH

    b) Temperature

    c) Dissolved oxygen

    d) Chloride

    e) Nitrate Nitrogen

    f) Ammoniacal Nitrogen

    g) Dissolved reactive phosphorus

    h) E. coli

    i) Total Kjeldahl Nitrogen

Table 4: Surface water monitoring sites

Site ID	Description	NZTM Ref
397	Porangahau Stream upstream of discharge	At or about E1889114 N5564779
2431	Porangahau Stream downstream of discharge	At or about E1890768 N5565456

* 'Site ID' is the HBRC water quality database ID number

Reporting

32. The consent holder shall maintain a detailed record of wastewater discharged to each irrigation block, including the following;

    a) The date and time of each application of wastewater;

b) The soil moisture at the start of each application of wastewater to any run in Block E-wet;

c) The irrigation run onto which the wastewater was applied;

d) The mass (kg) and rate (kg N/ha) of total nitrogen applied to each irrigation run during each application of wastewater;

e) The total cumulative nitrogen applied from all sources to each irrigation run over the period 1 October each year to 30 September the following year (see Advice Note 4);

f) The hydraulic loading (application depth in mm) for each application of wastewater to each irrigation run;

g) Cancelled;

h) The volume (m^3) of wastewater applied to each irrigation run for each application.

33. The consent holder shall maintain a record of all activities associated with the wastewater disposal system, including;

a) Cancelled;

b) Cancelled;

c) Cancelled;

d) The total volume (m^3) of wastewater discharged each day;

e) The weather conditions, including daily rainfall, potential evapotranspiration, hourly wind speed and direction;

f) Details of pipeline flushing.

34. The consent holder shall maintain records of:

a) The weight of dry matter removed from each irrigation area; and

b) The nitrogen content of that dry matter.

c) The name and mass (kg) and rate (kg N/ha) of any nitrogen based fertiliser applied, the irrigation block this has been applied to and the date of application.

35. The consent holder shall install, to the satisfaction of the Council (Manager Resource Use), and maintain telemetered soil moisture measuring equipment (Aquaflex or similar) in each irrigation block and a control block. At least three measuring sites shall be required within one irrigation run for each irrigation block, to compensate for spatial variations in soil characteristics and application rate. Relocation and installation of any existing soil moisture measuring equipment shall be completed within six months of the granting of this consent. The installation of all new soil moisture measuring equipment required by this consent shall be completed within 18 months of the granting of this consent. The location and installation details of any relocated or new soil moisture measuring equipment to be installed shall be agreed upon with Hawke's Bay Regional Council (Manager Resource Use), prior to its installation.

36. Cancelled.

37. All irrigation records collected in accordance with this consent shall be summarised for each irrigation run within each irrigation block and provided to the Council at monthly intervals. All records and results of analyses collected in accordance with the conditions of this consent shall be provided to the Council (in electronic form) at monthly intervals, or at any other time that may be requested by the Council. Records shall be provided no more than seven days following the end of the month to which they relate. Raw laboratory data shall be provided to the Council (Manager Resource Use) on request.

38. The consent holder shall log all complaints received. The log shall include the date, time, and nature of the complaint and the name, telephone number, and address of the complainant, weather information (including wind speed and direction), details of key operating parameters at the time of the complaint, the remedial action taken to mitigate the effects of the incident and the steps taken to prevent further incidents. Complaints shall be reported to the Council within 24 hours of receipt and the log of complaints shall be made available to the Council on request.

39. Before 31 December 2000 and annually thereafter, the consent holder shall provide the Council with a monitoring report for the 12 month period ending at the previous 30 September. The format of the monitoring report shall be to the satisfaction of the Council (Manager Resource Use) and shall include (but not be limited to);

    a) A summary of analyses and records collected in accordance with the conditions of this consent; and

    b) A comment on the extent that each consent condition has been complied with.

New Conditions following s 127 Application 13 April 2010.

40. The rate of wastewater application to land, over all blocks, shall comply with the following:

Maximum Application Depth (mm per application)	Minimum Return Period (Days)
Up to 30	7
31 to 45	10
46 to 65	14

41. The discharge of wastewater to land shall not exceed 65 mm per application.

42. From 1 July 2014, the field capacity of any irrigated soil shall not be exceeded as a result of the discharge of wastewater.

43. The consent holder shall maintain flow meters on every travelling irrigator in accordance with the Council's *"Technical Specifications and Installation Requirements for Flow Meters" (February 2010)* (as attached).

44. For every irrigator on which telemetry equipment has not been installed, the consent holder shall read the wastewater flow meters at daily intervals and shall provide the Council with a record of the following:

    a) The meter readings (in cubic metres);

    b) The daily volume of wastewater discharged to each block (in cubic metres);

    c) The date and time of each reading;

d) The block that the record relates to.

This information shall be supplied no later than 7 days after the end of each month.

For irrigators on which telemetry equipment has been installed, that equipment shall be capable of measuring the instantaneous discharge rate (L/sec) and the daily volume of wastewater discharged (m^3) to each irrigator, to an accuracy of +/- 5%. The telemetered flow meters shall be maintained in accordance with the Council's *"Technical Specifications and Installation Requirements for Flow Meters" (February 2010).* Rates, volumes, pressures, location and speeds shall be recorded every 15 minutes, and every 15 minute interval of data shall be date and time stamped with the New Zealand Standard Time at the end of the 15 minute interval. Data shall be transmitted to the Hawke's Bay Regional Council telemetry system at least once per day.

45. The consent holder shall install, to the satisfaction of the Council (Manager Resource Use), and maintain telemetered rainfall measuring equipment at the site that is capable of measuring rainfall (mm) in real time.

46. The mass and rate of total nitrogen applied to each irrigation run during each application of wastewater, as specified in condition 32(d) of this consent, shall be calculated as follows:

a) The average monthly total nitrogen concentration (g/m^3) shall be calculated by averaging the last wastewater sample from the previous month and the two wastewater samples in the month to be calculated. These samples shall be taken in accordance with condition 24 of this consent.

b) The average monthly total nitrogen concentration for each month shall then be multiplied by the volume (m^3) of wastewater applied to each irrigation run, in order to calculate the mass of total nitrogen applied (kg) per application to each irrigation run.

c) The mass of total nitrogen applied (kg) per application shall then be divided by the area (ha) of each irrigation run to calculate the rate (kg N/ha) of nitrogen loading per application per irrigation run.

d) The area (ha) irrigated during each application of wastewater shall be calculated by multiplying the distance the irrigator travelled by the irrigation run width.

47. The consent holder shall submit to the Council (Manager Resource Use), by 31 December each year, an annualised nutrient mass balance, for the 12 -month period ending at the previous 30 September. The nutrient mass balance shall provide an estimate of the annual losses of nitrogen (in kg N/ha) from each of the irrigation areas and crop management classes and the detailed calculations that were used to generate the nutrient mass balance.

48. The consent holder shall engage the services of a suitably qualified ecologist to undertake macroinvertebrate monitoring at the sites listed in Table 4 of this consent. The sampling shall be undertaken once annually during the period 1 January to 31 March, at least 4 weeks following a "significant fresh". For the purposes of this consent a "significant fresh" is defined as 3 times the median flow (see Advice Note 5). The results of the sampling shall be submitted to the Council within one month of being received by the consent holder.

49. By 30 September each year the consent holder shall submit to the Council (Manager Resource Use) the results of analyses of soil samples taken from areas representative of each soil type and cover crop combination within the 213 hectares of land application

area. The soil sampling shall be undertaken by a suitably qualified person approved by the Council (Manager Resource Use) prior to the commencement of sampling.

(A "suitably qualified person" means a person who has several years as a practitioner of taking soil samples and whose judgement can be used to resolve a technical problem with sampling.)

50. The soil samples required by condition 49 shall be analysed for the following:

a) Olsen-P

b) Total phosphorous

c) pH

d) Soil moisture

e) Cation Exchange Capacity

f) Total Base Saturation

g) Calcium

h) Potassium

i) Magnesium

j) Sodium

k) Anion Storage Capacity

l) Total Organic Carbon

m) Available Nitrogen (Anaerobic Mineralisable N)

51. The soil samples for each area sampled shall consist of 0-75 mm cores collected along a stretched 'W', or 'X' transect, or a grid pattern in each area. Each sample shall consist of not less than 20 entire cores to form a composite sample.

52. The consent holder shall record the GPS location, operating speed (m/s) and operating pressure (kPa) of each of the travelling irrigators used to discharge wastewater on which GPS equipment has been installed, at all times when they are in operation. For irrigators on which GPS equipment has not been installed, the consent holder shall record the GPS location of the irrigator, and time, at the start, and end, of each irrigator run.

53. All time-series data required to be recorded by Conditions 35, 43, 45 and 52, shall:

a) record the rates, volumes, pressures, location and speeds every 15 minutes. Each 15 minute interval of data shall be date and time stamped with the New Zealand Standard Time at the end of the 15 minute interval.

b) Data shall be transmitted to the Hawke's Bay Regional Council telemetry system at least once per day.

c) Shall be transmitted in a format compatible with Hawke's Bay Regional Council telemetry system and storage system.

54. The consent holder shall calibrate the wastewater and waste solids irrigators in accordance with the method outlined in the "Wastewater and Solids Management Plan" at least once every three months to determine the irrigator application rate (in mm per pass or mm per hour). The results of each calibration shall be recorded and submitted to the Council (Manager Resource Use) in accordance with condition 37 of this consent.

55. There shall be no grazing of stock at any time on blocks A – E without the prior approval of the Hawke's Bay Regional Council (Manager Resource Use).

56. The consent holder shall undertake all operations in accordance with a written Wastewater and Solids Management Plan held on site that includes (but is not limited to):

    a) A description of the purpose of the plan;

    b) The names and contact phone numbers and addresses of key personnel;

    c) A general description of the activities undertaken at the site;

    d) Identification of the potential sources of contamination of groundwater and surface water and odour.

    e) A full description of the systems in place to prevent contamination of groundwater and surface water and odour.

    f) Relevant operating procedures that need to be undertaken and the frequency by which they must be undertaken.

    g) Details of the method used to calibrate the travelling irrigators at each of the speeds they are operated at and to calibrate the waste solids irrigators.

    h) An inventory of relevant equipment and materials;

    i) An equipment maintenance programme;

    j) A contingency plan in the event that there is an adverse effect as a result of contamination of groundwater or surface water, or an offensive or objectionable odour beyond the boundary;

    k) A list of records that need to be kept including maintenance and control parameters, weather records and complaint and investigation records;

    l) A description of staff training relating to the management of wastewater, including methods, frequency and training records;

    m) A description of the process for reviewing the overall system performance.

57. The consent holder shall review and update the Wastewater and Solids Management Plan at least every two years and shall provide a copy of the Wastewater and Solids Management Plan to the Council (Manager Resource Use) on request.

58. No later than one year prior to the expiry of the consent, the consent holder shall submit to the Council (Manager Resource Use) a peer reviewed report that details (but is not limited to) future wastewater treatment, discharge and storage options. The purpose of the report will be to initiate pre-application discussions with the Hawke's Bay Regional Council, prior to the application for a new consent.

59. This consent is complementary to and is exercised in conjunction with consent number DP981039Lb.

REVIEW OF CONSENT CONDITIONS BY THE COUNCIL

The Council may review conditions of this consent by serving notice of its intention to do so pursuant to section 128 and section 129 of the Resource Management Act 1991.

Times of service of notice of any review:	During the month of May of any year.
Purposes of review:	To ensure conditions are consistent with any policies and rules in regional plans that may be established after the commencement of the consent. Requiring the adoption of the best practicable option to remove or reduce any adverse effect on the environment. To deal with any adverse effect on the environment which may arise from the exercise of this consent, which it is appropriate to deal with at that time, or which became evident after the date of issue. To require the installation of a wastewater holding pond if it is evident that the conditions of this consent cannot be complied with. To modify the monitoring programme if the record of monitoring to date indicates that it is inappropriate.

ADVICE NOTES

1 The visible deposition of particulate material as shown in the photographs attached to this consent as Appendix 2 shall be considered to be more than minor.

2. A bore permit is required before any new bore can be drilled. Please contact the Hawke's Bay Regional Council to confirm the location of any new groundwater monitoring well prior to it being drilled.

3. The Ministry for the Environment's "A National Protocol for State of the Environment Groundwater Sampling in New Zealand" (November 2006) is available at http://www.mfe.govt.nz/publications/water/national-protocol-groundwater-dec06/

4. Total nitrogen from all sources includes nitrogen from wastewater, 'fertiliser', **and** solid organic waste material.

5. The consent holder is advised to contact the Council's Environmental Science section for information on median flow and assistance with this condition.

REASONS FOR DECISION
(Original decision December 1999)

1. Based on the comprehensive evaluation of resource provided with the application the Council is satisfied that it can sustain the activity.

2. The conditions of consent will ensure that the actual effects of the activity will be adequately monitored and any significant adverse affects that may occur are detected as early as possible.

3. The duration of the consent, and the provision to review conditions is sufficient to provide consent holder with appropriate security without significant risk to the environment or potentially affected parties.

4. The activity is consistent with relevant plans and policies and with the Resource Management Act.

REASON FOR DECISION
(s127 application September 2001)

1. The changes relate to measuring and recording results only and will have no environmental effects.

REASON FOR DECISION
(s127 Application January 2002)

1. The increase in weekly & annual effluent volume and the ability to evaluate trial crops for nitrogen removal efficiency, undertaken in accordance with amended and existing conditions, will result in the adverse effects of the activity being unchanged.

REASON FOR DECISION
(s127 Application April 2009)

The activity will have minor actual or potential adverse effects on the environment and is not contrary to any relevant plans or policies. The activity is also consistent with the purpose and principles of the Resource Management Act 1991.

REASONS FOR DECISION
(Change Of Consent Conditions –May 2012)

The activity will have minor actual or potential adverse effects on the environment and is not contrary to any relevant plans or policies. The activity is also consistent with the purpose and principles of the Resource Management Act 1991.

REASONS FOR DECISION
(Change Of Consent Conditions –November 2013)

The activity will have minor actual or potential adverse effects on the environment and is not contrary to any relevant plans or policies. The activity is also consistent with the purpose and principles of the Resource Management Act 1991.

REASONS FOR DECISION
(Change Of Consent Conditions –February 2016)

The effects of the activity on the environment will not be more than minor. Granting the consent is consistent with the purpose and principles of the RMA, the National Policy Statement for Freshwater, the Resource Management (National Environmental Standards for Sources of Human Drinking Water) Regulations 2007 and with all relevant plans and policies.

MONITORING BY THE COUNCIL

Routine inspections of the site of this consent will be undertaken by Council officers at a frequency of no more than four times per year. The costs of these routine inspections and any formal monitoring programme that may be established in consultation with the consent holder will be charged to the consent holder.

On request the consent holder shall advise the Council of sampling dates and times so that concurrent audit samples can be taken by Council officers. The audit samples will be analysed by an alternative laboratory independently accredited by IANZ, and the costs of sampling and analysis will be charged to the consent holder.

"Non routine" inspections will be made on other occasions if there is reason to believe (e.g. following a complaint from the public, or monitoring) that the consent holder is in breach of the conditions of this consent. The cost of non-routine inspections will be charged to the consent holder in the event that non-compliance with conditions is determined, or if the Consent holder is deemed not to be fulfilling the obligations specified in section 17(1) of the Resource Management Act (RMA) 1991 shown below.

Section 17(1) of the RMA 1991 states;

> *Every person has a duty to avoid, remedy, or mitigate any adverse effect on the environment arising from an activity carried on by or on behalf of the person, whether or not the activity is carried on in accordance with*
>
> *a) any of sections 10, 10A, 10B, and 20A; or*
>
> *b) a national environmental standard, a rule, a resource consent, or a designation.*

Consent Impact Monitoring

In accordance with section 36 of the RMA (which includes the requirement to consult with the consent holder) the Council may levy additional charges for the cost of monitoring the environmental effects of this consent, either in isolation or in combination with other nearby consents. Any such charge would generally be set through the Council's Annual Plan process.

Debt Recovery

It is agreed by the consent holder that it is a term of the granting of this resource consent that all costs incurred by the Council for, and incidental to, the collection of any debt relating to the monitoring of this resource consent shall be borne by the consent holder as a debt due to the Council, and for that purpose the Council reserves the right to produce this document in support of any claim for recovery.

CONSENT HISTORY

Consent No. (Version)	Date	Event	Relevant Rule Number	Plan
DP981043L & DP981044A	14/12/1999	Consent initially granted	Rule 6-1	Proposed Regional Water Resources Plan (Dec 2000)
			Rule 21	Regional Air Plan (Jan 1998)
			Rules 30 & 50	Proposed Regional Resource Management Plan (June 2001)
DP981043La & DP981044Aa	08/05/2012	Change of conditions application withdrawn	Section 127	Resource Management Act
DP981043Lb & DP981044Ab	08/05/2012	Changes to Conditions 1, 4A, 8, 10, 11, 12, 13, 14, 19, 25, 26, 32, 34, 35 and 37	Section 127	Resource Management Act
DP981043Lc & DP981040Ac	02/12/2013	Minor changes to Conditions 26 & 31, and Appendix 1	Section 127	Resource Management Act
DP981043Ld and DP981044Ad	05/02/2016	Change of conditions – Changes to timeframes within the monitoring regime	Section 127	Resource Management Act

Appendix 1: Takapau Plant Land Area Showing Indicative Location of Land Blocks, Bores, Lysimeters, and Surrounding Area.

Appendix 2: Visible Deposition More Than Minor

Appendix B

Domestic wastewater memorandum

Pattle Delamore Partners Limited

TECHNICAL MEMORANDUM

INVESTIGATION	DOMESTIC WASTEWATER PLANT REVIEW	**PROJECT**	SILVER FERN FARMS TAKAPAU CONSENT RENEWALS
CLIENT	**Silver Fern Farms Management Limited**	**PROJECT NO**	A02164500
		PREPARED BY	Alana Bowmar and Daryl Irvine
		SIGNATURE	Final
		DATE	26 March 2018

Introduction

This technical memorandum has been prepared by Pattle Delamore Partners Limited (PDP) on behalf of Silver Fern Farms, to summarise the investigation of the onsite domestic wastewater treatment and irrigation system at the Silver Fern Farms Takapau Plant. All domestic wastewater from staff based facilities at the Takapau plant, including ablutions, showers and kitchen facilities, is collected separately of process wastewaters and treated in a dedicated 2,200 m^2 oxidation pond. Note that the oxidation pond is considered technically to be a facultative lagoon, because it is deeper than a traditional oxidation pond, however, it will be referred to as an oxidation pond herein for consistency with Silver Fern Farms documents and the resource consent. All treated wastewater is then irrigated to land via a 1.6 ha border dyke irrigation system. The treated wastewater is irrigated to land under consent DP981040L, which is due to expire on 31 December 2018 and PDP has been engaged to assist with applying for a replacement consent. As part of the consent application process, PDP has conducted an assessment of the existing onsite domestic wastewater management systems.

Staff from PDP (Daryl Irvine and Jack Feltham) conducted a site visit on 18 October 2017 to investigate the domestic wastewater management system and review its operation and performance, including collection of soil samples for analysis. The expected performance of the land treatment system was also assessed utilising an Overseer® nutrient budget. This technical memorandum provides a summary of the assessment of the onsite domestic wastewater management system and provides a summary of the findings and recommendations.

Oxidation Pond Assessment

Silver Fern Farms monitors the flow and concentrations out of the oxidation pond, however, monitoring of the flow and loads entering the oxidation pond is not conducted. Based on the nitrogen concentration and flows exiting the oxidation pond, the load on the oxidation pond can be estimated as summarised in Table 1. The BOD load is estimated on the assumption that minimal nitrogen is removed by the oxidation pond (nitrogen concentrations monitored in the treated effluent are at expected incoming concentrations) and BOD concentrations are approximately four times the nitrogen concentration (as would be expected for domestic wastewater). Phosphorus loads are estimated based on a 5:1 ratio for nitrogen : phosphorus.

The load on the treatment plant was expected to be highly seasonal, predominantly based around the lamb processing season, however, flow monitoring suggests that the flow is relatively constant throughout the year, with likely stormwater influences during winter. Nitrogen and BOD concentration monitoring also indicates relative consistency between the samples, which have been collected in March and July each year since 2010, suggesting that some balancing of loads is provided by the oxidation pond.

The sizing of the oxidation pond is 2,200 m^2 with an unknown depth but assumed to be at least 1.5 m deep, based on our site observations. Based on the aerial size of the oxidation pond, the BOD treatment capacity of the existing pond is expected to be in the order of 30 kg BOD/d, as derived from Mara (1992), for the expected average daily temperature (15°C), excluding out of season months (winter). The derived BOD loading rate of 5 kg BOD/d is within the treatment capacity of the pond. The quality of the treatment wastewater provided by the oxidation pond is in keeping with what would be expected for a system of this nature.

Table 1: Wastewater Flows and Loads

	Raw Wastewater	Treated Wastewater
Average Daily Flow	28 m^3/d	
Average Biochemical Oxygen Demand	*173 g/m^3*	33 g/m^3
	5 kg/d	1 kg/d
Average Total Nitrogen	43 g/m^3	
	1.2 kg/d	
Average Total Phosphorus	*8.7 g/m^3*	
	0.25 kg/d	

Note:

1. *Italics indicates derived value.*

Based on visual observation of the oxidation pond on 18 October 2017, the water level was high, above the wave band, due to a wet spring, however there was no evidence of floating sludge or excessive upwelling (as would indicate an over loaded system, and there was no odour from the pond. The water in the pond was relatively clear, with minimal algal content, and there was no visual evidence of a large build-up of a sediment layer (though probing to identify a sludge layer was not conducted). As a general comment, the oxidation pond appeared to be operating well. The potential soakage rate from the pond was not assessed, however, this is expected to be low given the age of the pond and expected sediment layer that would have formed in the base of oxidation ponds.

Border Dyke Irrigation System

Treated domestic wastewater from the oxidation pond is periodically discharged to a 1.4 ha border dyke irrigation system adjacent to the oxidation pond. The irrigation area is spilt into two equal sized areas, with an irrigation event occurring every 21 days, alternating between the two irrigation blocks. The irrigated area is periodically grazed with sheep to maintain grass levels.

During the site assessment by PDP on 18 October 2017, there was an area of ponding evident in the south eastern corner that had not drained away. The southern half was in operation at the time (but not actively irrigating), and it was apparent that this was the low point of the southern half of the border dyke area and ponding at this location was a regular occurrence.

During the site assessment, a visual soil assessment was conducted for both the northern and southern halves of the border dyke irrigation area at representative locations. The soils in both areas were identified as stony recent soils. Soil samples were also collected for nutrient and heavy metal assessments and permeability testing.

Visual Assessment

The visual soil assessment was undertaken to assess the general condition of the soil, assessing against the "Soil Indicator" criteria in the Visual Soil Assessment Guideline developed by Landcare Research (Shepherd, 2000). Table 2 provides a summary of the visual assessment results. Based on a ranking of an overall scoring of <10 = poor, 10 – 20 = Moderate and > 20 = Good, the conditions of the soils within the border dyke irrigation system can be assessed as Moderate to Good. The southern block ranked better than the northern block, mostly due to earth worm count.

Table 2: Visual Soil Assessment Results - Domestic Block

	Visual Indicator of Soil Quality		Weighting	VS Ranking	
Site	Dom South	Dom North		Dom South	Dom North
Soil Structure & Consistency	1	0	X3	3	0
Soil Porosity	2	1	X3	6	3
Soil Colour	2	2	X2	4	4
Soil Mottles	2	2	X2	4	4
Earthworm Counts	1	0	X3	3	0
Surface Relief	2	2	X1	2	2
RANKING SCORE (Sum of VS rankings)				22	13

Soil Laboratory Analysis

Soils samples were collected to a depth of 75 mm, with approximately 20 to 30 core samples collected randomly across each block to make up a single composite sample for the combined border dyke irrigation area. The samples were sent to Hill Laboratories in Hamilton for nutrient testing and heavy metal testing. The soil test results are provided in Appendix A.

Nutrient levels in the soils are generally within optimum range for pasture growth. Phosphorus is slightly elevated, though this would be expected for a land treatment system. Cation ratios in the soil are good with a low sodium level and a low exchangeable sodium percentage of 1.5%.

Monitoring of heavy metal levels indicates that concentrations are well below guideline limits (refer to Table 3). On this basis, no adverse effects on stock or plant growth are expected. These are also well below the applicable guideline limits for the protection for human health in MfE (2011), and for nickel and zinc in NEPC (2013).

Table 3: Heavy Metal Testing

Soil Parameter	Result	Guideline Limit
Total Arsenic (mg/kg)	3.7	20
Total Cadmium (mg/kg)	0.148	1
Total Chromium (mg/kg)	14.5	600
Total Copper (mg/kg)	11.8	100
Total Lead (mg/kg)	10.5	300
Total Nickel (mg/kg)	9.8	60
Total Zinc (mg/kg)	59.1	300

Notes:

1. *Guideline limits based on the Guidelines for safe application of Biosolids to land in New Zealand (NZWWA, 2003).*

Soil Permeability Testing

Soil core samples were collected from the top 100 mm of soil for soil permeability testing, including both K_{sat} and K_{-40} testing. K_{sat} testing provides an indication of the rate of infiltration under saturated conditions, while the K_{-40} provides an indication of infiltration through micro-pores only. Comparison of the two measured infiltration rates provides an indication of pore size distribution in the soil and also provides an indication of the loading rate to promote flow though micro-pores and not through macro-pores, so as to promote effective land treatment. Table 4 details the results of the infiltration testing conducted on cores collected from the domestic irrigation areas. The results indicate high infiltration rates under saturated conditions, which is in keeping with the soil type. Unsaturated infiltration rates (K_{-40}) are also high and while the south block measured lower, the difference would be within the expected variation for the test, given the small sample set.

Table 4: Border Dyke Irrigation Area Infiltration Tests

Infiltration test	Domestic South	Domestic North
K_{sat} (mm/hr)	211	337
K_{-40} (mm/hr)	41	123

The high infiltration rates measured by the K_{sat} and K_{-40} testing indicates that the soils can potentially manage the method of irrigation (border dyke) however, the ponding at the south east corner may indicate that the method of irrigation is either too high for the soils or remedial action is required in parts of the irrigation area, such as scarifying, to remove limiting layers. It may be that build-up of silt has occurred at this location, limiting macro-pore flow path ways and restricting drainage.

Nutrient Management

The irrigation activity (treated domestic wastewater irrigation only) has been modelled using the OVERSEER nutrient modelling program (Version 6.2.3, released 7 November 2016) to identify the level of nutrient leaching that could be expected from the existing system. The model has been developed based on a grazed pasture system, with an assumed stocking rate of 20 sheep (20 RSU). Further details of the nutrient model are provided in Appendix B. The average nutrient summary for the area, as generated by OVERSEER, is provided in Table 6.

Table 5: Nutrient Budget Summary

	Nitrogen	Phosphorus
Nutrients Added (kg/ha/yr)		
Rainfall	2	0
Biological Fixation	0	0
Irrigation (Modelled as Fertiliser)	277	55
Total	**279**	**55**
Nutrients Removed (kg/ha/yr)		
As Products	24	2
To Atmosphere via Denitrification and Volatilisation	49	0
To Water	100	3.9
Changes in Nutrient Pools (kg/ha/yr)		
Organic Pool	107	17
Inorganic Mineral	0	4
Inorganic Soil Pool	0	27

Nutrient load entering the area, primarily through irrigation, is 279 kg/ha/yr of nitrogen and 55 kg/ha/yr of phosphorus. The nutrient load is partially utilised by farming operations, with 24 kg/ha/yr of nitrogen and 2 kg/ha/yr of phosphorus exported as wool, based on the grazing assumptions made. The remaining nutrient loss is via leaching through the soil column, which accounts for 100 kg/ha/yr of nitrogen, as well as to the atmosphere via denitrification and volatilisation, which accounts for 49 kg/ha/yr of nitrogen. The model suggests that 3.9 kg/ha/yr of phosphorus is lost via runoff, though this is considered unlikely as the entire irrigation areas is bunded.

The modelled leaching rate is relatively high compared to the surrounding land use of sheep farming, which could be expected to have a nitrogen leaching rate of less than 15 kg TN/ha/yr, but it is a significant improvement on the approximately 277 kg TN/ha/yr that is applied to the irrigation system.

Other contaminants and receiving environment

The pond and border dyke irrigation area are located adjacent to the Porangahau Stream and are also located up-gradient of the water supply bores to the plant, although the bores are considered to be in deeper aquifers. The discussion above has focused on nitrogen, but pathogens also need to be considered. There is expected to be limited removal of pathogens in the oxidation pond. The regular monitoring does not include pathogens or indicator species (*E. coli)*. A reasonable degree of pathogen removal could be expected through the soils of the land treatment area, but this is difficult to quantify in the absence of monitoring data.

There are no monitoring bores directly down-gradient of the border dyke system. It is understood that the nearest water supply bores in the deeper aquifers have had no recorded *E. coli*. It is noted that the water from these bores is also chlorinated prior to use. However, it is important to minimise the risk of contamination to bores, so it could be helpful for Silver Fern Farms to better understand the impact of the border dyke scheme on down-gradient groundwater with appropriate monitoring and assessment. The deeper aquifers are expected to be recharged from the shallower aquifers based on the groundwater level information.

Impacts from this system and the other discharges on the Porangahau Stream are not evident in the regular consent monitoring undertaken. It is possible that the Porangahau Stream is losing water to groundwater in this section, which could be confirmed by a period of surface water level and groundwater level monitoring in the vicinity of the plant.

Based on the treatment expected and proximity to potential receptors (surface water ways and supply bores), it would be prudent to install at least one additional monitoring bore down-gradient of the border-dyke system, and ideally one bore up-gradient of the system and monitor these to better assess the local impact from the discharge on groundwater. In addition, a bore between the system and the Porangahau Stream would be helpful to better assess impacts on groundwater that the stream may be receiving.

Overall, the available monitoring information indicates that an upgrade is not required to address adverse local effects. However, it would be ideal to have additional monitoring data in order to better understand potential local water quality effects.

Summary of Domestic System Performance

The existing domestic wastewater management system is considered to be operating well, with the oxidation pond of suitable size and providing sufficient treatment for the following irrigation system.

The border dyke irrigation system is providing for disposal of the treated wastewater, and while the soils appear to be in moderate to good condition, there is evidence of ponding occurring at the south east corner of the southern irrigation field. The nitrogen leaching rate that has been modelled is also relatively high and there is potential for improvement to reduce the nitrogen leaching rate.

As a minimum, the irrigation areas need to be scarified to break up any silt sealing layer that may be occurring. This needs to be a regular practice (annually at minimum) with particular focus in the south eastern corner.

Operating the irrigation system approximately every two weeks, results in an instantaneous application rate of

50 mm per event. While this is not an excessive depth, it occurs very rapidly. It may be possible to decrease the potential for ponding by increasing the frequency of application (such as weekly) or installing an alternative irrigation method, such as spray irrigation (such as solid set).

If spray irrigation was installed, the application rate can be significantly reduced to well below soil infiltration capacity, and would be considered a better practice than the current border dyke irrigation system. Notwithstanding this, modelling of an equivalent spray irrigation system indicates no reduction in nitrogen leaching, but there is limited ability in Overseer to manipulate the way the irrigation method is operated and inputs are based on monthly data. In reality, we would expect a reduction in nitrogen leaching because a spray irrigation system can be managed at similar rates to evapotranspiration, with a lower potential of exceeding field capacity in the soil.

If spray irrigation was to be installed, this would require a pump system, power supply at the site and a new reticulation system.

Heavy metal concentrations in the soil are well within guideline limits. On this basis, no adverse effects on stock or plant growth are expected. Some additional monitoring bores in the site vicinity could be helpful to better understand the environmental effects of the activity, particularly potential effects on the Silver Fern Farms supply bores and the Porangahau Stream.

References

Mara D.D (1992), *Waste Stabilisation Ponds: A design manual for Eastern Africa.* Great Britain Overseas Development Administration, Lagoon Technology International.

Ministry for the Environment (MfE), 2011. *Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health.* Wellington: Ministry for the Environment.

National Environment Protection Council (NEPC), 2013. *Guideline on the Investigation Levels for Soil and Groundwater (Assessment of Site Contamination Amendment Measure 2013)*, National Environment Protection Council of Australia.

APPENDIX A: SOIL MONITORING RESULTS

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TRIED, TESTED AND TRUSTED

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ANALYSIS REPORT

Client:	Pattle Delamore Partners Limited	**Lab No:**	1863821	ASUPv1
Contact:	Mr D Irvine	**Date Received:**	20-Oct-2017	
	C/- Pattle Delamore Partners Limited	**Date Reported:**	26-Oct-2017	
	PO Box 9528	**Quote No:**	88522	
	Newmarket	**Order No:**		
	Auckland 1149	**Client Reference:**	A02164500	
		Submitted By:	Mr D Irvine	

Sample Type: Soil

Sample Name:		A02164500-Domestic			
Lab Number:		1863821.1			
pH	pH Units	6.3 ± 0.2	-	-	-
Olsen Phosphorus	mg/L	53 ± 6	-	-	-
Sulphate Sulphur	mg/kg	10 ± 2	-	-	-
Potassium	MAF units	13 ± 2	-	-	-
Calcium	MAF units	13 ± 2	-	-	-
Magnesium	MAF units	43 ± 4	-	-	-
Sodium	MAF units	12 ± 2	-	-	-
Extractable Organic Sulphur*	mg/kg	5 ± 2	-	-	-
Potentially Available Nitrogen (15cm Depth)*	kg/ha	147 ± 58	-	-	-
Anaerobically Mineralisable N*	µg/g	122 ± 49	-	-	-
Anaerobically Mineralisable N/Total N Ratio*	%	2.8	-	-	-
Organic Matter*	%	7.5 ± 1.4	-	-	-
C/N Ratio*		9.8 ± 3.4	-	-	-
Anion Storage Capacity*	%	32 ± 10	-	-	-
Total Carbon*	%	4.3 ± 0.8	-	-	-
Total Nitrogen*	%	0.44 ± 0.13	-	-	-
Potassium	me/100g	0.80 ± 0.11	-	-	-
Calcium	me/100g	13.0 ± 1.8	-	-	-
Magnesium	me/100g	2.39 ± 0.30	-	-	-
Sodium	me/100g	0.34 ± 0.06	-	-	-
Potassium	%BS	3.7 ± 0.6	-	-	-
Calcium	%BS	60 ± 10	-	-	-
Magnesium	%BS	11.0 ± 1.7	-	-	-
Sodium	%BS	1.6 ± 0.3	-	-	-
CEC	me/100g	22 ± 2	-	-	-
Total Base Saturation	%	76 ± 10	-	-	-
Volume Weight	g/mL	0.80 ± 0.07	-	-	-

The reported uncertainty is an expanded uncertainty with a level of confidence of approximately 95 percent (i.e. two standard deviations, calculated using a coverage factor of 2). Reported uncertainties are calculated from the performance of typical matrices, and do not include variation due to sampling.

For further information on uncertainty of measurement at Hill Laboratories, refer to the technical note on our website: www.hill-laboratories.com/files/Intro_To_UOM.pdf, or contact the laboratory.

Analyst's Comments

Sample 1 Comment:
The medium or optimum range guidelines shown in the histogram report relate to sampling protocols as per Hill Laboratories' crop guides and are based on reference values where these are published. Results for samples collected to different depths than those described in the crop guide should be interpreted with caution.
For pastoral soils, the medium ranges are specific for a 75mm sample depth, but if a 150mm sampling depth is used the nutrient levels measured may appear low against these ranges, as nutrients are typically more concentrated in the top of the soil profile. These soil profile differences are altered upon cultivation or contouring.

Sample 1 Comment:
The Potentially Available Nitrogen (kg/ha) test above assumes the sample is taken to a 15 cm depth. If the depth is 7.5 cm, then the result reported above should be divided by two.
To calculate Potentially Available Nitrogen (as kgN/ha) for other sample depths use the reported Anaerobic Mineralisable Nitrogen (AMN) result in the following equation:
AN (kg/ha) = AMN (µg/g) x VW (g/ml) x sample depth (cm) x 0.1
Note that the AN and AMN results reported include the readily available Mineral N (NH4-N and NO3-N) fraction, which is typically quite low.

Sample 1 Comment:
Anion Storage Capacity (also known as Phosphate Retention) is an inherent property of the soil type and does not change. Phosphorus and sulphur fertiliser recommendations should take this value into account. Soils may be classified as Low (less than 30%), Medium (30-60%) or High (greater than 60%) ASC.

Appendix No.1 - Chain of Custody

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Soil

Test	Method Description	Default Detection Limit	Sample No
Sample Registration*	Samples were registered according to instructions received.	-	1
Soil Prep (Dry & Grind)*	Air dried at 35 - 40°C overnight (residual moisture typically 4%) and crushed to pass through a 2mm screen. Analysed at 25 Te Aroha Street, Hamilton.	-	1
pH	1:2 (v/v) soil:water slurry followed by potentiometric determination of pH. Analysed at 1 Clyde Street, Hamilton.	0.1 pH Units	1
Olsen Phosphorus	Olsen extraction followed by Molybdenum Blue colorimetry. . Analysed at 1 Clyde Street, Hamilton.	1 mg/L	1
Sulphate Sulphur	0.02M Potassium phosphate extraction followed by Ion Chromatography. Analysed at 1 Clyde Street, Hamilton.	1 mg/kg	1
Potassium (MAF)	1M Neutral ammonium acetate extraction followed by ICP-OES. Analysed at 1 Clyde Street, Hamilton.	1 MAF units	1
Calcium (MAF)	1M Neutral ammonium acetate extraction followed by ICP-OES. Analysed at 1 Clyde Street, Hamilton.	1 MAF units	1
Magnesium (MAF)	1M Neutral ammonium acetate extraction followed by ICP-OES. Analysed at 1 Clyde Street, Hamilton.	1 MAF units	1
Sodium (MAF)	1M Neutral ammonium acetate extraction followed by ICP-OES. Analysed at 1 Clyde Street, Hamilton.	2 MAF units	1
Extractable Organic Sulphur*	Determined by NIR, calibration based on; 0.02M Potassium phosphate extraction. Total extractable S determined by ICP-OES from which the Sulphate-S is subtracted. Analysed at 1 Clyde Street, Hamilton.	2 mg/kg	1
Potentially Available Nitrogen*	Determined by NIR, calibration based on Available N by Anaerobic incubation followed by extraction using 2M KCl followed by Berthelot colorimetry. (Calculation based on 15cm depth sample). Note that any Mineral N present is included in the AN/AMN result reported. Analysed at 1 Clyde Street, Hamilton.	1 mg/L	1
Anaerobically Mineralisable N*	As for Potentially Available Nitrogen but reported as µg/g. Analysed at 1 Clyde Street, Hamilton.	5 µg/g	1
Organic Matter*	Organic Matter is 1.72 x Total Carbon. Analysed at 1 Clyde Street, Hamilton.	0.2 %	1
Anion Storage Capacity*	Determined by NIR, calibration based on; Equilibration with 1000 mg/L P solution followed by colorimetric analysis. Analysed at 1 Clyde Street, Hamilton.	10 %	1
Total Carbon*	Determined by NIR, calibration based on Total Carbon by Dumas combustion. Analysed at 1 Clyde Street, Hamilton.	0.1 %	1
Total Nitrogen*	Determined by NIR, calibration based on Total N by Dumas combustion. Analysed at 1 Clyde Street, Hamilton.	0.04 %	1
Potassium	1M Neutral ammonium acetate extraction followed by ICP-OES. Analysed at 1 Clyde Street, Hamilton.	0.01 me/100g	1

Sample Type: Soil			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Calcium	1M Neutral ammonium acetate extraction followed by ICP-OES. Analysed at 1 Clyde Street, Hamilton.	0.5 me/100g	1
Magnesium	1M Neutral ammonium acetate extraction followed by ICP-OES. Analysed at 1 Clyde Street, Hamilton.	0.04 me/100g	1
Sodium	1M Neutral ammonium acetate extraction followed by ICP-OES. Analysed at 1 Clyde Street, Hamilton.	0.05 me/100g	1
Potassium (Sat)	1M Neutral ammonium acetate extraction followed by ICP-OES. Analysed at 1 Clyde Street, Hamilton.	0.1 %BS	1
Calcium (Sat)	1M Neutral ammonium acetate extraction followed by ICP-OES. Analysed at 1 Clyde Street, Hamilton.	1 %BS	1
Magnesium (Sat)	1M Neutral ammonium acetate extraction followed by ICP-OES. Analysed at 1 Clyde Street, Hamilton.	0.2 %BS	1
Sodium (Sat)	1M Neutral ammonium acetate extraction followed by ICP-OES. Analysed at 1 Clyde Street, Hamilton.	0.1 %BS	1
CEC	Summation of extractable cations (K, Ca, Mg, Na) and extractable acidity. May be overestimated if soil contains high levels of soluble salts or carbonates. Analysed at 1 Clyde Street, Hamilton.	2 me/100g	1
Total Base Saturation	Calculated from Extractable Cations and Cation Exchange Capacity. Analysed at 1 Clyde Street, Hamilton.	5 %	1
Volume Weight	The weight/volume ratio of dried, ground soil. Analysed at 1 Clyde Street, Hamilton.	0.01 g/mL	1

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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W. M. Homewood

Wendy Homewood
Operations Support - Agriculture

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ANALYSIS REPORT

Client:	Pattle Delamore Partners Limited	**Lab No:**	1863822 SPv1
Contact:	Mr D Irvine	**Date Received:**	20-Oct-2017
	C/- Pattle Delamore Partners Limited	**Date Reported:**	27-Oct-2017
	PO Box 9528	**Quote No:**	88522
	Newmarket	**Order No:**	
	Auckland 1149	**Client Reference:**	A02164500
		Submitted By:	Mr D Irvine

Sample Type: Soil

Sample Name:		A02164500-Domestic 18-Oct-2017	A02164500-Block A 18-Oct-2017	A02164500-Block D 18-Oct-2017	A02164500-Block G1 19-Oct-2017	A02164500-Block F 18-Oct-2017
Lab Number:		1863822.1	1863822.2	1863822.3	1863822.4	1863822.5
Heavy Metals, Screen Level						
Total Recoverable Arsenic	mg/kg dry wt	4	3	4	< 2	3
Total Recoverable Cadmium	mg/kg dry wt	0.15	0.19	0.26	0.20	0.26
Total Recoverable Chromium	mg/kg dry wt	14	14	15	10	12
Total Recoverable Copper	mg/kg dry wt	12	9	12	7	11
Total Recoverable Lead	mg/kg dry wt	10.5	9.3	11.6	8.3	11.1
Total Recoverable Nickel	mg/kg dry wt	10	8	9	6	9
Total Recoverable Zinc	mg/kg dry wt	59	68	81	43	77

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Soil

Test	Method Description	Default Detection Limit	Sample No
Heavy Metals, Screen Level	Dried sample, < 2mm fraction. Nitric/Hydrochloric acid digestion US EPA 200.2. Complies with NES Regulations. ICP-MS screen level, interference removal by Kinetic Energy Discrimination if required.	0.10 - 4 mg/kg dry wt	1-5

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

APPENDIX B: SUMMARY OF OVERSEER NUTRIENT MODELLING ASSESSMENT

DOMESTIC WASTEWATER MANAGEMENT: SUMMARY OF OVERSEER NUTRIENT MODELLING ASSESSMENT

A nutrient model has been developed by PDP, for the domestic wastewater irrigation system at Silver Fern Farms Takapau, utilising the OVERSEER nutrient modelling program (Version 6.2.3, released 7 November 2016). This model is used to identify nutrient utilisation and losses from the system and is summarised as follows.

FARM SYSTEM

LOCATION AND LAYOUT

The border dyke irrigation system (BDIS) is located near Takapau in central Hawke's Bay. It is within the larger Silver Fern Farm's Takapau Farm, which is bound by State Highway 2 to the North and Oruawharo Road to the South. It is on the western side of Fraser Road, and 40 m south of the Porangahau Stream a tributary of the Maharakeke Stream. The topography is gently sloped, being within the banks of the Porangahau Stream.

CLIMATE

The climate in the Hawke's Bay Region is temperate, but generally dry and warm. Rainfall is highly variable, the region often experiencing droughts and flooding. Daily data from the Silver Fern Farms Takapau weather station is recorded for rainfall and temperature; and potential evapotranspiration (PET) is recorded at the Central Hawke's Bay District Council weather station No. 33 (12 km from the Farm). This data has been summarised into the following OVERSEER inputs:

- Mean annual rainfall of 774 mm.
- Mean annual temperature of 12.6 °C.
- Annual PET of 692 mm with moderate variation (based off Overseer database).

FARM OPERATION

Across the BDIS area, grass growth is managed by mowing and sheep grazing. For the purposes of this assessment, it has been modelled in OVERSEER as a pastoral section with 20 RSU of sheep run continuously throughout the year.

OVERSEER GENERAL INPUT SUMMARY

The OVERSEER inputs used to model the nutrient budgets are summarised in Table 1. The BDIS is operated as two blocks (1 – 10 and 11 - 20).

Table B1: OVERSEER Input Summary

General Farm Inputs	
Location	East Coast North Island
Topography	Flat
Distance From Coast	37 km
Farming Operations	Pastoral
Sheep Grazing	20 RSU year round
Wool Production	150 kg/year
Block 1 - 10 [1]	0.8 ha; grass
Block 11 – 20 [1]	0.8 ha; grass

Notes:

1. *Block inputs are the total block area (measured from aerials).*

APPENDIX B: SUMMARY OF OVERSEER NUTRIENT MODELLING ASSESSMENT

SOILS

SOIL TYPES

The BDIS is underlain by predominantly Fluvial Raw Soil. This soil type is summarised in Table 2.

Table B2: Soil Irrigation Characteristics

Dominant Sibling Name	Soil Order	Phosphorus Retention	Drainage Class	Profile Available Water
Ashb_38a.1	Fluvial Raw Soil	Very Low (3 %)	Well Drained	Low

CURRENT SOIL NUTRIENT CONDITIONS

Annual soil testing is carried out within the BDIS area. The results of the most recent testing (18 October 2017) is summarised in Table 3.

Soil testing shows slightly high phosphorus levels (Olsen P) which are above the optimum range for pasture growth in sedimentary soils. Potassium and magnesium also have elevated quick test results, above optimum levels for pasture growth (Dairy NZ, 2012). Calcium and sodium have no upper limit for optimum pasture growth. However, elevated sodium levels can cause degradation of the drainage characteristics of the soil.

Table B3: Soil Test Results

	Olsen P	Potassium (MAF)	Calcium (MAF)	Magnesium (MAF)	Sodium (MAF)
	53	13	13	43	12
Optimum Pasture	**20 - 30**	**5 - 8**	**> 1**	**8 - 10**	**> 1**

IRRIGATION

Treated domestic wastewater, produced from the Silver Fern Farms factory, is irrigated across the BDIS with a combined irrigation area of 1.6 ha. The treated wastewater contains residual nutrients from the wastewater that contribute a nutrient load to the irrigated land. The average nutrient concentrations in the domestic wastewater are summarised in Table 4.

Table B4: Average Nutrient Data

Nitrogen [1]	Phosphorus [2]
43.3 g/m^3	8.7 g/m^3

Notes:

1. *Average nitrogen data is based on sampling results from March 2010 – July 2017 during this period, total nitrogen testing results have been stable.*
2. *Average phosphorus is based on typical domestic nitrogen to phosphorus ratio of 5:1.*

Irrigation is via a border dyke irrigation system, which periodically floods Block 1 – 10 or Block 11 - 20.

Irrigation rates for the domestic wastewater irrigation have been stable since 2010. The average monthly irrigation rate for each block was calculated from the January 2010 – August 2017 record, and is summarised in Table 5.

APPENDIX B: SUMMARY OF OVERSEER NUTRIENT MODELLING ASSESSMENT

Table B5: Average Monthly Irrigation Rates for Each Block		
	Block 1 - 10	**Block 11 - 20**
July	64 mm	40 mm
August	68 mm	50 mm
September	71 mm	52 mm
October	39 mm	56 mm
November	40 mm	45 mm
December	56 mm	51 mm
January	62 mm	30 mm
February	55 mm	54 mm
March	58 mm	64 mm
April	66 mm	51 mm
May	46 mm	63 mm
June	51 mm	40 mm

Wastewater irrigation was modelled as fertiliser application and irrigation of clean water. Monthly nutrient loads were determined for each block based on Tables 4 and 5. This modelling method was chosen to better model the expected nitrogen uptake, as the primary form of nitrogen in this wastewater is organic nitrogen.

NUTRIENT BUDGET

The irrigation activity has been modelled using the OVERSEER nutrient modelling program (Version 6.2.3, released 7 November 2016). The previously described characteristics have been used to generate the nutrient budget. The average nutrient summary for the area, as generated by OVERSEER, is provided in Table 6.

Nutrients enter the farm system primarily through irrigation, contributing 279 kg/ha/yr of nitrogen and 55 kg/ha/yr of phosphorus.

The nutrient load is partially utilised by farming operations, with 24 kg/ha/yr of nitrogen and 2 kg/ha/yr of phosphorus exported as wool. The remaining nitrogen loss is via leaching through the soil column, which accounts for 100 kg/ha/yr of nitrogen, as well as to the atmosphere via denitrification and volatilisation, which accounts for 49 kg/ha/yr of nitrogen.

Excess nutrients added are retained in the soil nutrient pools. Excess nitrogen and phosphorus is retained in organic matter in the soil; and excess phosphorus retained in inorganic mineral and soil pools.

APPENDIX B: SUMMARY OF OVERSEER NUTRIENT MODELLING ASSESSMENT

Table B6: Nutrient Budget Summary		
	Nitrogen	**Phosphorus**
Nutrients Added (kg/ha/yr)		
Rainfall	2	0
Biological Fixation	0	0
Irrigation (Modelled as Fertiliser)	277	55
Total	**279**	**55**
Nutrients Removed (kg/ha/yr)		
As Products	24	2
To Atmosphere via Denitrification and Volatilisation	49	0
To Water via Leaching	100	3.9
Changes in Nutrient Pools (kg/ha/yr)		
Organic Pool	107	17
Inorganic Mineral	0	4
Inorganic Soil Pool	0	27

NITROGEN BLOCK SUMMARY

A summary of the key aspects of the nitrogen budget for each modelled block is in Table 7. The highest nitrogen losses per ha were seen in block 1 – 10, where the greatest irrigation loads were applied.

Table 7: Nitrogen Block Summary				
Block	**Total N lost**	**N lost to water**	**N in drainage ***	**N surplus**
	kg N/yr	kg N/ha/yr	ppm	kg N/ha/yr
Block 1 - 10	84	106	13.2	269
Block 11 - 20	76	95	12.6	243

REFERENCES

Dairy NZ. (2012). *Critical Nutrient Levels for Pasture* (Farmfact No. 7-5). Dairy NZ.

Appendix C

Process wastewater nutrient memorandum

Pattle Delamore Partners Limited

TECHNICAL MEMORANDUM

INVESTIGATION	Nutrient Balance Model Summary	**PROJECT**	Takapau Plant Wastewater Irrigation Consenting
CLIENT	**Silver Fern Farms Management Limited**	**PROJECT NO**	A02164500
		PREPARED BY	Alana Bowmar and Daryl Irvine
		SIGNATURE	FINAL
		DATE	19 June 2018

Introduction

This technical memorandum has been prepared by Pattle Delamore Partners Limited (PDP) on behalf of Silver Fern Farms Management Limited (Silver Fern Farms) to summarise the investigations into the existing wastewater irrigation to land system at the Silver Fern Farms Takapau Plant. All wastewater generated from the Takapau plant, including Animal Assembly, Primary Butchery, Secondary Butchery and other processing areas is treated in a non-chemical Dissolved Air Flotation (DAF) treatment device and then irrigated to company owned land surrounding the plant. Irrigation of process wastewater is conducted under Resource Consent DP981043Ld & DP981044Ad, issued by Hawkes Bay Regional Council, which is due to expire on 31 December 2018. PDP has been engaged by Silver Fern Farms to assist with applying for a replacement consent and as part of the consent application process, PDP has conducted a review of the existing process wastewater irrigation system.

The assessment of the process wastewater irrigation system includes:

- A visual assessment of the soil conditions within the irrigation areas;
- An assessment of soil monitoring;
- An assessment of soil permeability;
- A nutrient model of the land holdings system, utilising the Overseer Nutrient Modelling programme.

Irrigation System Description

The wastewater irrigation system consists of 218 ha of irrigable area, which is utilised for cut and carry of pasture or lucerne as silage or hay. The irrigation blocks are divided into 5 main blocks, being Blocks A, B, C, D and E. The land holdings also consist of Blocks F, G, S1 and S2 which are utilised for disposal of stock yards solids. This soils assessment is focussed on the wastewater irrigation block only.

Several different soil types are identified by Landcare's S-map online soil database within the wastewater irrigation areas; however, many of these soil types are relatively similar. The process wastewater irrigation blocks can be categorised into two main soil order and drainage characteristic, being:

- Well to moderately well drained: Allophanic and Orthic Brown soils (Blocks A, B, C, D and part of E)
- Poorly drained: Perch-gley Pallic soils (part of Block E)

Wastewater is preferentially irrigated to the moderately well drained and well drained soils throughout the year and only to the poorly drained soils during dry periods.

The wastewater is irrigated utilising traveling rotary irrigators, of which six of the twelve irrigators are equipped with GPS tracking systems. Cropping of the pasture and lucerne across all irrigated blocks yields an average of 9.3 tonne DM/ha/yr (based on 2015/16 data).

Annual irrigation loading rates are summarised in Table 1.

Table 1: Wastewater Loading Rates

Parameter	Block				
	A	B	C	D	E
Hydraulic (mm/yr)	441	281	384	371	193
Nitrogen (kg/ha/yr)	382	243	333	321	167
Phosphorus (kg/ha/yr)	61	39	53	52	27
Sodium (kg/ha/yr)	401	255	349	337	175
Potassium (kg/ha/yr)	367	233	319	308	160
Calcium (kg/ha/yr)	158	101	138	133	69
Magnesium (kg/ha/yr)	36	23	32	30	16

Note:

1. *Based on the blocks average wastewater loading rates from January 2012 – August 2017*
2. *Block E has received an overall lower wastewater loading rate. This is due to areas of poorly drained soils and lower pipe pressure that restricted the number of irrigators until recent installation of booster pump.*
3. *Hydraulic and nutrient loads have been averaged across the block areas excluding the control block C3.*
4. *Nitrogen is measured as TKN.*

Visual Soil Assessment

The visual soil assessment was undertaken on all blocks irrigated with wastewater to assess the general condition of the soil, assessing against the "Soil Indicator" criteria in the Visual Soil Assessment Guideline developed by Landcare Research (Shepherd, 2009)[1]. The visual soil assessment is utilised to assess whether there is an obvious degradation of the soil condition as a result of the irrigation activity. The assessment considers:

- Soil structure and consistency;
- Soil porosity;
- Soil colour;
- Soil mottling;
- Earthworm numbers; and
- Surface relief (treading damage etc.)

A visual soil assessment was conducted for all irrigated blocks and Block G, as a control block (un-irrigated). Block G was selected over Block C for visual soil assessment, as Block G has had no known historical irrigation and has the same gley soils as parts of Block E. Because gley soils would generally score lower under a visual soil assessment, a gley soil control block was selected for comparison with Block E, to assess whether or not wastewater irrigation was contributing to the lower scoring of Block E or whether it was solely associated with soil type. Table 2 provides a summary of the visual assessment results.

The wastewater irrigation blocks on allophanic/brown soils, generally scored well on the visual soil assessment,

[1] Shepherd TG, (2009) *Visual Soil Assessment. Volume 1. Field Guide for Pastoral Grazing and Cropping on Flat to Rolling Country. 2nd edition,* Horizons Regional Council. 119p.

with moderate to good soil conditions. This included Blocks A, B, C, D and E3. Blocks E6, G1 and G2, contain gley soils and experience poor drainage resulting in anoxic conditions (as described above, Landcare's S-map identifies Block E and G as containing gley soils, which was confirmed on site). These soils all scored poorly with Poor to Moderate conditions. The soil conditions are therefore more affected by the soil type rather than the irrigation activity. While Block D scored as moderate, it was only marginally lower than the "Good" range, mainly due to earthworm count.

Table 2: Visual Soil Assessment Results

Irrigation Site	Ranking Score		
	Poor (<10)	Moderate (10 – 20)	Good (>20)
Block A North			22
Block A South			22
Block B3			22
Block C1			22
Block C2			25
Block D1		19	
Block D2			22
Block E3			28
Block E6	9		
Block G1 (Control)		11	
Block G2 (Control)	8		

Aside from the standard visual assessment, the appearance of the soils in the well-drained areas is good and they appear well managed. Very wet conditions were observed in the areas of Block E that contain poorly drained soils but this was also observed in the un-irrigated Block G. At the time of the visual assessment (spring) the poorly drained areas of Block E had not received wastewater irrigation since the previous summer/autumn; therefore, the wet conditions were attributed to rainfall.

Pasture cover was good for all blocks, with the exception of Block A where the pasture was clumpy, likely as a result of extended years of cropping without grazing or resowing and/or the grass height being allowed to grow too long between cropping events. It is recommended that Block A is resown for better pasture distribution. Consideration could also be given to grazing of residuals, which involves periodically grazing stock on the pasture to encourage lower level pasture removal and scuffing of soil surfaces. Sufficient stand-down time between wastewater application, grazing and stock processing would be required.

Soil Monitoring

Monitoring of soil nutrient levels is conducted by Silver Fern Farms on a regular basis. The last soil sampling event provided to us was undertaken on 30 August 2017, with the average results summarised in Table 3. Monitoring has been conducted to a depth of 75 mm. Block C3 is utilised as a control block and this is appropriate for comparison of nutrient levels as irrigation has not occurred on this block for a number of years.

Monitoring data indicates elevated Olsen P levels (plant available phosphorus) in the main irrigated blocks, A, B, C and D. The optimum Olsen P level for the land use is 30 – 40 mg/L (DairyNZ, 2012). As outlined in Table 6, based on the average cropping rate for the 2015/16 season of 9.3 T DM/ha/yr, the average phosphorus loading rates (19 kg/ha/yr balanced across the land holdings area) are slightly in excess of crop uptake rates (averaged at 15 kg TP/ha/yr, as balanced across the land holdings area). Therefore, it is expected that the Olsen P levels in the top soil layers will be elevated.

Sodium levels are elevated for all irrigated blocks, in comparison to the control block; however, the exchangeable sodium percentages remain relatively low. At the monitored ESP levels, it is not expected that the soils will be experiencing impaired permeability as a result of elevated sodium. The ESP levels will require on going monitoring identifying if there is an increasing trend and if lime or gypsum addition is required to offset sodium addition. pH levels in the soil remain at optimum levels (DairyNZ, 2012).

Table 3: Soil Monitoring Results

Monitoring Parameter	Block					
	A	B	C	D	E	Control (C3)
pH	6.4	5.7	6.4	6.2	6.3	5.9
Olsen P (mg/L)	81	98	94	83	30	14
Sodium (me/100g)	0.41	0.39	0.45	0.43	0.34	0.10
Potassium (me/100g)	1.7	1.4	1.7	1.4	0.6	0.6
Calcium (me/100g)	11	6	12	7	10	9
Magnesium (me/100g)	1.5	1.0	1.6	1.4	1.3	0.7
CEC (me/100g) [3]	18	14	21	15	16	17
ESP (%) [3]	2.3	2.3	2.7	2.9	2.2	0.6
ASC [3 4]	45	32	54	41	29	82
TOC (% w/w) [3 4]	4.4	3.6	4.9	4.0	3.6	9.0

Notes:

1. *Based on the blocks average of soil monitoring results from 30 August 2017 sampling event.*
2. *Control block C3 is not irrigated with wastewater but is harvested similar to the main irrigation blocks.*
3. *CEC = cation exchange capacity, ESP = exchangeable sodium percentage, ASC = anion storage capacity, TOC = total organic carbon.*
4. *Results not available for the 30 August 2017 sampling event, so the block average 29 July 2016 sampling event results were used.*

Soil samples for heavy metal analysis were also collected during our 18 October 2017 site visit from Blocks A and D for assessment against a selected control site, Block G, which has received no historic irrigation. Due to the accumulative nature of heavy metals, Block G was considered to be more appropriate as a control block. Table 4 summarises the soil heavy metal results from the samples collected on 18 October 2017. Monitoring of the irrigation blocks indicates that there is minimal increase in heavy metal concentrations in comparison to the background levels and all results are well below guideline limits. There may be a slight increase in zinc concentrations in comparison to the background levels, however, given the number of years that irrigation has been occurring at the site, the rate of increase is negligible.

Table 4: Heavy Metal Testing

Soil Parameter	Block A	Block D	Block G (Control)	Guideline Limit
Total Arsenic (mg/kg)	3	4	< 2	20
Total Cadmium (mg/kg)	0.19	0.26	0.2	1
Total Chromium (mg/kg)	14	15	10	600
Total Copper (mg/kg)	9	12	7	100
Total Lead (mg/kg)	9.3	11.6	8.3	300
Total Nickel (mg/kg)	8	9	6	60
Total Zinc (mg/kg)	68	81	43	300

Notes:

1. *Guideline limits based on the Guidelines for safe application of Biosolids to land in New Zealand (NZWWA 2003).*

Soil Permeability

Soil core samples were collected during the 18 October 2017 site visit from the top 100 mm of soil for soil permeability testing, including both K_{sat} and K_{-40} testing. Two cores were collected from each block (except for Block B which was stony and did not allow uniform core collection), and sent to Landcare Research for permeability testing). Block B will likely have similar permeability characteristics to blocks A, C and D due to the similar soil type.

K_{sat} testing provides an indication of the rate of infiltration under saturated conditions, while the K_{-40} provides an indication of infiltration through micro-pores only. Comparison of the two measured infiltration rates provides an indication of pore size distribution in the soil and provides an indication of the ideal loading rate to promote flow though micro-pores and not through macro-pores, so as to promote land treatment. Table 5 details the results of the infiltration testing conducted on cores collected from the irrigation areas.

Table 5: Irrigation Area Infiltration Tests

Block	Soil Type	K_{-40} (mm/hr)	K_{sat} (mm/hr)
A North	Allophanic/Brown	20	689
A South		10	57
C1		6	33
C2		16	17
D1		24	556
D2		4	176
E3		10	118
E6 (average of duplicate)	Gley	0.4	301
G1 (control)		0.9	28
G2 (control)		0.6	464

Permeability testing indicated highly variable saturated infiltration rates, which will partly be due to variations in macrospores (stones, roots and worm holes) in the soil cores collected.

The K_{-40} tests for the allophanic/brown soils were only moderately variable, ranging between 4 mm/hr and 24 mm/hr. When compared with the K_{sat} results, it is apparent that the particle size in the allophanic soils is well distributed, with reduced potential for bypass flows. The irrigation rate is 31.75 mm for the modified irrigators and 43.37 mm for the unmodified irrigators. While these rates exceed the K_{-40} rate, it is generally below the K_{sat} infiltration rate. This indicates that initially, there will be some bypass flow in the top 50 mm (approx.) of soil depth, but as soil micro-pores are filled, the rate of infiltration will decrease and bypass flow will be minimised at lower topsoil depths (but still well within the root zone).

K_{-40} tests within the gley soils indicated a very low unsaturated infiltration rate, yet K_{sat} tests indicate highly variable saturated infiltration rates. This indicated that the gley soils in parts of Block E are not well distributed, with very fine clay/silt particles and that infiltration is dominated by macro-pores, encouraging bypass flow. Hand augering indicated a very tight confining clay layer below 200 mm depth (resulting in the formation of a Gley soil), and while the top soil may achieve a high saturated infiltration rate, the confining layer will restrict ongoing infiltration, ultimately resulting in saturated conditions in the top soil. Block E permeability is not comparatively different to Block G, which contains the same soil type but is not irrigated.

Based on the infiltration testing, it is apparent that the allophanic/brown soils are suitable for wastewater irrigation under most annual conditions; however, the gley soils are unsuitable for wastewater irrigation other than under deficit conditions (which generally occur in summer and early autumn). It should be noted that Silver Fern Farms already applies lower hydraulic loading to these soils, as shown by the lower irrigation to Block E (in the areas containing gley soils) in Appendix B, Table B6.

Nutrient Modelling Assessment

The whole Takapau land holdings (including process and domestic wastewater irrigation, and stockyard solids spreading activities and un-irrigated areas) has been modelled using the OVERSEER nutrient modelling program (Version 6.3.0, released May 2018). This model is used to identify nutrient utilisation and losses based on the 2015/16 processing season. This record year was chosen as the most recent full year of records without significant discrepancies. The average nutrient summary for the land holdings, as generated by OVERSEER, is provided in Table 6. The nutrient model developed for the process wastewater irrigation system is provided in more detail in Appendix B.

The nutrient model utilised incorporates a number of factors, specific to each irrigation block, to estimate nutrient losses to atmosphere and water, via leaching and runoff. These factors include:

- Location and average climatic conditions;
- Irrigation depth;
- Nutrient loads from wastewater irrigation and solids spreading;
- Soil type and nutrient monitoring results;
- Pasture yield and carry rates.

Silver Fern Farms operate the irrigation system based on blocks and sub blocks, recording irrigation rates, solid spreading rates, grazing rates and cut and carry rates based on sub-blocks. While information presented in this report has been based on the average for each block, the Overseer nutrient model has been prepared based on sub blocks. Reporting in Table 6 has been summarised in to a rate across the whole land holdings but there is significant difference between the blocks, as detailed in Appendix B.

Nutrient modelling for the Silver Fern Farms Takapau land holdings has been carried out in the OVERSEER nutrient budget software. The results of this model show that process wastewater irrigation, domestic wastewater irrigation and solids spreading, account for 85 % of nitrogen entering the land holdings and 100 % of phosphorus. These activities contribute a modelled 120 kg/ha/yr of nitrogen and 19 kg/ha/yr of phosphorus.

The nutrient load is almost entirely utilised by the land management operations, with 119 kg/ha/yr of nitrogen and 15 kg/ha/yr of phosphorus exported as supplements.

There is some nutrient loss is via leaching through the soil column, and to the atmosphere via denitrification and volatilisation. Nitrogen leaching has been modelled at a rate of 17 kg/ha/yr, and denitrification and volatilisation is at a rate of 11 kg/ha/yr.

The nitrogen leaching rate of 17 kg/ha/yr is considered reasonable when compared to the predominantly sheep and beef farming land use in the wider area.

While the model shows that phosphorus is accumulating in the soil, due to the flat nature of the land, the model suggests that there is minimal loss of phosphorus to water.

Table 6: Whole Land Holdings Nutrient Budget Summary

	Nitrogen	Phosphorus
Nutrients Added (kg/ha/yr)		
Rainfall	2	0
Biological Fixation	17	0
Irrigation (Modelled as Fertiliser)	120	19
Total	**139**	**19**
Nutrients Removed (kg/ha/yr)		
Supplements Removed	119	15
To Atmosphere via Denitrification, and Fertilizer and Urine Volatilisation	11	0
To Water via Leaching	17	0
To Water via Runoff	0	0.1
Changes in Nutrient Pools (kg/ha/yr)		
Organic Pool	-10	18
Inorganic Mineral	0	5
Inorganic Soil Pool	0	-19

The OVERSEER model output was compared with lysimeter monitoring data collected onsite. Lysimeter data is sampled approximately twice monthly (deep and shallow) within 10 blocks. However, the failure rate of samples due to insufficient volume is high, at approximately 65 %. A summary of the modelled soil nitrogen concentration against the measured lysimeter data is provided in Table 7 below.

Table 7: Comparison of Modelled and Monitored Soil Water Nitrogen Concentrations

Block	Modelled OVERSEER Data (g/m^3)	2015/16 Monitored Lysimeter Data (g/m^3) [1]
A North	15.7	50.5
A South	6.3	29.9
B1	11.3	23.2
C2	6.9	44.7
C3/control	2.7	18.5
D	4.1	25.5
E1/E1A	9.5	21.6
E3	5.4	23.0
E5	3.6	13.3
E6	8.6	6.7

Notes:

1. *Lysimeter data is collected in sets of 3 or more, the median sample collected for each block on each sample date was used for analysis. The result shown on this table is the average of the median results collected throughout the 2015/2016 monitoring year.*

The lysimeter data shows much higher concentrations of nitrogen in the soil water than would be expected from the land management operation, as shown with the OVERSEER results.

While OVERSEER predicts the nitrogen leaching to be low, in light of the lysimeter results and in line with good practice, it is recommended that some consideration be given to further optimising management to minimise nitrogen leaching. This could include options for increasing pasture yield, for example re-sowing some irrigation areas with high-yield ryegrass species, particularly where pasture has become patchy, and considering irrigation with clean water to prevent grass die-off, if that becomes a possibility under the replacement groundwater abstraction consent.

Summary

The Silver Fern Farms Takapau plant irrigates all wastewater to cut and carry pasture and lucerne land holdings, owned and operate by the company. An assessment was undertaken by PDP to assess the conditions of the soils within the irrigation area and nutrient management within the land holdings. Key findings of the assessment are:

- The irrigation blocks containing allophanic/brown soils (Blocks A, B, C, D and parts of E) all have soils in moderate to good condition. The gley soils in parts of Block E were in poor condition, but this is attributed to the soil type and not as a result of wastewater irrigation.
- The soils within the main irrigation blocks (Blocks, A, B, C and D) all contain elevated Olsen P, which is attributed to a higher loading rate of phosphorus in the wastewater than what is currently being removed from these blocks. While the differences in loading and removal from cropping is not substantially different for 2015/16, the Olsen P data would suggest that the difference between loading rates and removal rates via cropping may have been greater for previous years. The high Olsen P levels will also be as a result of the system being a long term land treatment system.
- Sodium levels in the soils are elevated, however, ESP levels remain low, at a level where it is unlikely to be impacting on soil permeability.

- The wastewater irrigation activity is resulting in insignificant increases in heavy metals in the soils.
- Soil permeability testing indicates that the allophanic/brown soils have good particle distribution and are suitable for the existing irrigation rate. Permeability testing of the gley soils and visual observation, confirms that wastewater irrigation of this soil type is unsuitable except for deficit irrigation during summer and early autumn.
- Nutrient modelling indicates rates of nitrogen leaching across the whole land holdings system are low for this type of wastewater management system; however this is not supported by the lysimeter data.

APPENDIX A: VISUAL SOIL ASSESSMENT RESULTS

Table A1: Visual Soil Assessment Results - Block A					
	Visual Indicator of Soil Quality		Weighting	VS Ranking	
Site	A north	A south		A north	A south
Soil Structure & Consistency	2	2	X3	6	6
Soil Porosity	2	2	X3	6	6
Soil Colour	2	2	X2	4	4
Soil Mottles	2	2	X2	4	4
Earthworm Counts	0	0	X3	0	0
Surface Relief	2	2	X1	2	2
RANKING SCORE (Sum of VS rankings)				22	22

Table A2: Visual Soil Assessment Results - Block B			
	Visual Indicator of Soil Quality	Weighting	VS Ranking
Site	B3		B3
Soil Structure & Consistency	2	X3	6
Soil Porosity	2	X3	6
Soil Colour	2	X2	4
Soil Mottles	2	X2	4
Earthworm Counts	0	X3	0
Surface Relief	2	X1	2
RANKING SCORE (Sum of VS rankings)			22

Table A3: Visual Soil Assessment Results - Block C					
	Visual Indicator of Soil Quality		Weighting	VS Ranking	
Site	C1	C2		C1	C2
Soil Structure & Consistency	1	2	X3	3	6
Soil Porosity	1	2	X3	3	6
Soil Colour	2	2	X2	4	4
Soil Mottles	2	2	X2	4	4
Earthworm Counts	2	1	X3	6	3
Surface Relief	2	2	X1	2	2
RANKING SCORE (Sum of VS rankings)				22	25

APPENDIX A: VISUAL SOIL ASSESSMENT RESULTS

Table A4: Visual Soil Assessment Results - Block D					
	Visual Indicator of Soil Quality		Weighting	VS Ranking	
Site	D1	D2		D1	D2
Soil Structure & Consistency	1	1	X3	3	3
Soil Porosity	1	2	X3	3	6
Soil Colour	2	2	X2	4	4
Soil Mottles	2	2	X2	4	4
Earthworm Counts	1	1	X3	3	3
Surface Relief	2	2	X1	2	2
RANKING SCORE (Sum of VS rankings)				19	22

Table A5: Visual Soil Assessment Results - Block E					
	Visual Indicator of Soil Quality		Weighting	VS Ranking	
Site	E3	E6		E3	E6
Soil Structure & Consistency	2	0	X3	6	0
Soil Porosity	2	0	X3	6	0
Soil Colour	2	0	X2	4	0
Soil Mottles	2	1	X2	4	2
Earthworm Counts	2	2	X3	6	6
Surface Relief	2	1	X1	2	1
RANKING SCORE (Sum of VS rankings)				28	9

APPENDIX B: SUMMARY OF OVESEER NUTRIENT MODELLING ASSESSMENT

COMPLETE LAND HOLDINGS SYSTEM: SUMMARY OF OVERSEER NUTRIENT MODELLING ASSESSMENT

A nutrient model has been developed by PDP for the complete land holdings system at Silver Fern Farms Takapau, utilising the OVERSEER nutrient modelling program (Version 6.3.0, released May 2018).

The results of this model aim to evaluate the likely:

- Nutrient loading to soils across the land holdings.
- Nutrient uptake in crops that are grown over the land holdings, and by animals that are grazed.
- Nutrients retained and lost in the soil profile.
- Nutrients lost to water, including via leaching at the base of the soil column.

This model is used to identify nutrient utilisation and losses based on the 2015/16 processing season. This record year was chosen as the most recent full year of records without significant discrepancies.

LAND HOLDINGS SYSTEM

1. LOCATION AND LAYOUT

The land holdings are located near Takapau in central Hawke's Bay. It is bound by State Highway 2 to the North, and Oruawharo Road to the South. It extends on both sides of Fraser Road and spans approximately 480 ha.

The Porangahau Stream runs through the land holdings from west to east. The topography is generally flat, with gentle slopes either side of the Porangahau Stream.

2. CLIMATE

The climate in the Hawke's Bay Region is temperate, and generally dry and warm. Rainfall is highly variable, the region often experiencing droughts and flooding. Daily data from the Silver Fern Farms Takapau weather station is recorded for rainfall and temperature; and potential evapotranspiration (PET) is recorded at the Central Hawke's Bay District Council weather station No. 33 (12 km from the land holdings). This data has been summarised into the following OVERSEER inputs based on the full data record (Aug 2010 to Sep 2017):

- Mean annual rainfall of 774 mm.
- Mean annual temperature of 12.6 °C.
- Annual PET of 1,304 mm with moderate variation.

3. LAND HOLDINGS OPERATION

The land holdings are operated as four different land management systems, which represent 408 ha:

- Process wastewater irrigation blocks (Blocks A – E, excluding S2/E8), which are operated as cut and carry blocks and alternated between grass and lucerne crops.
- Solids spreading blocks (Blocks F, G and S), which utilise grazing and harvesting to manage growth.
- Domestic wastewater border dyke irrigation blocks (Dam Dyke blocks).
- Other pastoral areas, which do not receive any waste products, and utilise grazing and harvesting to manage growth.

The total land holdings (480 ha) includes the processing plant and unutilised areas surrounding streams.

3.1. OVERSEER GENERAL INPUT SUMMARY

The OVERSEER inputs used to model the nutrient budgets are summarised in Table 1.

APPENDIX B: SUMMARY OF OVESEER NUTRIENT MODELLING ASSESSMENT

Table B1: OVERSEER Input Summary

General Inputs

Location	East Coast North Island
Distance From Coast	37 km
Total Land holdings Area	480 ha

General Block Inputs

Block Name [1]	Area (ha) [2]	Crop Type [3]	Operation	Additional Nutrient Loads
A North	35.2	Grass	Cut and Carry	Process Wastewater Irrigation
A South	35.7	Grass	Cut and Carry	Process Wastewater Irrigation
B1	8.4	Lucerne	Cut and Carry	Process Wastewater Irrigation
B2	4.1	Lucerne	Cut and Carry	Process Wastewater Irrigation
B3	9.8	Lucerne	Cut and Carry	Process Wastewater Irrigation
C1	4.9	Grass	Cut and Carry	Process Wastewater Irrigation
C2 a	10.3	Grass	Cut and Carry	Process Wastewater Irrigation
C2 b	10.3	Grass	Cut and Carry	Process Wastewater Irrigation
C3/control	5.0	Lucerne	Cut and Carry	Process Wastewater Irrigation
D	25.9	Grass	Cut and Carry	Process Wastewater Irrigation
E1/E1A	11.7	Grass	Cut and Carry	Process Wastewater Irrigation
E2/E2A	12.0	Grass	Cut and Carry	Process Wastewater Irrigation
E3	5.3	Grass	Cut and Carry	Process Wastewater Irrigation
E4	6.0	Grass	Cut and Carry	Process Wastewater Irrigation
E5	12.4	Grass	Cut and Carry	Process Wastewater Irrigation
E6	15.8	Grass	Cut and Carry	Process Wastewater Irrigation
E7	6.0	Grass	Cut and Carry	Process Wastewater Irrigation
F1	5.8	n/a	Pastoral	Solids Spreading
F2	16.8	n/a	Pastoral	Solids Spreading
F3	9.9	n/a	Pastoral	Solids Spreading
F4	6.9	n/a	Pastoral	Solids Spreading
G1	41.6	n/a	Pastoral	Solids Spreading
G3	17.6	n/a	Pastoral	Solids Spreading
G4	4.2	n/a	Pastoral	Solids Spreading
G5	14.0	n/a	Pastoral	Solids Spreading
S1 (North, South, Substation)	8.5	n/a	Pastoral	Solids Spreading
S2/E8	5.0	Grass	Cut and Carry	Solids Spreading
Cottage	3.2	n/a	Pastoral	
Dam Dyke 1 - 10	0.8	n/a	Pastoral	Domestic Wastewater Irrigation
Dam Dyke 11 - 20	0.8	n/a	Pastoral	Domestic Wastewater Irrigation
Domestic Dam	1.6	n/a	Pastoral	
Dressage	2.5	n/a	Pastoral	
Effluent Dam	3.5	n/a	Pastoral	
Non Potable	6.9	n/a	Pastoral	
Old Dam	5.8	n/a	Pastoral	
South River 1	13.8	n/a	Pastoral	
South River 2	7.5	n/a	Pastoral	
Sub 1	0.6	n/a	Pastoral	
Well 10	3.4	n/a	Pastoral	
Well 12	1.8	n/a	Pastoral	
Well 15	4.6	n/a	Pastoral	
Woolshed	2.7	n/a	Pastoral	

Notes:

1. *Block names and locations were taken from a Silver Fern Farms Takapau Grazing Area Map (email, 23 April 2018).*
2. *Areas were taken, where available, from the 2015/16 Annual Monitoring Report (preferred) or the harvest data. If no other data was available Areas were estimated from 03/06/2016 aerials available on Google Earth.*
3. *Crop type (relevant only for cut and carry operations) is alternated between grass and lucerne depending on soil condition. The crop type for the 2015/16 year is used in this table and in the OVERSEER model.*

APPENDIX B: SUMMARY OF OVESEER NUTRIENT MODELLING ASSESSMENT

3.2. HARVESTING SUMMARY

The OVERSEER inputs are summarised in Table B2.

Table B2: OVERSEER Harvesting Summary

Block Harvested	Supplement Made	Dry Weight (Tonnes)	Destination
A North	Grass Silage	286	Off site
A South	Grass Silage	457	Off site
B1	Lucerne Silage	7	Off site
	Lucerne Baleage	9	Off site
B2	Lucerne Silage	3	Off site
	Lucerne Baleage	5	Off site
B3	Lucerne Silage	6	Off site
	Lucerne Baleage	19	Off site
C1	Grass Silage	46	Off site
C2 a/b	Grass Silage	228	Off site
C3/control	Lucerne Silage	18	Off site
D	Grass Hay	280	Off site
	Grass Silage	208	Off site
E1/1A	Grass Baleage	9	Off site
	Grass Silage	54	Off site
E2/2A	Grass Baleage	6	Off site
	Grass Silage	56	Off site
E3	Grass Baleage	5	Off site
	Grass Silage	35	Off site
E4	Grass Baleage	5	Off site
	Grass Silage	33	Off site
E5	Grass Baleage	30	Off site
	Grass Silage	87	Off site
E6	Grass Baleage	43	Off site
	Grass Silage	66	Off site
E7	Grass Silage	37	Off site
F1	Grass Hay	102	Off site
F2	Grass Hay	28	Off site
F3	Grass Hay	102	Off site
	Grass Silage	19	Off site
F4	Grass Silage	19	Off site
G1	Grass Silage	62	Off site
S1 (North, South, Substation)	Grass Silage	9	Off site
S2/E8	Grass Silage	22	Off site
South River 1	Grass Silage	55	Off site
South River 2	Grass Silage	14	Off site
Well 10	Grass Silage	10	Off site
Well 12	Grass Silage	8	Off site

Notes:

1. *Harvesting quantities and products were taken from harvesting records provided by Silver Fern Farms Takapau for the 2015/16 monitoring year (October 2015 to September 2016).*

APPENDIX B: SUMMARY OF OVESEER NUTRIENT MODELLING ASSESSMENT

SOILS

SOIL TYPES

Several different soil types are identified by Landcare's S-map online soil database on the land holdings; however, many of these soil types are relatively similar. The land holdings were observed to have three groups of soils that demonstrate differing characteristics when irrigated. These are:

- Allophanic and Orthic Brown soils.
- Perch-gley Pallic soils.
- Fluvial Raw soils.

The Allophanic Brown and Orthic Brown soils underlie the majority of the process water irrigation blocks. Orthic Brown soils are moderately well drained, with medium phosphorus retention. The Allophanic Brown soils are Brown soils that contain an Allophanic soil horizon. This horizon typically increases the phosphorus retention and drainage class to high phosphorus retention and well drained respectively.

The Perch-gley Pallic soil extends across approximately half of Block E. This soil contains a confining clay layer that forms a rooting and hydraulic barrier. This soil is typically associated with poor drainage and low phosphorus retention. This was supported by PDP observations of highly saturated soil in this area (*site walkover*, 18 October 2017), and by a reduced irrigation loading rate to this area (Section: Irrigation).

The Fluvial Raw soils are found underlying streams, which run through the land holdings. This soil is very young due to sedimentation processes occurring from stream flow. Consequently; it lacks a significant topsoil layer. This soil is typically well drained, with low to moderate profile available water and very low phosphorus retention.

The interface between the soil types is irregular, and has been approximated by the block operational area delineation for simplicity. All soil types are summarised in Table B3.

Table B3: Soil Irrigation Characteristics

Dominant Sibling Name	Soil Order	Phosphorus Retention	Drainage Class	Profile Available Water	Area (ha) [1]	Blocks
Ruat_7a.1	Perch-gley Pallic Soil	Low (22 %)	Poorly Drained	Moderate to High	35	E2, E6, E7, G1, S2/E8
Tarar_6a.1	Allophanic Brown Soil	High (66 %)	Well Drained	Moderate to High	33	B1, C2 b, C3/control, D, E1, E3, E4, E5, Effluent Dam, Old Dam
Bushg_14a.1	Allophanic Brown Soil	High (66 %)	Well Drained	Moderate to High	36	A North, F1, F4, Sub 1
Mand_22a.1	Orthic Brown Soil	Medium (36 %)	Moderately Well Drained	Moderate to High	59	A South, B2, B3, C1, C2 a, S1
Orono_83a.1	Orthic Brown Soil	Medium (36 %)	Moderately Well Drained	Moderate to High	84	F3, G4, Dressage, Woolshed, Non Potable
Ashb_38a.1	Fluvial Raw Soil	Very Low (3 %)	Well Drained	Low to Moderate	161	F2, G3, G5, Domestic Dam, Dam Dyke, South River 1, South River 2, Well 10, Well 12, Well 15

Notes:

1. *The dominant soil type for each block was chosen for OVERSEER modelling purposes, other soil types were often present. Soil type delineation was from PDP A02164201 Figure 3 Rev C and where further information was required; Landcare Research S-map online database was used. The area above is calculated as the total area that was modelled as that soil type (based on the dominant soil of the block).*

APPENDIX B: SUMMARY OF OVESEER NUTRIENT MODELLING ASSESSMENT

CURRENT SOIL NUTRIENT CONDITIONS

Annual soil testing is carried out within every block by Silver Fern Farms. The results of the soil testing is summarised in Table B4.

Soil testing across the land holdings shows high phosphorus levels (Olsen P), which are above the optimum range for pasture growth in sedimentary soils. Potassium and magnesium also have elevated quick test results, which are above optimum levels for pasture growth (Dairy NZ, 2012).

Elevated phosphorus, potassium and magnesium levels are occurring across the land holdings with the exception of some of Block E. This indicates that wastewater irrigation is likely to be contributing to these levels as Block E receives lower irrigation rates (refer to the section below on irrigation).

Calcium and sodium have no upper limit for optimum pasture growth. However, elevated sodium levels can cause degradation of the drainage characteristics of the soil. It is recommended that ESP levels are maintained below 6%. As per Table 3, ESP as monitored on 30 August 2017 was below 3% for all blocks.

Table B4: Soil Test Results

Sample Location	Olsen P	Potassium (MAF)	Calcium (MAF)	Magnesium (MAF)	Sodium (MAF)
A North	78	32	11	22	13
A South	80	35	12	25	22
B1	83	23	9	23	13
B2	63	18	8	21	12
B3	102	27	9	23	13
C1	104	30	12	21	7
C2	89	32	14	28	23
C3/control	29	15	13	13	2
D	82	24	10	20	17
E1/1A	42	14	15	27	16
E2/2A	17	6	15	30	19
E3	46	19	14	23	18
E4	44	7	16	28	19
E5	31	7	11	19	14
E6	18	3	12	22	21
E7	60	20	15	30	17
F1	45	11	15	27	9
F2	32	10	13	25	6
F3	53	9	14	34	7
F4	39	9	11	20	4
G1	18	3	11	22	6
G3	42	8	8	17	8
S2/E8	48	4	14	37	5
Optimum Pasture	**20 - 30**	**5 - 8**	**> 1**	**8 - 10**	**> 1**

Notes:

1. *MAF conversion method was as described by Hill Laboratories (2017).*
2. *Soil sampling results from 29 June 2015 were used to best represent the soil condition prior to the nutrient loading during the 2015/16 monitoring year. These results were not available from Blocks F1, F2, F3, F4 and G3 so the 29 July 2016 results were used.*

APPENDIX B: SUMMARY OF OVESEER NUTRIENT MODELLING ASSESSMENT

PROCESS WASTEWATER IRRIGATION

Treated wastewater, produced from Silver Fern Farms' processing plant, is irrigated across the Blocks A, B, C, D and E, with a combined irrigation area of 218 ha. The treated wastewater contains residual nutrients, which contribute a nutrient load to the irrigated land.

Wastewater generated from the processing plant each day varies. The volume of the wastewater discharge is limited to 35,000 m^3/7 day period and 1,365,000 m^3/year (between 1 October and 30 September) by the existing Resource Consents DP981043Ld and DP981044Ad. The average measured nutrient concentrations in the treated wastewater are summarised in Table B5.

Table B5: Average Nutrient Data

Nitrogen	Phosphorus	Potassium	Calcium	Magnesium	Sodium
73.6 g/m^3	11.8 g/m^3	75.5 g/m^3	36.2 g/m^3	7.9 g/m^3	82.5 g/m^3

Notes:

1. *Average nutrient data is based on sampling results from the 2015/16 monitoring year (October 2015 to September 2016).*

Irrigation is via a travelling irrigator system, irrigating a row at a time. Daily irrigation records are recorded by run. Irrigation occurs year round and the application area shifts daily to spread the treated wastewater evenly across the irrigable areas. Poor drainage across Block E limits the application rate at this location, and lower irrigation loads are applied across this block. Table B6 shows there is no or minimal irrigation on Block E at certain times of year, which is consistent with the reported operation.

Average monthly irrigation rates have been assessed for each block, based on the 2015/16 monitoring year (October 2015 to September 2016), and are shown in Table B6.

Table B6: Average Monthly Irrigation Rates for Each Block

	A	B	C	D	E
July (mm)	17	12	48	59	18
August (mm)	19	20	36	54	12
September (mm)	6	3	2	4	1
October (mm)	38	0	33	36	0
November (mm)	38	0	47	50	10
December (mm)	39	25	47	60	21
January (mm)	49	23	21	28	38
February (mm)	36	39	12	8	27
March (mm)	55	4	64	24	37
April (mm)	41	34	54	17	20
May (mm)	74	10	5	40	27
June (mm)	43	20	52	42	31
Annual Total (mm)	**455**	**190**	**421**	**422**	**242**

Wastewater irrigation was modelled as fertiliser application and irrigation of clean water. Monthly nutrient loads were determined for each block based on Tables B5 and B6. This modelling method was chosen to better model the expected nitrogen uptake, as the primary form of nitrogen in this wastewater is organic nitrogen.

DOMESTIC WASTEWATER IRRIGATION

Treated domestic wastewater, produced from the Silver Fern Farms plant, is irrigated across the BDIS with a combined irrigation area of 1.6 ha. The treated wastewater contains residual nutrients from the wastewater that contribute a nutrient load to the irrigated land. The average nutrient concentrations in the domestic

APPENDIX B: SUMMARY OF OVESEER NUTRIENT MODELLING ASSESSMENT

wastewater are summarised in Table B7. Please note that this data varies from the domestic irrigation nutrient model (PDP 2018) in that it utilises data for 2015/16 only and has been developed utilising Overseer version 6.3.0.

Table B7: Average Nutrient Data

Nitrogen [1]	Phosphorus [2]
38.0 g/m^3	7.6 g/m^3

Notes:

1. *Average nitrogen data is based on sampling results from the 2015/16 monitoring year (October 2015 to September 2016).*
2. *Average phosphorus is based on typical domestic nitrogen to phosphorus ratio of 5:1.*

Irrigation is via a border dyke irrigation system, which periodically floods Block 1 – 10 or Block 11 - 20.

The monthly irrigation rate for each block was calculated from the 2015/16 monitoring year (October 2015 to September 2016), and is summarised in Table B8.

Table B8: Average Monthly Irrigation Rates for Each Block

	Block 1 - 10	Block 11 - 20
January (mm)	66	0
February (mm)	93	93
March (mm)	0	93
April (mm)	92	77
May (mm)	92	0
June (mm)	93	92
July (mm)	0	87
August (mm)	93	0
September (mm)	92	62
October (mm)	81	65
November (mm)	0	64
December (mm)	89	80

Wastewater irrigation was modelled as fertiliser application and irrigation of clean water. Monthly nutrient loads were determined for each block based on Tables 4 and 5. This modelling method was chosen to better model the expected nitrogen uptake, as the primary form of nitrogen in this wastewater is organic nitrogen.

SOLIDS SPREADING

Sheep yard solids are spread across Blocks F, G and S and spread in runs which are 2.5 m wide and 550 – 570 m in length. The solids are washed down from the sheep yard and collected on a screen. This application was treated as nutrient loads of nitrogen and phosphorus as monthly applications of fertiliser. The sheep yard solids were not specifically analysed for phosphorus, and this has been estimated assuming a 5:1 ratio of nitrogen to phosphorus.

The monthly solids application for each block is summarised in Table B9.

APPENDIX B: SUMMARY OF OVESEER NUTRIENT MODELLING ASSESSMENT

Table B9: Monthly Nutrient Loads from Solids Spreading

	E8/S2	F1	F2	F4	G3	G4
Nitrogen Loads						
January (kg/ha)					19	
February (kg/ha)					18	
March (kg/ha)	2	3			8	2
April (kg/ha)	20	2				
May (kg/ha)		15				
June (kg/ha)		22				
July (kg/ha)		5	1			
August (kg/ha)			3			
September (kg/ha)			1			
October (kg/ha)				2	5	
November (kg/ha)				27		
December (kg/ha)				19	7	
Phosphorus Loads						
	E8/S2	**F1**	**F2**	**F4**	**G3**	**G4**
January (kg/ha)					4	
February (kg/ha)					4	
March (kg/ha)	0	1			2	
April (kg/ha)	4	0				
May (kg/ha)		3				
June (kg/ha)		4				
July (kg/ha)		1	0			
August (kg/ha)			1			
September (kg/ha)			0			
October (kg/ha)				0	1	
November (kg/ha)				5		
December (kg/ha)				4	1	

Notes:

1. *Nitrogen loads are based on records provided by Silver Fern Farms Takapau for the 2015-2016 monitoring year (October 2015 to September 2016).*

GRAZING

A grazing map provided by Silver Fern Farms Takapau indicates that grazing occurs across the majority of the land holdings area excluding process wastewater irrigation blocks. Grazing is irregular; however, good grazing records are kept for Blocks F, G and S1 and are summarised for the 2015/16 monitoring year (October 2015 to September 2016) in Table B10. Grazing records were modified to a suitable OVERSEER input into an equivalent flock grazing the block full time for a month for the land holdings.

For the blocks without grazing records, it was confirmed with Silver Fern Farms Takapau that nominal grazing does occur, so a nominal 5 sheep/ha were applied across these areas.

APPENDIX B: SUMMARY OF OVESEER NUTRIENT MODELLING ASSESSMENT

Table B10: Monthly Nutrient Loads from Solids Spreading												
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Number of Sheep	813	49	117	81	1,857	2,778	696	1541	932	870	1,494	2335

OVERSEER does not allow for different stocking rates to be applied for each month and block; rather, land holdings stock numbers per month, and relative productivity of the blocks. The grazing records were used to determine the average stocking rates, which were used for relative productivity for each block and are summarised in Table B11.

Table B10: Monthly Nutrient Loads from Solids Spreading	
Block	**Average Stocking Rate**
F1	6.8 sheep/ha
F2	6.8 sheep/ha
F3	6.8 sheep/ha
F4	6.8 sheep/ha
G1	6.8 sheep/ha
G3	6.8 sheep/ha
G4	6.8 sheep/ha
G5	6.8 sheep/ha
S1 (North, South, Substation)	16.7 sheep/ha
Cottage	5.0 sheep/ha
Dam Dyke 1 - 10	5.0 sheep/ha
Dam Dyke 11 - 20	5.0 sheep/ha
Domestic Dam	5.0 sheep/ha
Dressage	5.0 sheep/ha
Effluent Dam	5.0 sheep/ha
Non Potable	5.0 sheep/ha
Old Dam	5.0 sheep/ha
South River 1	5.0 sheep/ha
South River 2	5.0 sheep/ha
Sub 1	5.0 sheep/ha
Well 10	5.0 sheep/ha
Well 12	5.0 sheep/ha
Well 15	5.0 sheep/ha
Woolshed	5.0 sheep/ha

APPENDIX B: SUMMARY OF OVESEER NUTRIENT MODELLING ASSESSMENT

NUTRIENT BUDGET

The irrigation activity and underlying land management systems have been modelled using the OVERSEER nutrient modelling program (Version 6.3.0, released May 2018). This model is used to identify nutrient utilisation and losses. The previously described characteristics have been used to generate the nutrient budget. The average nutrient summary for the land holdings, as generated by OVERSEER, is provided in Table B11.

Table B11: Nutrient Budget Summary

	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium	Sodium
Nutrients Added (kg/ha/yr)						
Rainfall	2	0	2	2	4	16
Biological Fixation	17	0	0	0	0	0
Irrigation (Modelled as Fertiliser)	120	19	118	56	12	129
Nutrients Removed (kg/ha/yr)						
Supplements Removed	119	15	102	26	5	7
To Atmosphere via Denitrification, and Fertilizer and Urine Volatilisation	11	0	0	0	0	0
To Water via Leaching or runoff	17	0.2	29	62	7	23
Changes in Nutrient Pools (kg/ha/yr)						
Organic Pool	-10	18	0	0	0	0
Inorganic Mineral	0	5	-8	-3	-4	-5
Inorganic Soil Pool	0	-19	-4	-28	9	120

Nutrients enter the land holdings primarily through process wastewater irrigation, domestic wastewater irrigation and solids spreading: accounting for 85 % of nitrogen entering the land holdings and 100 % of phosphorus. These activities contribute 120 kg/ha/yr of nitrogen and 19 kg/ha/yr of phosphorus.

The nutrient load is almost entirely utilised by the land management operations, with 119 kg/ha/yr of nitrogen and 15 kg/ha/yr of phosphorus exported as supplements.

The remaining nutrient loss is via leaching through the soil column, and to the atmosphere via denitrification and volatilisation. Nitrogen leaching has been modelled at a rate of 17 kg/ha/yr, and denitrification and volatilisation is at a rate of 11 kg/ha/yr.

1. NITROGEN BLOCK SUMMARY

A summary of the key aspects of the nitrogen budget for each modelled block is in Table B12.

The highest nitrogen losses per hectare were seen in the domestic wastewater irrigation blocks, with elevated nitrogen loss also in some of the process wastewater irrigation blocks which received higher hydraulic loading. The lowest nitrogen loss was seen on Block C3/control.

APPENDIX B: SUMMARY OF OVESEER NUTRIENT MODELLING ASSESSMENT

Table B12: Nitrogen Block Summary				
Block	**Total N lost**	**N lost to water**	**N in drainage**	**N surplus**
	kg N/yr	kg N/ha/yr	ppm	kg N/ha/yr
A North	2,163	61	15.7	128
A South	876	25	6.3	37
B1	250	30	11.3	73
B2	146	36	12.7	74
B3	264	27	9.7	51
C1	188	38	9.8	74
C2 a	289	28	7.2	46
C2 b	252	24	6.5	46
C3/control	25	5	2.7	-13
D	410	16	4.1	-34
E1/E1A	315	27	9.5	58
E2/E2A	382	32	10.8	60
E3	80	15	5.4	22
E4	127	21	7.5	40
E5	126	10	3.6	2
E6	401	25	8.6	42
E7	141	23	8	39
F1	50	9	4.5	-179
F2	175	10	4.8	4
F3	75	8	4.1	-157
F4	56	8	4.2	7
G1	311	7	4	-4
G3	190	11	5	55
G4	31	7	4	14
G5	145	10	4.8	14
S1 (North, South, Substation)	106	12	6.5	10
S2/E8	25	5	2.7	-35
Cottage	29	9	4.1	12
Dam Dyke 1 - 10	119	149	23.5	300
Dam Dyke 11 - 20	97	122	23	269
Domestic Dam	14	9	4.1	12
Dressage	17	7	3.8	11
Effluent Dam	23	7	3.8	11
Non Potable	47	7	3.8	11
Old Dam	39	7	3.8	11
South River 1	124	9	4.1	-45
South River 2	67	9	4.1	-8
Sub 1	4	7	3.8	11
Well 10	31	9	4.1	-23
Well 12	16	9	4.1	-55
Well 15	41	9	4.1	12
Woolshed	19	7	3.8	11

APPENDIX B: SUMMARY OF OVESEER NUTRIENT MODELLING ASSESSMENT

CONCLUSIONS AND RECOMMENDATIONS

Nutrient modelling for Silver Fern Farms land holdings has been carried out in the OVERSEER nutrient budget software. The results of this model show that process wastewater irrigation, domestic wastewater irrigation and solids spreading: accounting for 85 % of nitrogen entering the land holdings and 100 % of phosphorus. These activities contribute 120 kg/ha/yr of nitrogen and 19 kg/ha/yr of phosphorus.

The nutrient load is almost entirely utilised by the land management operations, with 119 kg/ha/yr of nitrogen and 15 kg/ha/yr of phosphorus exported as supplements.

There is some nutrient loss is via leaching through the soil column, and to the atmosphere via denitrification and volatilisation. Nitrogen leaching has been modelled at a rate of 17 kg/ha/yr, and denitrification and volatilisation is at a rate of 11 kg/ha/yr.

REFERENCES

Dairy NZ. (2012). *Critical Nutrient Levels for Pasture* (Farmfact No. 7-5). Dairy NZ.

Hill Laboratories. (2017). *Soil Tests and Interpretation: Technical Note* [Version 5]. Hamilton: Hill Laboratories.

Appendix D

Macroinvertebrate Monitoring at Sites in the Porangahau Stream Adjacent to Silver Fern Farms Takapau: 2018 Survey

MACROINVERTEBRATE MONITORING

AT SITES IN THE PORANGAHAU STREAM
ADJACENT TO SILVER FERN FARMS
TAKAPAU: 2018 SURVEY

MAY 2018

REPORT No: 18001

PROJECT No: TFN13004

Macroinvertebrate monitoring at sites in the Porangahau Stream adjacent to Silver Fern Farms Takapau; 2018 survey.

Report prepared by:

Shade Smith

Prepared for:

Silver Fern Farms

May 2018

Triplefin report no. 18001
Triplefin Project No. TFN13004

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1. INTRODUCTION

Silver Fern Farms operate a mixed species meat processing plant located in Takapau, Central Hawke's Bay. Wastewater from various sources within the plant is treated through a series of onsite treatment units and is ultimately discharged to land located adjacent to the plant via irrigators. The irrigated land is used to support a 'cut and carry' cropping operation, with the plants using the wastewater as a source of nutrients. Down gradient of the irrigated land lies the Porangahau Stream which cuts through the Silver Fern Farms property, and subsequently flows into the Maharakeke Stream which is itself a tributary to the Tukituki River.

1.1 BACKGROUND

Silver Fern Farms currently holds consents (DP981043Ld and DP981044Ad), which allow among other things for the discharge of wastewater to land. Condition 48 of the consents requires the consent holder to undertake a survey of the macroinvertebrate community at monitoring sites as follows:

"The consent holder shall engage a suitably qualified ecologist to undertake macroinvertebrate monitoring of the sites listed in Table 4 of this consent. The sampling shall be undertaken once annually during the period 1 January to 31 March, at least four weeks following a "significant fresh". For the purposes of this consent a "significant fresh" is defined as 3 times the median flow (see Advice Note 5). The results of sampling shall be submitted to the Council within one month of being received by the consent holder."

The rationale for the monitoring is to ascertain the current 'health' of the macroinvertebrate communities at sites in the Porangahau Stream upstream and downstream of the Silver Fern Farms Takapau operation. Comparing the health status of upstream and downstream sites, and how they track over time, provides the opportunity for an assessment of effects to be made.

1.2 THIS STUDY

Silver Fern Farms engaged Triplefin Environmental Consulting (Triplefin) to conduct this round of annual monitoring of the receiving environment in accordance with condition 48 of discharge permits DP981043Ld and DP981044Ad, and to the same level of detail as previous years surveys (Smith 2013; Smith 2014; Smith 2015; Smith 2016; Smith 2017). In addition to monitoring requirements as set out in the consents, an additional site, termed the 'alternative downstream' site and added during the 2014 survey, was also sampled, results interpreted and included in analyses in the present survey. This proposal to include this additional site stemmed from a recommendation in the 2013 monitoring report (Smith 2013) that;

"the upstream reference site be better matched in terms of site characteristics to the downstream site to improve comparability between sites".

This recommendation was put forward because of differences in substrate and topography between the upstream and downstream sites. Better matching of site characteristics between sites removes the confounding effects on community assemblage from differences in site characteristics, and provides for a more robust assessment of effects of the discharge to land. The 'alternative downstream' site, located 235m downstream of the existing downstream site is just outside the Silver Fern Farms boundary and is a better match to the existing upstream reference site. However it must be noted that, given the 'alternative downstream site' is located on a neighbouring property, site specific influences there are outside the control of Silver Fern Farms. This was evidenced during the 2015 survey when grazing cattle in and around the stream environs precluded sampling.

This report presents the findings of field survey work conducted in February 2018, interpretation, and comparison of resultant data within and between years.

2. STUDY SITES AND METHODOLOGY

2.1 SITE DESCRIPTIONS

Locations of sites sampled during the present survey are shown in Figure 1. More generally these sites are located upstream (upstream reference site 397 – E1889114 N5564779 NZTM 2000) and downstream of the irrigated land blocks (downstream site 2431 – E1890776 N5565479). The alternative downstream site (E1890928 N5565393) was located approximately 235m downstream of the consented 'downstream' site 2431. These sites are situated at an altitude of around 180m and are therefore classified as upland streams. Site photos offering views upstream and downstream of sites are included in Appendix 1.

The assessment at sites along the Porangahau Stream was performed during a site visit on 23 February 2018. No rain resulting in >3x median flow (i.e. a 'significant fresh' event) had been recorded in the catchment in the previous month with rainfall in the area below historical averages for the previous two months (https://cliflo.niwa.co.nz/) and summer low flow conditions evident in the stream at the time of sampling.

The upstream reference site 397 is described as hard bottomed with the bed predominantly consisting of small cobbles (6-13 cm, 60%), gravels (0.2 – 6cm, 20%), large cobbles (13-26cm, 20%) and silt/sand (<0.2cm, 0%). The hard substrates provide good armouring and were not easily disturbed. Thick brown mats of periphyton and short filamentous green algae strands were extensive with longer strands evident in deeper areas, accounting for approximately 60% cover. Wetted width was 3.7m with an average depth of 15cm. Some shading of the stream was evident both upstream and downstream of the sampling site being afforded primarily by willows along the true right bank.

The downstream site consisted of 10% small cobbles, 75% gravels and 15% sand/silt. Long green filamentous algae was extensive, ~ 90% cover. There was good shading on the true left bank afforded by willow extending out to around half the wetted width that was ~ 7m. Topography (gradient) was different, with the upstream reference site a riffle/run reach leading into a small pool reflecting a steeper gradient, whereas the downstream site was a glide/run reach reflecting a lower gradient. The stream was slightly shallower (10cm) compared to the upstream reference site. The substrate was not as well armoured and was easily disturbed with occasional patches of soft sediments evident on the stream bed.

The alternative downstream site was described as a riffle/run habitat with the substrate comprising 50% small cobbles, 10% gravels, 40% large cobbles. Algal growth was patchy with some sections having extensive coverage of long filamentous green algae while in the swifter flowing thalweg periphyton was minimal with thin brown mats of approximately 60% coverage of cobbles on the bed. Wetted width was 3.5m with an average depth of 14cm. Some shading was evident downstream.

Extensive stands of emergent macrophyte were evident along the sides of all sites with the dominant species being watercress (*Rorippa nasturtium-aquaticum*), and water celery (*Apium nodiflorum).*

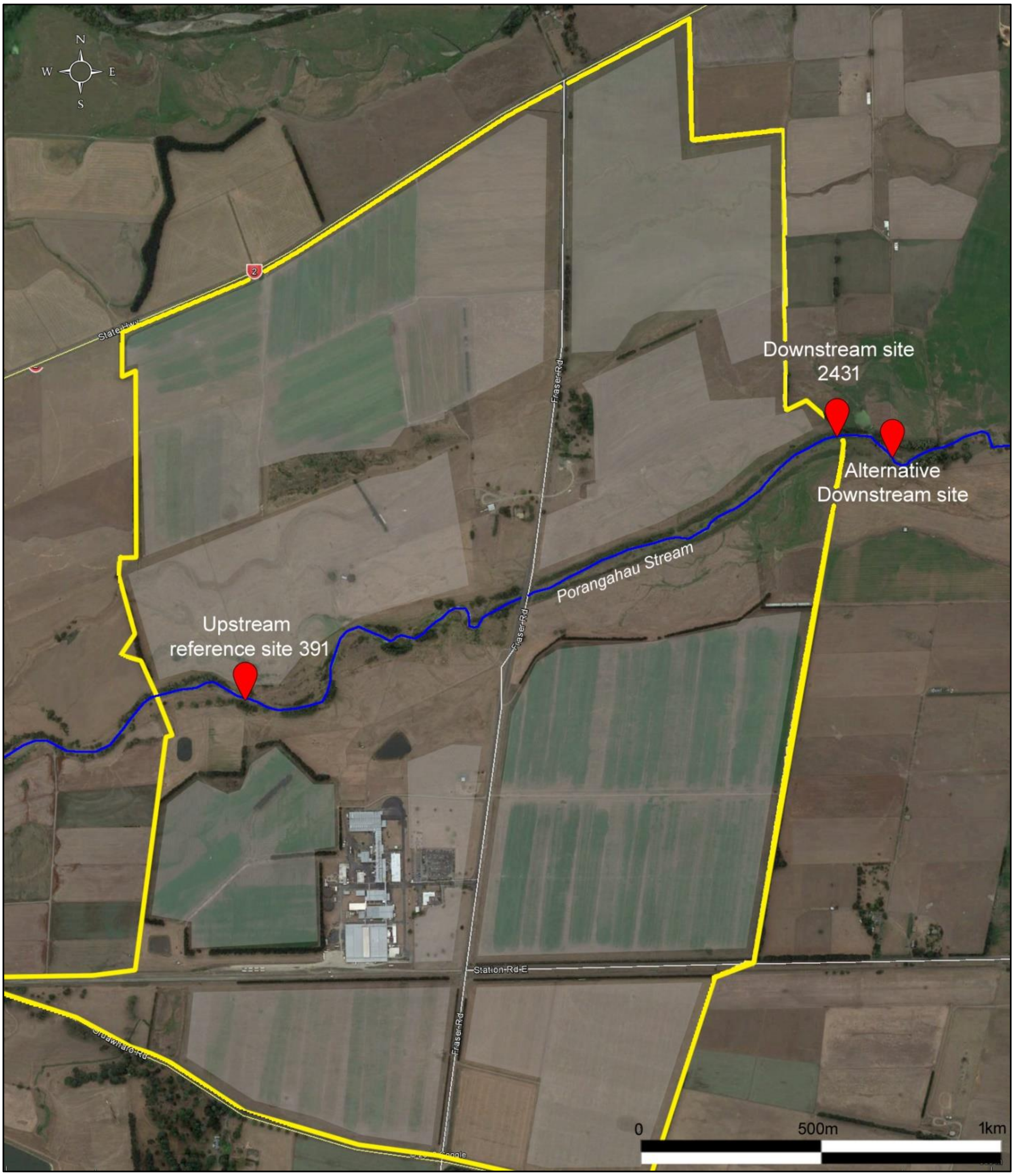


FIGURE 1: SILVER FERN FARMS TAKAPAU SITE (BOUNDARY OUTLINED IN YELLOW), BLOCKS SUBJECT TO NUTRIENT APPLICATION (SHADED GREY) AND MACROINVERTEBRATE SAMPLING SITES IN THE PORANGAHAU STREAM.

2.2 METHODOLOGY

At each site temperature, pH, conductivity, and dissolved oxygen (DO) measurements were measured *in situ* using a calibrated WTW Multi 350i portable water quality field meter.

Aquatic invertebrates were collected using a hand net in which semi – quantitative samples from each site were collected using a combination of kick and sweep techniques as described in Protocol C1: 'Hard-bottomed, semi-quantitative' (Stark, Boothroyd et al. 2001). At each site two replicates were subsequently composited into a single sample. Once collected, the macroinvertebrate samples were preserved in 80% ethyl alcohol and transported to Triplefins lab where samples were sorted, sub-sampled and taxa identified in accordance with Protocol P2: 'Semi-quantitative, fixed count + scan for rare taxa' (Stark, Boothroyd et al. 2001). From these results the Macroinvertebrate Community Index (MCI – hard bottomed streams), Quantitative Macroinvertebrate Community Index (QMCI – hard bottomed streams) scores were determined.

Benthic macroinvertebrates include the diverse assemblage of organisms that live on the surface, under or within the substrates of streams and include insect larvae (e.g., mayflies, stoneflies, caddisflies, and beetles), aquatic oligochaetes (worms), snails and crustaceans (e.g., shrimps and crayfish). Because stream macroinvertebrates are such a diverse group and are strongly influenced by aquatic habitat and water quality, they are used widely for monitoring and evaluating water quality and more broadly 'stream health' in New Zealand and overseas. A benefit of using macroinvertebrates is that they can be indicators of ecosystem health through the calculation and interpretation of biological indices such as MCI and QMCI.

The MCI responds to any perturbation that alters the list of taxa (i.e. taxonomic composition) present at a site. The QMCI responds to changes in taxonomic and numerical composition or relative abundances. An advantage of the MCI and QMCI indices is that they provide a simple pollution tolerance score for each taxon ranging from 1 (very pollution tolerant) to 10 (pollution-sensitive), and site scores can be compared to national guideline values (see Table 1). MCI values can theoretically range from 0 to 200; however streams generally do not have an MCI of over 150 (Stark 1993). Streams with an MCI of >119 are believed to be of pristine conditions with very good water quality, and only streams which are extremely polluted will have scores of less than 50 (Stark 1993).

Table 1: Interpretation of MCI-type biotic indices (Stark and Maxted 2007).

Quality Class	MCI	QMCI
Excellent	>119	>5.99
Good	100-119	5.00-5.90
Fair	80-99	4.00-4.99
Poor	<80	<4.00

Other diversity biometrics also calculated included; taxonomic richness, Ephemeroptera, Plecoptera and Trichoptera (EPT) taxon richness, % EPT abundance and % EPT taxa richness. The EPT indices are also indicators of water quality as these species are pollution intolerant. High EPT scores will generally indicate good water quality (however it can also be related to substrate type). A low EPT score may indicate a sandy silt substrate rather than nutrient enriched conditions. Used in association with MCI an indication of the substrate influence can be assessed.

Temporal analyses of physico-chemical water quality parameters and biometric indices (within sites) were conducted using the non-parametric Mann-Kendall trend test within the computer program Time Trends (NIWA 2008). Trends were examined by computing a Mann-Kendall statistic, *S*, and associated *p*-value. Trends were considered to be significantly positive (i.e. increasing with time) or negative (i.e. decreasing with time) if the probability (two-sided *p*-value) of rejecting a correct hypothesis (in this case, no trend) was ≤ 0.05, in other words testing at the 95% level of significance. Statistically significant trends were considered to be ecologically meaningful if the difference was more than 1% of the value per annum. Given the small number of observations small sample size probabilities were used to determine *p*-values.

3. RESULTS

3.1 WATER QUALITY

3.1.1 PRESENT SURVEY

Field measured water quality parameters were consistent with those typical for moderately disturbed upland rivers and are detailed in Table 2.

Table 2: Field measured water quality parameters at monitoring sites in the Porangahau Stream during the present survey (2018), and relevant ANZECC default trigger levels (chemical stressors) for a slightly disturbed upland river.

Site Description Site ID	Upstream reference site site 397	Downstream site site 2431	Alternative Downstream site	ANZECC guidelines
Sample Time (hrs)	1147	1248	1310	
Water depth (m)	0.15	0.1	0.14	
pH (units)	8.258	8.264	8.689	7.3 – 8.0
Temperature (°C)	19.1	21.7	20.8	
Conductivity (µS/cm)	365	331	330	
DO (mg/L)	12.25	9.24	9.86	
DO % Sat.	133.1	105.8	111.1	99 - 103

pH

Relevant water quality guideline trigger values for pH specify a range between 7.3 – 8.0 for upland rivers (ANZECC 2000). At all sites pH values were slightly alkaline and were elevated compared to those specified in the ANZECC guidelines. Generally there was a pattern of increasing pH with distance downstream.

TEMPERATURE

To ensure the functioning of aquatic ecosystems the Hawke's Bay Regional Resource Management Plan (RRMP) (HBRC 2006) specifies that a discharge must not change natural water temperatures by more than 3°C, nor be raised above 25°C after reasonable mixing. Temperature increased by 2.6°C between the upstream and downstream sites and then cooled slightly between the downstream and alternative downstream site (Table 2).

CONDUCTIVITY

Conductivity is an indirect measure of the presence of dissolved solids such as chloride, nitrate, sulphate, phosphate, sodium, magnesium, aluminium, calcium, and iron, and can be used as an indicator of water pollution. The moderately low load of ions decreases slightly from upstream to downstream suggesting some uptake of dissolved nutrients between sites (moving downstream). In general these results are typical of upland mesotrophic waters (Table 2).

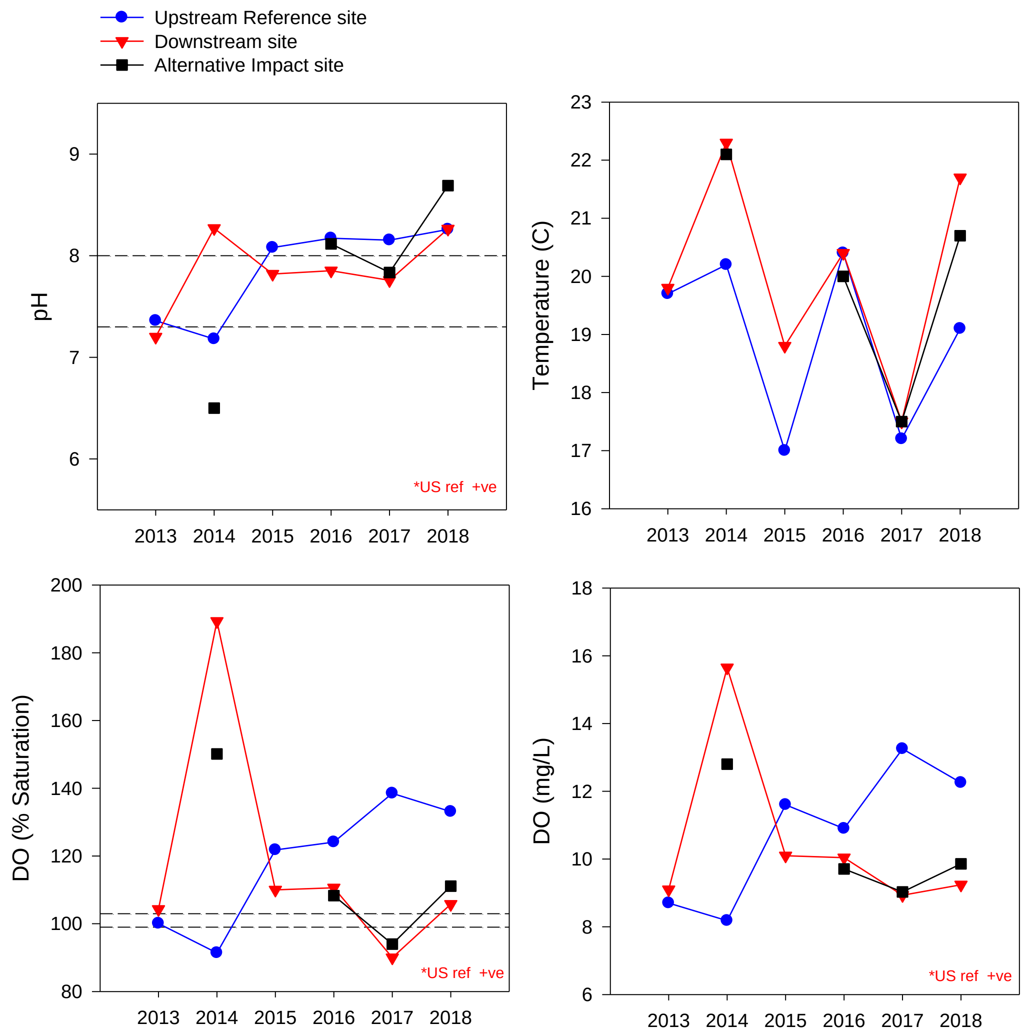
DISSOLVED OXYGEN

Prior to interpretation of dissolved oxygen data it is important to note weather conditions, season, and evidence of water stratification at the time of sampling.

During the present survey overhead conditions were clear and sunny (cloud cover ~10%). Time of sampling, water depth and DO results are detailed in Table 2. Measured levels at all sites were outside the range of ANZECC guidelines for upland rivers, with all sites higher than the specified range. These results tend to reflect the contribution to instream DO from the large quantity of long green filamentous algae at all sites. Although an early morning measurement of DO was not taken on the day of the present survey, in previous years when a DO minima has been measured, it was around 40% lower at all sites in the early morning. At the likely DO minima levels the risk of impairment to fish populations would be minimal, however, in terms of macroinvertebrates, some of the most sensitive species, e.g. EPT species, may not be fully protected such that small shifts in community composition could occur

3.1.2 INTERSURVEY COMPARISON

Inter-survey variability of physico-chemical water quality parameters are shown in Figure 2. The important points to look for are within site variability between years and whether or not any trends are apparent. In general, among all sites inter-survey variability was highest at the alternative downstream site among pH, temperature, and conductivity while the highest level of variability in DO and % DO saturation was observed at the downstream site. Trend testing of parameters among sites found significant trends at the upstream reference site only. These were in pH (*p* = 0.028, 2.4% annual change), DO (*p* = 0.028, 9% annual change), and % DO saturation (*p* = 0.008, 7.8% annual change).



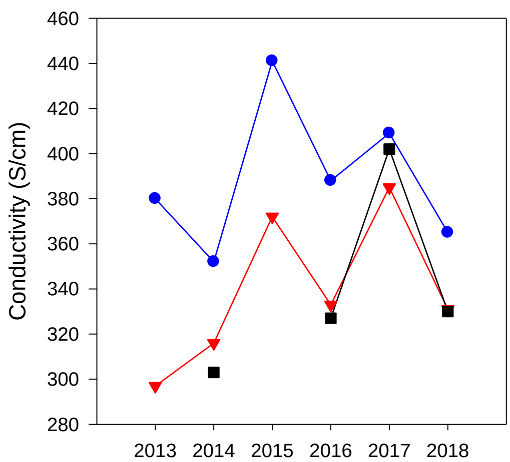


FIGURE 2: TEMPORAL COMPARISON OF PHYSICO-CHEMICAL WATER QUALITY PARMETERS AT MONITORING SITES IN THE PORANGAHAU STREAM. DASHED LINES INDICATE DEFAULT TRIGGER VALUES (UPPER AND LOWER LIMITS), CHEMICAL STRESSORS, FOR SLIGHTLY-MODERATELY DISTURBED UPLAND RIVERS (ANZECC 2000). STATISTICALLY SIGNIFICANT TRENDS ARE MARKED WITH AN ASTERISK {*) WITH DIRECTION OF TREND; POSITIVE (+VE) OR NEGATIVE (–VE), ALSO SHOWN.

3.2 MACROINVERTEBRATE COMMUNITY

3.2.1 PRESENT SURVEY

A complete list of benthic macroinvertebrate data from the present survey is included in Appendix 2. The percentages of major groups of taxa that comprise the community at each site are presented in Figure 3. Diversity biometrics for each site calculated from this data including number of taxa at each site (taxa richness), MCI, QMCI, number of EPT taxa, % EPT abundance and % EPT taxa are presented in Figure 4. Observations of other fauna during sampling included freshwater crayfish (*Paranephrops planifrons*) at the downstream site, and numerous *Gobiomorphus basalis*. Three of these fish were caught while collecting the macroinvertebrate sample from the upstream site while two were caught at the alternative downstream site.

Despite the differing physical characteristics of the upstream reference site and the downstream site the macroinvertebrate communities at these sites were fairly similar in the present survey (Figure 3). Principal differences were largely a result of a slightly higher proportion of mayflies (Ephemeroptera) mostly *Deleatidium* spp. and crustaceans at the downstream site, and higher proportions of caddisflies (Trichoptera) and molluscs at the upstream reference site.

Examining the macroinvertebrate community at the alternative downstream site it was evident that caddisflies were dominant, followed by mayflies, then molluscs then crustaceans (Figure 3). In comparison the upstream reference site was dominated by mayflies, then caddisflies, then crustaceans then molluscs.

it is worthwhile noting that the most frequently occurring Ephemeropteran at the downstream site was the Hydroptilid mayfly *Oxyethira* which is regarded as tolerant of organic pollution and are more common in soft sediment areas or degraded stream environments. Similarly, Muscid larvae, also more common at degraded sites, were reasonably common at both the downstream and alternative downstream sites but were not encountered at the upstream reference site.

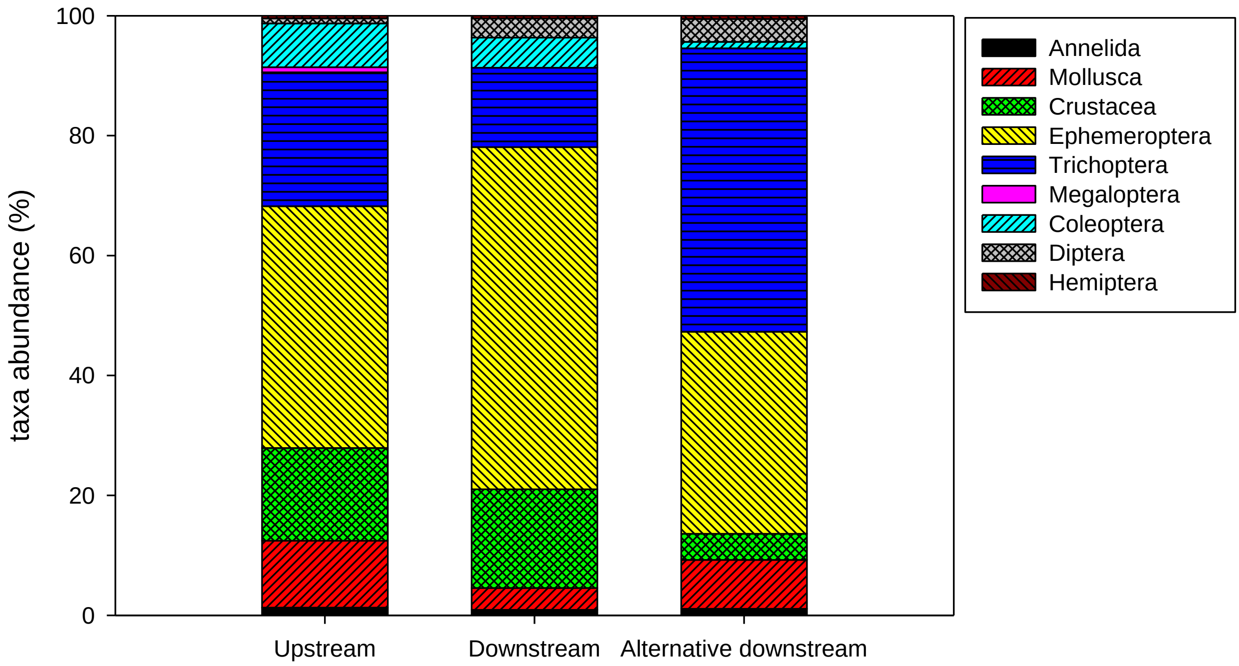


FIGURE 3: MAJOR MACROINVERTEBRATE TAXA GROUPS AT MONITORING SITES IN THE PORANGHAU STREAM DURING THE PRESENT SURVEY (2018).

Examining the various biometric indices, overall taxa diversity among all sites was moderate with 19 genera recorded at the upstream reference site, 18 at the downstream site and 20 at the alternative downstream site (Figure 4a). This level of diversity is indicative of a fair-moderately healthy system, with typically productive ecosystems having taxa numbers between 20 & 30.

This overall diversity included moderately high abundances and diversity of EPT taxa with 9 genera encountered at each site (Figure 4d,e,f). Of particular note was the large proportion of *Deleatidium* mayflies that comprised the community at the downstream site. At these levels of EPT abundance and taxa numbers all sites would be considered reasonably healthy with an EPT taxa richness >5 indicating a healthy assemblage.

Given the consistency in the number of EPT taxa among sites it was not unexpected that MCI scores were also very similar, with scores at the upstream reference site and downstream site falling within the lower range of the "good" category, while the alternative downstream site score fell within the upper range of the "fair" category. QMCI scores for these sites were rated as "good" for both the upstream reference site and the alternative downstream site and "excellent" for the downstream site (Figures 4b,c). An "excellent" rating is indicative of clean water, a "good" rating suggests water quality is doubtful or possible mild pollution is occurring, and a "fair" rating suggests there is probable moderate organic pollution occurring. These results provide evidence that organic enrichment occurring in the stream is mild-moderate, with the macroinvertebrate community typical of a middle reach stream of moderate flow that drains farmland.

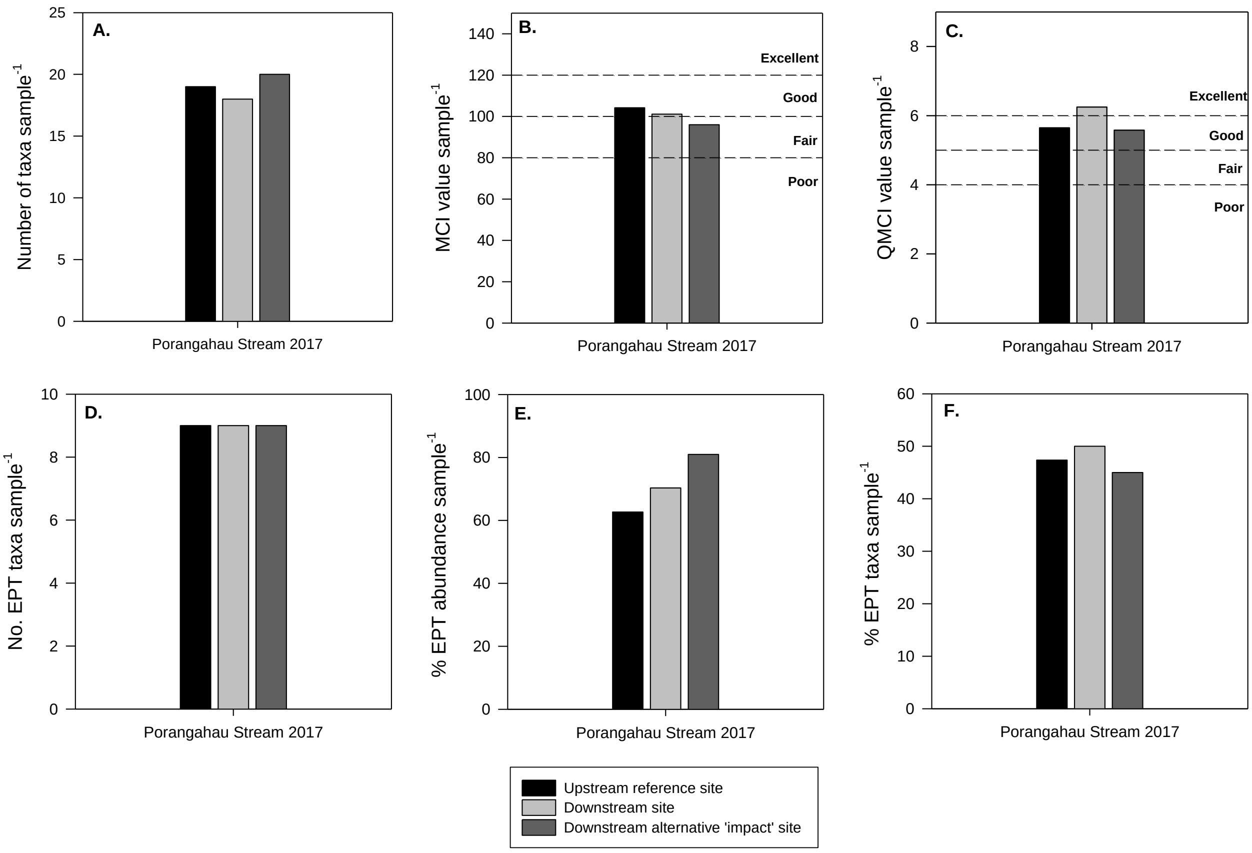


FIGURE 4: COMPARISON OF A) TAXA RICHNESS, B) MCI, C) QMCI, D) EPT TAXA RICHNESS, E) % EPT ABUNDANCE, AND F) % EPT TAXA RICHNESS AT MONITORING SITES IN THE PORANGAHAU STREAM DURING THE PRESENT SURVEY (2018).

3.2.2 INTER-SURVEY COMPARISON

The percentages of major groups of taxa that comprise the community at each site for each year are presented in Figure 5.

Examining temporal change in dominant taxa groups it is clear that the upstream reference site is the least variable in terms of proportions and rankings while both the downstream site and alternative downstream site display a pattern of variability in proportions and rankings of groups over time (Figure 5). As stress is generally considered to increase variability the increased variability suggests these sites are subject to higher levels of stress than the upstream reference site.

Trend testing of taxa group proportions was also conducted for each site. Despite the apparent stability of the community at the upstream reference site significant positive (increasing) trends were estimated for both the Mollusca and Trichoptera groups (both p = 0.028). No other trends among other sites or groups were detected.

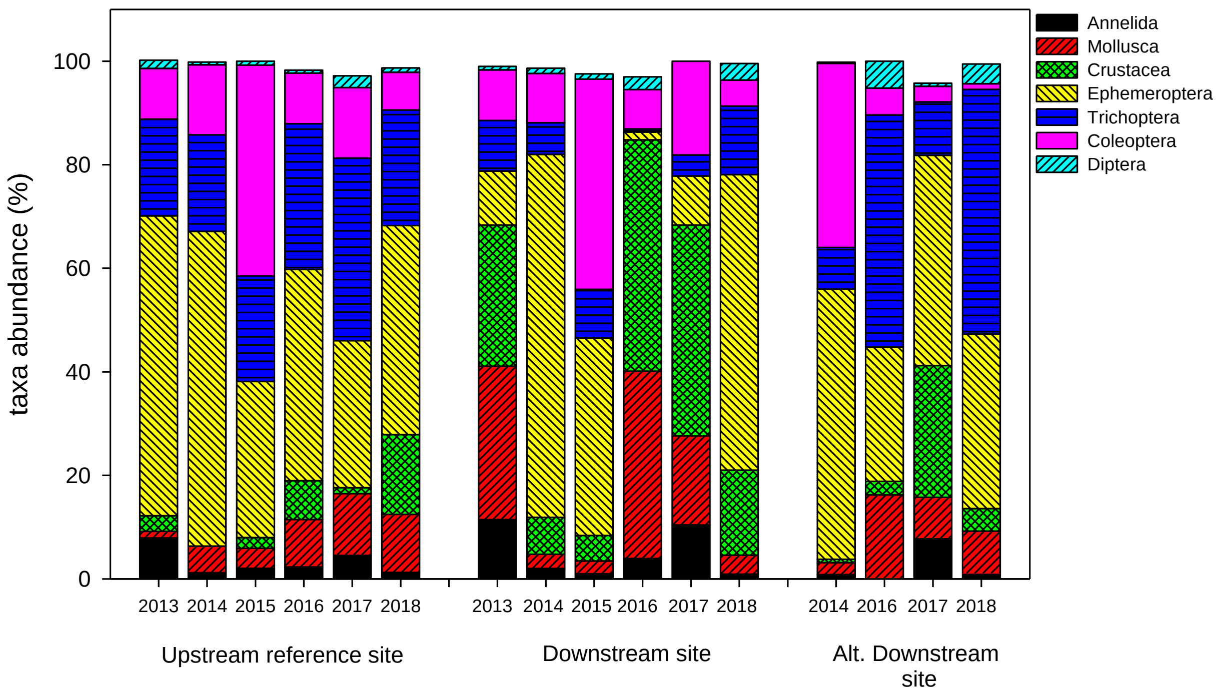


FIGURE 5: COMPARISON OF MAJOR MACROINVERTEBRATE TAXA GROUPS BETWEEN YEARS AT THE UPSTREAM REFERENCE SITE, DOWNSTREAM SITE, AND ALTERNATIVE DOWNSTREAM SITE IN THE PORANGAHAU STREAM.

The comparison of biometric indices between years is shown in Figure 6.

As with the temporal comparison of major taxa groups the comparison of biometric indices shows increased inter-survey variability at the downstream and alternative downstream site compared to the upstream reference site. Trend testing detected only one significant trend among sites and indices; a negative/decreasing trend at the upstream reference site in the QMCI (p = 0.008). The decrease was estimated at 4.9%/year.

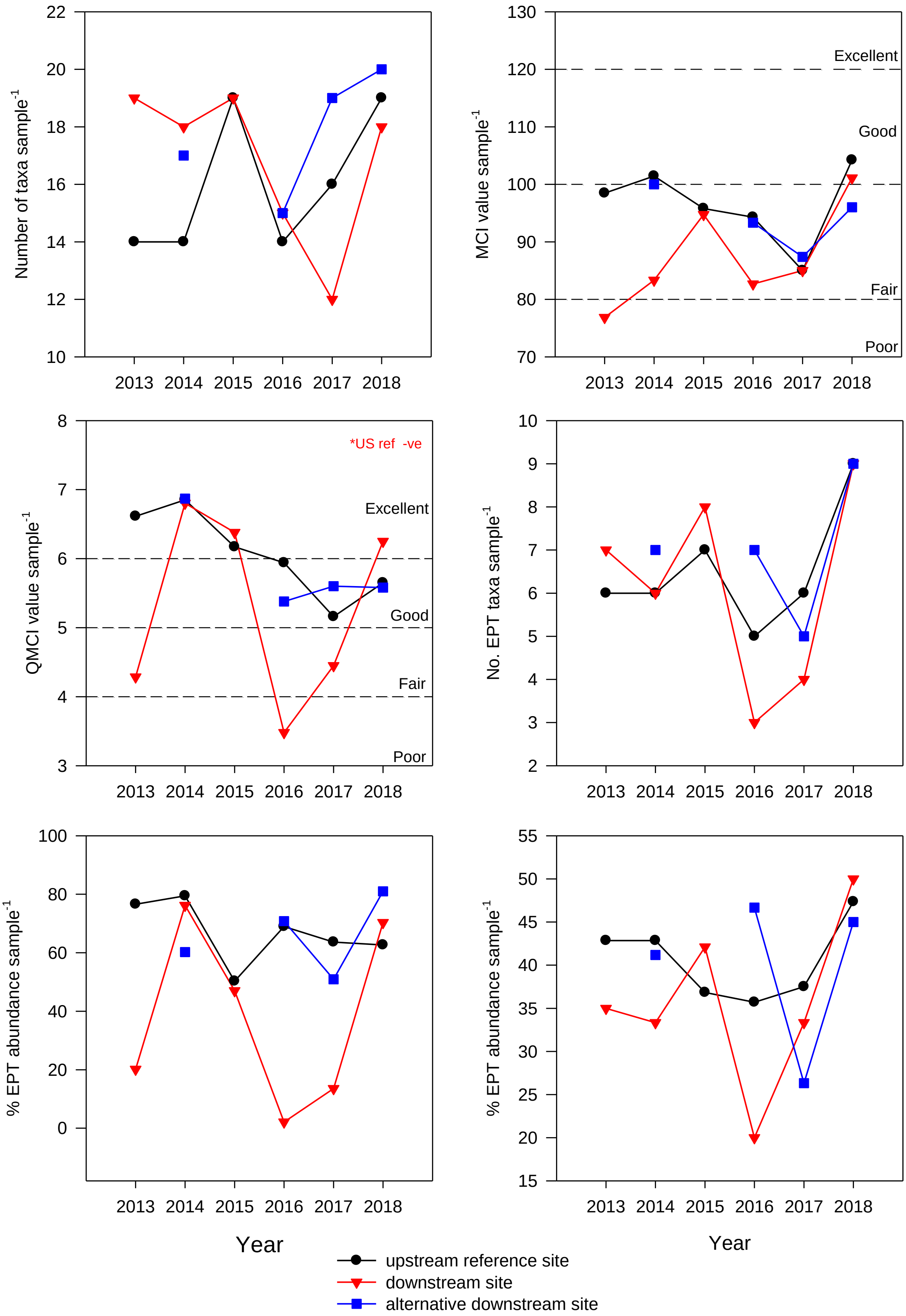


FIGURE 6: TEMPORAL COMPARISON OF TAXA RICHNESS, MCI, QMCI, EPT TAXA RICHNESS, % EPT ABUNDANCE, AND % EPT TAXA RICHNESS AT THE UPSTREAM REFERENCE SITE, DOWNSTREAM AND ALTERNATIVE DOWNSTREAMM SITES IN THE PORANGAHAU STREAM. STATISTICALLY SIGNIFICANT TRENDS ARE MARKED WITH AN ASTERISK (*) WITH DIRECTION OF TREND; POSITIVE (+VE) OR NEGATIVE (–VE), ALSO SHOWN.

4. DISCUSSION

The Silver Fern Farms, Takapau discharge to land is an existing activity subject to compliance with a number of resource consent conditions set out in the discharge permits DP981043Ld and DP981044Ad. One of these conditions requires annual monitoring of macroinvertebrate communities. The purpose of the monitoring is to assess the effects of the discharge to land on the receiving environment of the Porangahau Stream.

The approach used was an upstream/downstream comparison of physico-chemical water quality parameters and macroinvertebrate communities incorporating biometric indices including the MCI and QMCI. In adopting a recommendation from the 2013 report, an alternative downstream monitoring site was also sampled during this survey and included in the comparison. Physical characteristics of this site were more similar to the upstream reference site, compared to the original downstream monitoring site reducing the confounding effects on community assemblage from differences in site characteristics allowing a more robust assessment of the effects of the discharge to be made.

WATER QUALITY

Stream levels were at or near low flow levels during the day of the survey. Water quality results among sites suggest that the Porangahau Stream as a whole is mesotrophic, i.e. moderately productive and mildly degraded. The extensive growth of periphyton and submerged filamentous green algae at all sites provides additional support to this classification of the stream. Measured pH and DO levels were elevated compared to national water quality guidelines with these findings suggested to be a result of the large quantities of filamentous green algae observed at all sites. Moreover DO at the upstream reference site was elevated compared to the downstream sites, with this difference potentially of ecological significance. There are a number possible explanations for the difference in DO between sites, though it is suggested this is a reflection of a combination of low stream levels, and thus increased aeration and high cover of submerged filamentous algae at the upstream site. The positive, or increasing, trends in pH, absolute DO and DO % saturation at the upstream site does suggest that either aeration or submerged algae or both are increasing over time. This may suggest a general deterioration of water quality at the reference site, and consequently among downstream sites as well. In the case that the submerged algae are increasing over time, at the likely DO minima levels among all sites the risk of impairment to fish populations would be minimal, however, in terms of macroinvertebrates, some of the most sensitive species, e.g. EPT species, may not be fully protected such that small shifts in community composition could occur.

It must be noted that the estimate of significant trends should be regarded with some caution given the low number of observations, however this is the second year running that a positive trend has been detected in DO parameters at the upstream reference site.

MACROINVERTEBRATE COMMUNITY

Community composition at the upstream reference site and the downstream site were similar despite the very different physical characteristics of the sites. At both sites communities were dominated by mayflies, caddisflies and crustaceans. The alternative downstream site, which better matches the physical characteristics of the upstream reference site, also had a community resembling those of the other sites but had a much higher proportion of caddisflies. The similarity in taxa composition, and particularly the number of EPT taxa between sites, was also largely reflected among the various biometric indices, with little differences evident in taxa diversity, MCI, QMCI, EPT abundance or EPT taxa diversity between sites.

These results tend to suggest sites remain reasonably healthy in terms of macroinvertebrate community, with the MCI ratings of “fair-good” among sites suggesting mild-moderate organic pollution occurring.

Given the different physical characteristics of the upstream reference site and alternative downstream site to the downstream site and the influence these different characters have on macroinvertebrate community structure, the similarity in community composition and biometric scores between sites suggests some other overriding factor, aside from the discharge to land, influencing results.

Despite the reasonably healthy system and current lack of evidence of significant adverse effects from the Silver Fern Farms discharge to land on stream health there is evidence to suggest a general deterioration in stream health of the Porangahau Stream. This includes; increasing pH and DO parameters at the upstream reference site, and increasing proportions of molluscs and trichopterans and a decreasing trend in the QMCI, also at the upstream reference site.

5. CONCLUSION

The moderately productive and mildly degraded Porangahau Stream is suggested to be deteriorating in health, as a whole, as evidenced by the decline in QMCI scores as well as increasing pH and DO parameters and unusually extensive cover of submerged algae at the upstream reference site. Despite the deterioration the overall health of the stream remains at a reasonable level with a moderately diverse assemblage of species including good numbers of sensitive EPT taxa at all monitoring sites. Adverse effects from the Silver Fern Farms discharge to land therefore are considered to be no more than minor on macroinvertebrate communities and stream health of the Porangahau Stream. However it must be stressed that cumulative effects from catchment wide sources of contaminants, particularly organic constituents are apparent, with this being the second consecutive annual monitoring round where this had been noted.

6. REFERENCES

ANZECC (2000). Australian and New Zealand guidelines for fresh and marine water quality 2000, Volume 1., National Water Quality Management Strategy Paper No. 4. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

HBRC (2006). Hawke's Bay Regional Resource Management Plan Operative 28 August 2006.

NIWA (2008). Time Trends, Ian Jowett**:** Analysis of trends in water quality data.

Smith, S. (2013). Macroinvertebrate monitoring atsites in the Porangahau Stream adjcent to Silver Fern Farms Takapau: 2013 survey, Triplefin Environmental Consulting.

Smith, S. (2014). Macroinvertebrate monitoring atsites in the Porangahau Stream adjcent to Silver Fern Farms Takapau: 2014 survey, Triplefin Environmental Consulting.

Smith, S. (2015). Macroinvertebrate monitoring atsites in the Porangahau Stream adjcent to Silver Fern Farms Takapau: 2015 survey, Triplefin Environmental Consulting.

Smith, S. (2016). Macroinvertebrate monitoring atsites in the Porangahau Stream adjcent to Silver Fern Farms Takapau: 2016 survey, Triplefin Environmental Consulting.

Smith, S. (2017). Macroinvertebrate monitoring atsites in the Porangahau Stream adjcent to Silver Fern Farms Takapau: 2017 survey, Triplefin Environmental Consulting.

Stark, J. D. (1993). "Performance of the Macroinvertebrate Community Index: effects of sampling method, sample replication, water depth, current velocity, and substratum on index values. ." New Zealand Journal of Marine and Freshwater Research **27**: 463-478.

Stark, J. D., I. K. G. Boothroyd, et al. (2001). Protocols for sampling macroinvertebrates in wadeable streams. New Zealand Macroinvertebrate Working Group Report No. 1. Project No. 5103. , Prepared for the Ministry for the Environment. Sustainable Management Fund 57 p.

Stark, J. D. and J. R. Maxted (2007). A user guide for the Macroinvertebrate Community Index. Prepared for the Ministry for the Environment. Nelson, Cawthron**:** 58 pp.

APPENDIX ONE

SITE PHOTOS

PLATE A1-2: UPSTREAM REFERENCE SITE INCLUDING VIEW LOOKING UPSTREAM AND SUBSTRATE OF SAMPLING SITE.

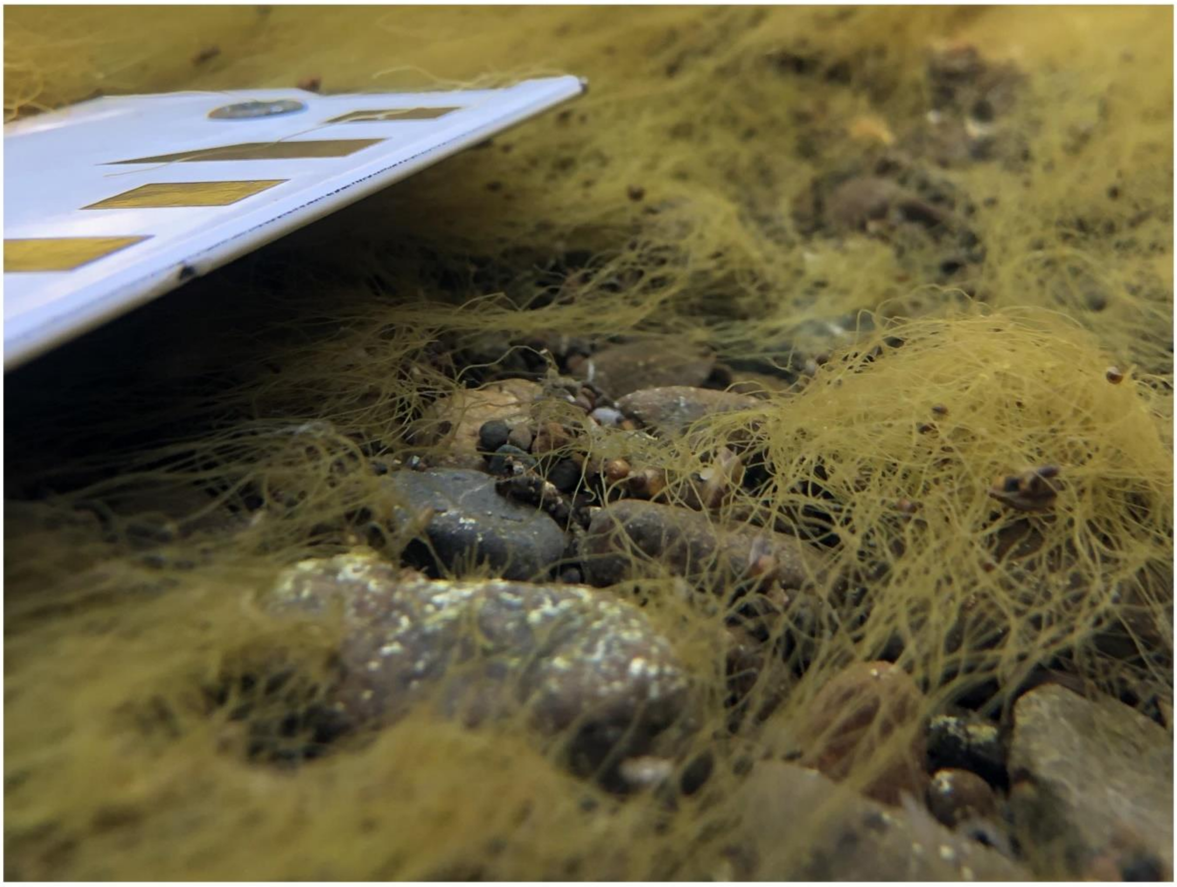


PLATE A1-2: DOWNSTREAM SITE INCLUDING VIEW LOOKING UPSTREAM AND SUBSTRATE OF SAMPLING SITE.

PLATE A1-3: ALTERNATIVE DOWNSTREAM SITE INCLUDING VIEW LOOKING UPSTREAM AND SUBSTRATE OF SAMPLING SITE.

APPENDIX TWO

MACROINVERTEBRATE DATA:

General group	Taxa	MCI Score	Upstream Reference site 397	Downstream site 2431	Alternative downstream site
Ephemeroptera (Mayflies)	*Atalophlebioides* spp.	9	5	4	2
Ephemeroptera (Mayflies)	*Austroclima* spp.	9	1	5	5
Ephemeroptera (Mayflies)	*Austronella spp.*	7		1	
Ephemeroptera (Mayflies)	*Deleatidium* spp.	8	88	115	55
Trichoptera (Caddisflies)	*Aoteapsyche spp.*	4	32	7	38
Trichoptera (Caddisflies	*Hudsonema* spp.	6	2	4	
Trichoptera (Caddisflies	*Neurochorema* spp.	6	1		
Trichoptera (Caddisflies	*Oxythira* spp.	2		14	1
Trichoptera (Caddisflies	*Plectrocnemia* spp.	8			1
Trichoptera (Caddisflies	*Psilochorema* spp.	8	1	2	4
Trichoptera (Caddisflies	*Pycnocentrodes* spp.	5	14	2	42
Trichoptera (Caddisflies	*Triplectides* spp.	5	2		1
Coleoptera (Beetle)	Elmidae	6	17	11	2
Diptera (True Flies)	Orthocladiinae	2	2		1
Diptera (True Flies)	Tanytarsini	3			1
Diptera (True Flies)	Muscidae	3		7	5
Hemiptera (Bug)	*Anisops* spp.	5	1	1	1
Megaloptera (Dobsonflies)	*Archichauliodes* spp	7	2		
Ostracoda (Crustacea)	Unid. ostracod	3	35	22	7
Amphipoda (Crustacea)	*Paracolliope* spp	5	1	14	1
Gastropoda (Mollusc)	*Gyraulus* spp.	3	9	2	1
Gastropoda (Mollusc)	*Physella* spp.	3	8	5	9
Gastropoda (Mollusc)	*Potamopyrgus* spp.	4	9	1	5
Oligochaeta (unsegmented worm)	Unid. oligochaete	1	3	2	2
	NO. OF TAXA		**19**	**18**	**20**
	NO. OF INDIVIDUALS		**233**	**219**	**184**
	MCI		**104.21**	**101.11**	**96**
	QMCI		**5.85**	**6.25**	**5.58**

APPENDIX THREE

REPORT LIMITATIONS

Triplefin Consulting Ltd (Triplefin) has provided this Document, and is subject to the following limitations:

I. This Document has been prepared for the particular purpose outlined in Triplefin's proposal and no responsibility is accepted for the use of this Document, in whole or in part, in other contexts or for any other purpose.

II. The scope and the period of Triplefin's Services are as described in Triplefin’s proposal, and are subject to restrictions and limitations. Triplefin did not perform a complete assessment of all possible conditions or circumstances that may exist at the site referenced in the Document. If a service is not expressly indicated, do not assume it has been provided. If a matter is not addressed, do not assume that any determination has been made by Triplefin in regards to it.

III. Conditions may exist which were undetectable given the limited nature of the enquiry Triplefin was retained to undertake with respect to the site. Variations in conditions may occur between investigatory locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation and which have not therefore been taken into account in the Document. Accordingly, additional studies and actions may be required.

IV. In addition, it is recognized that the passage of time affects the information and assessment provided in this Document. Triplefin's opinions are based upon information that existed at the time of the production of the Document. It is understood that the services provided allowed Triplefin to form no more than an opinion of the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings, or any laws or regulations.

V. Any assessments made in this Document are based on the conditions indicated from published sources and the investigation described. No warranty is included, either express or implied, that the actual conditions will conform exactly to the assessments contained in this Document.

VI. Where data supplied by the Client or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted by Triplefin for incomplete or inaccurate data supplied by others.

VII. The Client acknowledges that Triplefin may have retained sub-consultants affiliated with Triplefin to provide Services for the benefit of Triplefin. Triplefin will be fully responsible to the Client for the Services and work done by all of its sub-consultants and subcontractors. The Client agrees that it will only assert claims against and seek to recover losses, damages or other liabilities from Triplefin and not Triplefin's affiliated companies, and their employees, officers and directors.

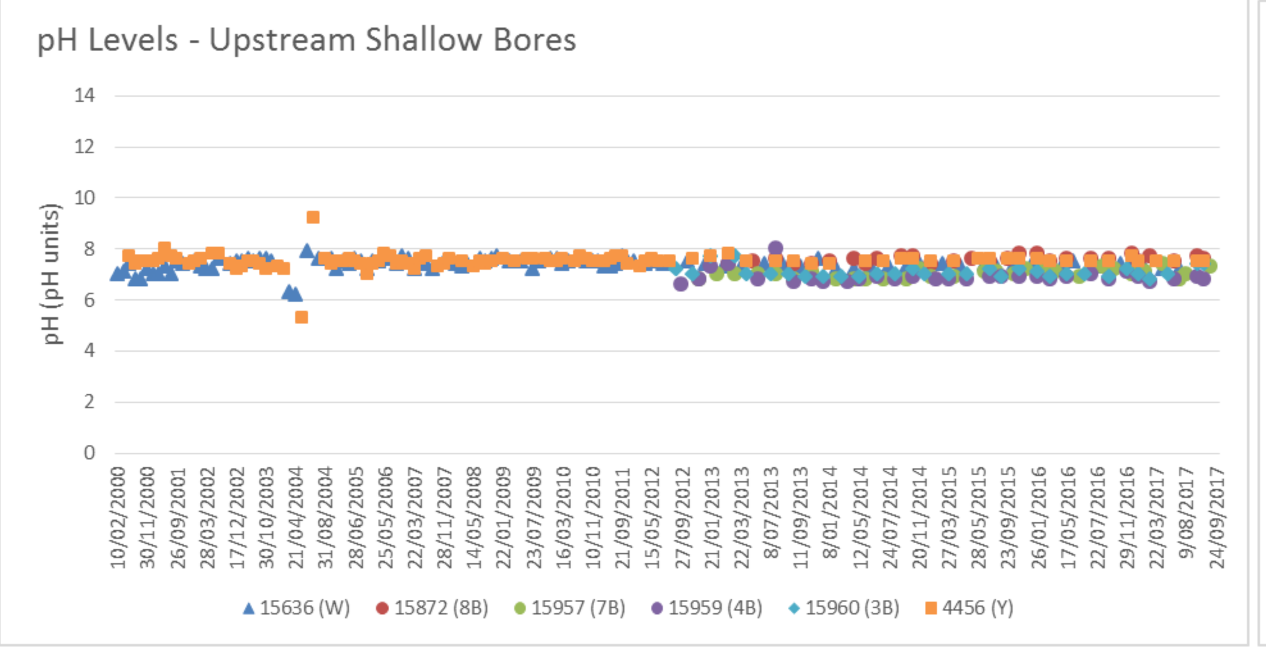
VIII. This Document is provided for sole use by the Client and is confidential to it and its professional advisers. No responsibility whatsoever for the contents of this Document will be accepted to any person other than the Client. Any use which a third party makes of this Document, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Triplefin accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this Document.

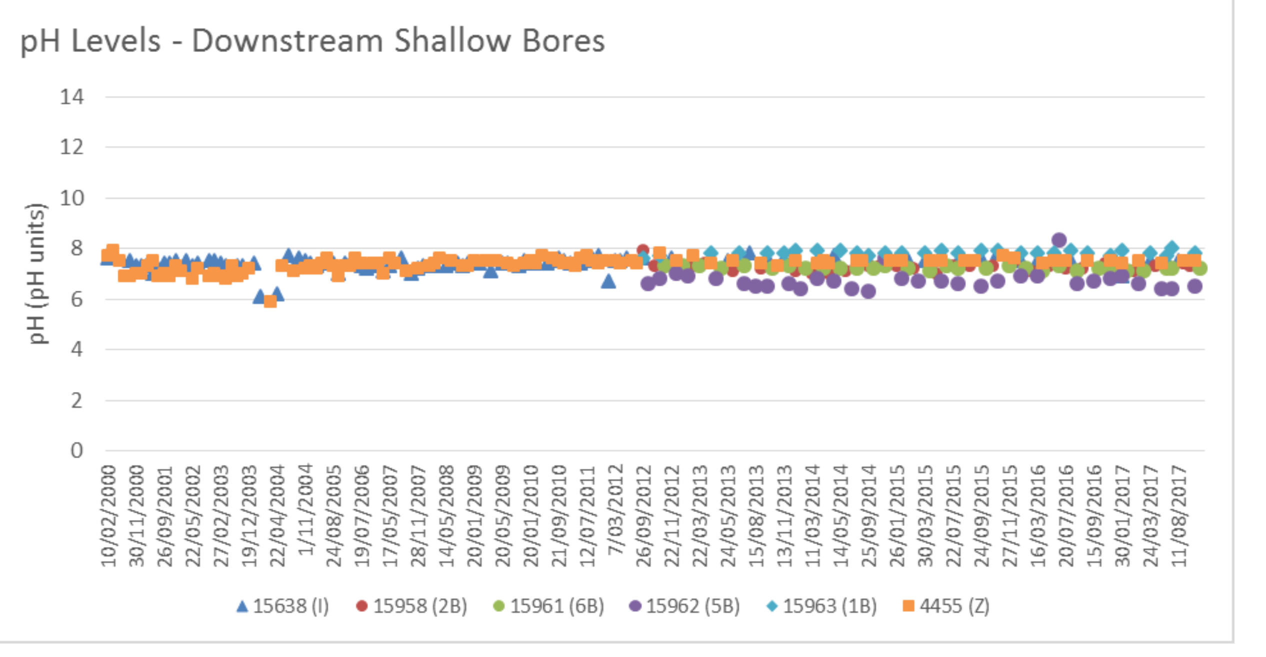
Appendix E

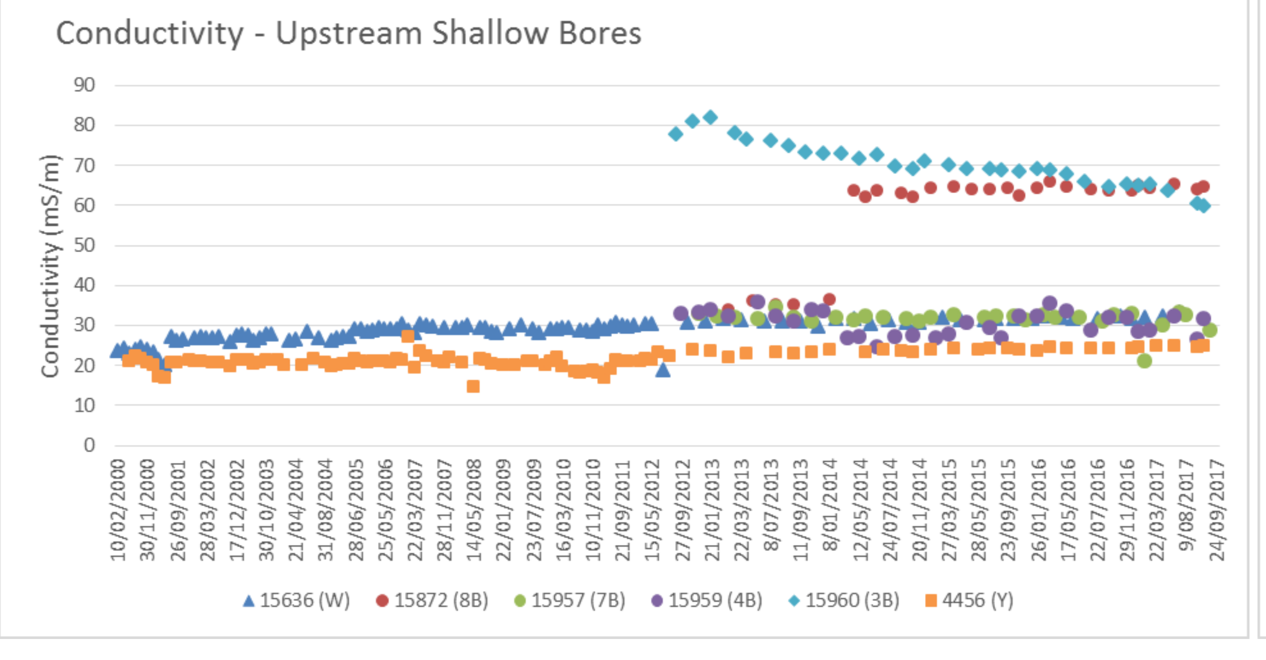
Silver Fern Farms Groundwater Sampling Results

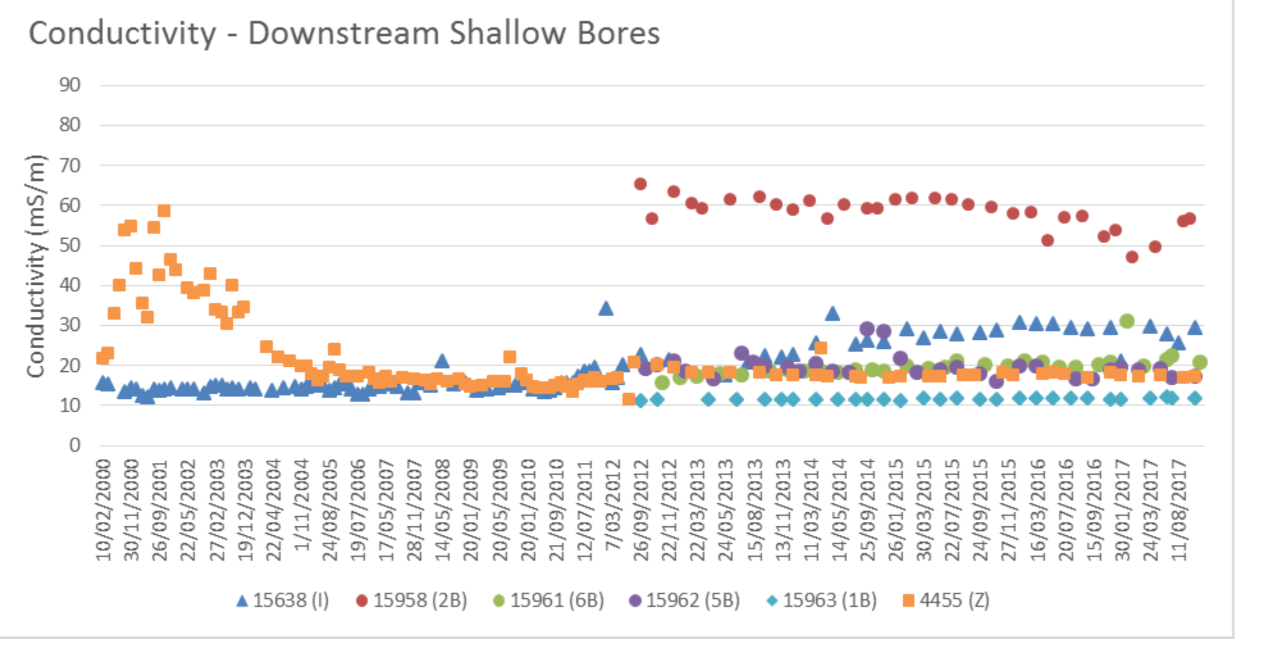
Appendix E: Silver Fern Farms Groundwater Sampling Results

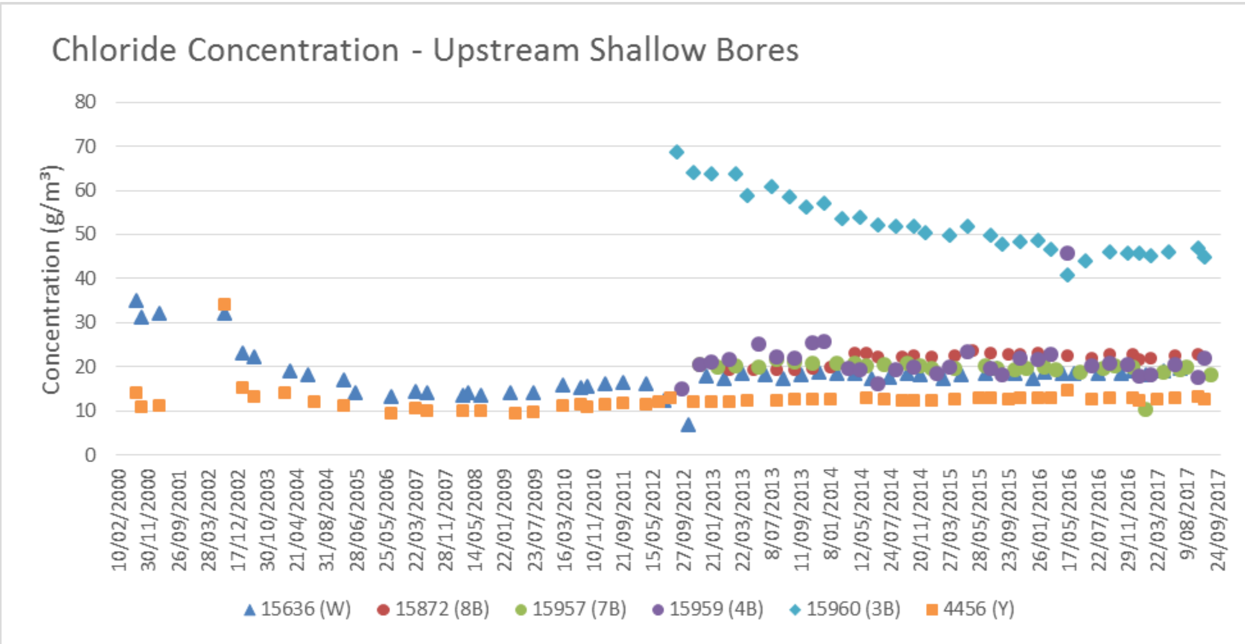
Shallow Bores

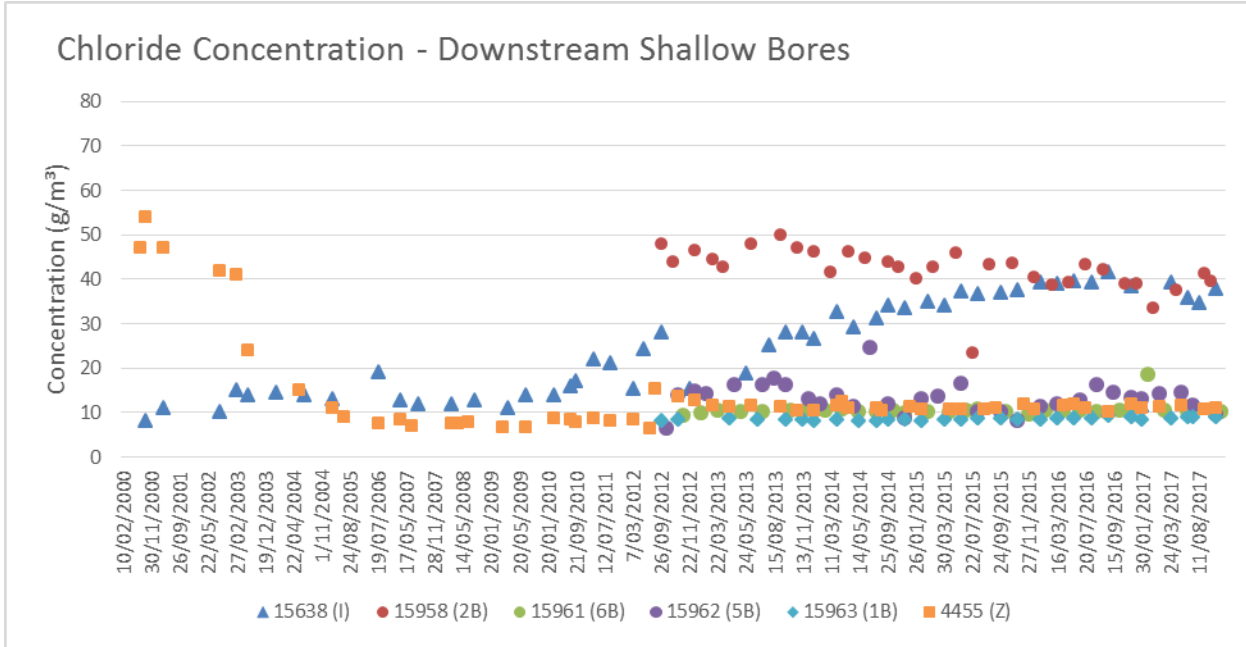


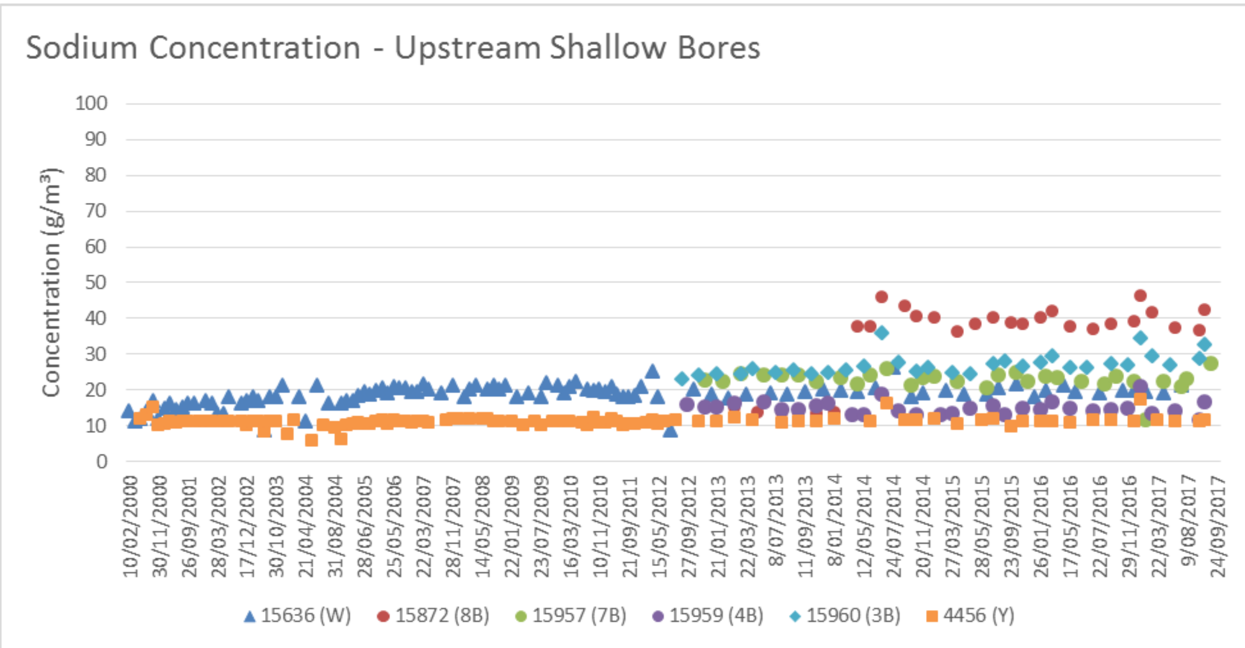


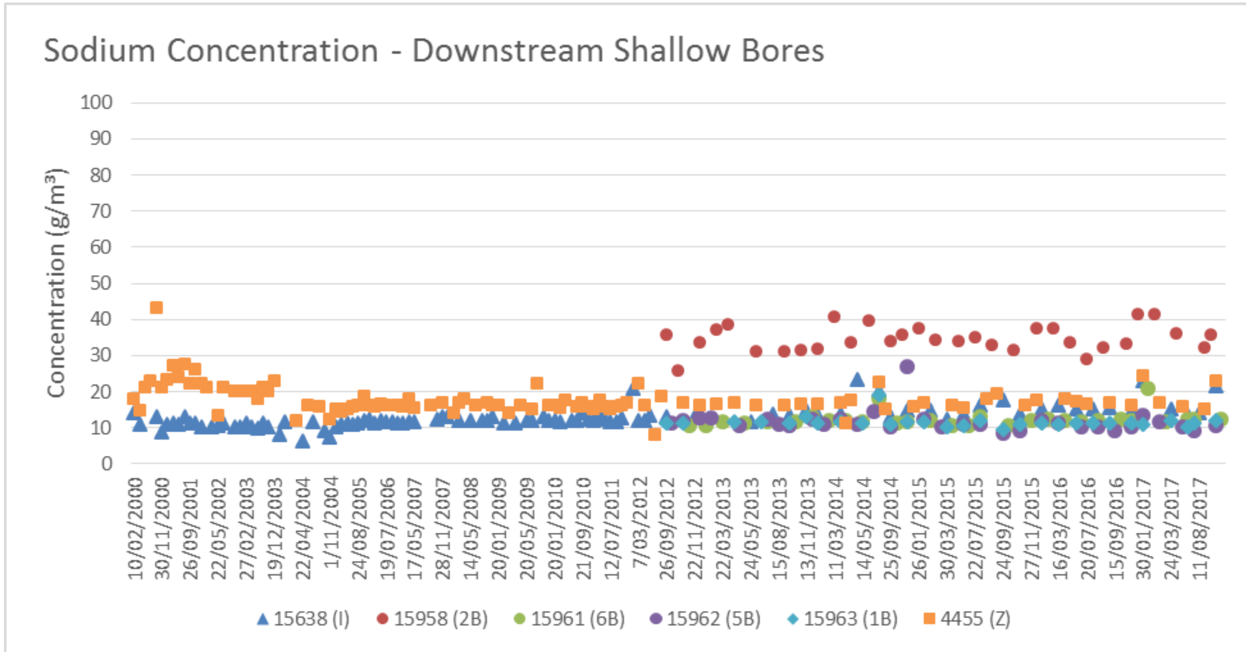


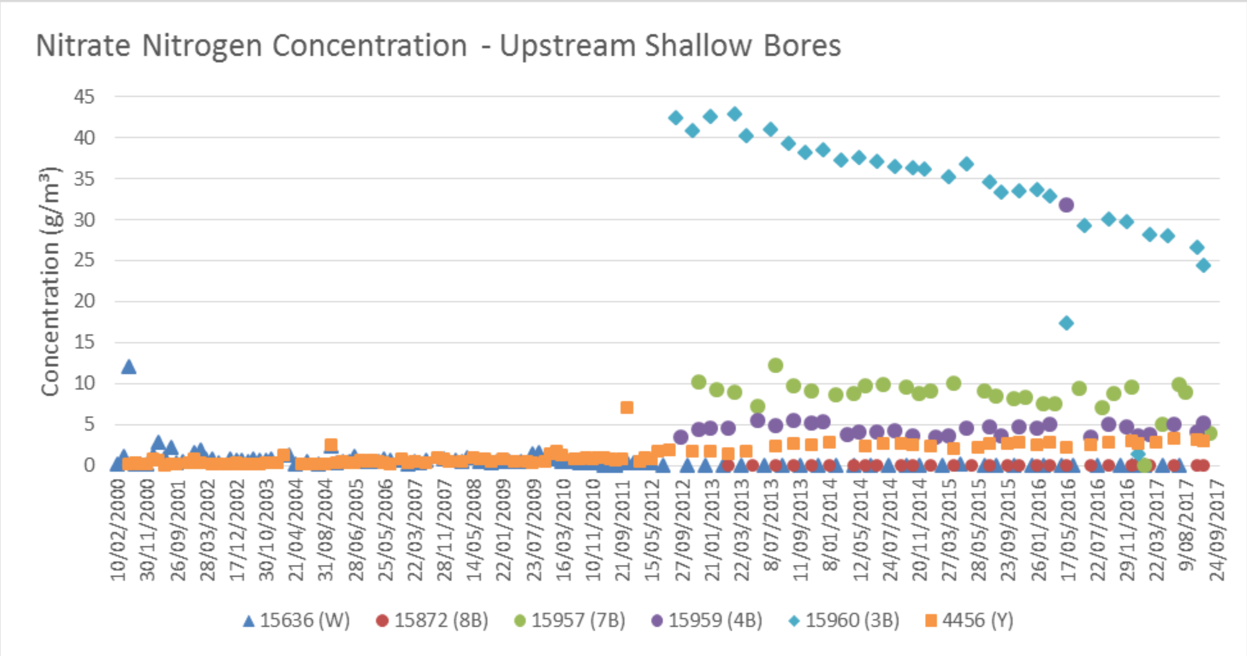


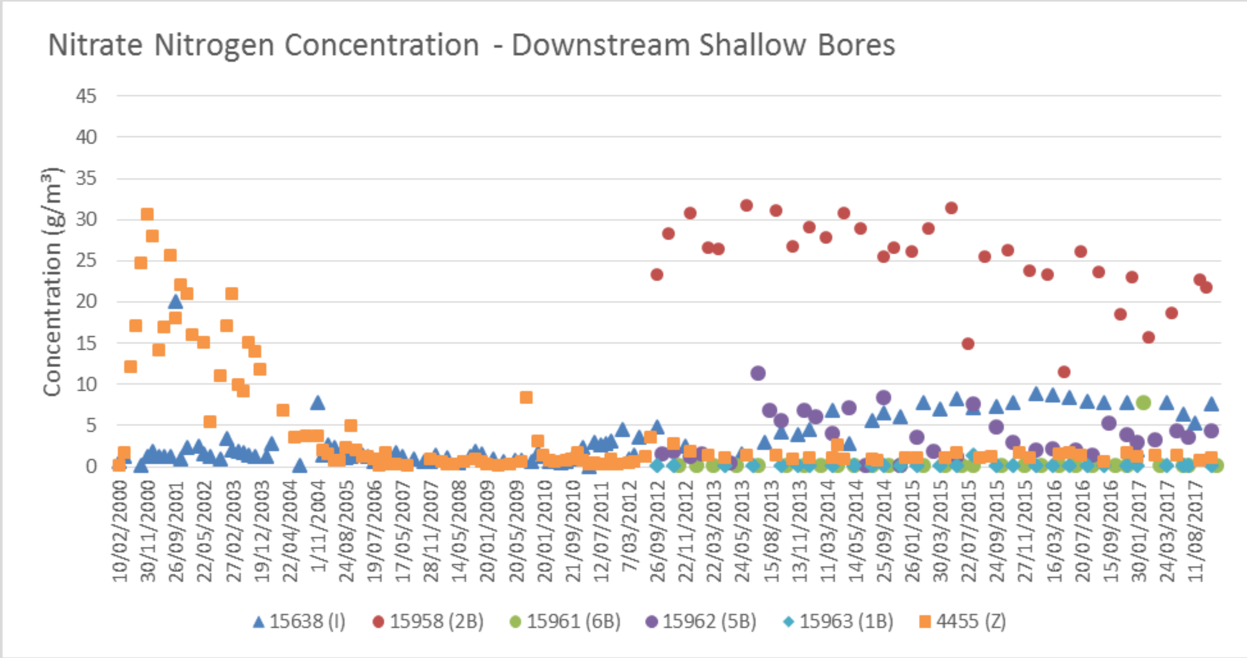

Chloride Concentration - Upstream Shallow Bores
Concentration (g/m³)
80
70
60
50
40
30
20
10
0
10/02/2000
30/11/2000
26/09/2001
28/03/2002
17/12/2002
30/10/2003
21/04/2004
31/08/2004
28/06/2005
25/05/2006
22/03/2007
28/11/2007
14/05/2008
22/01/2009
23/07/2009
16/03/2010
10/11/2010
21/09/2011
15/05/2012
27/09/2012
21/01/2013
22/03/2013
8/07/2013
11/09/2013
8/01/2014
12/05/2014
24/07/2014
20/11/2014
27/03/2015
28/05/2015
23/09/2015
26/01/2016
17/05/2016
22/07/2016
29/11/2016
22/03/2017
9/08/2017
24/09/2017
15636 (W)
15872 (8B)
15957 (7B)
15959 (4B)
15960 (3B)
4456 (Y)

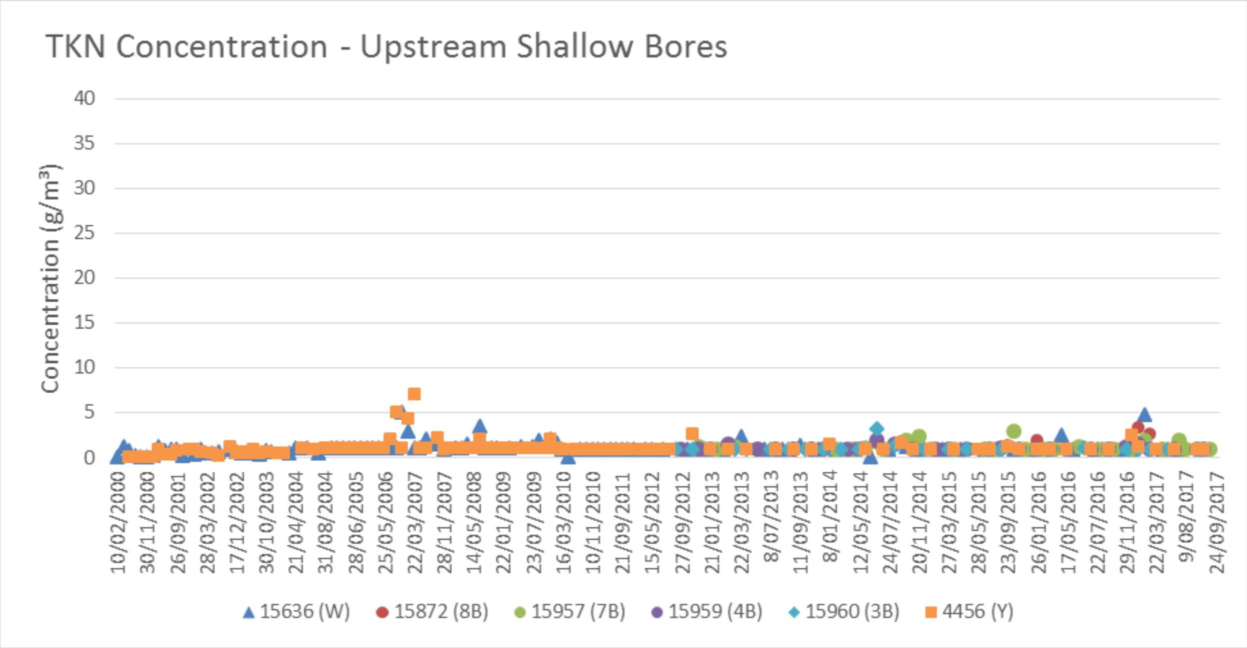

Chloride Concentration - Downstream Shallow Bores
Concentration (g/m³)
80
70
60
50
40
30
20
10
0
10/02/2000
30/11/2000
26/09/2001
22/05/2002
27/02/2003
19/12/2003
22/04/2004
1/11/2004
24/08/2005
19/07/2006
17/05/2007
28/11/2007
14/05/2008
20/01/2009
20/05/2009
20/01/2010
21/09/2010
12/07/2011
7/03/2012
26/09/2012
22/11/2012
22/03/2013
24/05/2013
15/08/2013
13/11/2013
11/03/2014
14/05/2014
25/09/2014
26/01/2015
30/03/2015
22/07/2015
24/09/2015
27/11/2015
16/03/2016
20/07/2016
15/09/2016
30/01/2017
24/03/2017
11/08/2017
15638 (I)
15958 (2B)
15961 (6B)
15962 (5B)
15963 (1B)
4455 (Z)

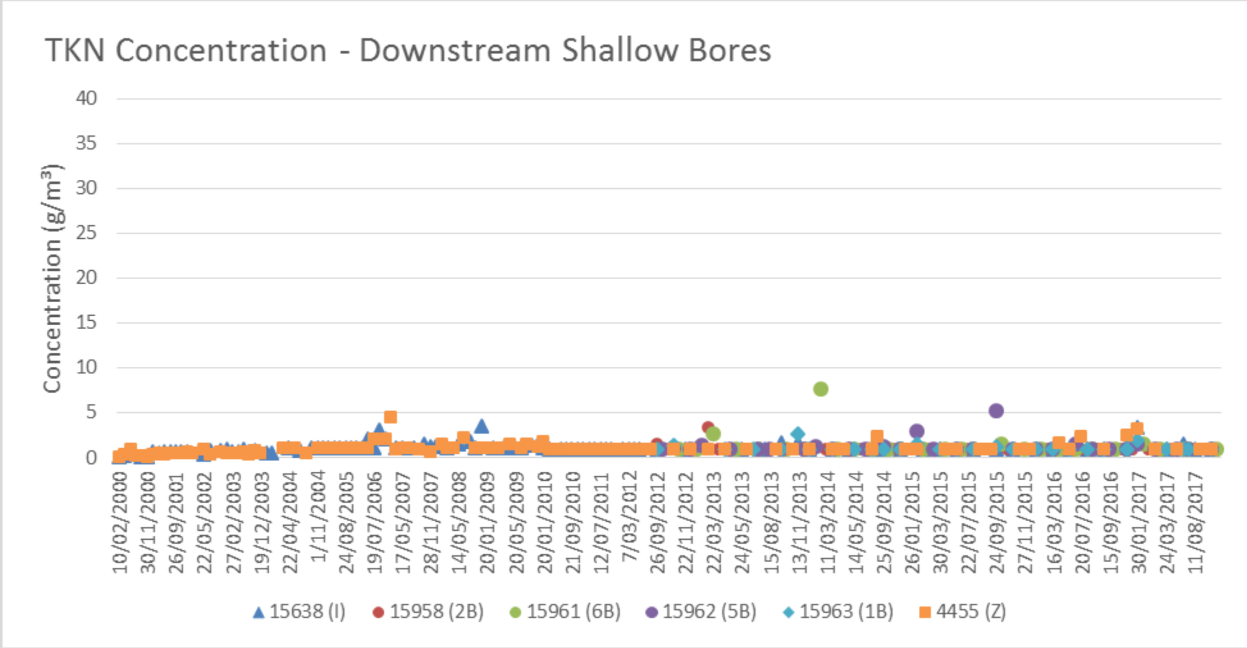

Sodium Concentration - Upstream Shallow Bores
Concentration (g/m³)
100
90
80
70
60
50
40
30
20
10
0
10/02/2000
30/11/2000
26/09/2001
28/03/2002
17/12/2002
30/10/2003
21/04/2004
31/08/2004
28/06/2005
25/05/2006
22/03/2007
28/11/2007
14/05/2008
22/01/2009
23/07/2009
16/03/2010
10/11/2010
21/09/2011
15/05/2012
27/09/2012
21/01/2013
22/03/2013
8/07/2013
11/09/2013
8/01/2014
12/05/2014
24/07/2014
20/11/2014
27/03/2015
28/05/2015
23/09/2015
26/01/2016
17/05/2016
22/07/2016
29/11/2016
22/03/2017
9/08/2017
24/09/2017
15636 (W)
15872 (8B)
15957 (7B)
15959 (4B)
15960 (3B)
4456 (Y)

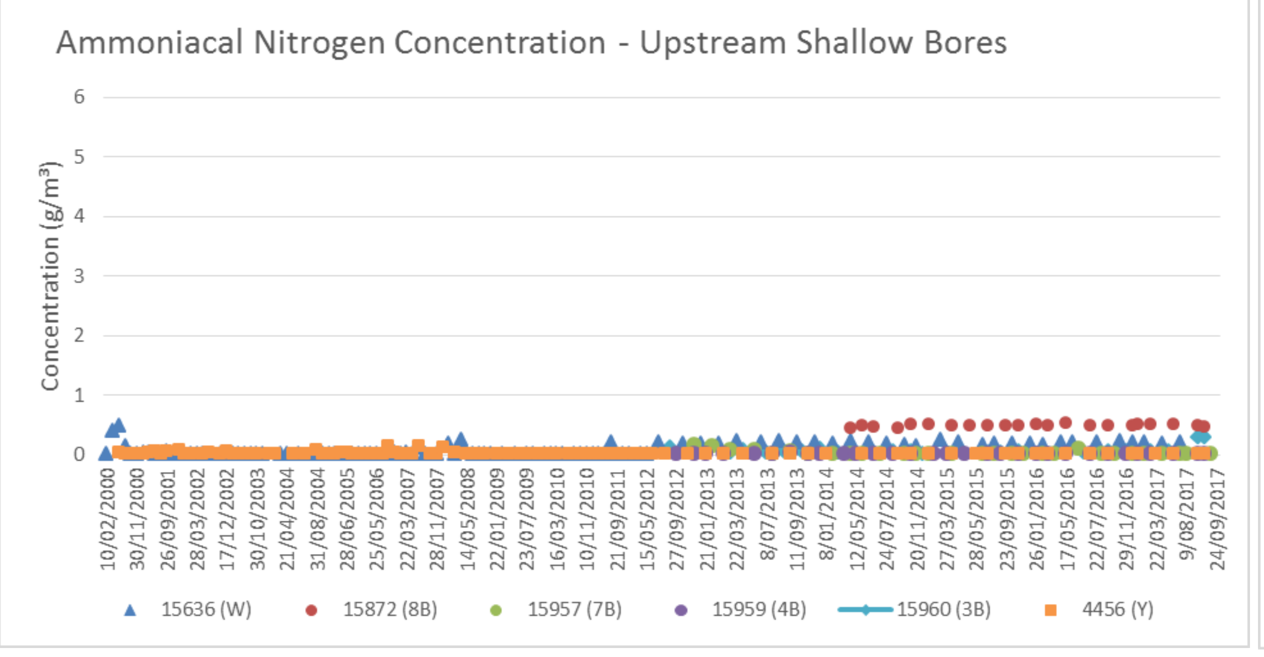

Sodium Concentration - Downstream Shallow Bores
Concentration (g/m³)
100
90
80
70
60
50
40
30
20
10
0
10/02/2000
30/11/2000
26/09/2001
22/05/2002
27/02/2003
19/12/2003
22/04/2004
1/11/2004
24/08/2005
19/07/2006
17/05/2007
28/11/2007
14/05/2008
20/01/2009
20/05/2009
20/01/2010
21/09/2010
12/07/2011
7/03/2012
26/09/2012
22/11/2012
22/03/2013
24/05/2013
15/08/2013
13/11/2013
11/03/2014
14/05/2014
25/09/2014
26/01/2015
30/03/2015
22/07/2015
24/09/2015
27/11/2015
16/03/2016
20/07/2016
15/09/2016
30/01/2017
24/03/2017
11/08/2017
15638 (I)
15958 (2B)
15961 (6B)
15962 (5B)
15963 (1B)
4455 (Z)

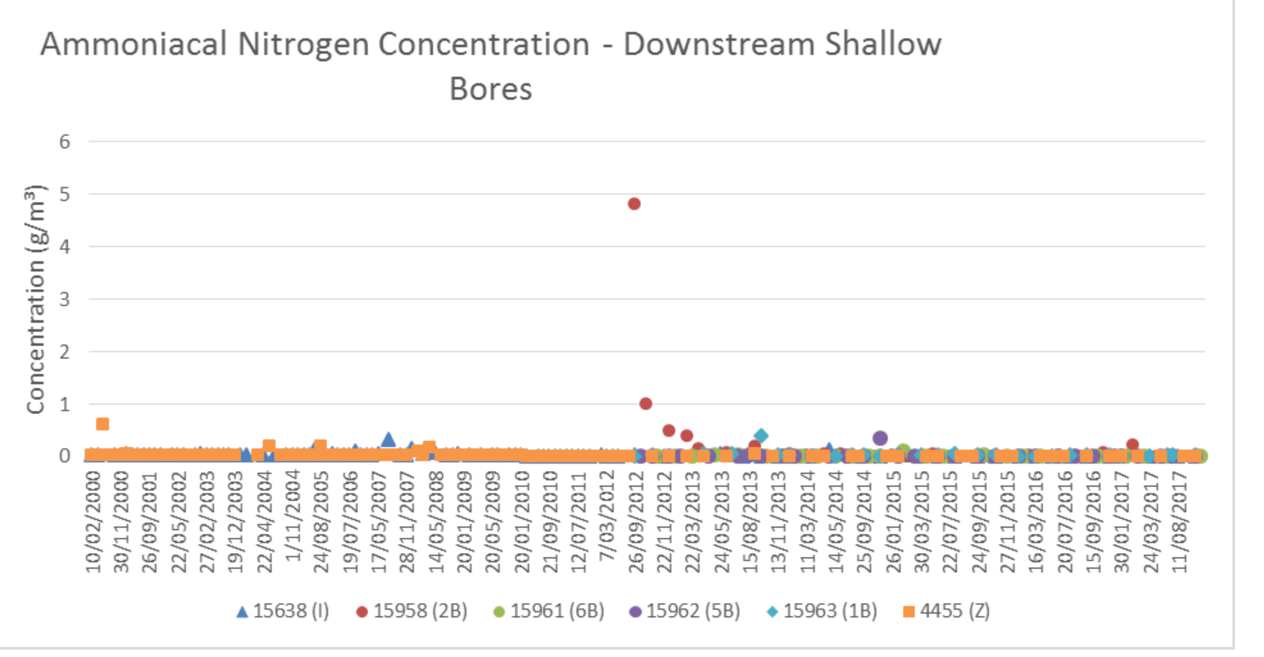

Nitrate Nitrogen Concentration - Upstream Shallow Bores
Concentration (g/m³)
15636 (W)
15872 (8B)
15957 (7B)
15959 (4B)
15960 (3B)
4456 (Y)

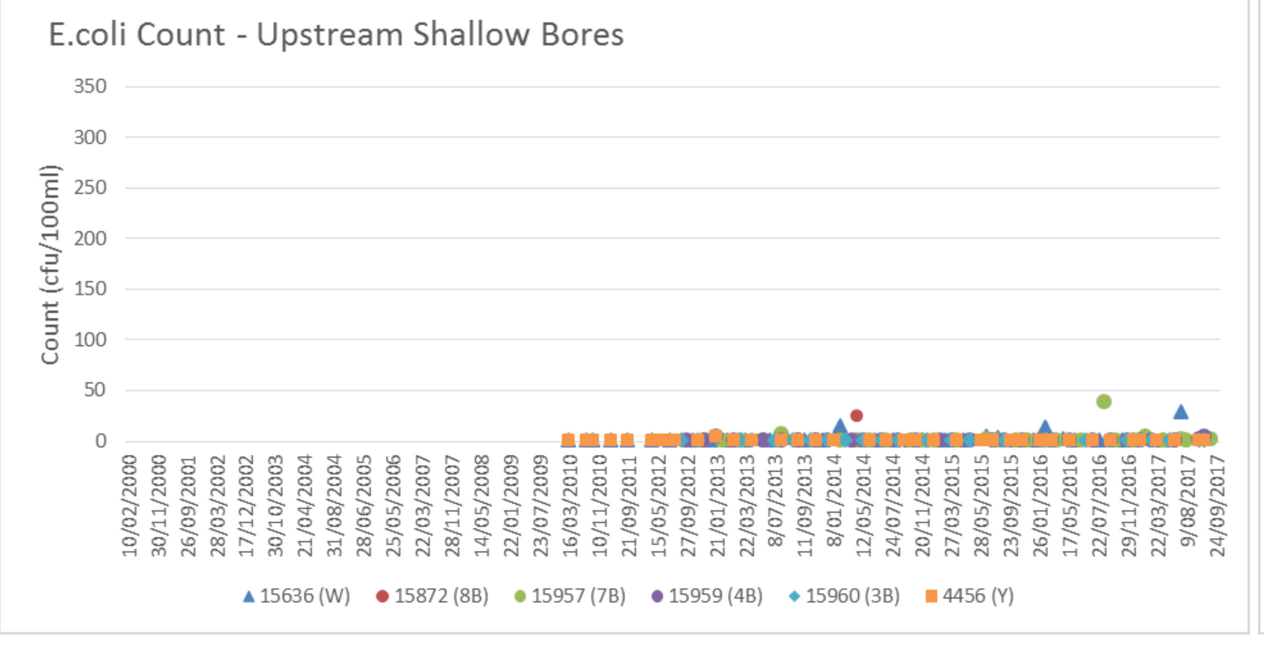

Nitrate Nitrogen Concentration - Downstream Shallow Bores
Concentration (g/m³)
15638 (I)
15958 (2B)
15961 (6B)
15962 (5B)
15963 (1B)
4455 (Z)

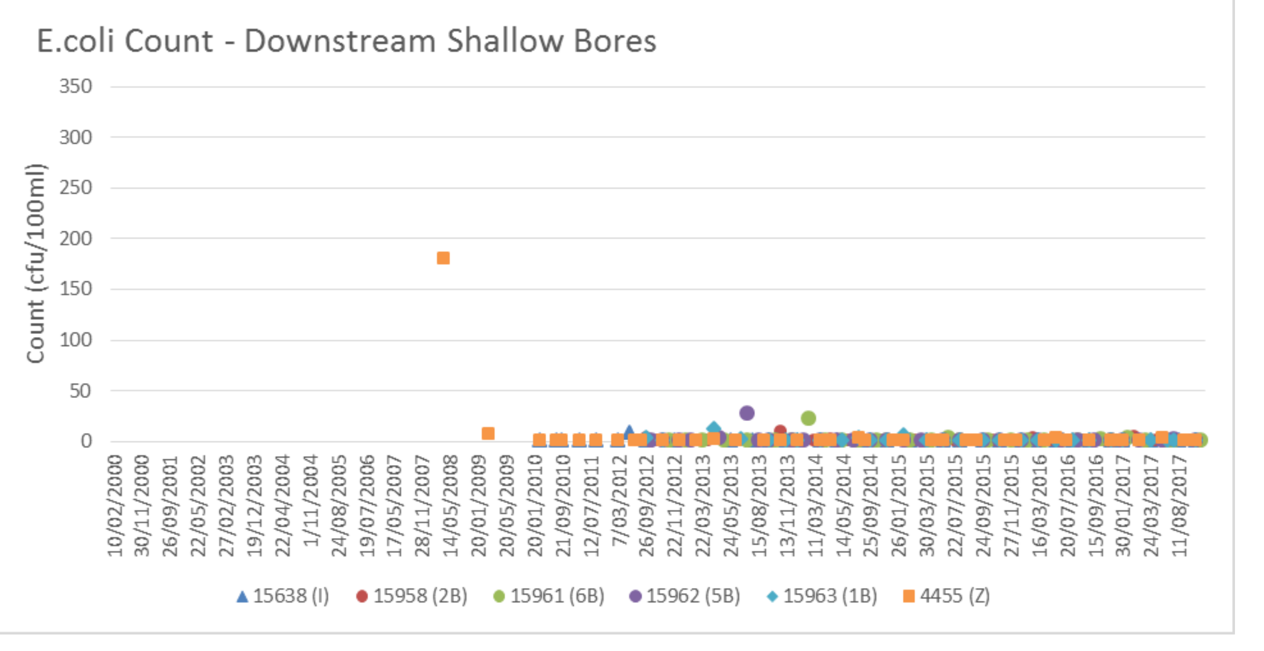

TKN Concentration - Upstream Shallow Bores
Concentration (g/m³)
15636 (W)
15872 (8B)
15957 (7B)
15959 (4B)
15960 (3B)
4456 (Y)


TKN Concentration - Downstream Shallow Bores
Concentration (g/m³)
15638 (I)
15958 (2B)
15961 (6B)
15962 (5B)
15963 (1B)
4455 (Z)

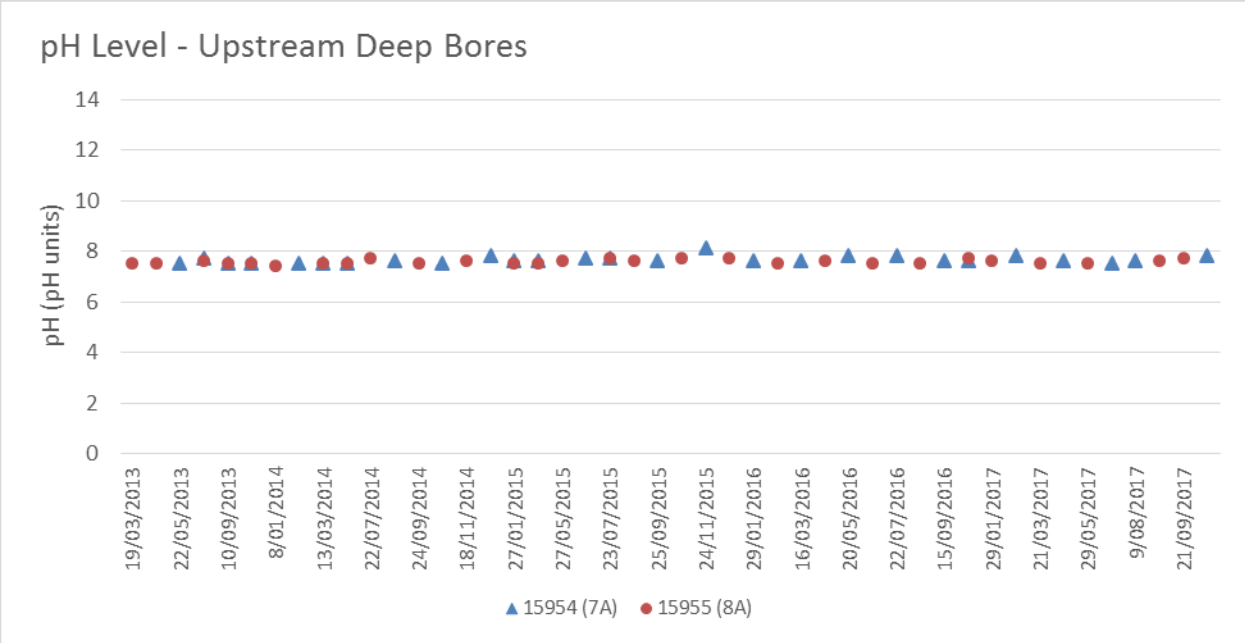

Ammoniacal Nitrogen Concentration - Upstream Shallow Bores
Concentration (g/m³)
15636 (W)
15872 (8B)
15957 (7B)
15959 (4B)
15960 (3B)
4456 (Y)

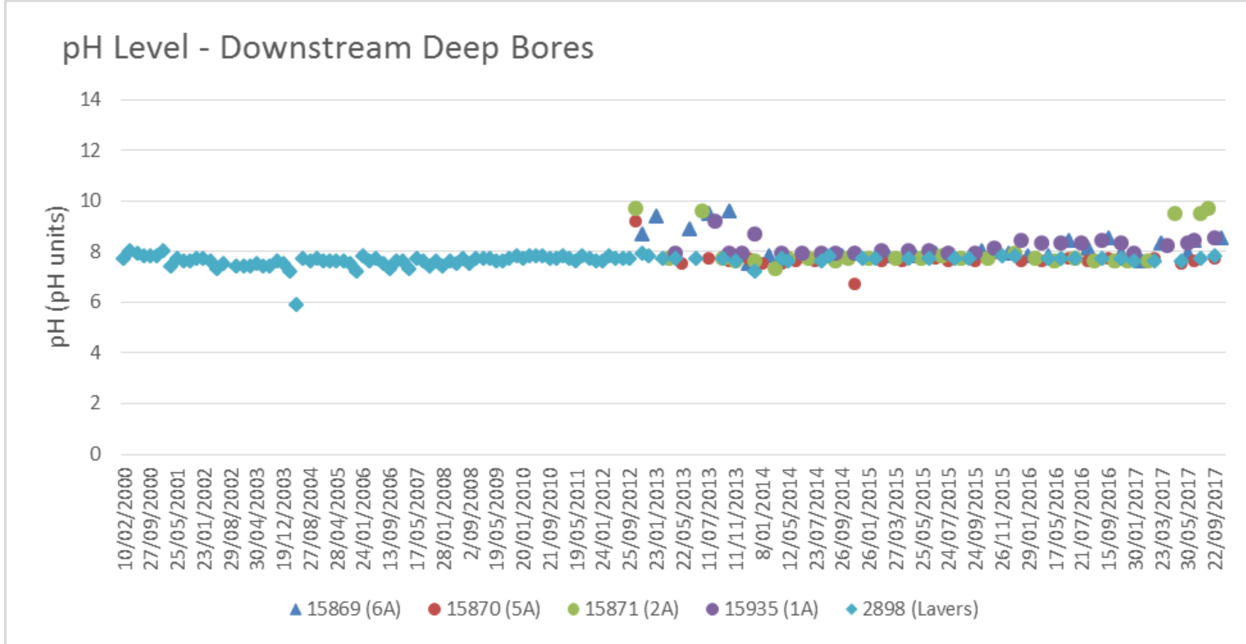

Ammoniacal Nitrogen Concentration - Downstream Shallow Bores
Concentration (g/m³)
15638 (I)
15958 (2B)
15961 (6B)
15962 (5B)
15963 (1B)
4455 (Z)

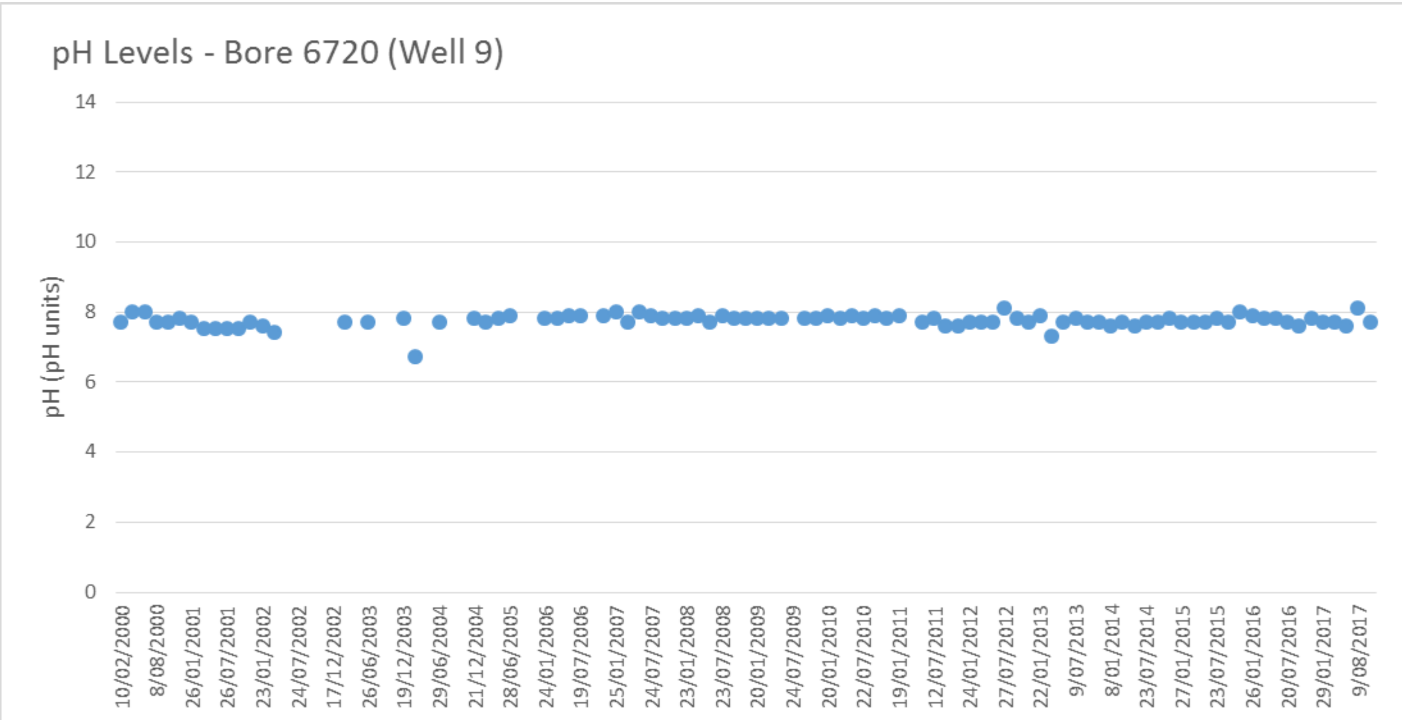

E.coli Count - Upstream Shallow Bores
Count (cfu/100ml)
15636 (W)
15872 (8B)
15957 (7B)
15959 (4B)
15960 (3B)
4456 (Y)


E.coli Count - Downstream Shallow Bores
Count (cfu/100ml)
15638 (I)
15958 (2B)
15961 (6B)
15962 (5B)
15963 (1B)
4455 (Z)

Deep Bores


pH Level - Upstream Deep Bores
pH (pH units)
14
12
10
8
6
4
2
0
19/03/2013
22/05/2013
10/09/2013
8/01/2014
13/03/2014
22/07/2014
24/09/2014
18/11/2014
27/01/2015
27/05/2015
23/07/2015
25/09/2015
24/11/2015
29/01/2016
16/03/2016
20/05/2016
22/07/2016
15/09/2016
29/01/2017
21/03/2017
29/05/2017
9/08/2017
21/09/2017
15954 (7A)
15955 (8A)


pH Level - Downstream Deep Bores
pH (pH units)
14
12
10
8
6
4
2
0
10/02/2000
27/09/2000
25/05/2001
23/01/2002
29/08/2002
30/04/2003
19/12/2003
27/08/2004
28/04/2005
24/01/2006
13/09/2006
17/05/2007
28/01/2008
2/09/2008
19/05/2009
20/01/2010
21/09/2010
19/05/2011
24/01/2012
25/09/2012
23/01/2013
22/05/2013
11/07/2013
11/11/2013
8/01/2014
12/05/2014
23/07/2014
26/09/2014
26/01/2015
27/03/2015
25/05/2015
24/07/2015
24/09/2015
26/11/2015
29/01/2016
17/05/2016
21/07/2016
15/09/2016
30/01/2017
23/03/2017
30/05/2017
22/09/2017
15869 (6A)
15870 (5A)
15871 (2A)
15935 (1A)
2898 (Lavers)


pH Levels - Bore 6720 (Well 9)
pH (pH units)
14
12
10
8
6
4
2
0
10/02/2000
8/08/2000
26/01/2001
26/07/2001
23/01/2002
24/07/2002
17/12/2002
26/06/2003
19/12/2003
29/06/2004
21/12/2004
28/06/2005
24/01/2006
19/07/2006
25/01/2007
24/07/2007
23/01/2008
23/07/2008
20/01/2009
24/07/2009
20/01/2010
22/07/2010
19/01/2011
12/07/2011
24/01/2012
27/07/2012
22/01/2013
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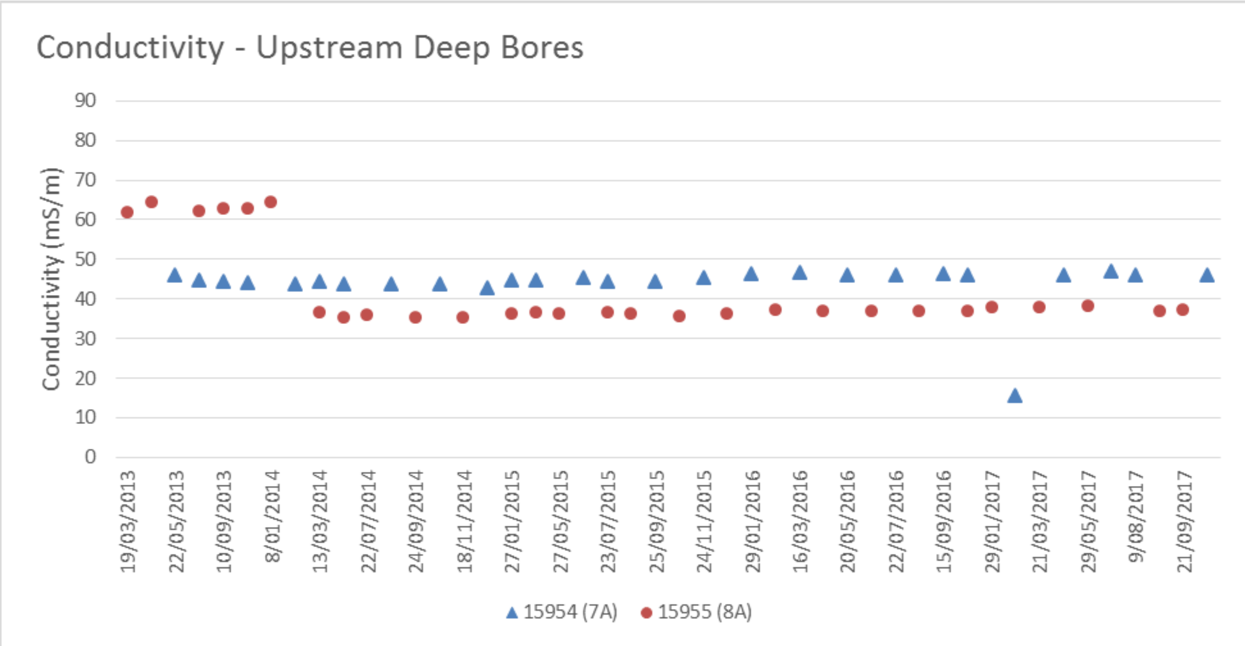
29/01/2017
9/08/2017


Conductivity - Upstream Deep Bores
Conductivity (mS/m)
90
80
70
60
50
40
30
20
10
0
19/03/2013
22/05/2013
10/09/2013
8/01/2014
13/03/2014
22/07/2014
24/09/2014
18/11/2014
27/01/2015
27/05/2015
23/07/2015
25/09/2015
24/11/2015
29/01/2016
16/03/2016
20/05/2016
22/07/2016
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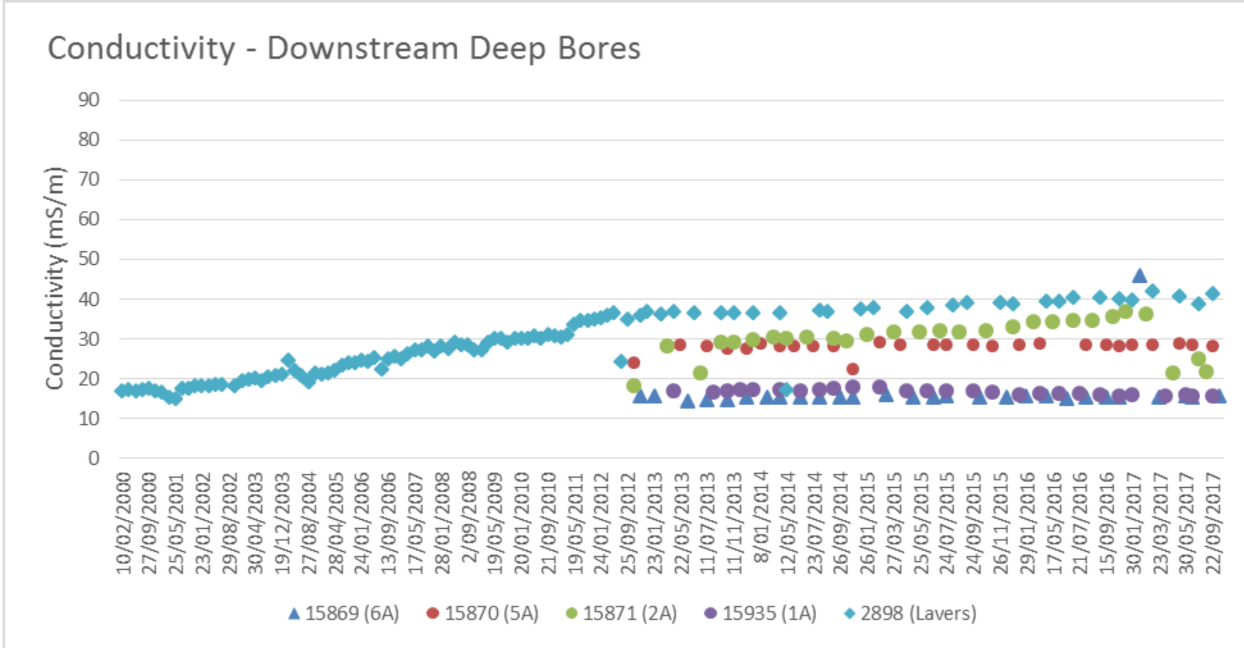
21/09/2017
15954 (7A)
15955 (8A)


Conductivity - Downstream Deep Bores
Conductivity (mS/m)
90
80
70
60
50
40
30
20
10
0
10/02/2000
27/09/2000
25/05/2001
23/01/2002
29/08/2002
30/04/2003
19/12/2003
27/08/2004
28/04/2005
24/01/2006
13/09/2006
17/05/2007
28/01/2008
2/09/2008
19/05/2009
20/01/2010
21/09/2010
19/05/2011
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23/01/2013
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11/11/2013
8/01/2014
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23/07/2014
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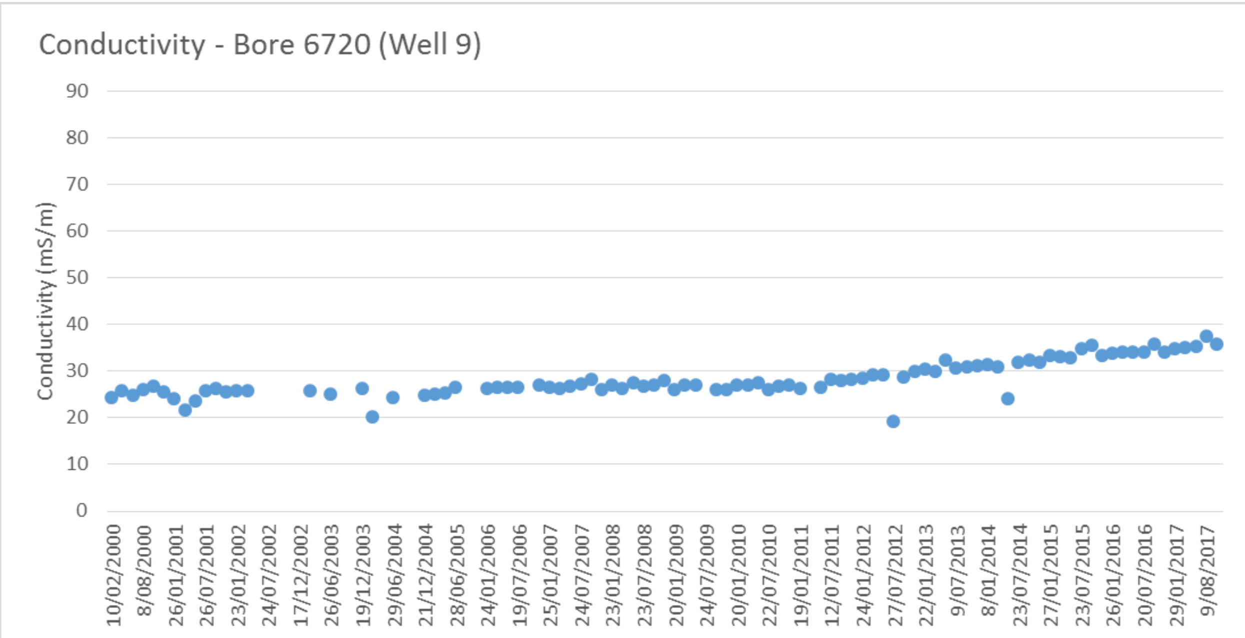
24/07/2015
24/09/2015
26/11/2015
29/01/2016
17/05/2016
21/07/2016
15/09/2016
30/01/2017
23/03/2017
30/05/2017
22/09/2017
15869 (6A)
15870 (5A)
15871 (2A)
15935 (1A)
2898 (Lavers)


Conductivity - Bore 6720 (Well 9)
Conductivity (mS/m)
90
80
70
60
50
40
30
20
10
0
10/02/2000
8/08/2000
26/01/2001
26/07/2001
23/01/2002
24/07/2002
17/12/2002
26/06/2003
19/12/2003
29/06/2004
21/12/2004
28/06/2005
24/01/2006
19/07/2006
25/01/2007
24/07/2007
23/01/2008
23/07/2008
20/01/2009
24/07/2009
20/01/2010
22/07/2010
19/01/2011
12/07/2011
24/01/2012
27/07/2012
22/01/2013
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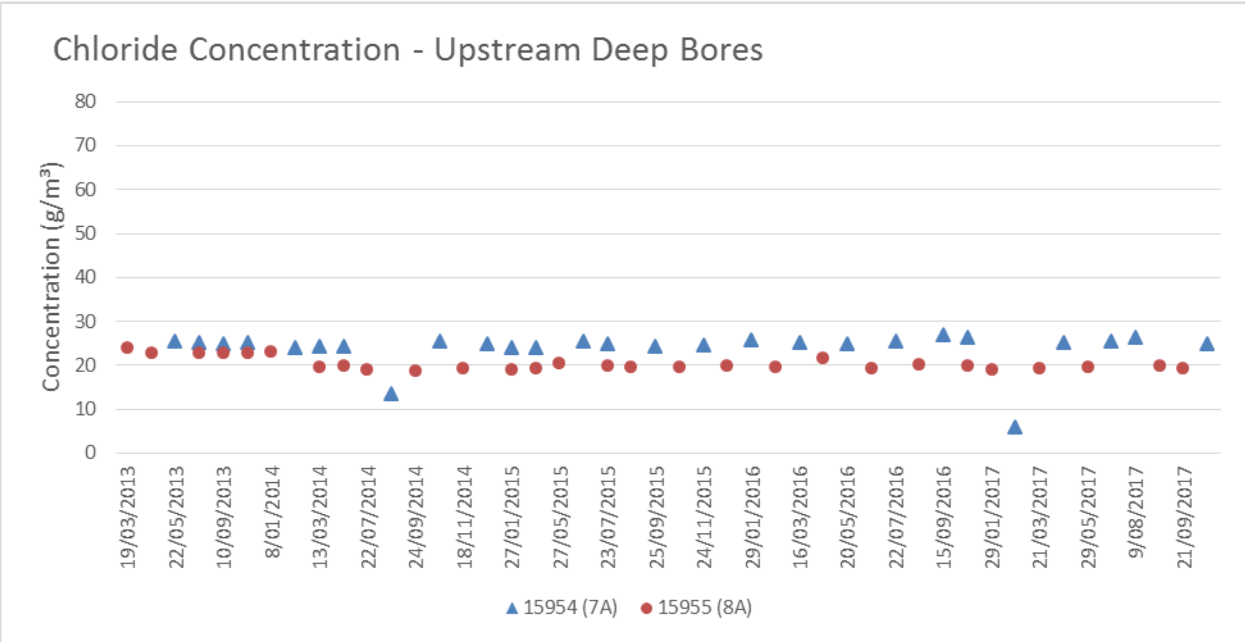
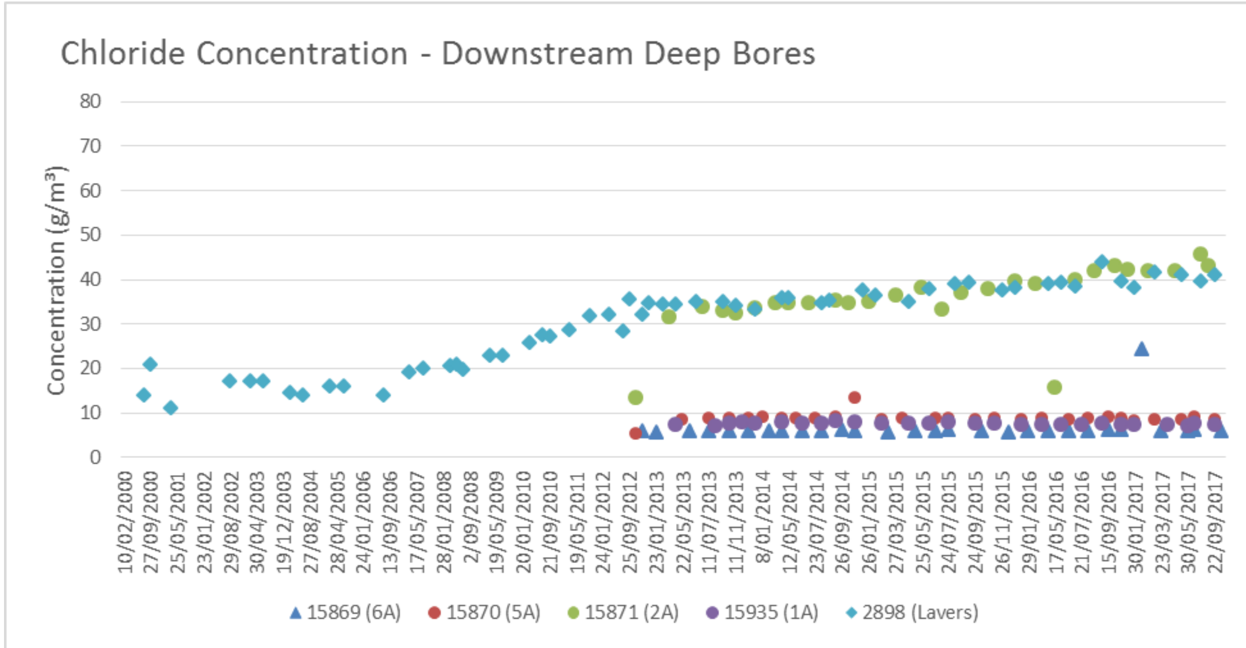
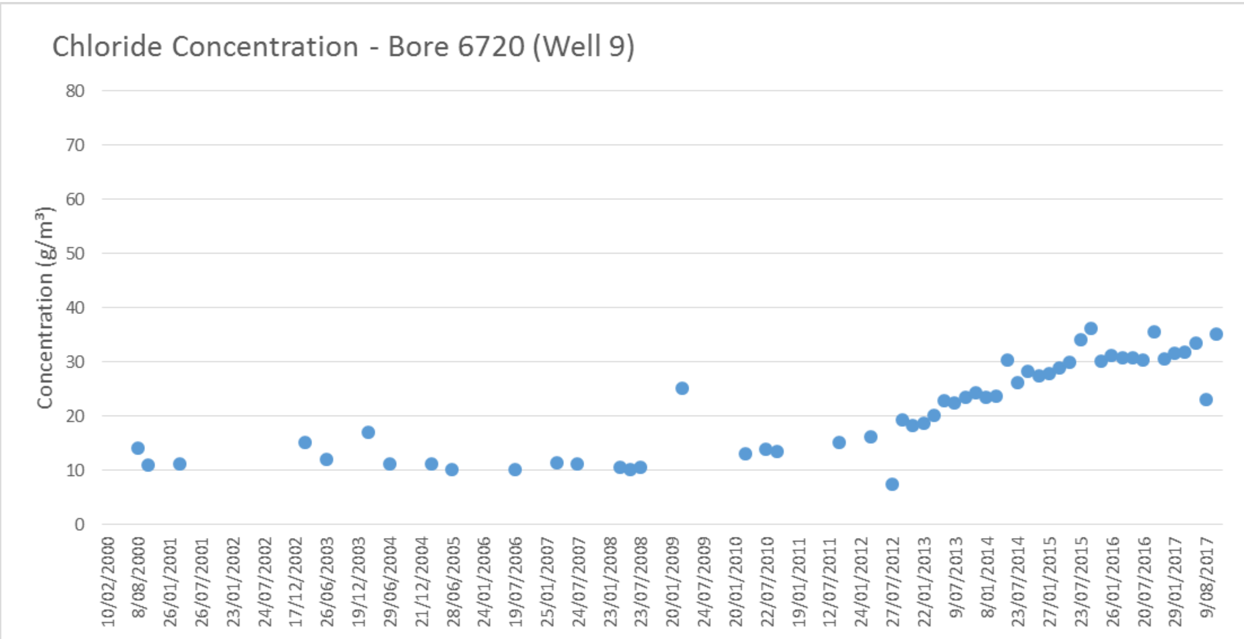
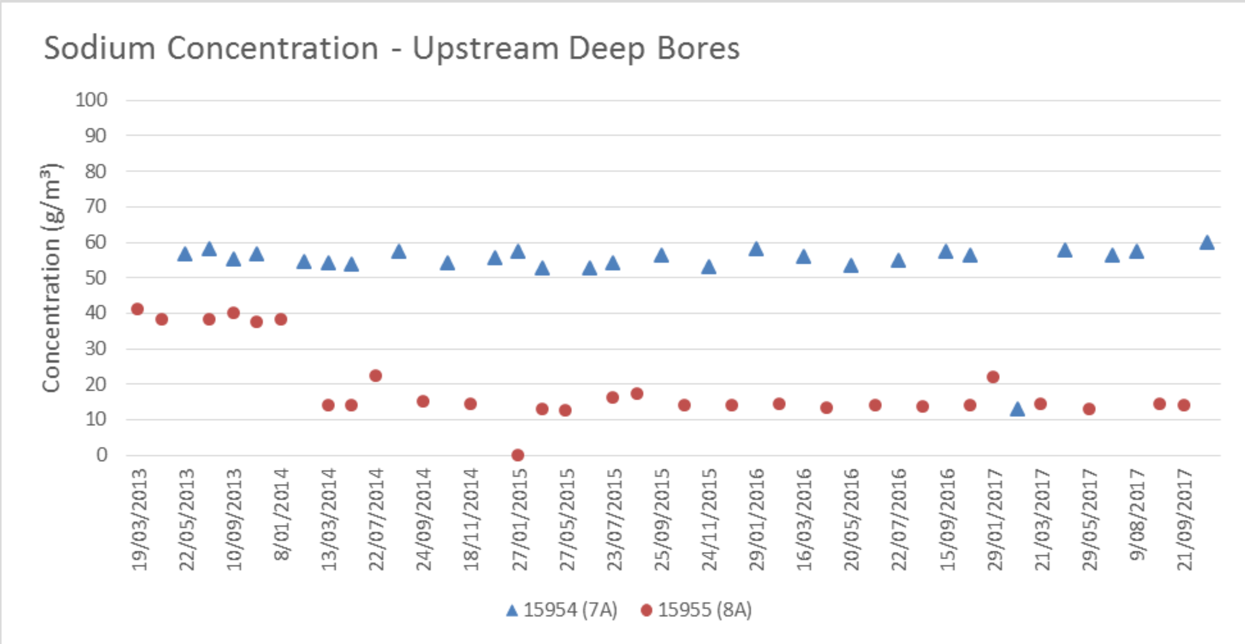
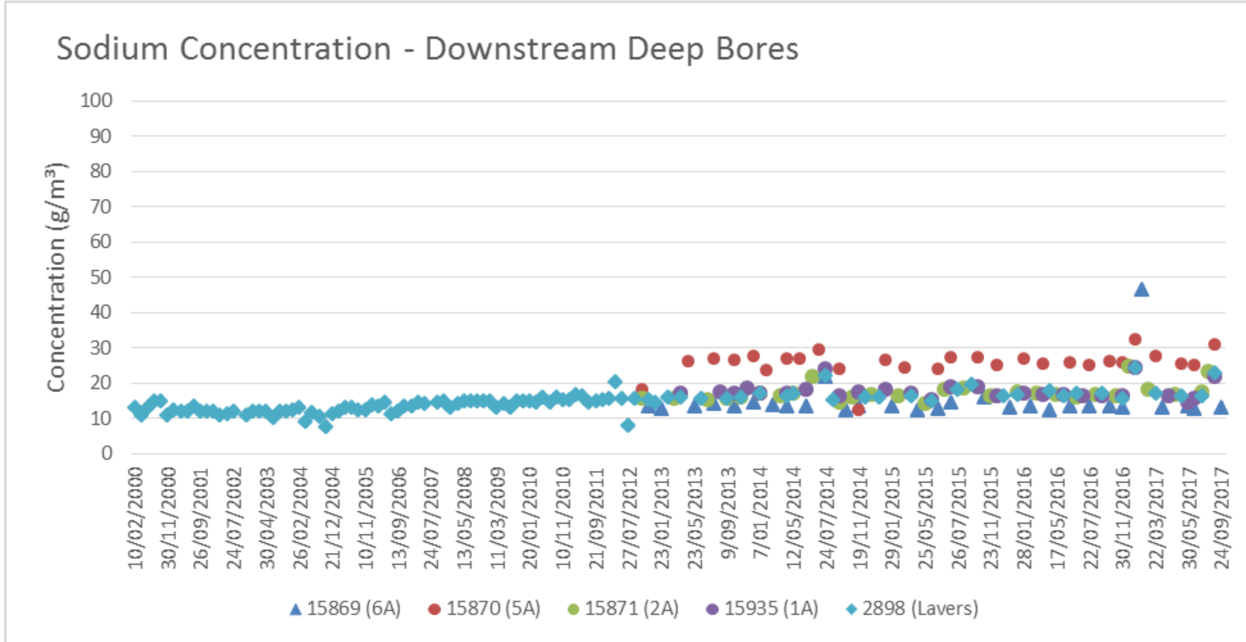
29/01/2017
9/08/2017

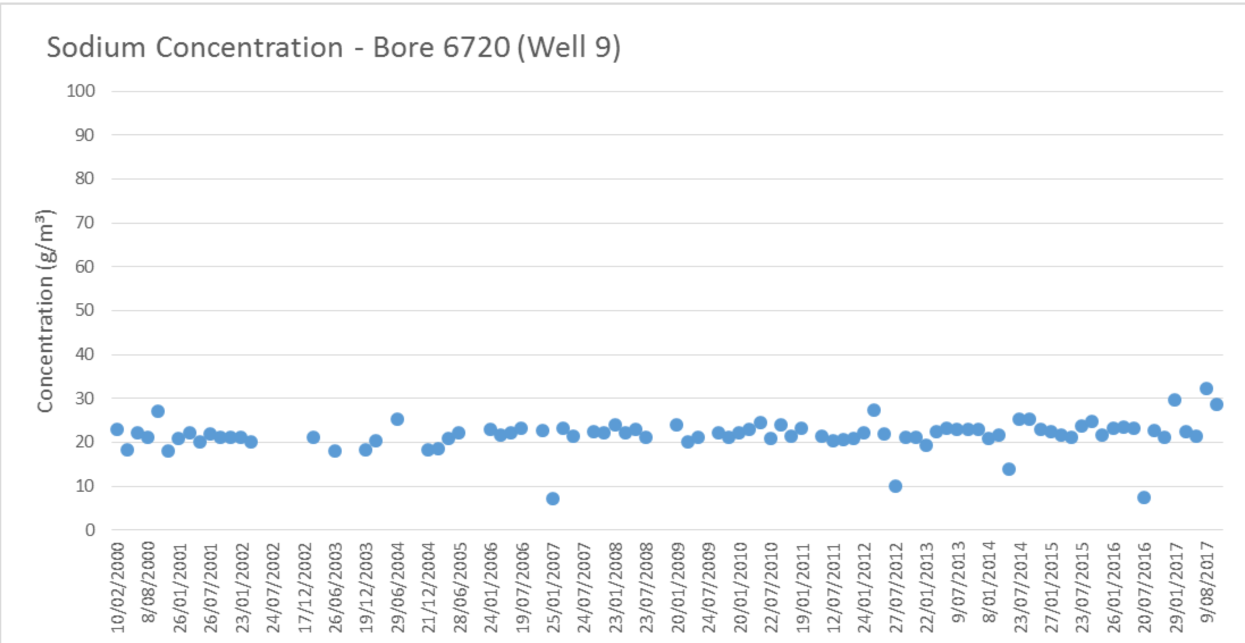

Chloride Concentration - Upstream Deep Bores
Concentration (g/m³)
15954 (7A)
15955 (8A)

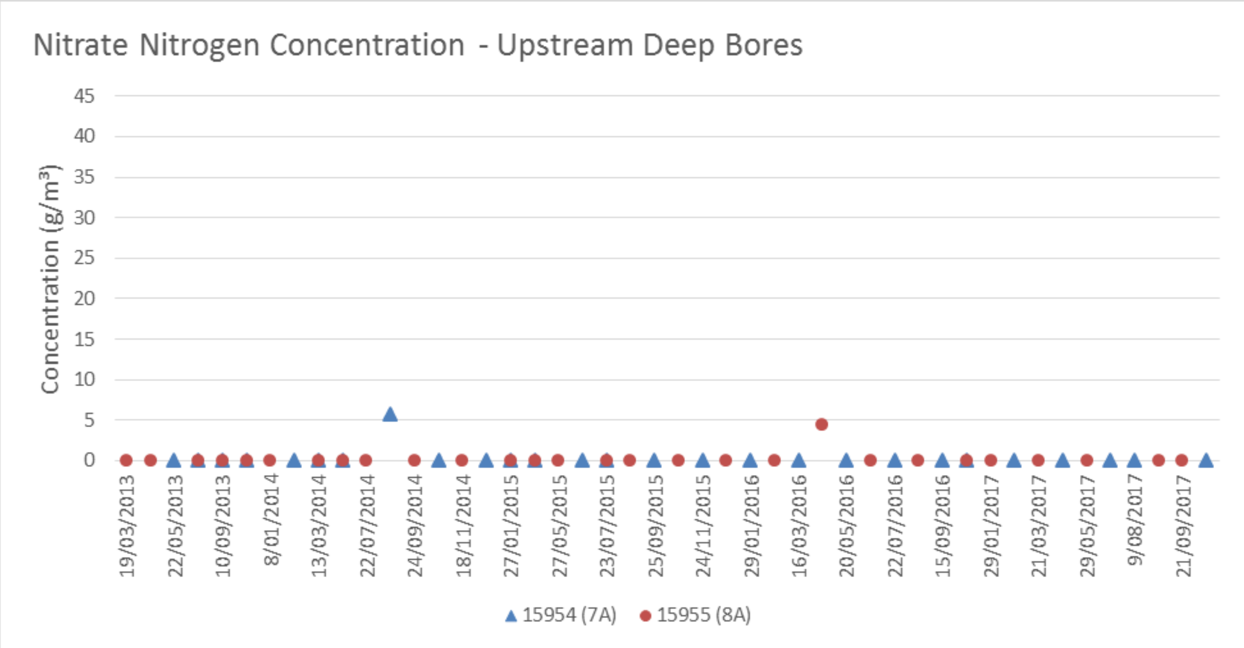

Chloride Concentration - Downstream Deep Bores
Concentration (g/m³)
15869 (6A)
15870 (5A)
15871 (2A)
15935 (1A)
2898 (Lavers)

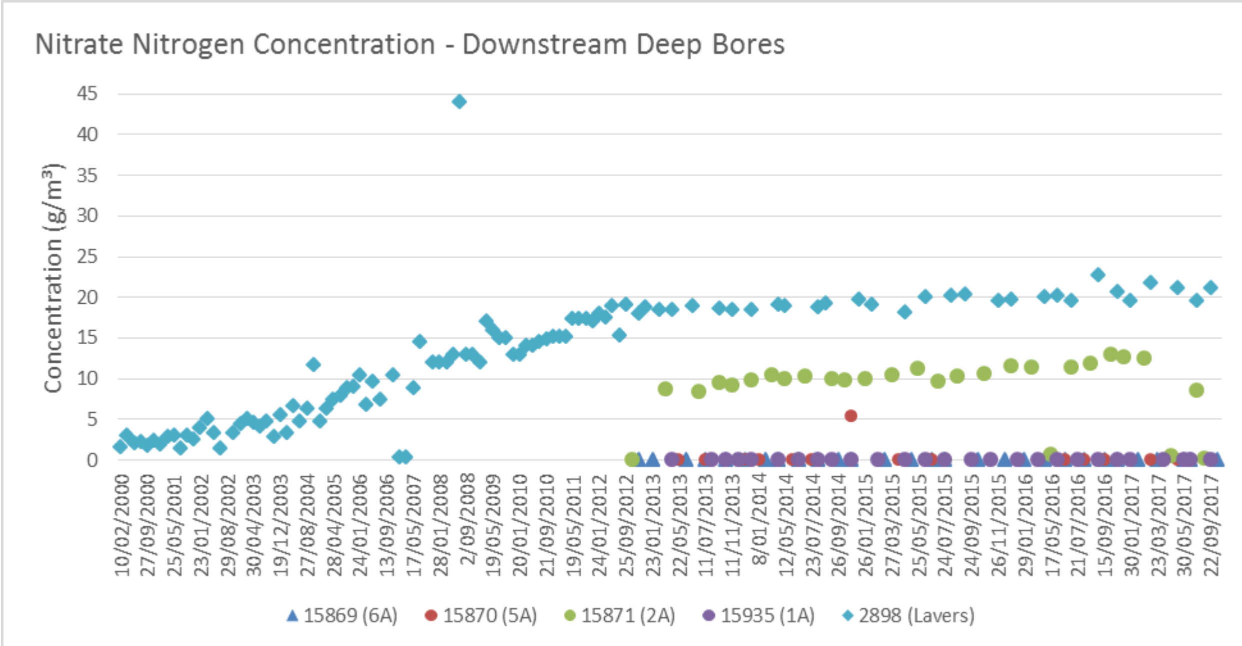

Chloride Concentration - Bore 6720 (Well 9)
Concentration (g/m³)

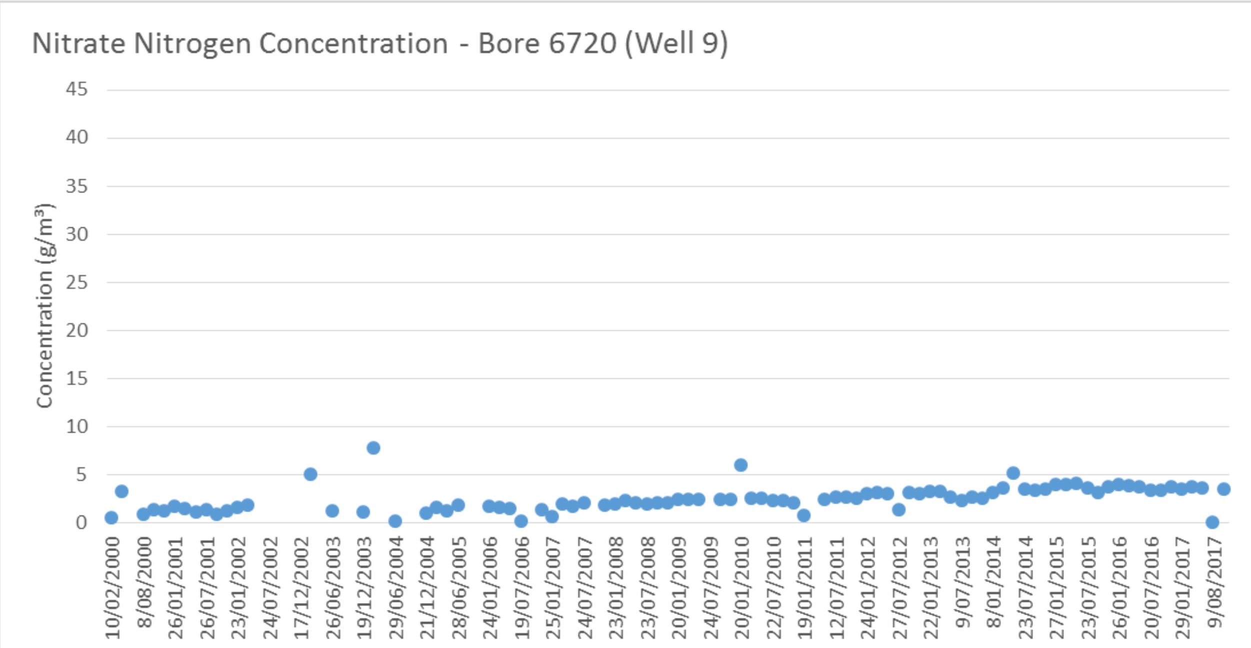

Sodium Concentration - Upstream Deep Bores
Concentration (g/m³)
100
90
80
70
60
50
40
30
20
10
0
19/03/2013
22/05/2013
10/09/2013
8/01/2014
13/03/2014
22/07/2014
24/09/2014
18/11/2014
27/01/2015
27/05/2015
23/07/2015
25/09/2015
24/11/2015
29/01/2016
16/03/2016
20/05/2016
22/07/2016
15/09/2016
29/01/2017
21/03/2017
29/05/2017
9/08/2017
21/09/2017
15954 (7A)
15955 (8A)

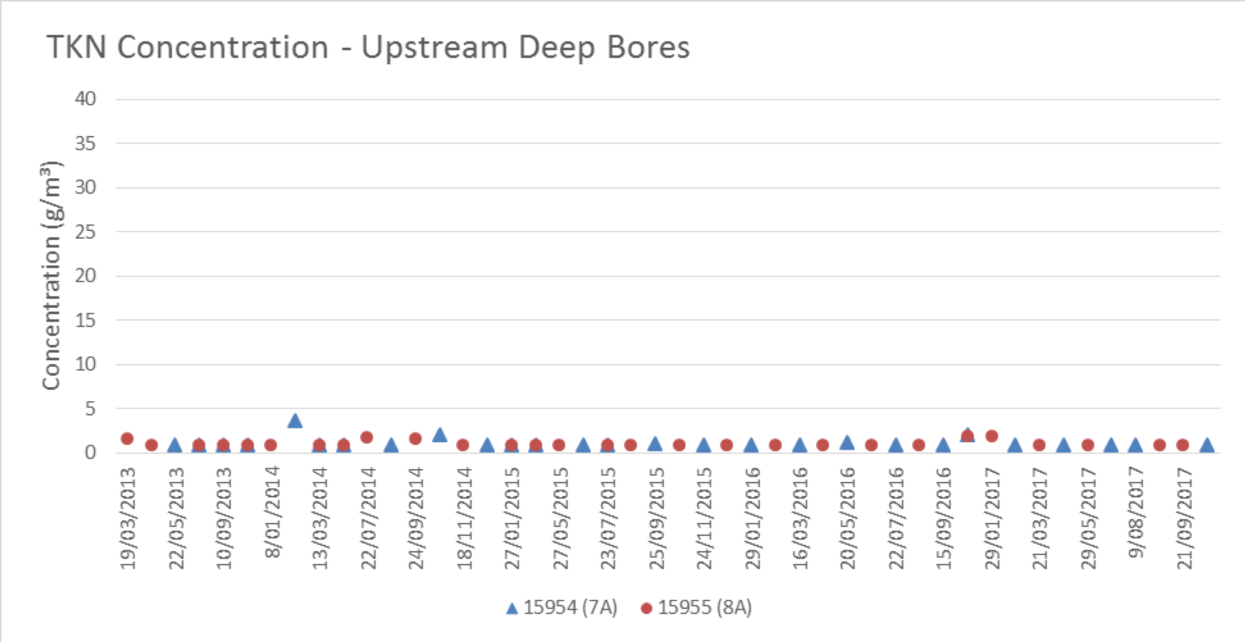

Sodium Concentration - Downstream Deep Bores
Concentration (g/m³)
100
90
80
70
60
50
40
30
20
10
0
10/02/2000
30/11/2000
26/09/2001
24/07/2002
30/04/2003
26/02/2004
21/12/2004
10/11/2005
13/09/2006
24/07/2007
13/05/2008
11/03/2009
20/01/2010
10/11/2010
21/09/2011
27/07/2012
23/01/2013
23/05/2013
9/09/2013
7/01/2014
12/05/2014
24/07/2014
19/11/2014
29/01/2015
25/05/2015
26/07/2015
23/11/2015
28/01/2016
17/05/2016
22/07/2016
30/11/2016
22/03/2017
30/05/2017
24/09/2017
15869 (6A)
15870 (5A)
15871 (2A)
15935 (1A)
2898 (Lavers)

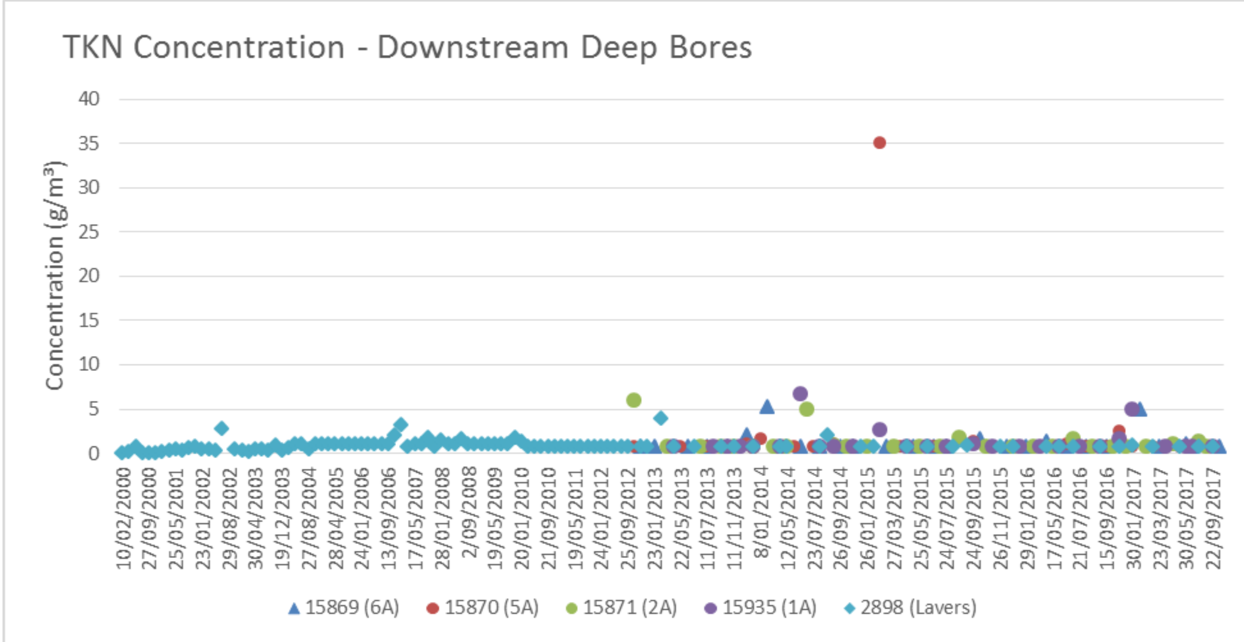

Sodium Concentration - Bore 6720 (Well 9)
Concentration (g/m³)
100
90
80
70
60
50
40
30
20
10
0
10/02/2000
8/08/2000
26/01/2001
26/07/2001
23/01/2002
24/07/2002
17/12/2002
26/06/2003
19/12/2003
29/06/2004
21/12/2004
28/06/2005
24/01/2006
19/07/2006
25/01/2007
24/07/2007
23/01/2008
23/07/2008
20/01/2009
24/07/2009
20/01/2010
22/07/2010
19/01/2011
12/07/2011
24/01/2012
27/07/2012
22/01/2013
9/07/2013
8/01/2014
23/07/2014
27/01/2015
23/07/2015
26/01/2016
20/07/2016
29/01/2017
9/08/2017

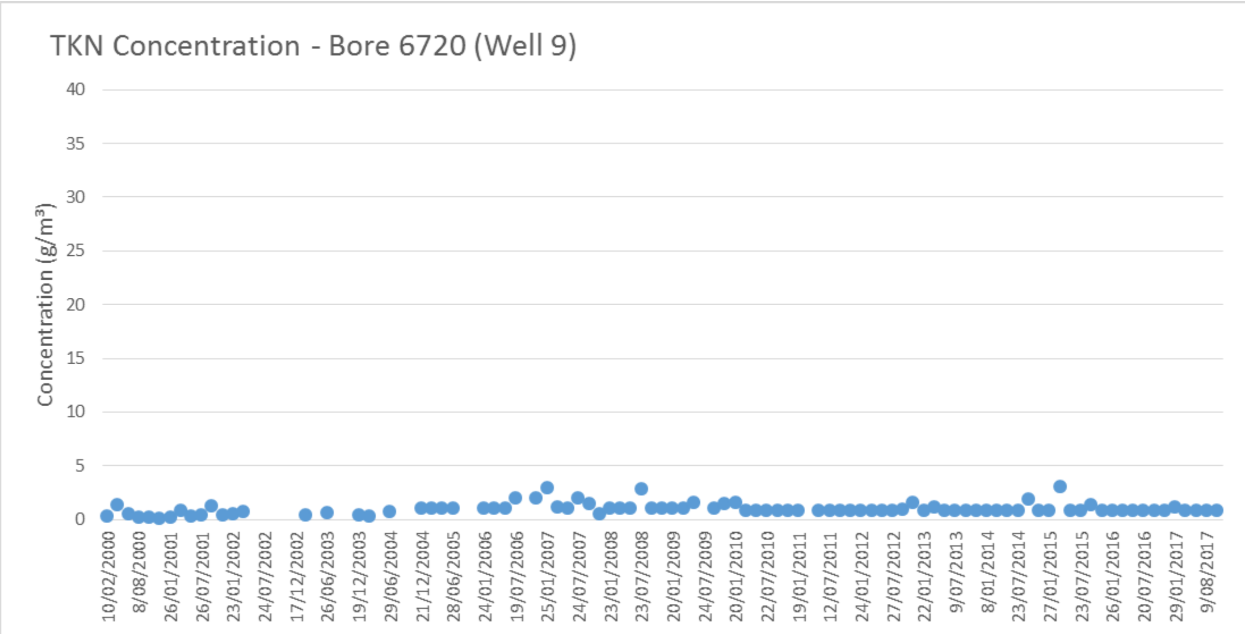

Nitrate Nitrogen Concentration - Upstream Deep Bores
Concentration (g/m³)
45
40
35
30
25
20
15
10
5
0
19/03/2013
22/05/2013
10/09/2013
8/01/2014
13/03/2014
22/07/2014
24/09/2014
18/11/2014
27/01/2015
27/05/2015
23/07/2015
25/09/2015
24/11/2015
29/01/2016
16/03/2016
20/05/2016
22/07/2016
15/09/2016
29/01/2017
21/03/2017
29/05/2017
9/08/2017
21/09/2017
15954 (7A)
15955 (8A)

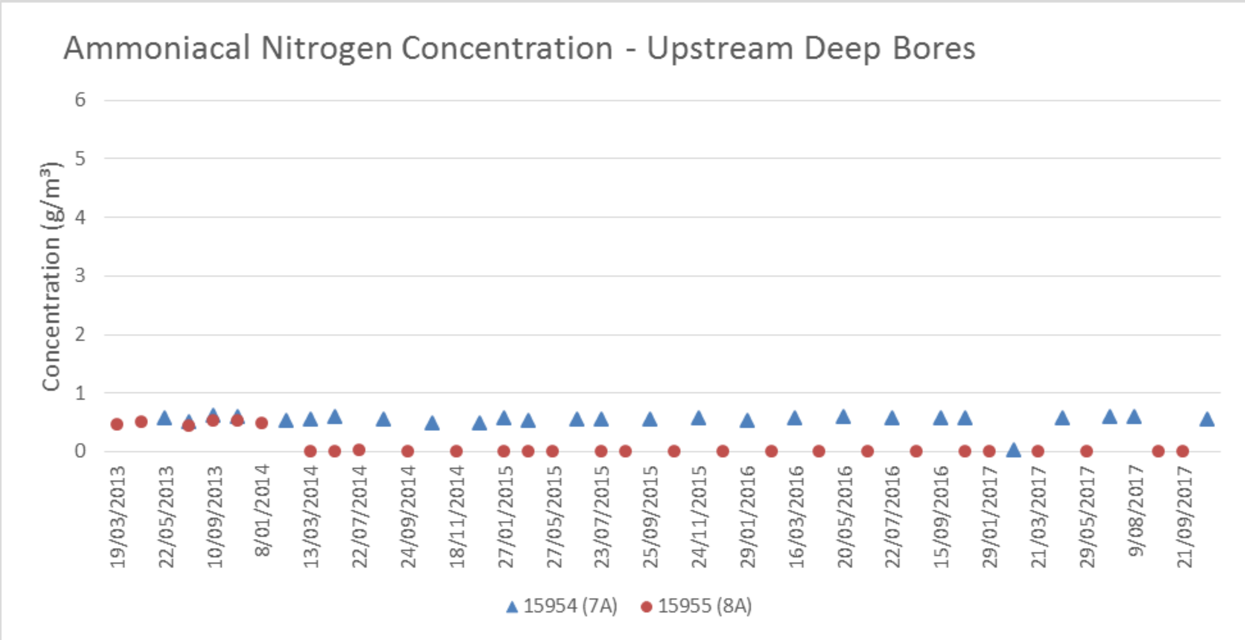

Nitrate Nitrogen Concentration - Downstream Deep Bores
Concentration (g/m³)
45
40
35
30
25
20
15
10
5
0
15869 (6A)
15870 (5A)
15871 (2A)
15935 (1A)
2898 (Lavers)

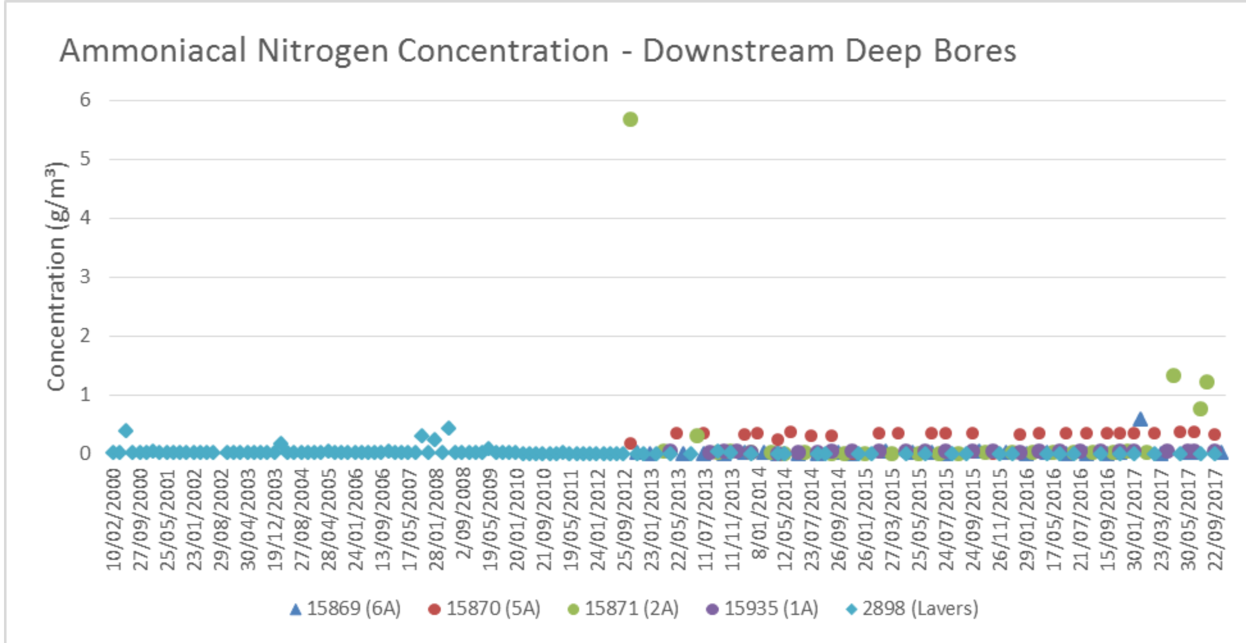

Nitrate Nitrogen Concentration - Bore 6720 (Well 9)
Concentration (g/m³)
45
40
35
30
25
20
15
10
5
0

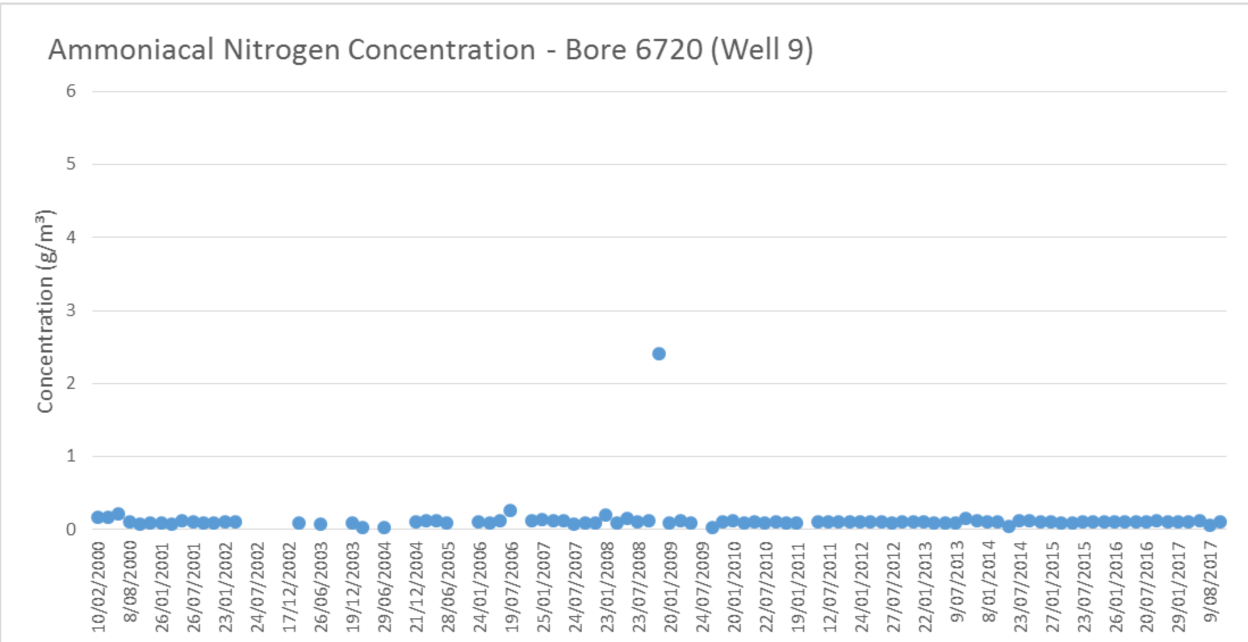

TKN Concentration - Upstream Deep Bores
Concentration (g/m³)
15954 (7A)
15955 (8A)

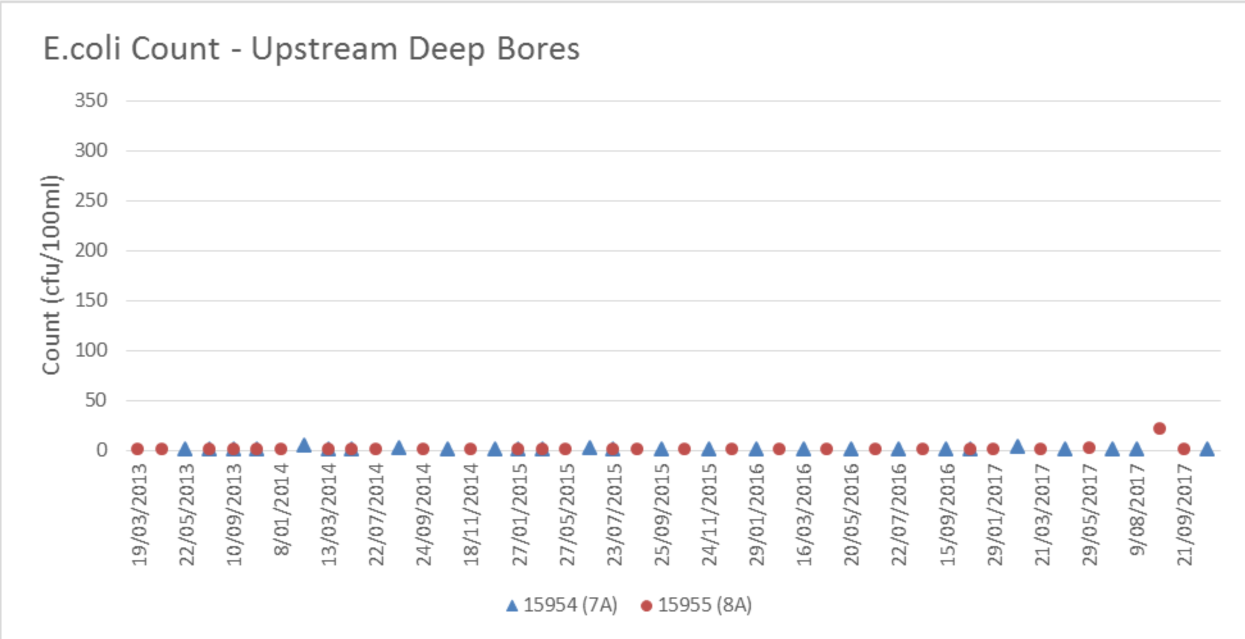

TKN Concentration - Downstream Deep Bores
Concentration (g/m³)
15869 (6A)
15870 (5A)
15871 (2A)
15935 (1A)
2898 (Lavers)

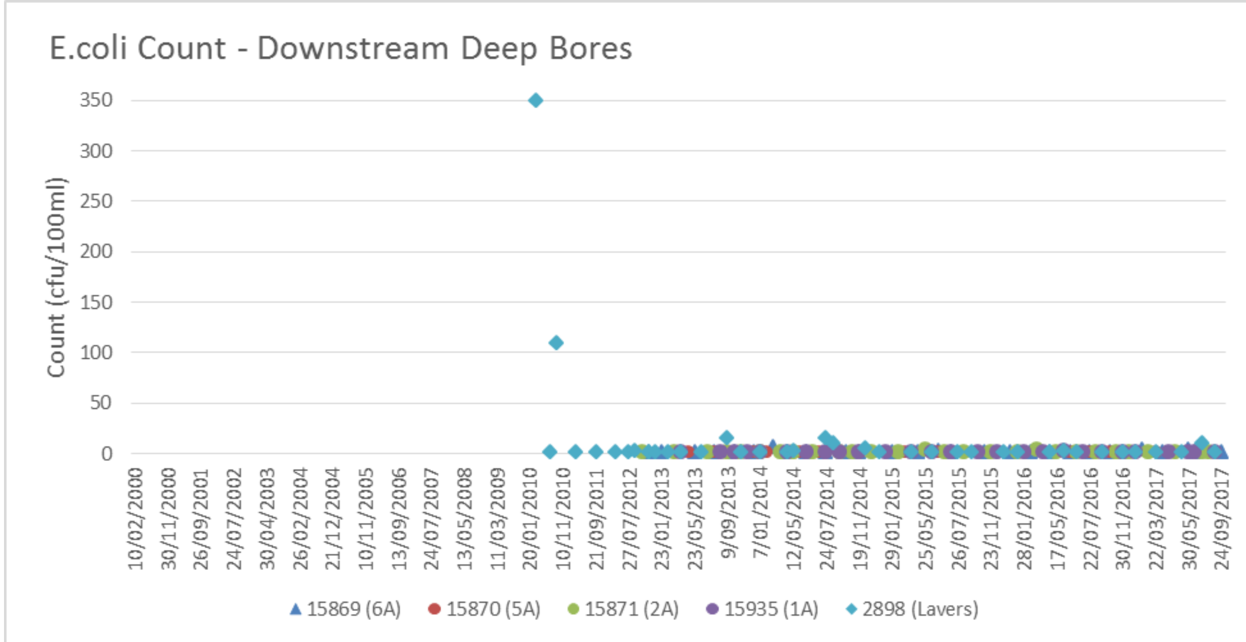

TKN Concentration - Bore 6720 (Well 9)
Concentration (g/m³)

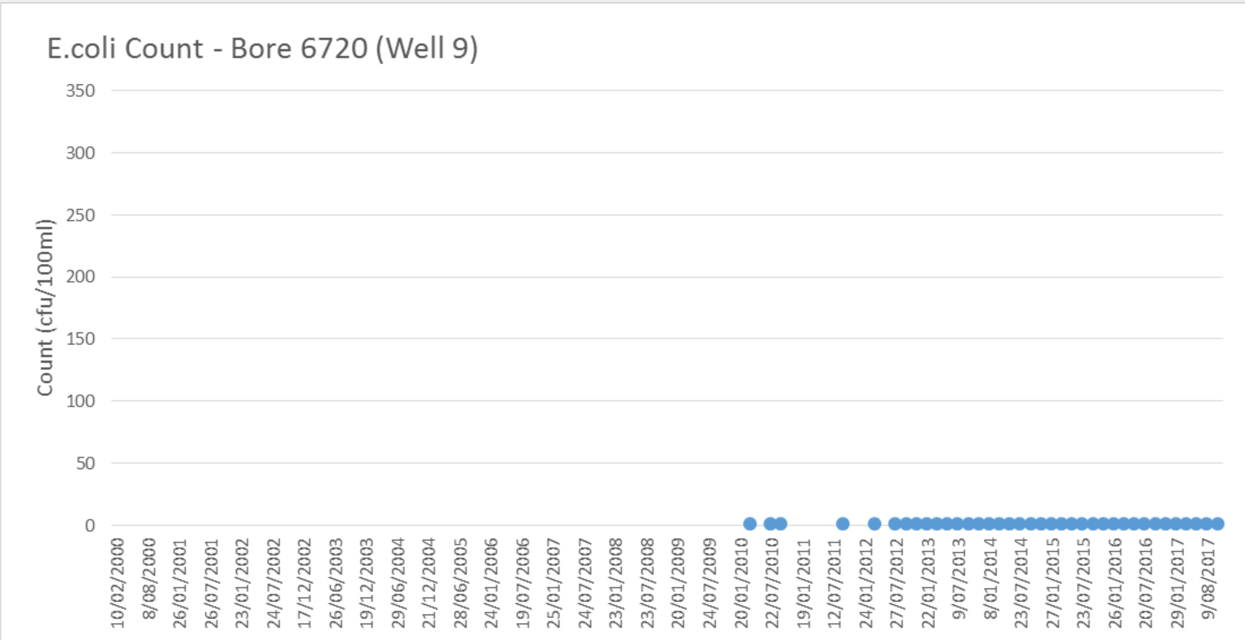

Ammoniacal Nitrogen Concentration - Upstream Deep Bores
Concentration (g/m³)
0
1
2
3
4
5
6
19/03/2013
22/05/2013
10/09/2013
8/01/2014
13/03/2014
22/07/2014
24/09/2014
18/11/2014
27/01/2015
27/05/2015
23/07/2015
25/09/2015
24/11/2015
29/01/2016
16/03/2016
20/05/2016
22/07/2016
15/09/2016
29/01/2017
21/03/2017
29/05/2017
9/08/2017
21/09/2017
15954 (7A)
15955 (8A)


Ammoniacal Nitrogen Concentration - Downstream Deep Bores
Concentration (g/m³)
0
1
2
3
4
5
6
15869 (6A)
15870 (5A)
15871 (2A)
15935 (1A)
2898 (Lavers)


Ammoniacal Nitrogen Concentration - Bore 6720 (Well 9)
Concentration (g/m³)
0
1
2
3
4
5
6


E.coli Count - Upstream Deep Bores
Count (cfu/100ml)
350
300
250
200
150
100
50
0
19/03/2013
22/05/2013
10/09/2013
8/01/2014
13/03/2014
22/07/2014
24/09/2014
18/11/2014
27/01/2015
27/05/2015
23/07/2015
25/09/2015
24/11/2015
29/01/2016
16/03/2016
20/05/2016
22/07/2016
15/09/2016
29/01/2017
21/03/2017
29/05/2017
9/08/2017
21/09/2017
15954 (7A)
15955 (8A)

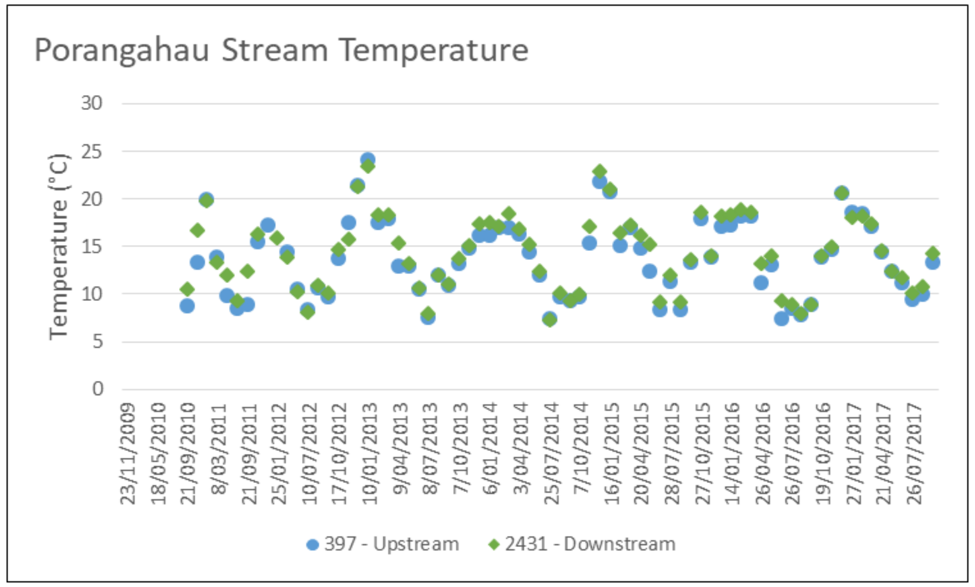

E.coli Count - Downstream Deep Bores
Count (cfu/100ml)
350
300
250
200
150
100
50
0
10/02/2000
30/11/2000
26/09/2001
24/07/2002
30/04/2003
26/02/2004
21/12/2004
10/11/2005
13/09/2006
24/07/2007
13/05/2008
11/03/2009
20/01/2010
10/11/2010
21/09/2011
27/07/2012
23/01/2013
23/05/2013
9/09/2013
7/01/2014
12/05/2014
24/07/2014
19/11/2014
29/01/2015
25/05/2015
26/07/2015
23/11/2015
28/01/2016
17/05/2016
22/07/2016
30/11/2016
22/03/2017
30/05/2017
24/09/2017
15869 (6A)
15870 (5A)
15871 (2A)
15935 (1A)
2898 (Lavers)

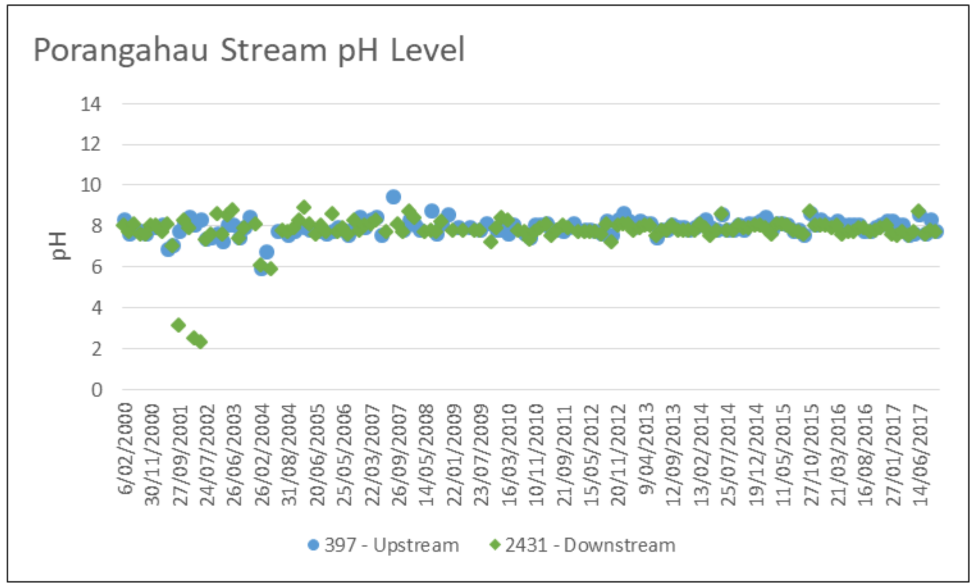

E.coli Count - Bore 6720 (Well 9)
Count (cfu/100ml)
350
300
250
200
150
100
50
0
10/02/2000
8/08/2000
26/01/2001
26/07/2001
23/01/2002
24/07/2002
17/12/2002
26/06/2003
19/12/2003
29/06/2004
21/12/2004
28/06/2005
24/01/2006
19/07/2006
25/01/2007
24/07/2007
23/01/2008
23/07/2008
20/01/2009
24/07/2009
20/01/2010
22/07/2010
19/01/2011
12/07/2011
24/01/2012
27/07/2012
22/01/2013
9/07/2013
8/01/2014
23/07/2014
27/01/2015
23/07/2015
26/01/2016
20/07/2016
29/01/2017
9/08/2017

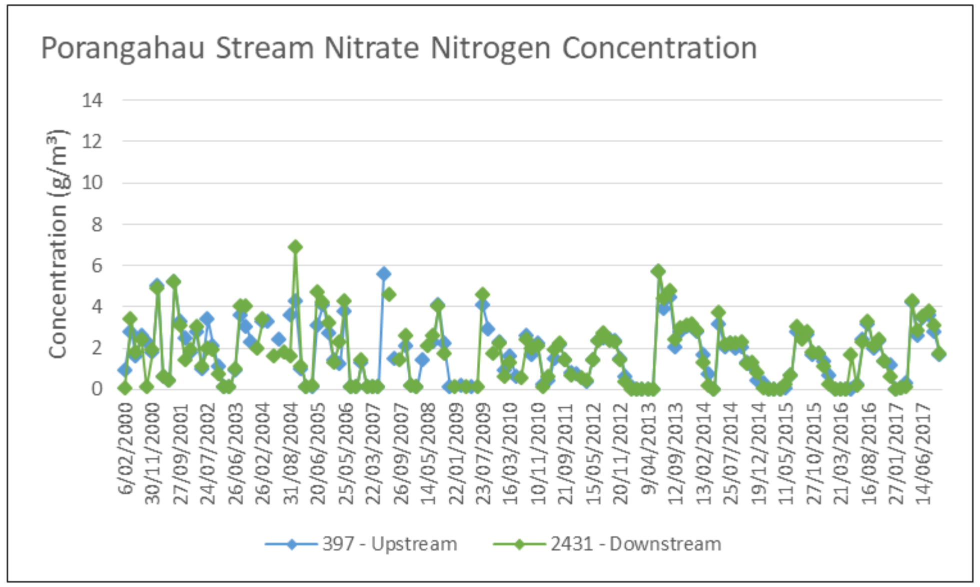
Appendix F

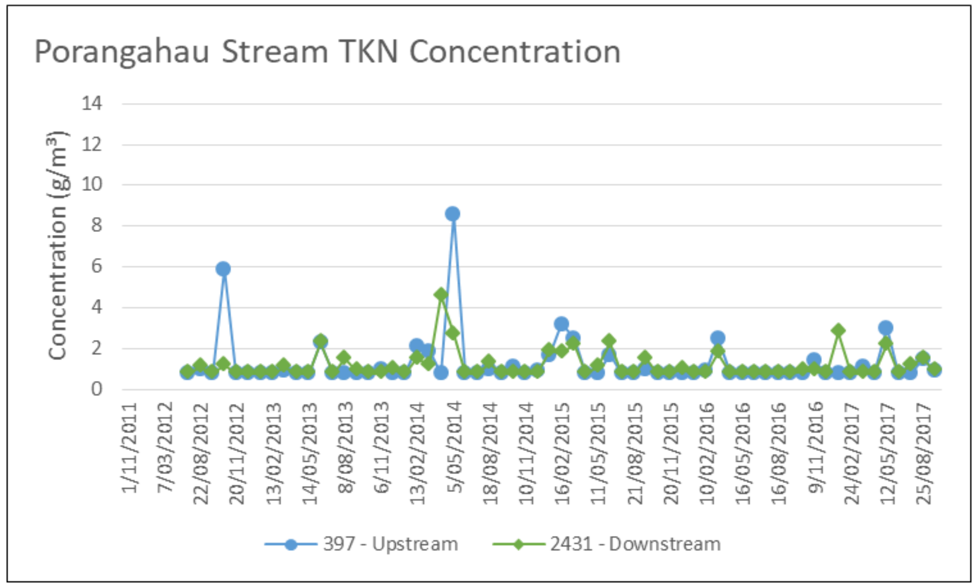
Silver Fern Farms Surface Water Sampling Results

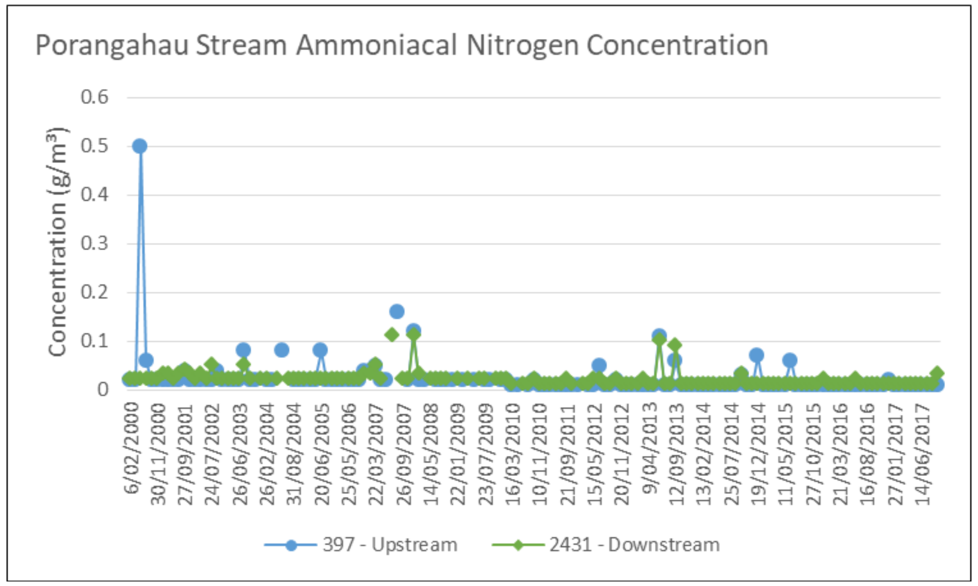
Appendix F: Silver Fern Farms Surface Water Sampling Results

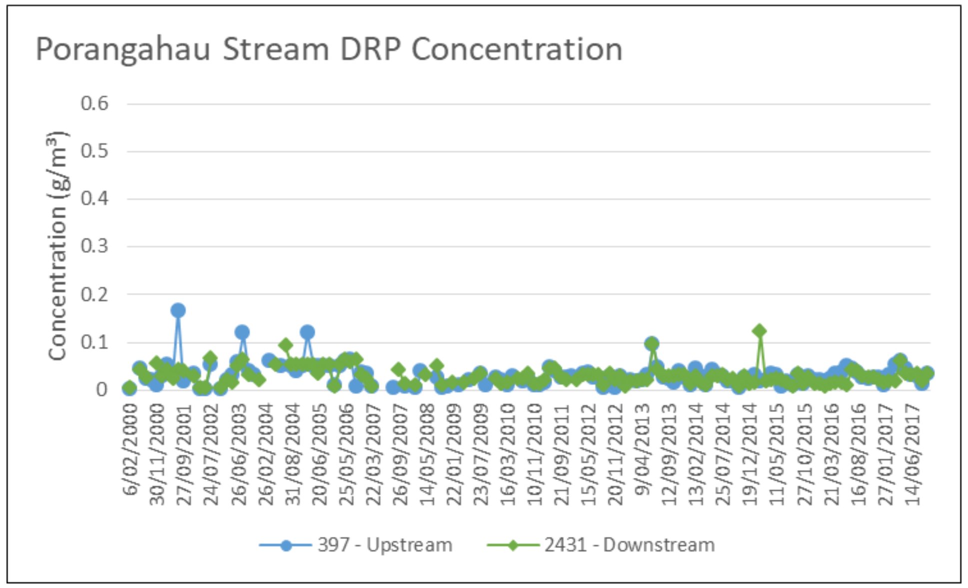


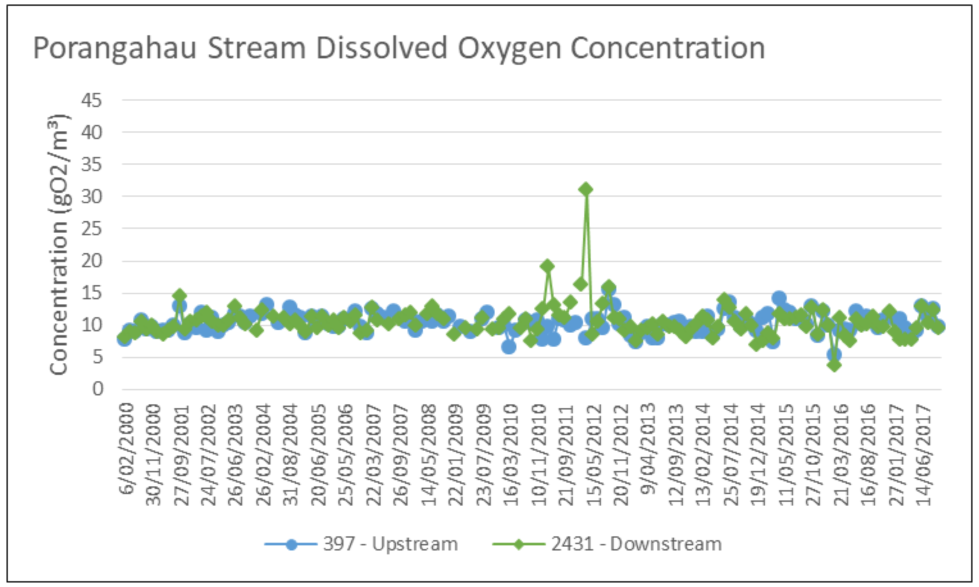


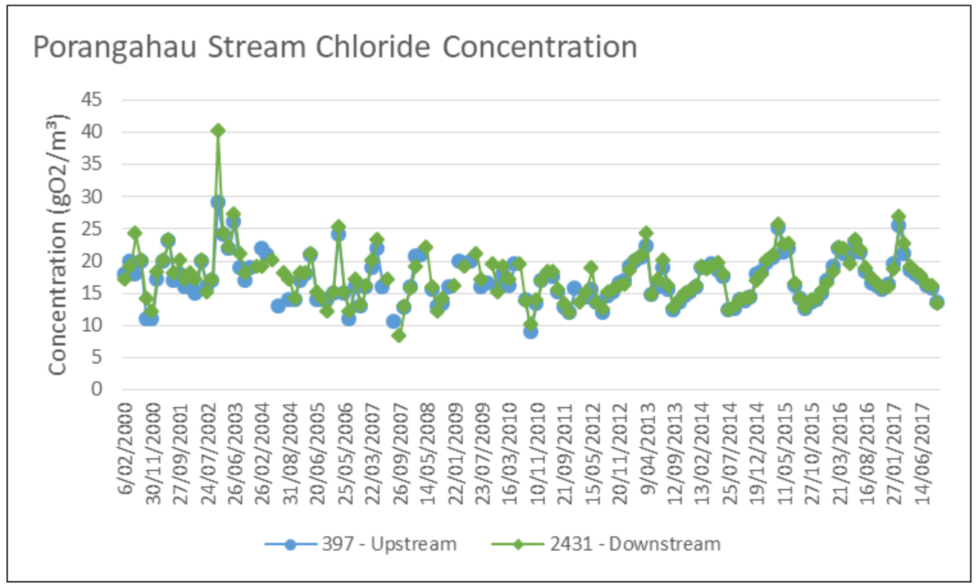


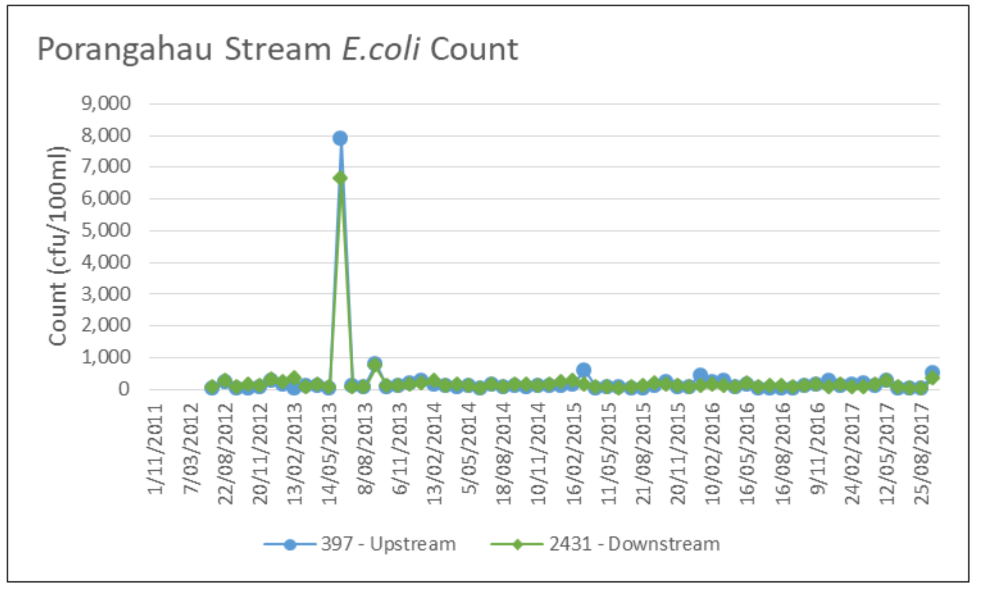



Porangahau Stream Ammoniacal Nitrogen Concentration
Concentration (g/m³)
397 - Upstream
2431 - Downstream


Porangahau Stream DRP Concentration
Concentration (g/m³)
397 - Upstream
2431 - Downstream


Porangahau Stream Dissolved Oxygen Concentration
Concentration (gO2/m³)
397 - Upstream
2431 - Downstream


Porangahau Stream Chloride Concentration
Concentration (gO2/m³)
397 - Upstream
2431 - Downstream


Porangahau Stream *E.coli* Count
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Count (cfu/100ml)
1/11/2011
7/03/2012
22/08/2012
20/11/2012
13/02/2013
14/05/2013
8/08/2013
6/11/2013
13/02/2014
5/05/2014
18/08/2014
10/11/2014
16/02/2015
11/05/2015
21/08/2015
20/11/2015
10/02/2016
16/05/2016
16/08/2016
9/11/2016
24/02/2017
12/05/2017
25/08/2017
397 - Upstream
2431 - Downstream