Huon Aquaculture Group Pty Ltd

Wastewater Reuse Environmental Management Plan

Parramatta Creek Fish Processing Facility

October 2019

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HUON
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1 Introduction

1.1 Parramatta Creek fish processing facility

1.1.1 Overview

The development of the Parramatta Creek fish processing factory in 2009 allowed Huon Aquaculture to consolidate its wet-processing activities and value-adding facility at a centralised site. Before that, it operated wet-processing facilities at Port Huon and Strahan and a value-adding facility in South Australia.

Rapid growth in the industry since 2009 has resulted in a need to increase production at the Parramatta Creek facility. Huon Aquaculture is planning to increase annual processing to 33,000 tonnes per annum of fish products within three years, pending regulatory approval.

Increases in processing will result in increased wastewater generation. Table 1 shows the planned annual increases in wastewater production. The reduced production in 2018/19 is due to the loss of fish in storms during the year which impacted fish harvest. By the end of 2021/22, it is anticipated that the annual wastewater production will be approximately 110ML. The maximum wastewater produced when the facility reaches 33,000tpa is 112.2ML.

Table 1 Past and predicted production and wastewater volumes

Financial year	Fish production (t)*	Total annual volume (kL)	Total annual volume (ML)
2017/18	22,695	77,163	77.2
2018/19	20,364	69,239	69.2
2019/20	26,400	89,760	89.8
2020/21	29,896	10,1645	101.6
2021/22	32,365	110,040	110.0
Max. production	33,000	112,200	112.2

** Production figures are for fish products produced*

1.1.2 Location

The Parramatta Creek fish processing facility site, and associated irrigation land, is located approximately 25km south-east of Devonport at Sassafras. The land is owned by Huon Aquaculture and the processing site is situated on approximately 56ha of land.

To date, irrigation of wastewater from the processing facility has been conducted on the processing facility property owned by Huon Aquaculture. This plan proposes an extension of irrigation activities to include the property adjacent to Huon Aquaculture, owned by the Layton family and managed by Mr Troy Layton. Table 2 outlines the land tenure details for these properties and the locations are shown at a regional level in Figure 1.

Table 2 Land tenure details

Name	HA processing and irrigation land	Adjacent irrigation land
Property address	7216 Bass Hwy Sassafras Tas 7307	7218 Bass Hwy Sassafras Tas 7307
Property ID	3000065	3058515
Title reference	158261/1	158261/2, 250684/1 and 221705/1
Owner's name	Huon Aquaculture Group Limited	T, R & H Layton

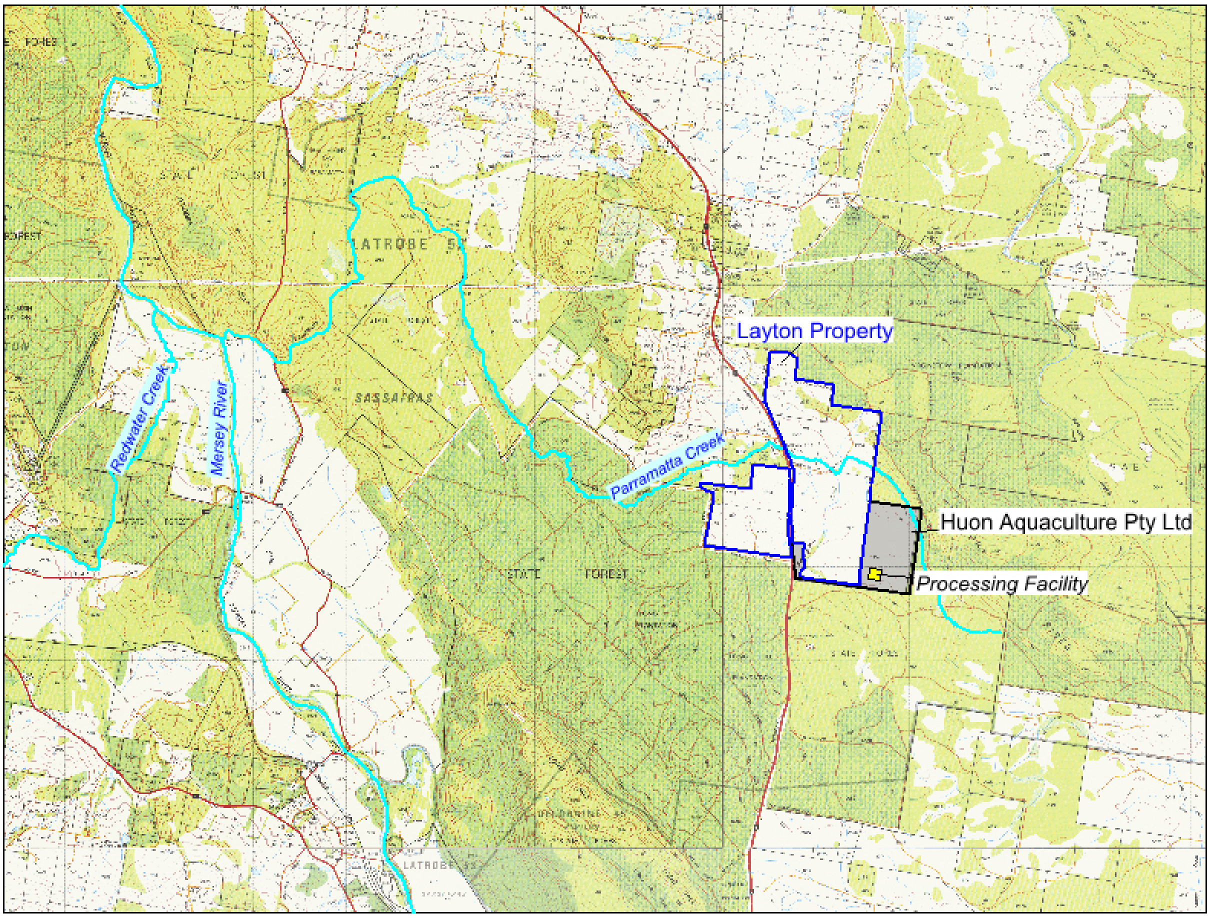

Figure 1 Parramatta Creek fish processing facility site and irrigation property location map

1.2 Objectives of the Wastewater Reuse EMP

The objectives of this Wastewater Reuse Environmental Management Plan (Wastewater Reuse EMP) are to:

- Meet the requirements of condition G10 in the Environmental Permit Conditions (No. 7894) issued by the Environment Protection Authority (EPA) for the site in December 2009.
- Identify a sustainable, land-based reuse solution for wastewater produced by the Parramatta Creek fish processing facility, to address existing wastewater volumes and forecast increased flows.
- Outline management practices required to ensure safe and sustainable wastewater irrigation.
- Detail an appropriate environmental monitoring program to monitor the impact of wastewater irrigation.

This Wastewater Reuse EMP has been developed to ensure a solution that has long term environmental sustainability, appropriately manages public health considerations and provides benefit to Huon Aquaculture (with a waste product to manage) and the entity(s) conducting irrigation activities using the wastewater.

Rather than a disposal-driven reuse scheme, this Wastewater Reuse EMP outlines an option which is consistent with the waste management hierarchy, based on beneficial reuse irrigation activities.

1.3 Regulatory framework

1.3.1 Environmental Management and Pollution Control Act 1994

The facility is a Level 2 activity under Schedule 2 of the *Environmental Management and Pollution Control Act 1994* (EMPCA). In order to obtain approval for increased processing tonnages a Development Proposal and Environmental Management Plan (DPEMP) will be submitted to the EPA for assessment under the Act.

1.3.2 Environmental Permit Conditions

The Wastewater Reuse EMP is a requirement of permit conditions issued by the EPA in December 2009 (Permit Conditions – Environmental No. 7894). Table 3 outlines the requirements of condition G10 (Wastewater Reuse EMP) and how this updated Wastewater Reuse EMP addresses each requirement.

Table 3 Summary of EPN condition G10 requirements and how they are addressed by WREMP

G10: Wastewater Reuse EMP		How the requirement is addressed
1.	At least 45 days prior to the discharge of effluent to a wastewater reuse scheme, or by a date specified in writing by the Director, a Wastewater Reuse Environmental Management Plan ('Wastewater Reuse EMP') must be submitted to the Director. This requirement will be deemed to be satisfactory only when the Director indicates in writing that the submitted document adequately addresses the requirements of this condition to his or her satisfaction.	Addressed – the irrigation scheme is existing but this Wastewater Reuse EMP addresses this requirement for an expanded scheme footprint.
2.	The plan must be consistent with Section 4.3 of the DPEMP as relevant to effluent storage and reuse.	Addressed - the DPEMP for the Parramatta Creek fish processing facility is currently being updated, with this Wastewater Reuse EMP outlining the future requirements for storing and using wastewater.
.	The plan must be prepared in accordance with *the Environmental Guidelines for the Use of Recycled Water in Tasmania* and in compliance with the following requirements:	Addressed – this Wastewater Reuse EMP has been prepared in accordance with these guidelines.
3.1	• No livestock are to be grazed on land subject to irrigation with effluent; and	Change to this condition has been requested (section 9.1) to allow livestock grazing with minimum 48-hour withholding period between irrigation and livestock access.
3.2	• No crops other than livestock fodder crops or non-human food crops are to be grown on land subject to irrigation with effluent.	Addressed - section 9.1
4.	Without limitation, the plan must include details of the following:	
4.1	• treated wastewater storage capacity to enable full effluent reuse in a 90th percentile wet year.	Addressed – section 5.4
4.2	• a construction timetable for the provision of effluent storage facilities to ensure that the total available storage capacity will be sufficient for a 90th percentile wet year at any time after discharge of the effluent to the reuse scheme.	Addressed – section 12
4.3	• crops to be grown and cropping schedule consistent with these conditions;	Addressed – section 6.5
4.4	• commercial arrangements for the wastewater reuse scheme management;	Addressed – section 11
4.5	• the results of baseline soil and groundwater monitoring and an agronomic and environmental assessment of the results;	Addressed – section 2.1.4
4.6	• effluent characterisation;	Addressed – section 5.2

G10: Wastewater Reuse EMP		How the requirement is addressed
4.7	• any effluent and groundwater monitoring programs additional to those specified in the WWTP construction and commissioning plan required under these conditions;	Addressed – section 10
4.8	• soil and surface water monitoring programs;	Addressed – section 10
4.9	• plans showing areas to be irrigated with effluent, the location of effluent storage facilities, map coordinates for the discharge points from effluent storage facilities to irrigation equipment and map coordinates for each designed soil, groundwater and surface water monitoring points;	Addressed Wastewater and irrigation infrastructure – section 7 Environmental monitoring points – section 10
4.10	• a table containing all the major commitments made in the plan;	Addressed – section 13
4.11	• an implementation timetable for key aspects of the plan; and	Addressed – section 12
4.12	• A reporting program to regularly advise the Director of the results of the plan.	Addressed – section 10.8
5	The plan, as amended from time to time with the written agreement of the Director, must be implemented to the satisfaction of the Director.	

1.3.3 Development Proposal and Environmental Management Plan

The Wastewater Reuse EMP will form part of the DPEMP currently under development, referred to within this document as DPEMP (September 2019), to reflect the increase in production capacity at Huon Aquaculture's Parramatta Creek Fish Processing Facility. The most significant proposed changes from the existing DPEMP (approved 2009) are:

- Increased production at Huon Aquaculture's Parramatta Creek fish processing facility to 33,000tpa of fish products produced at Lot 1, 7216 Bass Highway, Sassafras.
- Irrigation of treated wastewater produced on site at Lot 1, 7216 Bass Highway, Sassafras and at 7218 Bass Highway, Sassafras.

The Wastewater Reuse EMP outlines the management and monitoring requirements for sustainable reuse of the predicted volumes of effluent (wastewater) from increased production at the Parramatta Creek fish processing facility.

1.3.4 Wastewater reuse EMP review guidelines

This Wastewater Reuse EMP was prepared in accordance with the EPA's *Wastewater Reuse EMP Review Guidelines, 2014.*

1.3.5 Recycled water guidelines

In practical terms, recycled water in Tasmania is typically managed in accordance with the *Environmental Guidelines for the Use of Recycled Water in Tasmania, 2002*, referred to hereon as the Tasmanian Recycled Water Guidelines (TRWG).

The foreword of TRWG note that the TRWG are intended to provide a framework to allow the sustainable reuse and recycling of wastewater in a manner which is practical and safe for agriculture, the environment and the public. It is acknowledged that in applying the guidelines, they are to be used in a manner consistent with industry standards and best practice environmental management. Whilst the TRWG provide guidelines on various aspects of recycled water management, they also encourage a performance based, site specific approach to management.

1.4 Supporting documentation review

Documents consulted and reviewed in the development of this Wastewater Reuse EMP include:

- Tasmanian Recycled Water Guidelines: *Environmental Guidelines for the Use of Recycled Water in Tasmania*, DPIPWE, 2002.
- Permit Part B: Permit Conditions – Environmental No. 7894, issued under the EMPCA by the EPA, 2009.
- *Wastewater Reuse EMP Review Guidelines*, 2014, *EPA.*
- DPEMP (2009): *Parramatta Creek fish processing facility, development proposal and environmental management plan*, prepared for Huon Aquaculture Company Pty Ltd, 2009, by Pitt & Sherry.
- Draft DPEMP (September 2019*): Parramatta Creek fish processing facility, increase in production capacity – development proposal and environmental management plan (draft)*, prepared for Huon Aquaculture Company Pty Ltd, January 2018, by Caloundra Environmental Pty Ltd.
- Site *suitability assessment for effluent reuse – Layton's Farm Parramatta Creek*, April 2017, by Geo-Environmental Solutions (GES).
- *Orchard suitability for waste water application, Huon Aquaculture, Parramatta Creek, December 2010, by* Agricultural Resource Management*.*
- *Soil suitability for waste water application, Huon Aquaculture, Parramatta Creek, September 2010, by* Agricultural Resource Management*.*

The full list of references is provided in section 15.

2 Background

2.1 Previous wastewater reuse activities

2.1.1 Wastewater quantity

The existing DPEMP (approved 2009) was developed based on a production limit of 14,000tpa of fish products, which was estimated to generate an average of 106 kL/day or 38,690 kL/year (38.7 ML/year) of wastewater. The existing DPEMP (approved 2009) identified that 12ha of land was required for irrigation and 28 ML of winter storage capacity was needed in a 90th percentile wet year. Water balance calculations were based on pasture production and harvesting at the site.

2.1.2 Wastewater quality

2.1.2.1 Predicted quality

As shown in Table 4, in the existing DPEMP (approved 2009), the predicted wastewater quality from the Parramatta Creek fish processing facility was not anticipated to meet Class B recycled water standards for thermotolerant coliform count and biological oxygen demand (BOD). The wastewater irrigation activities described in the DPEMP were based on additional treatment being implemented to enable Class B requirements to be met.

The salinity of the wastewater at the facility was expected to be <1000mg/L (as Total Dissolved Solids), lower than at the previous fish processing facilities at Port Huon and Strahan, due to replacing salt water with chilled, fresh water for the transportation and cooling process.

2.1.2.2 Actual water quality

Annual median water quality results relevant to the TRWG and irrigation activities are presented in Table 4. Wastewater quality has historically not met Class B recycled water standards, based on one or more of the relevant parameters (thermotolerant coliforms, BOD or pH) being outside the specified range.

Additionally, the electrical conductivity of wastewater has been considerably higher than predicted, with particularly high salinity levels reached in 2015/16 (reaching 8,000µS/cm in June 2016) (Figure 2). Since then, the quality has improved, with a reduction in thermotolerant coliforms, BOD, salinity, ammonia and total nitrogen. Whilst there was a considerable improvement, salinity remained higher than what is considered optimal for agricultural production.

The increase in pH observed in the wastewater ponds is due to the improved operation of the water treatment ponds. The ponds utilise algae and bacteria to breakdown organics in the wastewater stream, this results in photosynthesis and respiration occurring in the pond. CO_2 and H+, which are both acids, are consumed during photosynthesis, resulting in an increased pH. The loss of CO_2 also decreases the pH buffering capacity of the wastewater. With reduced buffering capacity the higher pH wastewater will have little effect on soil pH when irrigated. Additionally, the soils of the area are naturally acidic, and pastures will respond positively to an increased water pH, although this is unlikely to occur.

Electrical Conductivity in the wastewater pond (pond 4) has steadily declined since 2015. Major improvements have been made to reduce the salinity levels in the wastewater stream. These include:

- 2015 - A waste stream audit from source to disposal including transport was conducted for salinity. As a result, strict protocols and procedures were introduced to prevent unnecessary salt use. This includes a data management system being introduced at Parramatta Creek and Port Huon to ensure that the salt slurry systems are operating at their minimum salt load and any issues can be identified.
- 2016 - A salt recovery system was installed at the Parramatta Creek site to capture clean high saline water that was entering the site waste stream and previously disposed of through the plant wastewater system. The high saline water is now recycled through the slurry production system. An estimated $100,000 spend of capital.
- 2017 - An upgrade of the salt slurry system at Port Huon to stabilise conductivity within the transport slurry water was completed in March 2017. An estimated $750,000 spend of capital.

Figure 2 shows the decrease in salinity since the improvements outlined above have been made. There has also been a slight increase in production during this time, which has not resulted in increases in salinity.

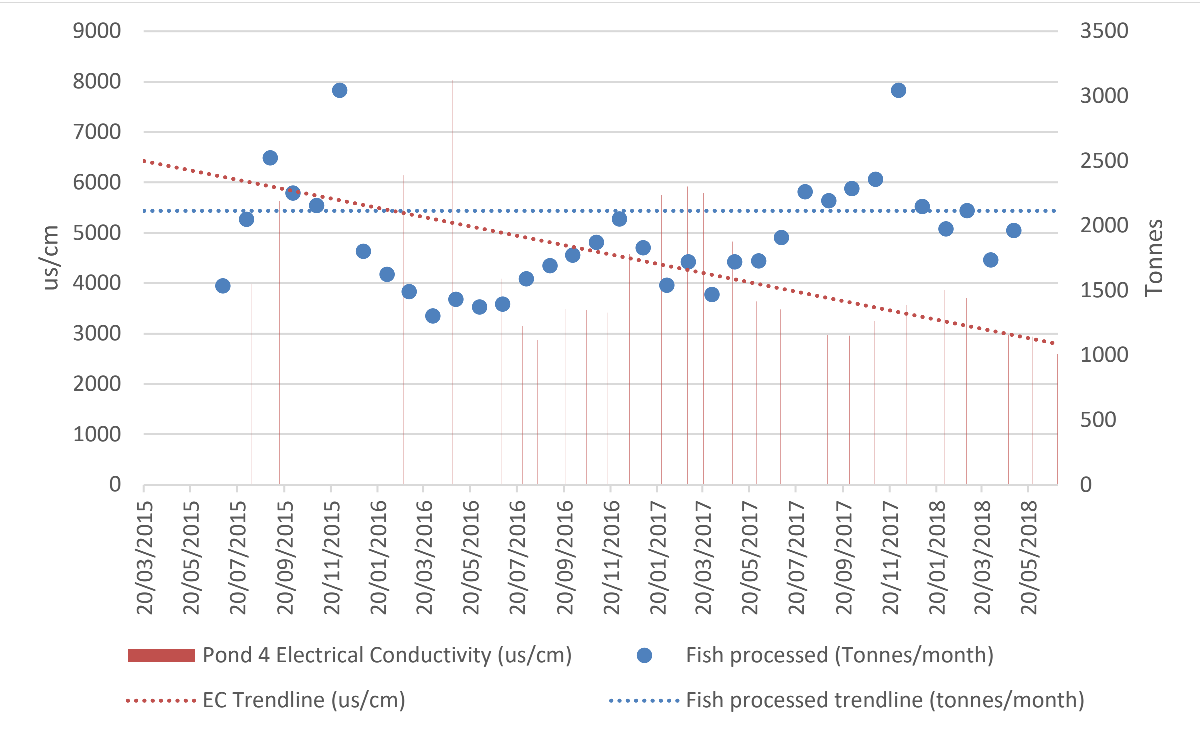

Figure 2 Salinity of the wastewater pond compared with the processed fish tonnes at Parramatta Creek fish processing facility from 2015 to 2018

Table 4 Historical annual median water quality results compared with TRWG Class B recycled water requirements

Parameter	TRWG Class B quality	Predicted (DPEMP, 2009)#	Annual median water quality results*						
			2011/ 2012	2013/ 2014	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019
Thermotolerant coliforms (cfu/100ml)	<1,000	10,000	150	10,000	800	240	250	175	145
BOD (mg/L)	<50	1,240	134	102	130	15	31	25.5	18.5
pH	5.5 – 8.0	6.5-8	7.3	7.3	7.8	7.8	8.7	8.4	7.8
Nutrient, toxicant and salinity controls									
Electrical conductivity (µS/cm)		<1,000	4,250	4,520	6,040	4,090	3,560	3,070	2,380
Ammonia (mg/L)		<5	44.8	47.5	55.5	11	1.2	2.3	6.55
Total nitrogen (mg/L)		140 (Total Kjeldahl N)	62.3	81.1	82.5	20	17	18	21

the DPEMP (2009) noted wastewater would need to meet the Class B recycled water requirement via additional treatment, however did not specify the quality that would be achieved post-secondary treatment.

**No data available for 2012/13.*

Note: red and green cells indicate whether the annual median result for thermotolerant coliforms, BOD and pH meet the Class B recycled water requirements.

2.1.3 Wastewater irrigation operations

Wastewater produced by fish processing operations and the truck washdown area is discharged to the wastewater treatment plant (lagoon system), where irrigation occurs predominantly from pond 4 (reuse dam) and occasionally from pond 3 (if pond 4 is empty).

The irrigation infrastructure has historically included:

- a system of four treatment lagoons (pond 1: 2.6ML, pond 2: 2.6ML, pond 3: 5.2ML, pond 4: 5.2ML, total capacity 15.6ML)
- a small irrigation shed housing the irrigation pump and pre-irrigation screen or filter, which prevents solids from entering the system
- irrigation equipment (originally solid set sprinklers, now a centre pivot irrigator).

Historically, wastewater was pumped from pond 4 (or occasionally pond 3) to a fixed sprinkler system for irrigation over approximately 15ha of pasture.

Recently, a 168m three-span centre pivot irrigator capable of irrigating 11.5ha of land was installed to more evenly distribute wastewater over land, replacing the fixed sprinkler setup.

Irrigation activities have historically been managed by Huon Aquaculture staff.

2.1.4 Environmental performance

The environmental performance of wastewater irrigation activities at the Parramatta Creek fish processing facility has been below expectation. The system has been challenged by several factors not being in line with the expectations forecast in the existing DPEMP (approved 2009), including:

- Wastewater salinity has been considerably higher than forecast and at times significantly outside of a range suitable for agricultural production.
- Wastewater quantity has exceeded the predicted volume, which was used as the basis for determining the irrigation area required and for which the irrigation system was designed.
- Insufficient land area for the actual volume of wastewater produced, resulting in per hectare application rates greater than what was deemed sustainable in the DPEMP.
- Insufficient storage capacity (with the increased wastewater quantity), resulting in irrigation practices at times being based on the need to empty the reuse dam, rather than plant irrigation requirements (i.e. irrigation of soils that may already be wet).
- The irrigation system was constructed to irrigate directly from the lagoon system, without capacity to shandy wastewater to manage wastewater salinity (either in the dam or in the pipeline).

Section 3 outlines baseline data and environmental performance to date, and the effect that the improvement in wastewater quality (section 2.1.2) has had on improving soil and groundwater parameters.

3 Baseline environment data

3.1 Soil

3.1.1 Overview

The soils on the Huon Aquaculture and Layton properties have been previously described by Agricultural Resource Management (2010) and Geo-Environmental Solutions (GES) (2017), and ground-truthed by Macquarie Franklin in the development of this Wastewater Reuse EMP. The ground-truthing methodology involved extensive field assessment of the Huon Aquaculture and Layton's properties, conducted by a senior consultant with over 20 years of experience in soil, irrigation and agronomic management. The predominant soil types present across the two properties, which are mapped and described in section 6.2.3, are:

- Alluvial loam (92.7ha)
- Duplex (deep topsoil) (45.9ha)
- Roebuck (moderately well drained) (25.4ha)
- Roebuck (poorly drained) (20.8ha)
- China (20.3ha)

These soil types have varying suitability for irrigation of wastewater, and combined with their location in the landscape, have been assessed for suitability in section 6.1.

3.1.2 Baseline data

Pitt and Sherry collected baseline data from Huon Aquaculture's property as part of the development of the original DPEMP (2009). This sampling event consisted of five sites of which two were within the HAC centre pivot site. The analysis data is provided in Appendix A.

A follow up soil sampling was conducted by Geo-Environmental Solutions (GES) in March 2016. The five sites sampled in 2009 sites were sampled and tested again. This enables a direct comparison of the impact of wastewater disposal on soil parameters (analysis data provided in Table 6). As part of the development of this WREMP, Macquarie Franklin conducted soil sampling of the Huon Aquaculture centre pivot in October 2018. This consisted of two sampling sites which were different to the Pitt and Sherry (2009) and GES (2016) sites. Data from this analysis is presented in Appendix C.

A soil monitoring event was conducted by Geo-Environmental Solutions (GES) in 2017 on Layton's property. This sampling event consisted of only two sites which were part of a soil profile assessment (data presented in Appendix B). Macquarie Franklin conducted an extensive soil sampling program on Layton's property in October 2018. This consisted of 14 locations associated with soil pit sites. None of the Macquarie Franklin sites duplicated the 2017 GES sampling sites. Data from this analysis is presented in Appendix C.

3.1.2.1 2009

Baseline data was collected for the Huon Aquaculture property as part of the development of the original DPEMP (2009), with the results and comments from the DPEMP presented in Table 5. The sampling locations, detailed data summary and analysis reports are provided in Appendix A.

Table 5 Summary of baseline soil results for Huon Aquaculture's property (Pitt & Sherry, 2009)

Parameter	Results range	Description in existing DPEMP (approved 2009)
pH (water)	Topsoil: 5.7-5.9 Subsoil: 5.7-5.8	All sites have a soil pH value slightly below an acceptable level of 6.0. The low pH result may be due to the local site soil type and structure. This will need to be monitored as irrigation starts to ensure that there are no negative effects on the ryegrass production and possible decline in soil structure.
EC (1:5 soil/water leach)	Topsoil: 10-15µS/cm Subsoil: 8-16µS/cm	The soil ECs are all well below an acceptable level of 100 µS/cm.
ESP	Topsoil: 2.1-9.1% Subsoil: 5.5-11.2%	The exchangeable sodium percentage (ESP) is a measure of the sodicity of the soils. Sodic soils can lead to degradation of soil structure, making the soil more erodible and less permeable to water possibly causing waterlogging. IASS5 both upper and lower samples were found to have relatively higher levels of ESP (greater than 6). ASS5 is located at BH5 which is near the drainage areas reporting to Parramatta Creek. This area will be avoided during irrigation minimising the impact of this site.

Parameter	Results range	Description in existing DPEMP (approved 2009)
Exchangeable Cations	Topsoil CEC: 4.4-12.2 meq/100g Subsoil CEC: 4.4-10.5 meq/100g	The cation exchange capacity (CEC) for most soils sampled fall in the low category. The preferred CEC level is above 10. CEC is a measure of the reactivity of the soil. This is not of concern at this stage as the treated effluent is expected to have relatively low salinity and therefore sodium concentrations minimising the risk of sodic soils. This will be monitored during possible irrigation practices to ensure that there are no negative effects from the application of the treated wastewater to the land. All soil sites have exchangeable calcium, magnesium, sodium and potassium levels fall within the suggested quantities
Heavy Metals and Trace Elements	Topsoil: • Al: 4,000-6,900 mg/kg • B: <50 mg/kg • Cd: <1 mg/kg • Cu: <5 mg/kg • Pb: 7-15 mg/kg • Mo: <2 mg/kg • Ni: <2-3 mg/kg • Se: <5 mg/kg • Zn: <5-13 mg/kg Subsoil: • Al: 3,820-7,590 mg/kg • B: <50 mg/kg • Cd: <1 mg/kg • Cu: <5 mg/kg • Pb: 6-17 mg/kg • Mo: <2 mg/kg • Ni: -3 mg/kg • Se: mg/kg • Zn: <5-16 mg/kg	All soil samples seem to have low or normal levels of heavy metals and trace elements and therefore there are no foreseeable problems associated with the levels found in the area.
Nutrients	Topsoil: • Total N (Kjeldahl):1,570-3,630 mg/kg • Total P: 141-615 mg/kg • Total K: 380-950 mg/kg • Total Mg: 240-590 mg/kg • Total Ca: 790-2,720 mg/kg Subsoil: • Total N (Kjeldahl): 820-2,100 mg/kg • Total P: 91-486 mg/kg	Soil nutrient levels are all within normal levels for ryegrass pasture. This will need to be monitored after irrigation starts to ensure that there are no negative effects on the ryegrass production and soil structure from additional nutrients applied from the treated wastewater.

Parameter	Results range	Description in existing DPEMP (approved 2009)
	• Total K: 380-810 mg/kg • Total Mg: 220-540 mg/kg • Total Ca: 420-1,290 mg/kg	
Organic Matter and Total Organic Carbon	Topsoil: • OM: 3.4-7.5% • TOC: 1.9-4.4% Subsoil: • OM: 1.9-4.4% • TOC: 1.1-2.5%	All soil sample sites have a level of organic matter greater than 1.7% and a level of organic carbon greater than 1.0% indicating that all sample sites have a moderate to very high rating. This means that the soils in the irrigation area have good structural condition and high structural stability making the land suitable for irrigation reuse of the treated wastewater.

3.1.2.2 2016

In March 2016, GES re-sampled the original (2009) sites on Huon Aquaculture's property. The results are summarised in Table 6 and Table 7 with the resulting GES interpretation discussed in section 3.1.3.

Table 6 Summary of soil test results from GES 2016 soil sampling event on Huon Aquaculture's property

Analyte	Unit	LOR	HA002		HA004		HA005		HA006		HA007	
Depth (cm)			0–10	10–38	0–131	13–38	0–14	14–43	0–14	14–43	0–14	14–43
pH		0.1	4.7	4	5	4.7	4.7	4.6	4.2	3.8	5	4.2
Electrical conductivity	µS/cm	1	742	265	429	333	451	269	21	11	590	418
Exchangeable calcium	meq/100g	0.1	1.8	0.7	4.4	4.1	3.8	3.8	4.3	1.4	26	3.4
Exchangeable magnesium	meq/100g	0.1	0.8	0.9	1.6	3.2	1.1	1.8	3	2.9	2.7	4.5
Exchangeable potassium	meq/100g	0.1	0.3	0.3	0.6	0.6	0.7	0.5	0.6	0.6	0.7	0.6
Exchangeable sodium	meq/100g	0.1	1.4	1.6	3.4	2	3.8	2.5	0.3	0.3	2.5	0.7
Cation exchange capacity	meq/100g	0.1	1.4	3.5	10	9.8	9.5	8.7	8.3	5.2	11.2	9.2
Sulfur (total as S)	%	0.01	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02
Chloride	mg/kg	10	1480	450	840	630	930	530	20	<10	1240	880
Soluble calcium	mg/kg	10	<10	<10	<10	<10	<10	30	<10	<10	<10	20
Soluble magnesium	mg/kg	10	<10	<10	<10	<10	<10	80	<10	<10	<10	20
Soluble sodium	mg/kg	10	1120	320	590	440	640	36	20	<10	850	490
Soluble potassium	mg/kg	10	30	20	10	10	10	100	<10	<10	30	10
Arsenic	mg/kg	5	<5	<5	13	16	11	12	12	10	11	11
Boron	mg/kg	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Cadmium	mg/kg	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Copper	mg/kg	5	<5	<5	<5	7	5	<5	<5	6	5	7
Lead	mg/kg	5	<5	<5	9	8	9	10	12	10	11	9
Molybdenum	mg/kg	2	<2	<2	2	2	<2	<2	<2	<2	2	<2
Nickel	mg/kg	2	<2	<2	3	2	3	2	<2	<2	2	<2
Tin	mg/kg	5	<5	<5	<5	<5	<5	< 5	<5	<5	<5	<5
Zinc	mg/kg	5	6	<5	13	15	14	13	14	15	15	14
Mercury	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.02	<0.12	<0.1	15	<0.1
Nitrite + nitrite as N	mg/kg	0.1	25.9	13	23.8	9.2	25.3	17.7	14.9	10.4	32.12	16.1
Total Kjeldahl nitrogen as N	mg/kg	20	1700	280	2200	880	920	630	1570	640	2050	1200
Total nitrogen as N	mg/kg	20	1720	290	2200	890	940	650	1580	650	2080	1220
Phosphate sorption capacity	mg P sorb/kg	250	1180	1100	1580	1760	1790	1420	2090	2110	1920	2440
Bicarbonate Ext P (Colwell)	mg/kg	2	18	72	44	< 5	85	12	8	6	9	<5
Organic matter	%	0.5	5.5	1.3	4.7	1.3	7.5	1.2	4.4	1.7	6.3	1.6
Total organic carbon	%	0.5	2.34	0.92	3.73	0.6	3.44	0.7	2.02	0.78	3.45	0.81

3.1.2.3 2017

In 2017, GES collected baseline soil data for the proposed irrigation expansion area on Layton's property. The results and comments are summarised in Table 7.

Table 7 Summary of baseline soil results for Layton's property (GES, 2017)

Parameter	Results range	Description in GES assessment (2017)
pH (water)	Topsoil: 4.6-5.9 Subsoil: 3.9-4.1	The pH on site is low, around 5.0-5.5 for topsoil and around 4.0 for subsoil. Soils formed on Permian deposits often have low pH, and the soil on the neighbouring Huon Aquaculture site have a similar and comparable low pH. Low pH values can make some nutrients less available for plant uptake, and soil pH should be carefully monitored and addressed with supplements (e.g. lime) as recommended by a suitably qualified agronomist.
EC (1:5 soil/water leach**)**	Topsoil: 63-112 µS/cm Subsoil: 18-38 µS/cm	The electrical conductivity (EC) is a measure of inorganic materials, which is relatable to salinity. The EC results at Layton's farm are moderate in the topsoil and low in the subsoil. The irrigation of effluent on the HAC site has increased the EC over time. The data collected at Layton's Farm forms a baseline to compare future measurements to, to determine if the irrigation of effluent is increasing the salinity.
ESP	Topsoil: 1.8-6.7 % Subsoil: 5.3-12.5 %	The exchangeable sodium percentage is a measure of sodicity. The results are moderate in the topsoil, and moderate to high in the subsoil. This is a function of the soils forming on Permian sediments having higher ESP, this is illustrated by the fact that the sample sites on the eastern side of the creek have high subsoil ESP. ESP has increased over time on the HAC site, hence this data forms a good baseline to compare future measurements to, to determine if the irrigation of effluent is increasing the sodicity.
Exchangeable Cations	Topsoil CEC: 8.9-13.1 meq/100g Subsoil CEC: 3.2-4.5 meq/100g	The exchangeable cations are generally low, including sodium, and Cation Exchange Capacity (CEC) is variable, but generally low.
Heavy Metals and Trace Elements	Topsoil: • Al:730-5,100 mg/kg • B: <50 mg/kg • Cd: <1 mg/kg • Cu: 7-24 mg/kg • Pb: <5-12 mg/kg • Mo: <2-5 mg/kg • Ni: <2 mg/kg	

Parameter	Results range	Description in GES assessment (2017)
	• Zn: 21-40 mg/kg Subsoil: • Al: 2,610-11,800 mg/kg • B: <50 mg/kg • Cd: <1 mg/kg • Cu: <5 mg/kg • Pb: <5-9 mg/kg • Mo: <2 mg/kg • Ni: -<2 mg/kg • Zn: <5-9 mg/kg	
Nutrients	Topsoil: • Total N (Kjeldahl):1,850-2,960 mg/kg • Bicarbonate extract P (Colwell): 8-90 mg/kg • Soluble K: 10-80 mg/kg • Soluble Mg: <10-20 mg/kg • Soluble Ca: <10-40 mg/kg Subsoil: • Total N (Kjeldahl): 330-930 mg/kg • Bicarbonate extract P (Colwell): <5 mg/kg • Soluble K: 10-90 mg/kg • Soluble Mg: <10-100 mg/kg • Soluble Ca: <10-20 mg/kg	Total nitrogen levels are moderate in the topsoil, and low in the subsoil. Total phosphorus is also high in the topsoil and low in the subsoil. Nitrogen and phosphorus nutrient levels are possibly a result of recent fertiliser applications as the natural soil is expected to be inherently low in nutrients. Extractable Potassium is low in all samples possibly due to pasture uptake.
Organic Matter and Total Organic Carbon	Topsoil: • OM: 3.4-7.5% • TOC: 1.9-4.4% Subsoil: • OM: 1.9-4.4% • TOC: 1.1-2.5%	

3.1.2.4 2018

In October 2018, Macquarie Franklin conducted soil sampling of Huon Aquaculture's existing wastewater centre pivot area and Layton's property (locations consistent with the sites for proposed ongoing monitoring program, as outlined in Section 10). The results are summarised in Table 8 and Table 9. The laboratory results from October 2018 soil testing for the Huon Aquaculture and Layton's properties are included in Appendix C.

Table 8 Summary of soil test results for the Huon Aquaculture site (Macquarie Franklin 2018)

Parameter	Results range	Description in Macquarie Franklin assessment (2018)
$pH_{CaCl2\ 1:5}$	Topsoil: 5.5-5.7 Subsoil: 4.4-5.6	The pH on site is optimal, average 7.0 for topsoil and 6.8 for subsoil. The current soil pH provides for optimal nutrient availability and soil biological activity.
EC_e	Topsoil: 0.7-0.8 dS/m Subsoil: 0.3-0.4 dS/m	The EC results have increased since the 2017 GES sampling event, with the topsoil increasing from 0.4 up to 0.7 dS/m with the subsoil levels increasing from 0.2-0.3 to 0.3-0.4 dS/m but are still considered optimal with respect to having no expected limit and/or constraint to pasture growth.
ESP	Topsoil: 17-20 % Subsoil: 11-40 %	The results are high in both the topsoil and the subsoil. These soils should be treated with gypsum to assist in dispersing the sodium from the soil.
Exchangeable Cations	Topsoil CEC: 9.8-12.7 cmol(+)/kg Subsoil CEC: 6.0-9.0 cmol(+)/kg	The exchangeable cations are generally low, excluding sodium, and Cation Exchange Capacity (CEC) is variable, but generally moderate.
Heavy Metals and Trace Elements	Topsoil: • As: 6-15 mg/kg • B: 0.4-0.5 mg/kg • Cd: <1 mg/kg • Cu: <1 mg/kg • Pb: <6-10 mg/kg • Mn: 21-23 mg/kg • Ni: <3 mg/kg • Zn: 1.0-1.1 mg/kg Subsoil: • As: 12-16 mg/kg • B: 0.2-0.2 mg/kg • Cd: <1 mg/kg • Cu: <5 mg/kg • Pb: 7-11 mg/kg • Mn: 18-35 mg/kg • Ni: 2 mg/kg • Zn: 0.1-0.3 mg/kg	
Nutrients	Topsoil: • Ammonium N 3.5-3.9 mg/kg • Total N (Kjeldahl):0.27-0.31% • Bicarbonate extract P (Colwell): 21-73 mg/kg • Available K: 180-320 mg/kg	Total nitrogen levels are low in the topsoil and the subsoil. Total phosphorus is moderate to optimal in the topsoil and low in the subsoil. Available Potassium is optimal to high in the topsoil and low in the subsoil. Sulphur is marginal.

Parameter	Results range	Description in Macquarie Franklin assessment (2018)
	• Sulphur S: 4.5-14 mg/kg Subsoil: • Ammonium N 3.1-4.3 mg/kg • Total N (Kjeldahl): 0.08-0.1% • Bicarbonate extract P (Colwell): 5-9 mg/kg • Available K: 140-270 mg/kg • Sulphur S: 4-17	
Organic Matter and Total Organic Carbon	Topsoil: • OC: 2.9-3.5% Subsoil: • OM: 0.6-0.8%	

Table 9 Summary of baseline soil test results for Layton's property (Macquarie Franklin 2018)

Parameter	Results range	Description in Macquarie Franklin assessment (2018)
pH_{water}	Topsoil: 6.2-7.0 Subsoil: 5.9-7.4	The pH on site is optimal, 6.6 for topsoil and 6.5 for subsoil. The current soil pH provides for optimal nutrient availability and soil biological activity.
EC_e	Topsoil: 0.2-0.6 dS/m Subsoil: 0.2-0.5 dS/m	The EC results are optimal with respect to having no expected limit and/or constraint to pasture growth.
ESP	Topsoil: 0.4-3.3 % Subsoil: 2.6-6.1 %	The results are low in both the topsoil and subsoil.
Exchangeable Cations	Topsoil CEC: 7.6-20.4 cmol(+)/kg Subsoil CEC: 4.1-16 cmol(+)/kg	The exchangeable cations are generally low, excluding sodium, and Cation Exchange Capacity (CEC) is variable, but generally moderate.
Heavy Metals and Trace Elements	Topsoil: • As: <5-18 mg/kg • B: 0.3-1.4 mg/kg • Cd: <2-4 mg/kg • Cu: 15-27 mg/kg • Pb: <5-16 mg/kg • Mn: 1.7-26 mg/kg • Ni: <2-3 mg/kg • Zn: 4-20 mg/kg Subsoil: • As: <5-15 mg/kg • B: 0.2-1.1 mg/kg • Cd: <2-3 mg/kg	

Parameter	Results range	Description in Macquarie Franklin assessment (2018)
	• Cu: <5-13 mg/kg • Pb: <5-24 mg/kg • Mn: 0.3-14 mg/kg • Ni: <2-3 mg/kg • Zn: 0.5-3.8 mg/kg	
Nutrients	Topsoil: • Ammonium N 2.1-14.0 mg/kg • Total N (Kjeldahl):0.21-0.32% • Bicarbonate extract P (Colwell): 20-180 mg/kg • Available K: 41-530 mg/kg • Sulphur 1.8-11 Subsoil: • Ammonium N 0.9-5.3 mg/kg • Total N (Kjeldahl): 0.04-0.25% • Bicarbonate extract P (Colwell): 7-22 mg/kg • Available K:19-570 mg/kg • Sulphur 1.1-7.5	Total nitrogen levels are low in the topsoil and the subsoil. Total phosphorus is optimal in the topsoil and low in the subsoil. Available potassium is moderate to high in the topsoil and marginally low in the subsoil. Sulphur is deficient.
Total Organic Carbon	Topsoil: • TOC: 2.1-3.9% Subsoil: • TOC: 0.6-1.7%	

3.1.3 Monitoring results

3.1.3.1 Huon Aquaculture's property

The soil monitoring conducted by Geo-Environmental Solutions (GES) in March 2016 on the Huon Aquaculture property enabled an assessment of the soil nutrient and chemical status of soils where wastewater had been irrigated. Whilst the soil sample locations and sampling methodology varied from those in the original DPEMP (2009) and 2016, a considerable increase in electrical conductivity, chloride, sodium and sodicity levels was observed in soils irrigated with wastewater (Table 10). Concentrations increased in both the topsoil and subsoil, indicating the wastewater migrated through the soil profile. The elevated soil salinity and sodicity were not unexpected, given the elevated electrical conductivity of wastewater that was irrigated onto the site (refer to section 2.1.2.2).

Table 10 Comparison of relevant soil sampling sites between 2009 and 2016

Parameter	Average of Pitt & Sherry 2009		Average of GES 2016 (HA004 and HA005)	
	Topsoil	**Subsoil**	**Topsoil**	**Subsoil**
EC_{se} (dS/m)	0.2*	0.07*	3.5*	2.1*
ESP %	5.6	8.3	37**	24**
pH_{CaCl2}	5***	5***	4.8	4.6

**converted from $EC_{1:5}$ by applying a soil texture conversion value of 8 for the clay loam topsoil and 6.2 for the clay subsoil*
*** calculated from the CEC values for each soil depth*
****calculated from pH_{water} by subtracting 0.8*

The 2018 Macquarie Franklin soil sampling sites A and B on the Huon Aquaculture centre pivot are comparable with the 2016 GES soil sampling sites HA004 and HA005. Table 11 summarises the key parameters (pH, sodicity and salinity) for the Huon Aquaculture centre pivot soil tests from 2016 and 2018. Soil pH has increased, which is positive for nutrient availability and soil health. Any further increases in soil pH are likely to be moderated by the low pH buffering capacity of the wastewater and proposed future shandying prior to irrigation. Refer to section 5.2 for further information on the waste stream irrigation water pH management. Since 2016, a decrease has been observed in the electrical conductivity (EC) (top- and subsoil), while exchangeable sodium percentage (ESP) (sodicity) has decreased in the topsoil but marginally increased in the subsoil. The marginal increase in the subsoil sodicity indicates the migration of sodium further into the soil profile, through the leaching effects of rainfall.

The decreased soil salinity and sodicity observed are consistent with the measurable improvement in the waste stream salinity over the past three years (Section 2.1.2.). The salinity of the Huon Aquaculture centre pivot is still within acceptable limits for pasture growth, however the ESP are high enough to be detrimental to soil health and structure. This can be remediated as outlined in section 4. The phosphorus and potassium levels have decreased slightly but are still within acceptable levels.

Table 11 Comparison of key soil parameters on Huon Aquaculture centre pivot between 2016 and 2018

Sampling sites	Average of HA004 and HA005 GES 2016		Average of A and B MF2018	
	Topsoil	**Subsoil**	**Topsoil**	**Subsoil**
EC_{se} (dS/m)	3.5*	2.1*	0.75	0.35
ESP %	37**	24**	18.5	25.5
pH_{CaCl2}	4.8	4.6	5.6	5

**converted from $EC_{1:5}$ by applying a soil texture conversion value of 8 for the clay loam topsoil and 6.2 for the clay subsoil*
*** calculated from the CEC values for each soil depth*

3.1.3.2 Layton's property

Some differences are apparent between the 2016 and 2018 soil tests, although the sampling locations and methodology used were different. Therefore, some caution is required when interpreting the results. Soil pH has increased, to a level more optimal for plant and soil performance. The fertility levels of Layton's soil in the 2018 soil tests had similar phosphorus level to the 2016 soil tests, with one outlying result of 180 mg/kg, the average value of 54 mg/kg is comparable to the average 2016 results. Due to the differences between the 2016 (soluble potassium) and the 2018 (available potassium) analytical methods it is not possible to make direct comparison on changes in potassium during the past two years.

Irrigation of Layton's property soils with slightly saline water (shandied to 1100µS/cm) is likely to result in little, if any, increase in the soil conductivity and sodicity levels due to the annual winter flushing from rainfall. Refer to section 5.5 for further information on the salt budget and predicted flushing impact of annual rainfall.

3.2 Surface water

3.2.1 Overview

As outlined in section 10.4, there are two main watercourses which flow through the Huon Aquaculture and Layton properties, Felminghams Creek and Parramatta Creek. The Felminghams Creek catchment contains a sand mine, forestry, remnant vegetation and the Bass Highway, with the headwaters of its catchment approximately three kilometres south of the proposed irrigation area. Parramatta Creek's catchment contains remnant vegetation and forestry, with its headwaters approximately one-kilometre south-east of the properties. The confluence of the two creeks is in the middle of Layton's property. Given the existing land uses within the catchments, they would be classified as slightly to moderately disturbed according to the ANZECC (2000) guidelines.

Figure 3 shows the location of Parramatta Creek within the Mersey River catchment.

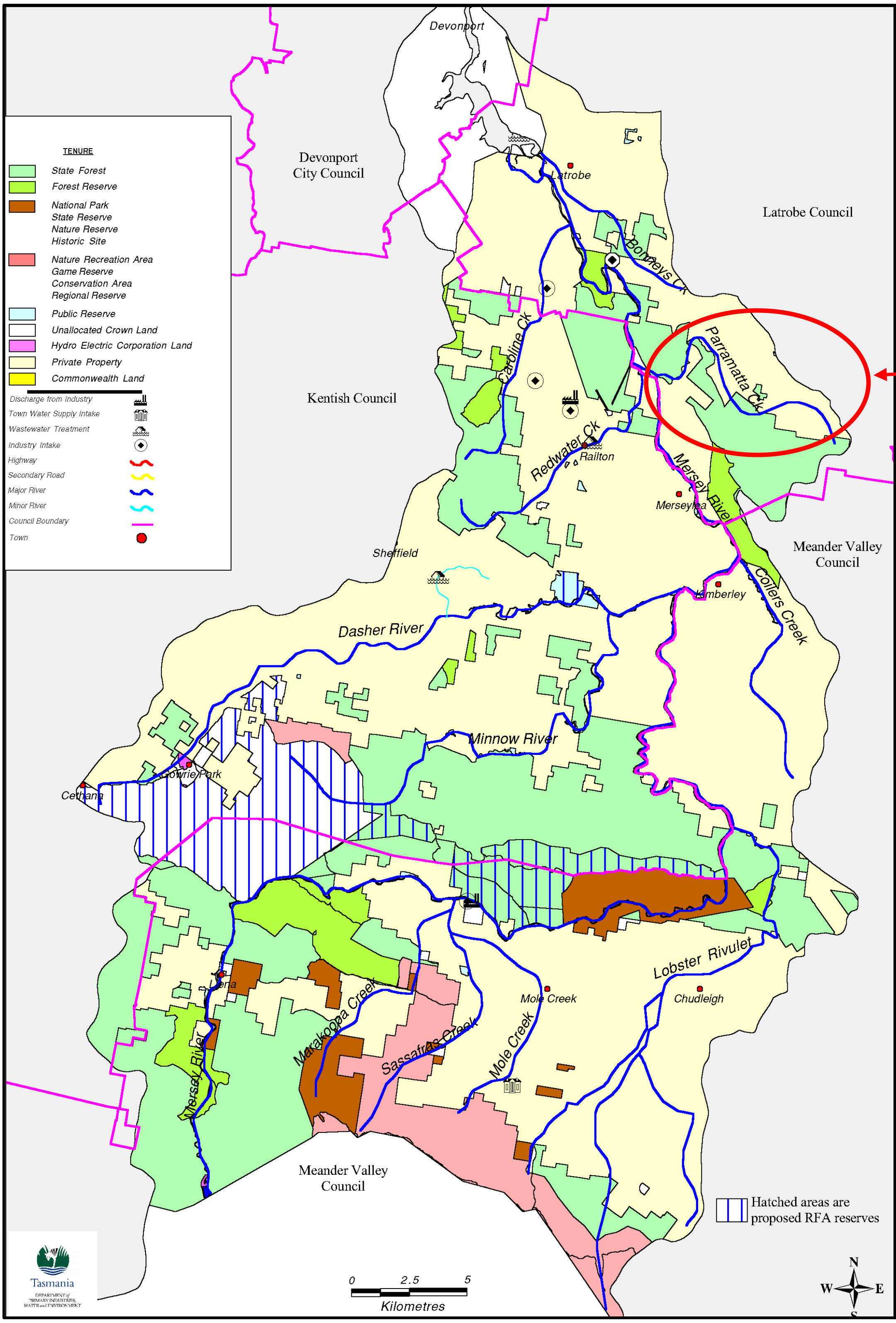

Figure 3 Mersey River middle catchment

Source: EPA website http://epa.tas.gov.au/Pages/Document.aspx?docid=766 accessed 22 December 2017

3.2.2 Baseline data

3.2.2.1 Historical data

Surface water baseline data was not presented in the original DPEMP (2009) and there is limited background data available for Parramatta Creek or similar tributaries.

A description from a Mersey River catchment perspective contained in the *Environmental management goals for Tasmanian surface waters, Mersey River catchment, March 2001,* is as follows:

> *Water quality assessment of rivers in the Mersey Catchment indicate that while most water quality parameters show a gradual deterioration downstream they are diluted by main stream flows. Tributaries of the Mersey, in particular Coilers Creek and Redwater Creek in the middle catchment and Parramatta and Kings creeks in the lower catchment, appear to be much more degraded than the Mersey. Nitrogen and phosphorus levels sufficient to cause algal blooms are evident in Coilers Creek and Redwater Creek. These high concentrations appear to be related to intensive animal industries and sewage treatment plant effluent. The origins of pollutant inputs into Parramatta and Kings creeks are, because of their proximity to Latrobe, more complex due to the greater variety of catchment activities.*
>
> *Microbiological results were also worse in Mersey Catchment tributaries than in the main stream. Six out of 18 sites exceeded ANZECC guidelines for primary contact. Stock access to waterways may underline these results.*

The report also acknowledged that low oxygen concentrations can occur in Parramatta Creek during low flow events. The report then provides the following macroinvertebrate assessment:

> *Macroinvertebrate communities in the region's waterways appear to be in reasonable health although subject to some impacts arising from degraded water quality, habitat degradation from both forestry and agricultural practices and water diversion. Changes in flow and habitat below the Parangana Dam has had some impact on stream invertebrates, and there is a detectable impact in the lower Mersey, possibly due to degraded water quality.*
>
> *Tributaries in the lower catchment – Kings, Parramatta and Bonneys creeks, the lower Dasher River and Coilers Creek – are of major concern, with reduced species richness probably due to degraded water quality and habitat alteration.*

On 27 September 2018, the EPA provided historic water quality values for Parramatta Creek close to the confluence with the Mersey River (presented in Table 12). The data shows the seasonal variation in salinity due to reduced runoff events during summer, causing an increasing electrical conductivity in summer and autumn. This can be attributed to the summer surface water flows being influenced by groundwater discharge more so than rainfall events.

Table 12 Historic values for Parramatta Creek water quality (EPA, 2018)

Analyte	Units	Range	Median	80th percentile	Source
pH		6.68-7.65	7.28	7.1-7.5	Parramatta creek at Native Plains Road historic data 2005-2007
EC	uS/cm	265-657	500	540	Parramatta creek at Native Plains Road historic data 2005-2007
Ammonia N	mg/L			0.02	Mersey at Union Bridge
Nitrate N	mg/L			0.94	Redwater Creek above the Railton sewage treatment plant
Total Nitrogen	mg/L			1.4	Redwater Creek above the Railton sewage treatment plant
Total Phosphorus	mg/L			0.05	Redwater Creek above the Railton sewage treatment plant

3.2.2.2 2018/19 data

A surface water sampling program was undertaken during spring 2018 (3 October 2018) and Autumn 2019 (1 April 2019) by Macquarie Franklin in accordance with the proposed program in section 10.5 (map included in section 10.5). Analytical results are shown in Table 13 and Table 14. The results show a steady increase in pH and electrical conductivity moving down gradient within the Parramatta Creek system. These parameters show a strong correlation with the baseline groundwater results (Table 20) and can be attributed to the creek falling with in a groundwater discharge area (Appendix L). The nutrient levels at all sites were relatively low during spring when compared with historical results within Parramatta Creek (Table 12), however nitrogen and phosphorus levels increased significantly in Autumn. SS3 and SS4 recorded moderate to high levels of thermotolerant coliforms, this is likely due to the impacts from native animals or livestock, as cattle were grazing along the creek at the time of sampling. SS3 also recorded high levels of ammonia and total kjeldahl nitrogen during autumn, likely attributed to stock access to drying pools.

Table 13 Surface water monitoring results 3 October 2018 (site location and description provided in Table 39 - 10.5.2.1)

Analytes	Unit	SS3	SS4	SS5	SS6
Physiochemical results					
pH**water**		7.28	7.06	6.72	**5.8**
Temperature	°C	15.6	15.08	14.1	**13.6**
Electrical conductivity	µS/cm	710	380	270	**150**
Oxidation Reduction Potential	ms/cm	276.5	281	220	**315**
Analytical results					
Ammonia	mg/L	< 0.1	< 0.1	0.2	**< 0.1**
Nitrite as N	mg/L	< 0.01	< 0.01	< 0.01	**< 0.01**
Nitrate as N	mg/L	0.04	0.08	0.16	**0.02**
Nitrite + nitrite as N	mg/L	0.04	0.08	0.16	**0.02**
Total Kjeldahl nitrogen as N	mg/L	0.4	0.4	0.4	**0.4**
Total nitrogen as N	mg/L	0.4	0.6	0.6	**0.4**
Total phosphorus	mg/L	< 0.05	0.05	0.06	**< 0.05**
Thermotolerant coliforms	cfu/100 mL	420	660	30	**< 10**
E. coli	**cfu/100 mL**	**410**	**660**	**30**	**< 10**

Table 14 Surface water monitoring results 1 April 2019 (site location and description provided in Table 39 - 10.5.2.1)

Analytes	Unit	SS3	SS4	SS5	SS6
Physiochemical results					
pH**water Lab**		7.1	7.3	Dry	Dry
Temperature	°C	17.2	15.2		
Electrical conductivity	µS/cm	380	380		
Oxidation Reduction Potential	ms/cm	54.3	43.9		
Analytical results					
Ammonia	mg/L	1.8	0.4		
Nitrite as N	mg/L	< 0.01	0.02		
Nitrate as N	mg/L	< 0.01	0.71		
Nitrite + nitrite as N	mg/L	0.01	0.73		
Total Kjeldahl nitrogen as N	mg/L	5.9	1.3		
Total nitrogen as N	mg/L	6	2		
Total phosphorus	mg/L	0.79	0.09		
Thermotolerant coliforms	cfu/100mL	21000	2500		
E. coli	**cfu/100mL**	**21000**	**2500**		

3.2.3 Monitoring results

Surface water quality has been measured at the Huon Aquaculture site (SS1) downstream of the irrigation area, where groundwater seepage and surface run off occurs, prior to entering Parramatta Creek. Results from this sampling program are provided in Table 15.

Table 15 Surface water monitoring results for SS1 sampling location

Analytes	Unit	Aug 12	Aug 13	Aug 14	Feb 15	Aug 15	Feb 16	Oct 18	Apr 19
Physiochemical results									
pHwater Lab		7.15	6.5	6.09	6.93	4.41	4.12	**3.8**	3.5
Temperature	°C	nd	nd	nd	nd	nd	16.9	**11.4**	15.7
Electrical conductivity	µS/cm	792	1,693	449	6,230	1,118	2,764	**2200**	2468
Oxidation Reduction Potential	ms/cm	nd	nd	nd	nd	nd	560	**418**	148.1
Analytical results									
Nitrite as N	mg/L	<0.01	0.03	<0.01	0.02	<0.01	<0.01	**<0.01**	**< 0.01**
Nitrate as N	mg/L	0.03	0.74	0.33	0.04	0.95	0.92	**2.1**	**1.6**
Nitrite + nitrite as N	mg/L	0.03	0.77	0.33	0.06	0.95	0.92	**2.1**	**1.6**
Total Kjeldahl nitrogen as N	mg/L	1.3	7.1	1.7	51.5	1.2	1.3	**0.5**	**1.8**
Total nitrogen as N	mg/L	1.3	7.9	2	51.6	2.2	2.2	**2.6**	**3.4**
Total phosphorus	mg/L	0.09	0.25	0.17	11.6	0.14	0.03	**<0.05**	0.05
BOD	mg/L	2		<2	100	<2	<2		
Thermotolerant coliforms	cfu/100 mL	550	260	19,000	9,000	12	3	**130**	20
E. coli	cfu/100 mL	550	260	16,000	8,800	13	120	10	20

The results of the surface water monitoring at location SS1 (refer to Figure 20), near Parramatta Creek on the north eastern side of the site, have shown a deterioration in surface water quality since monitoring commenced in August 2012. This deterioration is evident through increased salinity, decreasing pH and increasing nutrients.

The pH levels have decreased in every sampling event, except for February 2015, which rose slightly before decreasing again in August 2015. Electrical conductivity has varied over time, potentially reflecting changes in electrical conductivity of the wastewater being irrigated. Typically, higher EC results have been recorded in February when salts may be more concentrated due to lower rainfall and increased evaporation.

Limited surface water monitoring has been conducted in Parramatta Creek downstream of the processing facility. A sampling event was conducted in November 2017 by GES. This sampling event included two sites; one on Parramatta Creek and another on Felminghams Creek. The results from this sampling event were reported alongside the only known surface water monitoring results for Parramatta Creek, collected prior to the fish processing facility being operational (Table 16). The

'Parramatta Creek above Mersey' site was situated just above the junction with the Mersey River and data included is from several sampling events conducted in 2006.

The sample data from 2017 is too limited to draw conclusions, but it does show results broadly consistent with levels measured further downstream in Parramatta Creek prior to the construction of the fish processing facility.

Table 16 Surface water monitoring results

Parameter	Felminghams Creek	Parramatta Creek	Parramatta Creek above Mersey*	Parramatta Creek above Mersey*	Parramatta Creek above Mersey*	Parramatta Creek above Mersey*
Date	**01-Nov-17**	**01-Nov-17**	**02-Feb-06**	**08-May-06**	**07-Jul-06**	**12-Sep-06**
Temperature °C			20.8	9.2	7.6	5.6
Dissolved oxygen (mg/L)			7.1		10.4	11.1
Turbidity (NTU)			11.2	35.9	31.3	15
Ammonia mg-N/L	0.026	0.019				
Chloride mg/L	35.9	130				
Conductivity µS/cm (laboratory)	155	524	433	500	315	454
Nitrate mg-N/L	<0.010	0.17	0.153	0.707	0.716	0.237
Nitrite mg-N/L	<0.010	0.008				
Nitrogen, Total mg-N/L	0.51	1	0.566	1.7	1.6	0.659
pH (laboratory)	4.6	7.4	7.43	6.86	7.54	7.24
Phosphorus, dissolved reactive mg-P/L	0.004	0.017				
Phosphorus, Total mg-P/L	<0.01	0.08	0.019	0.062	0.052	0.022
Sulfate mg/L	3.2	13.6				
TSS mg/L	7	28				

**prior to Huon Aquaculture's operation at the site and wastewater irrigation*

3.2.4 Aquatic Ecosystems

Assessments using the Australian river assessment (AusRivAS) methodology were carried out by Kanunnah P/L in spring 2017 and autumn 2018 (Appendix M). The aim of the assessment was to determine the health of Parramatta Creek. The location of the assessment was downstream of Huon Aquaculture's property, Layton's property and the Bass Highway.

Table 17 Assessment location

Site	Northing	Easting
HUONPARRAMATTA01	5424443	460730

AUSRIVAS is a rapid procedure to quantify impacts on in-stream biota. This is achieved by predicting the occurrence of macroinvertebrate families at test sites using environmental variables and a large database of high-quality reference sites. The output from this process is a list of the families of invertebrates expected in a standard sample from the site, the probability of occurrence of each family in that sample and a tally of which of those families did occur in the actual sample. These predicted taxa are then compared with the sampled taxa to provide an observed/expected score.

The samples were collected from the edge habitats as riffles were not present. There were significant sediment levels, high turbidity and conductivity at the time of sampling. There are agricultural impacts evident and a major highway upstream of the site. The site itself is a driver rest area, with little riparian cover and displays obvious human impacts such as litter and poor water quality.

The taxa found included worms, various fly larvae, amphipods and one family of stonefly and caddis fly. Those taxa found are representative of poor sites and typical of sites with obvious human impacts such as urban creeks. The taxa missing include mites, beetle larvae and adults, cranefly larvae, mayflies, sensitive stoneflies (Eusthenidae) and numerous caddis flies. These taxa tend to be missing in poorer quality sites.

The observed/expected (O/E) scores for the site were 0.46 for spring 2017 and 0.36 for autumn 2018, placing the site in band C. The *O/E* score is a ratio relating the number of families of macro invertebrates recorded in a sample to the number of families expected in that sample according to the predictions of the model for least-disturbed conditions.

Table 18 Scoring system for AusRivAS

O/E Score	Band	Explanation
>1.19	X	Richer than reference. More macroinvertebrate families found than expected
0.82-1.19	A	Similar to reference. Most or all the expected families found.
0.45-0.81	B	Significantly impaired. Several expected families not found.
0.08-0.44	C	Severely impaired. Many expected families not found
0.00-0.07	D	Extremely impaired. Extremely few of the expected macroinvertebrate families found

3.3 Groundwater

3.3.1 Overview

Six groundwater bores were installed on the Huon Aquaculture property in July 2009 as part of the groundwater survey undertaken for the initial site approval for Huon Aquaculture's Parramatta Creek Fish Processing Facility. Regular monitoring events have been undertaken since then.

In November 2018, six groundwater monitoring bores were installed on Layton's property to capture baseline data for the proposed irrigation expansion area. An additional bore was installed on the Huon Aquaculture property to monitor the existing ponds and irrigation areas. A preliminary groundwater sampling event was conducted on each of the bores on 26 November 2018. The location of these bores was determined using an understanding of the groundwater flow systems and process operating at Parramatta Creek (Cromer, 2018). This report is provided in Appendix L.

3.3.2 Baseline data

3.3.2.1 Huon Aquaculture property

Sampling events were conducted on the Huon Aquaculture property in July and December 2009 to collect baseline groundwater data for the existing DPEMP (approved 2009). Results from these initial sampling events are presented in Table 19 and interpretation of the results summarised in Table 20.

The baseline groundwater assessment, as described in the existing DPEMP (approved 2009), found groundwater was close to the surface and that groundwater quality across the site and seasonally was below the ANZECC trigger values for freshwater at 95% level of protection for most parameters tested (with the exception of pH for all locations and aluminium at one site). In 2009, groundwater had a variable, but generally low pH (average pH of 5.3), was highly oxidising and variable (but not high) electrical conductivity (140 to 680 µS/cm).

Table 19 Baseline groundwater monitoring results (2009) for Huon Aquaculture property groundwater monitoring bores

	Location											
Analyte (mg/L)	**BH1**		**BH2**		**BH3**		**BH4**		**BH5**		**BH6**	
	Jul	**Dec**	**Jul**	**Dec**	**Jul**	**Dec**	**Jul**	**Dec**	**Jul**	**Dec**	**Jul**	**Dec**
pH	5.32	5.05	5.17	5.05	5.33	5.16	5.28	5.25	6.5	6.61	4.16	4.45
Sodium absorption ratio	4.16	4.3	2.85	3.22	2.74	4.98	<0.1	<0.1	2.31	2.06	1.2	0.96
Electrical conductivity (µS/cm)	276	204	145	140	143	123	125	118	445	425	370	680
Total dissolved solids mg/L	140	160	84	120	94	90	71	82	254	240	210	460
Carbonate mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate mg/L	20	23	17	14	15	21	11	23	148	178	<1	<1
Sulfate mg/L	37	33	22	21	19	16	5	5	37	34	133	315
Chloride mg/L	34	35	21	25	19	22	22	27	34	21	18	19
Calcium mg/L	3	1	2	1	2	1	<1	<1	30	28	13	43
Magnesium mg/L	2	1	1	1	1	<1	<1	<1	7	6	6	19
Sodium mg/L	35	49	27	20	22	30	20	30	53	60	41	30
Potassium mg/L	2	1	2	1	1	<1	<1	<1	1	6	4	5
Aluminium mg/L	0.05	0.1	0.06	0.009	0.06	0.04	0.09	<0.01	<0.01	<0.01	5.94	8.92
Iron mg/L	<0.05	0.45	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.29	0.06
Fluoride mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.2	0.2	0.6
Ammonia as N	0.05	0.03	0.01	0.03	<0.01	0.01	<0.01	0.07	0.01	0.02	0.06	0.11
Nitrite as N mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N mg/L	0.02	0.02	0.04	0.02	0.23	0.44	<0.01	0.03	<0.01	<0.01	0.47	0.01
Total Kjeldahl nitrogen as N	<0.2	<0.1	<0.2	<0.1	<0.2	<0.1	<0.2	<0.1	<0.2	<0.1	<0.2	0.1
Total nitrogen as N mg/L	<0.1		<0.1		0.2		<0.1		<0.1		0.5	
Total phosphorus as P mg/L	<0.01	0.03	0.02	0.04	0.1	0.1	<0.01	0.03	0.32	0.29	0.12	0.41

Table 20 Summary of baseline groundwater results analysis provided in existing DPEMP (Pitt & Sherry, approved 2009)

<table>
<tr><th>Parameter</th><th>Description in existing DPEMP (approved 2009)</th></tr>
<tr><td>pH</td><td>All sites have a groundwater pH value slightly below an acceptable level of 6.0 except for borehole 5. The low pH results may be due to the local site soil type and structure. This will need to be monitored as irrigation starts to ensure that there are no negative effects on the ryegrass production and further decline in soil structure.</td></tr>
<tr><td>EC and TDS</td><td>All sites have a low EC and TDS result and can be classified as “fresh water”.
<table>
<tr><th>Category</th><th>TDS (mg/L)</th><th>EC (μS/cm)</th></tr>
<tr><td>Fresh water</td><td>0 - 1500</td><td>0 - 2400</td></tr>
<tr><td>Brackish water</td><td>1500 - 3000</td><td>2400 - 4700</td></tr>
<tr><td>Saline water (stock)</td><td>3000 - 14 000</td><td>4700 - 22 000</td></tr>
<tr><td>Saline</td><td>14 000 - 35 000</td><td>22 000 - 50 000</td></tr>
<tr><td>Hyper saline</td><td>35 000 - 100 000</td><td>50 000 - 160 000</td></tr>
<tr><td>Brine</td><td>More than 100 000</td><td>More than 160 000</td></tr>
</table>
Table 3-8: Water categories based upon total dissolved solids.</td></tr>
<tr><td>Bicarbonates and SAR</td><td>The groundwater bicarbonate (HCO3) levels in all boreholes are below 200 mg/L. While there are no ANZECC trigger values for bicarbonates in irrigation waters, elevated levels of bicarbonates can adversely affect irrigation equipment, soil structure and crop foliage. Bicarbonates cause hardness and can result in calcium and magnesium in the soil and water precipitating as insoluble carbonates. Sodium is left behind after removal of the calcium and magnesium, leading to an increase in sodicity 14 . This should not be a problem with such low results at each of the sites. SAR readings are also relatively low indicating that the surface soils in the area have good soil structure and are permeable to water resulting in minimal waterlogging.</td></tr>
<tr><td>Chlorides and Dissolved Cations</td><td>Consistent with the low TDS readings for all groundwater samples, chloride and dissolved cations are also low and indicate that the groundwater is “fresh water”.</td></tr>
<tr><td>Aluminium and Iron</td><td>All groundwater samples were found to be below the ANZECC freshwater of 0.055 mg/L except for borehole 6. BH6 was found to have a slightly elevated Aluminium level of 5.94 mg/L. This should not be a problem given that the groundwater is not used for drinking water purposes in the area. This will be monitored for the management of the reuse application to ensure that levels do not increase further. There are no ANZECC guidelines for Iron, however BH6 is slightly elevated and should also be monitored for the reuse application</td></tr>
<tr><td>Nutrients</td><td>Groundwater nutrient levels at all boreholes are within normal levels and meet the freshwater ANZECC guidelines. Nutrient levels will need to be monitored after commencement of irrigation to ensure that there are no negative effects on the groundwater from the application of treated wastewater to the area.</td></tr>
<tr><td>Thermotolerant Coliforms and Enterococcus</td><td>The results from the groundwater microbiological analysis indicate that the groundwater at all borehole sites is clean and do not contain pathogens at significant levels</td></tr>
</table>

3.3.2.2 Layton's property

Six new bores were installed on Layton's property in November 2018, to monitor the proposed wastewater irrigation areas and to provide baseline data (Figure 21). Preliminary groundwater sampling events were conducted on each of the bores on 26 November 2018, 27 February 2019, 1 April 2019 and 31 July 2019 (MW14 on 29 July 2019). Results are summarised in Table 21, 22 and 23. The higher altitude bores MW08 and MW14 have relatively low salinity (100-400 µS/cm), low pH (pH 3.97-5.9) and slow recharge rates, consistent with groundwater recharge zones. The higher salinity (310-1000 µS/cm) and slightly higher pH (pH 5.7-6.9) of the remaining, lower-lying bores suggests discharge conditions. Preliminary results suggest that there is a seasonal influence on groundwater quality on Laytons property, with an increase in electrical conductivity observed in most bores through the summer (Figure 4).

An assessment of the groundwater conditions at Huon Aquacultures site and Layton's Property was completed by groundwater Geologist, Bill Cromer (Appendix L). The assessment found that the majority of both properties fall within groundwater discharge areas.

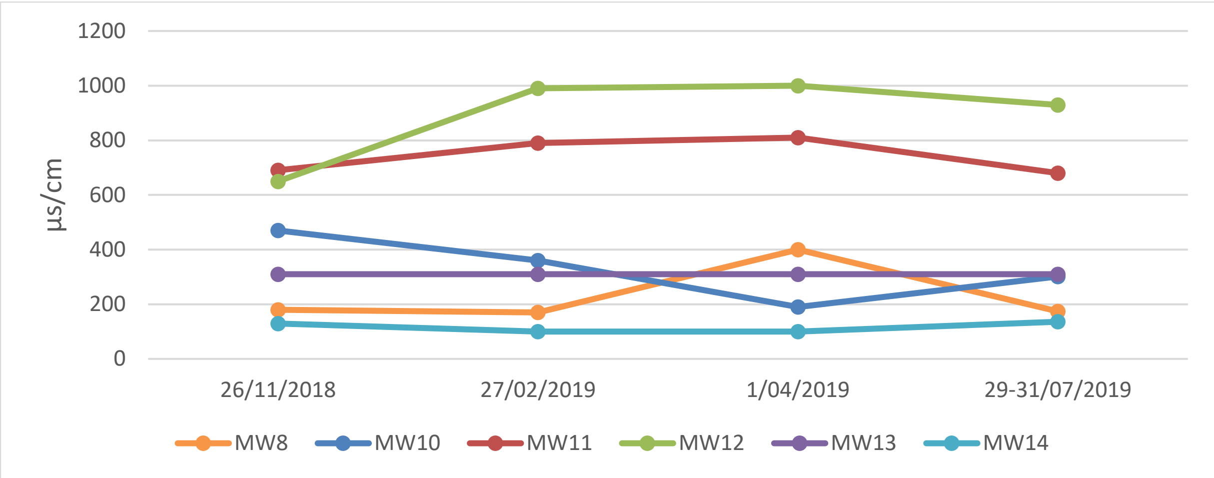

Figure 4 Electrical conductivity in the monitoring bores on Layton's property

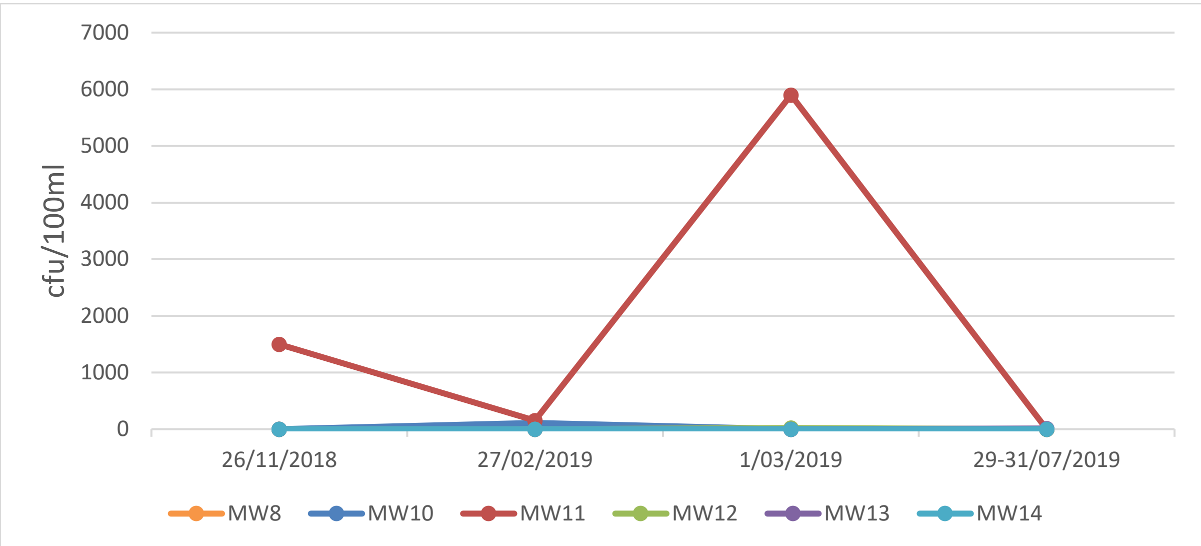

Figure 5 Thermotolerant coliforms in the monitoring bores on Layton's property

Table 21 Layton's Farm baseline groundwater monitoring results (November 2018)

		Location					
Analyte (mg/L)	**Units**	**MW08**	**MW10**	**MW11**	**MW12**	**MW13**	**MW14**
Alkalinity as CaCO3	mg/l	14	47	120	54	66	7
Standing Water Level	m bgl	2.6	2.97	0.71	1.09	1.43	3.03
pH		5.5	5.8	6.2	6.2	6.2	5
EC	µS/cm	180	470	690	650	310	130
TDS	mg/l	130	260	420	400	190	82
Chloride	mg/l	100	37	120	120	46	20
Fluoride	mg/l	0.09	0.08	0.16	0.08	0.07	< 0.05
Aluminium	mg/l	0.07	0.09	< 0.01	0.01	< 0.01	0.06
Iron	mg/l	0.43	0.79	0.01	< 0.01	0.73	0.08
Total Nitrogen	mg/l	0.2	0.7	< 0.1	0.2	< 0.1	3.5
Ammonia	mg/l	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Nitrite	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nitrate	mg/l	0.02	0.23	< 0.01	0.03	< 0.05	2.5
Calcium	mg/l	5	4	14	21	11	1
Potassium	mg/l	1	3	1	3	< 1	3
Magnesium	mg/l	3	3	6	8	4	3
Sodium	mg/l	75	22	100	100	43	14
Phosphate	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Sulphate	mg/l	28	15	39	120	23	12
Total Phosphorus	**mg/l**	0.09	0.21	0.07	0.05	0.1	0.12

Table 22 Layton's Farm baseline groundwater monitoring results (February 2019)

		Location					
Analyte (mg/L)	**Units**	**MW08**	**MW10**	**MW11**	**MW12**	**MW13**	**MW14**
Alkalinity as CaCO3	mg/l	< 2	< 2	< 2	< 2	< 2	**< 2**
Standing Water Level	m bgl	2.81	2.52	1.9	1.59	2.82	**3.45**
pH		5.90	6.20	6.80	6.80	6.80	**5.40**
EC	µS/cm	170.00	360.00	790.00	990.00	310.00	**100.00**
TDS	mg/l	100.00	240.00	100.00	490.00	120.00	**45.00**
Chloride	mg/l	37.00	80.00	37.00	150.00	40.00	**37.00**
Fluoride	mg/l	0.08	0.06	0.14	0.15	0.07	**< 0.05**
Aluminium	mg/l	0.12	0.04	< 0.01	0.12	< 0.01	**0.04**
Iron	mg/l	0.78	0.81	0.05	0.78	1.00	**0.02**
Total Nitrogen	mg/l	0.10	< 0.1	0.10	< 0.1	< 0.1	**2.30**
Ammonia	mg/l	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	**< 0.1**
Nitrite	mg/l	< 0.01	< 0.01	0.01	< 0.01	< 0.01	**< 0.01**
Nitrate	mg/l	0.13	0.13	0.10	0.03	0.06	**0.13**
Calcium	mg/l	3.3	3.1	23	30	12	**3.3**
Potassium	mg/l	3.30	1.00	1.60	3.50	1.00	**3.30**
Magnesium	mg/l	2.50	1.90	8.80	12.00	3.70	**2.50**
Sodium	mg/l	24.00	24.00	130.00	150.00	44.00	**14.00**
Sulphate	mg/l	14.00	21.00	52.00	150.00	20.00	**14.00**
Total Phosphorus	**mg/l**	**0.07**	**0.06**	**0.07**	**0.12**	**0.12**	**< 0.05**

Table 23 Layton's Farm baseline groundwater monitoring results (April 2019)

		Location					
Analyte (mg/L)	**Units**	**MW08**	**MW10**	**MW11**	**MW12**	**MW13**	**MW14**
Alkalinity as CaCO3	mg/l	< 2	< 2	< 2	< 2	< 2	**< 2**
Standing Water Level	m bgl	2.88	2.46	1.88	1.7	2.82	**3.6**
pH		5.80	6.10	6.60	6.90	6.50	**5.10**
EC	µS/cm	400.00	190.00	810.00	1000.00	310.00	**100.00**
TDS	mg/l	0.70	0.50	0.60	0.60	0.70	**0.80**
Chloride	mg/l	0.10	0.12	0.16	0.19	< 0.1	**< 0.1**
Fluoride	mg/l	0.10	0.12	0.16	0.19	< 0.1	**< 0.1**
Aluminium	mg/l	0.30	0.04	0.17	0.01	< 0.01	**0.03**
Iron	mg/l	0.91	1.20	0.01	0.69	0.92	**0.02**
Total Nitrogen	mg/l		1.40	1.00	0.30	0.20	**2.40**
Ammonia	mg/l	< 0.1	< 0.1	< 0.1	0.30	0.10	**< 0.1**
Nitrite	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	**0.02**
Nitrate	mg/l	< 0.01	1.40	0.54	< 0.01	< 0.01	**1.70**
Calcium	mg/l	4.00	3.00	24.00	31.00	11.00	**< 1**
Potassium	mg/l	1.00	3.00	3.00	4.00	1.00	**2.00**
Magnesium	mg/l	2.00	2.00	10.00	13.00	4.00	**2.00**
Sodium	mg/l	63.00	21.00	120.00	140.00	42.00	**13.00**
Sulphate	mg/l	24.00	15.00	54.00	170.00	21.00	**11.00**
Total Phosphorus	**mg/l**	**0.19**	**0.08**	**0.34**	**0.21**	**0.28**	**0.23**

Table 24 Layton's Farm baseline groundwater monitoring results (July 2019)

		Location					
Analyte (mg/L)	**Units**	**MW08**	**MW10**	**MW11**	**MW12**	**MW13**	**MW14**
Alkalinity as CaCO3	mg/l	<1	<1	<1	<1	<1	**<1**
Standing Water Level	m bgl	0.76	0.69	0.39	0.7	1.1	3.16
pH		3.97	5.7	6.46	6.78	6.55	**4.2**
EC	µS/cm	174	302	680	930	310	136
TDS	mg/l	160	200	392	636	190	**108**
Chloride	mg/l	35	62	169	163	39	21
Fluoride	mg/l	<0.1	<0.1	0.2	0.2	<0.1	**<0.1**
Aluminium	mg/l	0.11	1.15	0.94	0.36	0.75	0.11
Iron	mg/l	0.63	1.04	1.07	1.25	1.25	**<0.05**
Total Nitrogen	mg/l	0.4	0.8	0.7	0.3	0.3	2
Ammonia	mg/l	0.01	0.01	0.02	0.11	0.02	**0.01**
Nitrite	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate	mg/l	0.2	0.14	0.44	0.01	<0.01	**1.7**
Calcium	mg/l	3	2	15	31	12	<1
Potassium	mg/l	3	<1	<1	4	<1	**2**
Magnesium	mg/l	2	1	6	12	3	3
Sodium	mg/l	22	52	135	140	45	**16**
Sulphate	mg/l	15	26	47	144	22	16
Total Phosphorus	**mg/l**	0.07	0.05	0.04	0.2	0.1	<0.01

3.3.3 Monitoring results

The first groundwater monitoring events (GME) were conducted in 2009 on the Huon site. The next GME was in 2012, and since then they have been conducted on a quarterly basis. Results from the sampling program are presented in the following graphs (Figure 6, Figure 7, Figure 8 and Figure 9).

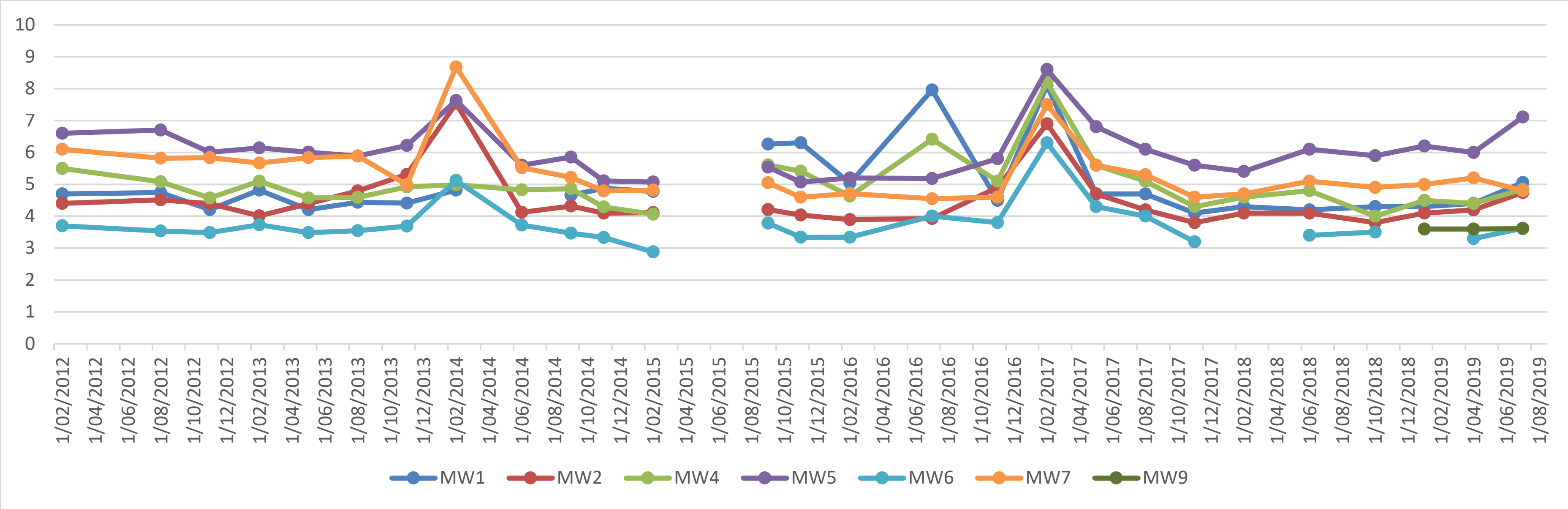

Figure 6 pH in the groundwater monitoring bores (2012-2019)

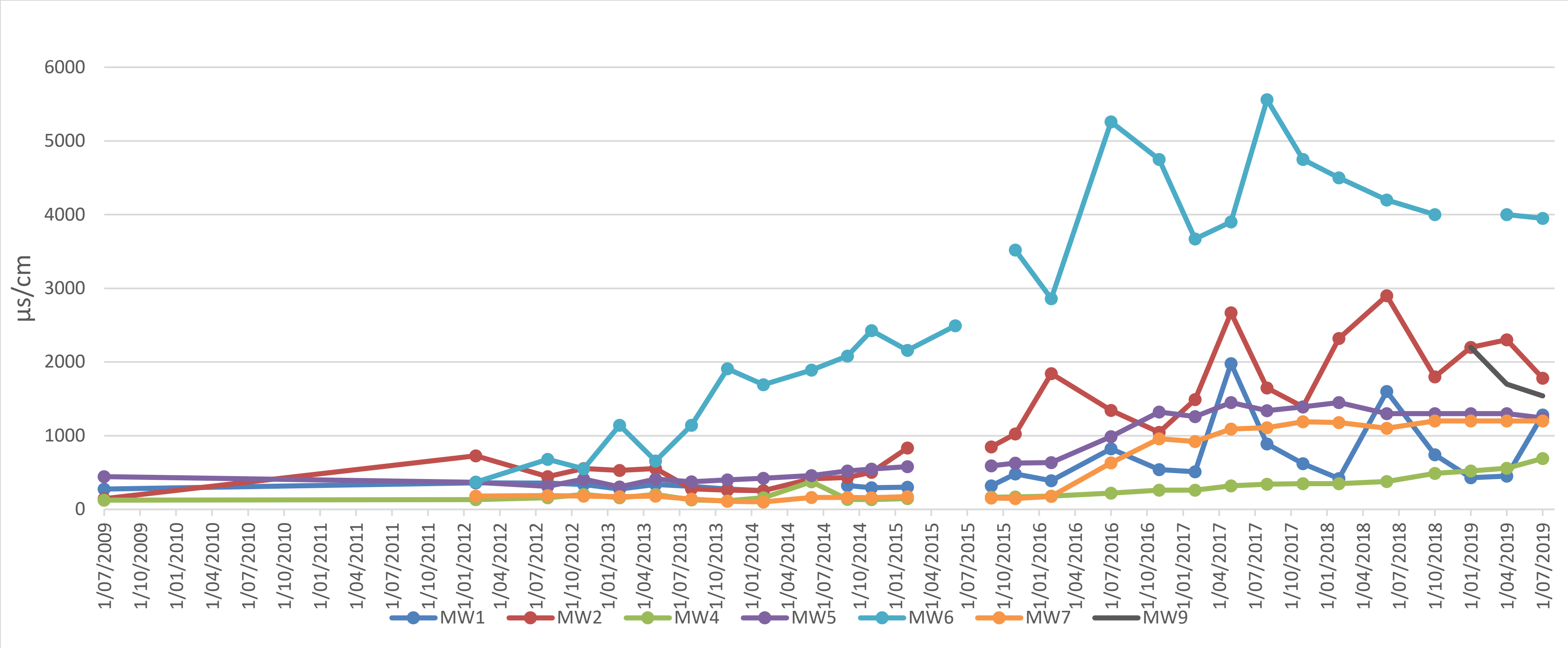

Figure 7 Electrical conductivity in the groundwater monitoring bores (2009-2019)

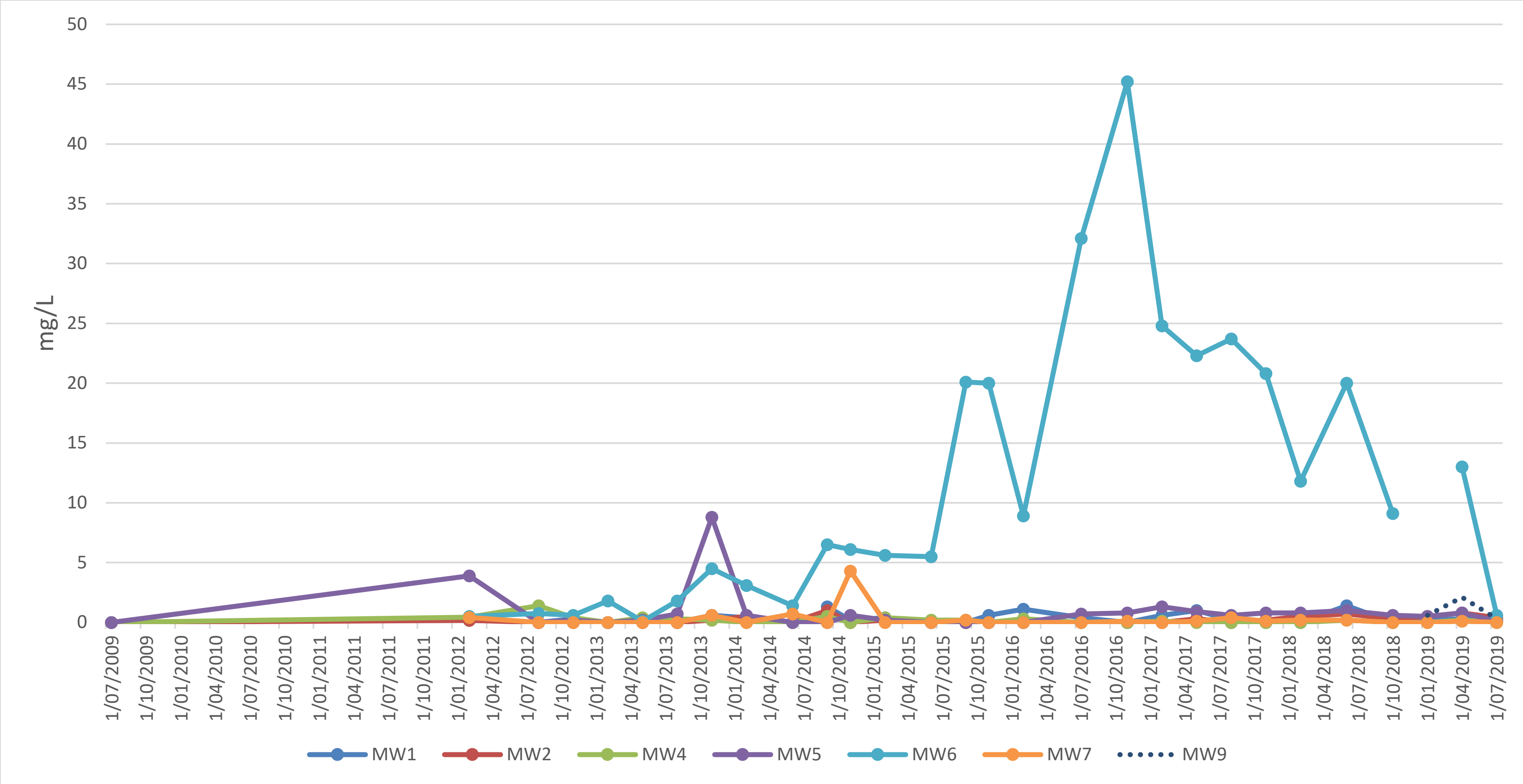

Figure 8 Total Nitrogen in the groundwater monitoring bores (2009-2019)

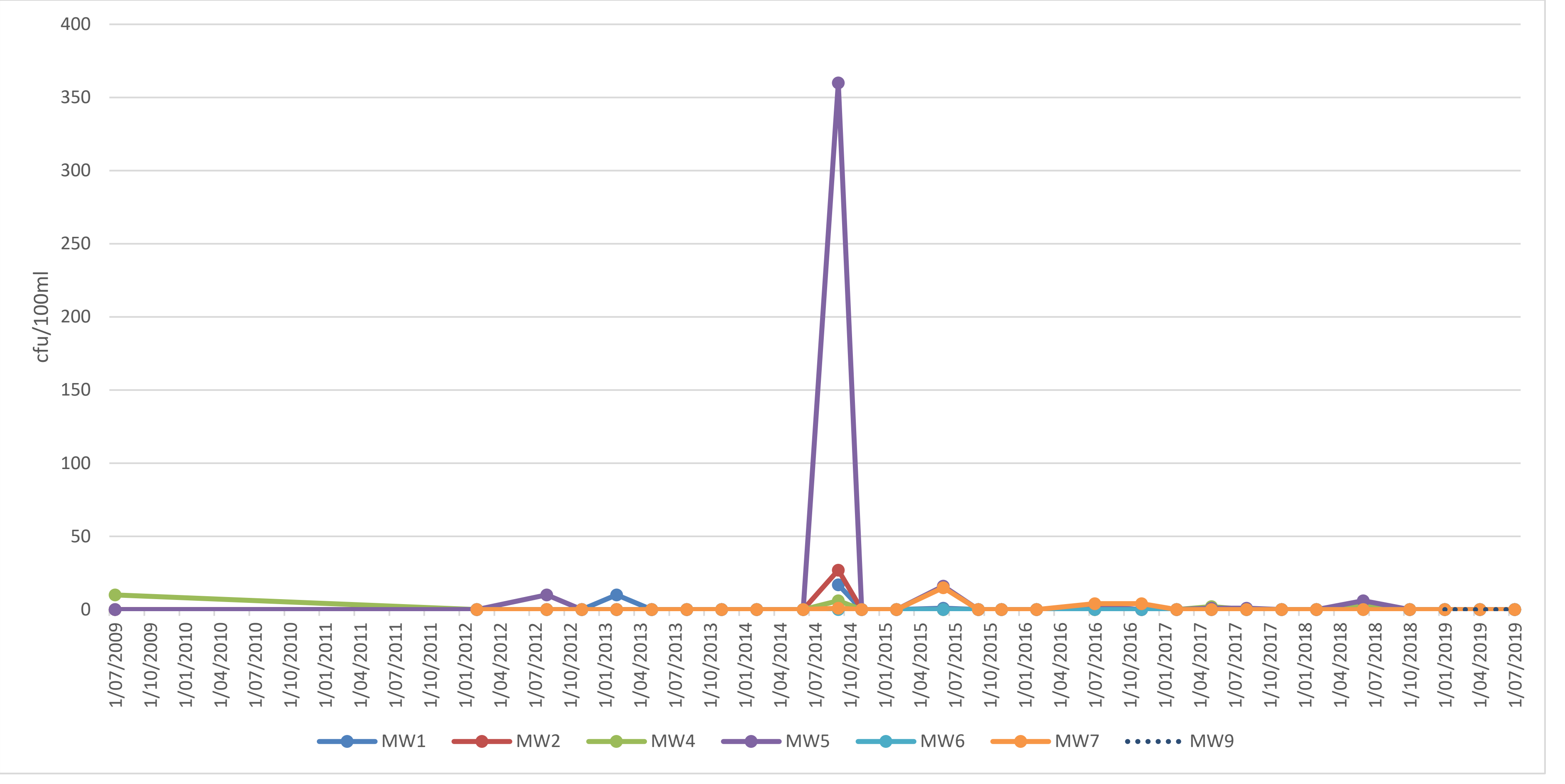

Figure 9 Thermotolerant coliforms in the groundwater monitoring bores (2009-2019)

3.3.4 Summary of groundwater monitoring activities

Results from the ongoing groundwater monitoring program suggest wastewater irrigation has had an adverse effect on the salinity of the groundwater at some bores on Huon Aquaculture's Parramatta Creek property. Recent improvements to the application method (via pivot irrigator) and improved wastewater quality (lower salinity) appear to have slowed the degradation, with parameters stabilising and decreasing trends becoming apparent. While elevated spikes in thermotolerant coliforms have been recorded from MW6, levels have declined to an acceptable range quickly. The elevated salinity in the monitoring bores shows seasonal fluctuation with the electrical conductivity increasing over summer and autumn and decreasing over winter and spring. These fluctuations indicate that the groundwater is heavily influenced by local recharge events with winter rainfall. This seasonal variation also indicates that the salinity levels will decrease in time with the improved management and shandied irrigation water.

4 Transition from current wastewater management to recommended wastewater management

4.1 Transition management

The existing centre pivot irrigation area on Huon Aquaculture's property is required for irrigation of wastewater until the new irrigation infrastructure on Layton's property is constructed and operational. There are no viable alternatives for wastewater disposal, which could be quickly implemented, for either on-site or off-site disposal. Huon Aquaculture have commissioned a refrigerated fish transport truck that came on-line in March 2019. The effectiveness of this alternative to salt slurry for transporting fish will be monitored over 12 months (until February 2020) for impact on fish quality (eating and food quality) and reductions in salinity of the wastewater stream. Based on the trajectory of improvements in wastewater quality over the past few years (Figure 2), the EC of wastewater during summer 2018/19 is likely to remain below 2500µs/cm.

4.1.1 HAC pivot site rehabilitation plan

The main soil sustainability issue which requires remediation at the HAC pivot site is sodicity. It is likely that the high levels of sodicity observed in both the top and subsoils are due to past irrigation with highly saline water. Over time, with appropriate management, sodicity can be reduced and the site can be returned to a productive, healthy condition. This has been demonstrated with the application of gypsum in June 2019 substantially reducing the sodicity levels (average of 17%) (Huon Aquaculture Parramatta Creek fish processing facility soil monitoring report – September 2019). The continued use of this site for wastewater irrigation is compatible with rehabilitation. Irrigation with slightly saline water will be important to maintain soil structure of the highly sodic soils, and to support vigorous pasture growth, including root development. Actively growing pastures will help to build soil carbon and stabilise soil structure.

The following key actions are proposed to rehabilitate this area:

- Fencing to exclude wildlife and to enable controlled grazing (nutrient removal) and optimal pasture growth to occur (completed in August 2019).

- Continued irrigation of site (with undiluted wastewater until new irrigation scheme is commissioned)
- Application of gypsum (applied in June 2019).
- Renovate existing pasture with a short-term highly productive pasture species (Italian ryegrass recommended) (spring 2019).
- Once pasture is established, commence rotational grazing. Monitor soil and pasture condition carefully during winter and remove cattle to prevent pugging or soil structure damage.
- Two years after the first renovation, repeat the pasture renovation and gypsum application. Combine with deep ripping to enable the gypsum to penetrate the subsoil and sow a perennial ryegrass species.
- Once pastures established, re-commence grazing and irrigation management using the recommended practices outlined in this WREMP.
- Once the Layton's irrigation scheme is operational, this site can be irrigated (to meet pasture water requirements) with shandied wastewater from the proposed pump shed.

4.1.2 HAC solid set sprinkler area rehabilitation plan

This land is only marginally suitable for agricultural use and is therefore not suitable for continued application of wastewater (wastewater application to cease once the new irrigation scheme is commissioned). This land should be top-dressed with gypsum at 10t/ha (June 2019), be fenced to exclude wildlife and rehabilitated into an amenity grassland area. Regular mowing is conducted to maintain control of the vegetation, and recycle organic matter, assisting to build soil structure.

4.1.3 Risks associated with ongoing irrigation of the HAC centre pivot

Table 25 outlines key risks associated with ongoing irrigation of the HAC centre pivot. The risks are low and can be adequately addressed via the mitigation plans outlined.

Table 25 Risk assessment for ongoing wastewater irrigation of HAC pivot site

Risk	Potential Causes	Potential Impacts	Mitigation Plans	Consequence	Likelihood	Residual Risk Rating	Contingency plans
Wastewater stream EC >3,000uS/cm.	Increases in production from the factory. Hot weather requires additional salt to be used to transport fish safely. Evapotranspiration levels high over summer, concentrating salts in wastewater ponds. Failure in slurry system saline water recycling	Continued leaching of high salt loads to groundwater. Local soil structure decline. Increased salinity and/or sodicity of soils. High salt loads to surface water. Scorching of pasture	Monitor wastewater salt loading regularly as per the Processing facility EC monitoring plan. Apply gypsum to soils by January 2019 to reduce sodium ions and decrease risk of sodicity. Game exclusion fencing and no livestock.	2	3	6 (Medium)	Flushing soils with fresh water from Layton's freshwater dam.
Thermotolerant coliforms >1000	Increases in production from the factory. Wastewater treatment breakdown.	High thermotolerant coliforms in surface water from runoff High thermotolerant coliforms in pastures.	No livestock grazing during the 2018/19 summer period. Game exclusion fencing and no livestock.	1	3	3 (Low)	Increase retention time in the ponds if there is the capacity The commissioning of a large wastewater storage dam with pond overflow to

Risk	Potential Causes	Potential Impacts	Mitigation Plans	Consequence	Likelihood	Residual Risk Rating	Contingency plans
	Poor performance of wastewater ponds/treatment plant.	Animal health issues (stock and wildlife mammals)	Increase retention time in the ponds if there is the capacity				that dam will provide additional retention time
High levels of nutrients in wastewater (compared to what is anticipated from 2018 median data)	Increases in production from the factory. Wastewater treatment breakdown. Poor performance of wastewater ponds/treatment plant.	Leaching of high nutrient loads to groundwater. Increased nutrient status of soils. High nutrient loads to surface water.	Continue monthly monitoring of wastewater ponds for nutrient levels. Game exclusion fencing and no livestock. Increase pond retention time to allow volatilisation	1	3	3 (Low)	NA
Wastewater volumes are excess to soil capacity	Increases in production from the factory. Above average summer rainfall events Impaired soil structure. Poor irrigation practices.	Surface water runoff. Soil erosion (rill and sheet) on bare soils. Anaerobic soil conditions. Death of pasture plants.	Game proof fencing to ensure good pasture cover Support to ensure correct irrigation scheduling. Gypsum application to improve soil structure. BoM forecast for summer rainfall (2018/19) is:	1	2	2 (Low)	NA

Risk	Potential Causes	Potential Impacts	Mitigation Plans	Consequence	Likelihood	Residual Risk Rating	Contingency plans
			Probability of exceeding median rainfall (Dec to Feb) 31%				

5 Wastewater quantity and quality

5.1 Quantity

Projected wastewater flows from increased production at the fish processing facility are outlined in Table 26. By the end of the 2021/22 financial year it is forecast that wastewater flows will be up to 110ML per year, with a maximum wastewater volume of 112ML. In reality these flows are likely to be lower, with water use efficiencies occurring within the factory and the transition to refrigerated transport of whole fish to the site over time (pending results from the transport trial period). For the purpose of ensuring a sustainable, long-term reuse option, the maximum flows have been utilised.

Table 26 Forecast monthly and annual wastewater production volumes

Financial year	Forecast monthly wastewater production (ML)												Total (ML)
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	
2017/18	5.8	6.9	6.7	7.0	7.1	9.3	6.5	6.0	6.4	5.3	5.5	4.7	77.2
2018/19	4.3	5.0	4.9	5.5	5.9	6.1	5.9	5.9	6.9	6.1	6.8	6.1	69.2
2019/20	5.8	7.0	6.9	7.5	7.8	8.1	7.8	7.8	8.3	7.3	8.2	7.4	89.8
2020/21	7.0	7.9	7.8	8.4	8.7	9.1	8.7	8.8	9.5	8.3	9.2	8.3	101.6
2021/22	7.9	8.8	8.7	9.4	9.7	10.1	9.7	9.8	9.8	8.0	9.5	8.5	110.0
Maximum	8	9	8.8	9.5	9.5	10.3	9.9	10	10	8.1	9.6	8.9	112.0

5.2 Quality

The quality of wastewater from the fish processing facility has continued to improve in recent years (Table 4 and Figure 2). It is anticipated that quality, particularly in terms of salinity, will continue to improve as Huon Aquaculture transitions to refrigerated transport of whole fish to the facility (pending the results from trialling this method), thereby reducing the quantity of salt (from the salt slurry fish are currently transported in) in the waste streams that enter the wastewater treatment system.

For the purpose of this Wastewater Reuse EMP, calculations and management practices are based on the 2018/19 median wastewater quality outlined in Table 4. In terms of meeting the TRWG Class B recycled water requirements, the wastewater is well below the thresholds for thermotolerant coliforms, pH and biological oxygen demand.

The pH has historically been above the TRWG class B recycled water requirements. However, advice from experienced water quality specialist, Daniel Ray (Aquatic Science, March 2017), recommends that the higher pH water be accepted as the normal operation of an effective lagoon system. He advised there is precedent for this from a regulatory standpoint, as sewage lagoons that are functioning well have high pH.

Whilst pH historically is a little more alkaline than the TRWG recommend, the soils in the region are naturally of lower pH and require liming periodically to increase the pH. The wastewater pH of 8.4 is not of concern, particularly given the acidic nature of the soils, and it is recommended that this

wastewater stream be treated as Class B recycled water. It is recommended that wastewater pH is maintained between 5.5-9.0.

Additional parameters monitored by Huon Aquaculture and reported monthly to the EPA are electrical conductivity, ammonia and total nitrogen. The median electrical conductivity level for 2018/19 is 2,380 µS/cm (Salinity Class 4 for irrigation), which is higher than recommended for irrigation at the site. Management of salt loadings is discussed in section 5.5.

Table 27 Current wastewater quality compared with TRWG requirements for Class B recycled water

Parameter	TRWG Class B quality	2018/ 2019 median results^
Thermotolerant coliforms (cfu/100ml)	<1,000	145
BOD (mg/L)	<50	18.5
pH	5.5 – 8.0	7.8
Nutrient, toxicant and salinity controls		
Electrical conductivity (µS/cm)	N/A	2380
Ammonia (mg/L)	N/A	6.55
Total nitrogen (mg/L)	N/A	21

^Median results were based on Huon Aquaculture's monthly wastewater quality monitoring program and comprised of 12 sampling events within the last 12 months to October 2018.

The July 2019 report to the EPA summarising wastewater quality in 2017/18 is provided in Appendix D.

5.3 Improvements to wastewater quality

Monthly wastewater quality has been collected and provided to the EPA since 2012. Table 28 shows the annual medians for pH, EC, biochemical oxygen demand (BOD) and thermotolerant coliforms. The data shows that since improvements have been implemented to the facility since 2015 (Section 2.1.2), wastewater quality has continually improved. In addition, a wastewater monitoring program has been developed and implemented to allow for further improvements to be identified (Appendix E).

Table 28 Comparison of annual median wastewater results

Parameter	2012	2013	2014	2015	2016	2017	2018	2019
EC µS/cm	4250	nd	4520	6040	4090	3560	2760	2380
BOD mg/L	134	nd	102	15	15	31	18	18.5
Thermotolerant coliforms (cfu/100ml)	150	nd	10000	240	240	250	90	145
pH Lab Units	7.3	nd	7.3	7.8	7.8	8.65	7.6	7.8

5.3.1 Ongoing management of wastewater salinity

Huon Aquaculture are in the process of introducing a refrigerated fish transport truck into their fleet as a trial. The refrigerated truck will require less salt to ensure transported fish meet the food safety standards. The wastewater monitoring program (Appendix E) will allow for the changes in the wastewater to be identified with the implementation of the refrigerated truck, as well as identifying further improvements.

5.4 Water balance

Water balance calculations were conducted for the projected stepped increases in wastewater production over the coming years using the water balance method outlined in the TRWG, with crop factors updated to reflect known pasture growth rates in the Parramatta Creek region. Table 29 summarises the outputs from these calculations for different wastewater production levels, mean and 90th percentile annual rainfall scenarios and the irrigated area being pasture.

Table 29 Water balance calculations for various wastewater production volumes and mean and 90th percentile annual rainfall conditions

Annual wastewater production volume (ML)	Mean rainfall		90th percentile rainfall	
	Irrigation area required (ha)	Storage volume required (ML)	Irrigation area required (ha)	Storage volume required (ML)
69	15	38	21	44
77	17	41	23	47
90	20	48	26	55
102	22	54	30	62
110	24	58	32	65
112	25	59	32	66

Climate statistics from Bureau of Meteorology: rainfall data from Devonport Airport (BoM site no: 091126) and evaporation data from Deloraine (Athol) (BoM site no: 091000).

Crop factors informed by pasture growth rates at Devonport, Deloraine and Sheffield (TIA pasture growth rates model).

Refer to sections 5.5.5 for irrigation area requirements for shandied wastewater flows.

Water balance calculation spreadsheets are provided in Appendix F.

To enable a sustainable, long-term wastewater reuse option to be implemented, this plan is based on developing capacity to manage wastewater flows of 112ML per year and be able to accommodate a 90th percentile rainfall year, both in terms of irrigation and storage. To achieve this, 66ML of storage capacity is required.

The irrigation area required is a little more complex, as the water balance summarised in Table 29 is based on projected flows of wastewater from the fish processing facility to enable the storage requirement for wastewater to be determined. As detailed in section 5.5, wastewater will (at least initially) need to be diluted (shandied) prior to irrigation to manage the salt load, which increases the land area required for irrigation. The irrigation areas required under different shandying scenarios and rainfall conditions are presented in Table 33 and Table 34.

5.5 Salt load management

5.5.1 Proposed irrigation water salinity level

The salinity of wastewater from the fish processing facility has varied over the years however it has been steadily improving each year since 2014/15 (Table 4 and Figure 2). Whilst advice from Huon Aquaculture is that the electrical conductivity of wastewater is likely to continue to decline as factory processes change and with potential impact of refrigerated trucks over time this WREMP has been prepared on the basis of current salinity (2500µS/cm).

An electrical conductivity (EC) of 1100µS/cm (1.1 dS/m) for irrigation has been determined as sustainable for this WREMP, based on the following factors:

- Pasture variety tolerance to irrigation water salinity.
- Experience with other irrigation schemes.
- Modelled leaching from rainfall (salt budget).

5.5.1.1 Pasture variety tolerance to irrigation water salinity

An EC of 1,100 µS/m will ensure the perennial ryegrass dominant pastures are productive, and that their growth and persistence is not compromised. Perennial ryegrass is classified as moderately tolerant to salinity and will tolerate irrigation water EC up to 3,700 µS/cm (3.7 dS/m) before a reduction in plant growth can be expected (Department of Primary Industries New South Wales, 2016). Application of irrigation water at 1,100 µS/cm (1.1 dS/m) is well below the acceptable tolerance of perennial ryegrass and no reduction in productivity and/or persistence would be anticipated. Perennial ryegrass is one of the main grasses used in improved pastures in Tasmania. It is a nutritious and palatable perennial that is well suited to fertile soils and consistent rainfall or irrigation and forms the basis of intensive grazing systems (e.g. dairy and beef production) throughout the state.

5.5.1.2 Experience of other irrigation operations

Macquarie Franklin's considerable experience with wastewater irrigation schemes across Tasmania and southern Australia, and knowledge arising from being involved in long term soil monitoring programs, were also factors in determining the recommended irrigation water EC. We have experience in many soil types being irrigated with water of similar, or higher, salinity, on soils with similar (or worse) constraints. Long-term monitoring in these situations has demonstrated the effectiveness of salts being leached by natural rainfall. In our professional experience we are confident that the proposed irrigation system is sustainable long-term.

5.5.2 Salt budget

5.5.2.1 Modelled impacts of saline water irrigation on soils

Salt leaching calculations were conducted to determine the amount of rainfall that would be required to flush salts from the soils irrigated with water of 1,100 µS/cm.

The leaching requirement (LR) for a perennial ryegrass system, such as at Layton's farm, was calculated as follows.

$$LR = \frac{\text{EC of the irrigation water being applied}}{(5 \times \text{maximum EC allowed in the soil saturation extract}) - (\text{EC of the leaching water})}$$

$$\text{Amount of leaching water required} = \frac{\text{Evapotranspiration loss}}{1.00 - LR}$$

In terms of this proposed irrigation scheme, where there is perennial ryegrass dominant pasture:

EC of the irrigation water being applied	1,100 µS/cm = 1.1 dS/m
Maximum EC allowed in the soil solution for perennial ryegrass	6 dS/m (but to be conservative, 1.5 dS/m was used in calculation – i.e. non saline soil)
EC of leaching water (as per natural rainfall)	0.1 dS/m used in calculations
Evapotranspiration loss (April to October)	240 mm

Using the formula above, the LR value is 0.149, and the amount of rainfall required is 282mm/ha or equivalent to 2.82 ML/ha.

The Parramatta Creek area receives on average 635mm of effective rainfall during from April to October, which is far more than the amount of rainfall required (282mm/ha) for effective leaching.

As the Parramatta Creek area experiences sufficient rainfall to ensure leaching of the salts that accumulate during the irrigation season, long-term, the soil will be maintained at a low salinity level (1.5 dS/m), which is well below the salinity level for productive growth of perennial ryegrass.

The leaching requirement equation and annual water requirement show that soil salinity will not impact pasture yields under irrigation of wastewater with an EC of 1,100 µS/cm. The median rainfall for the area exceeds the crop requirements and leaching requirements. However, rainfall will not meet pasture water requirements during the summer. Irrigation will supplement the pasture water requirements during summer, while leaching events will occur through natural rainfall during winter, while wastewater generated during this period will be stored in the dam.

With the rainfall exceeding the annual water requirements, the soil salinity levels will reach an equilibrium and the average rootzone saturation extract electroconductivity (ECse) can be calculated.

Based on the calculation below (Table 30).This equilibrium is estimated to be well below 1.6dS/m (saturated extract) with a wastewater irrigation EC of 1,100 µS/cm. Table 31 uses the salinity of the irrigation water and the leaching fraction above pasture water requirements to provide a guide on the average rootzone saturation extract electroconductivity under continued irrigation. As can be seen the leaching fraction (0.4) above crop evapotranspiration results in a low rootzone electroconductivity, of less than 1.06dS/cm.

Note. EC Sat. extract is different to EC values presented in the remainder of this section. Ryegrass can tolerate an ECse of 4.5-7.7dS/m. EC sat. extract takes into account soil types and better represents the risks of salinity to crops and pastures in differing soil types.

Table 30 Calculation for the leaching fraction above crop evapotranspiration requirements

LFa = 1-(ET/ARm) - LR	
ET - total irrigation season crop water demand (mm/season)	= 282mm/season
ARm - average irrigation season rainfall	= 635mm/season
LR - Leaching requirement	= 0.149
LFa = 1- (282-635)-0.149	= 0.40
LFa - leaching fraction requirement above crop evapotranspiration	= 0.40

Table 31 Average rootzone saturation extract electroconductivity (ECse) following long-term irrigation with a given salinity of water (ignoring precipitation/dissolution reactions in the soil) and leaching fraction (Ayers and Westcot 1985)

Irrigation water EC (dS/m)	Leaching fraction (LF) above crop ET requirement				
	0.05	0.1	0.15	0.2	0.3
0.2	0.62	0.41	0.32	0.27	0.21
0.6	1.87	1.24	0.97	0.81	0.64
1.0	3.12	2.06	1.61	1.36	1.06
1.5	4.69	3.09	2.42	2.04	1.60
2.0	6.25	4.12	3.23	2.72	2.13
2.5	7.81	5.15	4.03	3.39	2.66
3.0	9.37	6.18	4.84	4.07	3.19
3.5	10.94	7.21	5.65	4.75	3.72
4.0	12.50	8.24	6.46	5.43	4.26
4.5	14.06	9.27	7.26	6.11	4.79
5.0	15.62	10.30	8.07	6.79	5.32
5.5	17.19	11.33	8.88	7.47	5.85

5.5.2.2 Modelled impacts of saline water irrigation on ground and surface water

Salts do not readily adhere to sand particles, and as such, the sandy loam nature of the proposed irrigation land on the Layton property would ensure salt accumulated during the irrigation season would be readily leached during the following winter. Leaching once beyond the root zone will be slow due to the heavy clays from approximately 1.5-5.0m below ground level (Appendix H, bore logs). These salts will dilute in the groundwater and over time be discharged to Parramatta Creek within Layton's property. The possible increase in salinity in the groundwater will have no impact on other landholders as the recharge and discharge zones are entirely within Layton's property. The groundwater discharged to Parramatta Creek will potentially increase creek salinity levels over time, with levels between 500µs/cm and 1100µs/cm possible.

The Australian Drinking Water Guidelines (August 2018) do not prescribe a quality limit for salinity but state that "total dissolved solids (TDS) of 0-600mg/L is of good palatability, 600-900mg/L is of fair palatability". The conversion of TDS to electrical conductivity is approximately 0.64, resulting in a salinity of 1100µs/cm being of fair palatability at approximately 700mg/L TDS.

The main use of Parramatta Creek downstream of the property is for direct access by stock for drinking water. The ANZECC (2000) water quality guidelines for beef cattle drinking states the desirable maximum TDS concentration as 4000mg/L or approximately 6250µS/cm. Australia wide data suggest that aquatic biota will be adversely affected as salinity exceeds 1000mg/L (approximately 1500µS/cm) (Hart et al. 1991, Nielsen et al. 2003). While changes in salinity can have adverse effects on freshwater biota, any increases are expected to be small as a result of the shandying, and therefore there is a low risk of salinity changes impacting on freshwater biota.

5.5.3 Wastewater shandying

To achieve the maximum EC of 1100uS/cm in the irrigation water a shandying solution is proposed. As detailed in the TRWG, water of this salinity (class 3) is determined to be low salinity and suitable for irrigating moderately sensitive crops. The pasture grass and clover species grown in commercial grazing operations in Tasmania are suitable for irrigation with water of this salinity level.

To achieve this lower salinity level (1,100µS/cm), shandying with freshwater from the Mersey River (EC of approximately 150µS/cm) will be required. At the current salinity level (2018/19 median of 2,380µS/cm), a shandying rate of 1.2-parts freshwater to one-part wastewater is required. As the salinity level of wastewater decreases over time, the shandying ratio will require less freshwater (Table 32).

Table 32 Shandying ratio for wastewater and fresh water as wastewater salinity (EC) decreases

Reuse water EC	Ratio required to achieve target EC of irrigation water (1,100 µS/cm)
3,000 µS/cm	1 part wastewater : 2 parts freshwater
2,500 µS/cm*	1 part wastewater : 1.2 parts freshwater
2,000 µS/cm	1 part wastewater : 1 part freshwater
1,500 µS/cm	1 part wastewater : 0.4 parts freshwater
1,100µS/cm	No shandying required.

** current EC (September 2019) of wastewater stream*

Shandying will occur within the pipeline, prior to reaching the irrigation equipment. The storage dam will not be required to store shandied water. The irrigation system design to accommodate this requirement is detailed in section 7.

5.5.4 Impact of shandying on area required for irrigation

Shandying wastewater will increase the volume of water to be irrigated during months where there is irrigation demand. As shown in Table 33 and Table 34, the irrigation area required is considerably less when the salt load in the wastewater stream is reduced.

Table 33 Irrigation area requirements for different shandying rates in mean rainfall years

Annual wastewater production volume (ML)	Area (ha) required if shandying:				
	1 part wastewater : 2 parts freshwater	1 part wastewater : 1.2 parts freshwater*	1 part wastewater : 1 part freshwater	1 part wastewater : 0.4 parts freshwater	No shandying required
69	45	33	30	21	15
77	51	37	34	24	17
90	59	43	39	28	20
102	67	49	45	31	22
110	73	53	48	34	24
112	74	54	49	34	25

** shandy rate required based on current (2018/19) wastewater quality*

Table 34 Irrigation area requirements for different shandying rates in 90th percentile rainfall years (marginal = orange)

Annual wastewater production volume (ML)	Area (ha) required if shandying:				
	1 part wastewater : 2 parts freshwater	1 part wastewater : 1.2 parts freshwater	1 part wastewater : 1 part freshwater	1 part wastewater : 0.4 parts freshwater	No shandying required
69	60	44	40	28	20
77	66	49	44	31	22
90	77	56	51	36	26
102	86	63	58	40	29
110	93	68	62	44	31
112	95	70	63	44	32

The irrigation system design enables irrigation of 79.8ha of land (Table 39 and Figure 15 in section 7). At the current (2019) wastewater salinity level (2,380 µS/cm), up to 112ML per year under mean rainfall conditions can be irrigated (once shandied to 1100µS/cm) on 54ha, considerably less than the proposed 79.8ha.

In extremely wet years, where the annual rainfall is equivalent to 90th percentile rainfall conditions, at the current salinity level (2,380 µS/cm) there would be sufficient land (70ha required) to irrigate 100% of the forecasted wastewater production flows of 112ML.

This is a realistic expectation, as outlined in section 5.5.1, the median salinity level of wastewater from the fish processing facility has been continuing to decrease over time and actions are already being implemented to transition to processes that introduce less salt into the system (e.g. a move to refrigerated trucks for transporting whole fish).

6 Wastewater irrigation assessment

6.1 Land capability assessment

6.1.1 Background

This land capability report provides information on various features of Huon Aquaculture and Layton's properties including soil, topography, erosion risk, land management considerations, potential land use activity and the key limitations associated with each of the various land classification types.

6.1.2 Methodology

The currently recognised reference for identifying land capability is based on the class definitions and methodology described in the Land Classification Handbook (Grose, 1999).

Most agricultural land in Tasmania has been classified by the Department of Primary Industries and Water at a scale of 1:100,000, according to its ability to withstand degradation. A scale of 1 to 7 has been developed with class 1 being the most resilient to degradation processes and class 7 the least. Classes 1 to 3 are collectively termed "prime agricultural land". Factors influencing capability include elevation, slope, climate, soil type, rooting depth, salinity, rockiness and susceptibility to wind, water erosion and flooding.

6.1.3 Results

The land capability of the properties is dominated by class 4 land, with some class 4+5 land and smaller areas of class 5 land (Figure 10).

The class 4 land is associated with gently sloping and rolling ground, with the key features being;

- Soils range from duplex to dermosol
- Nil to minimal rock and stone fragments present
- Moderately well drained
- Minor climatic limitations
- Low erosion risk
- Considered suitable for cropping (lower intensity on a longer rotation length), pastoral use and perennial horticulture

The key limitation associated with class 4 land is related to the soil in terms of its variable texture and limited depth.

The class 5 land is associated with the lowest lying land north of the Huon Aquaculture factory, and the key features of the low-lying class 5 land are;

- Dermosol soils
- Minimal rock and stone fragments present
- Poorly drained
- Minor climatic limitations
- Low erosion risk
- Considered unsuitable for cropping and pastoral use with moderate limitations

The key limitations associated with the low-lying class 5 land are related to the soil's clayey nature, being poorly drained and prone to extended periods of soil water logging.

Most of the Class 4+5 land has the characteristics of the better class 4 land with some areas of lower quality class 5 land, which diminishes the overall potential productivity of this land.

Appendix J contains the complete land capability report.

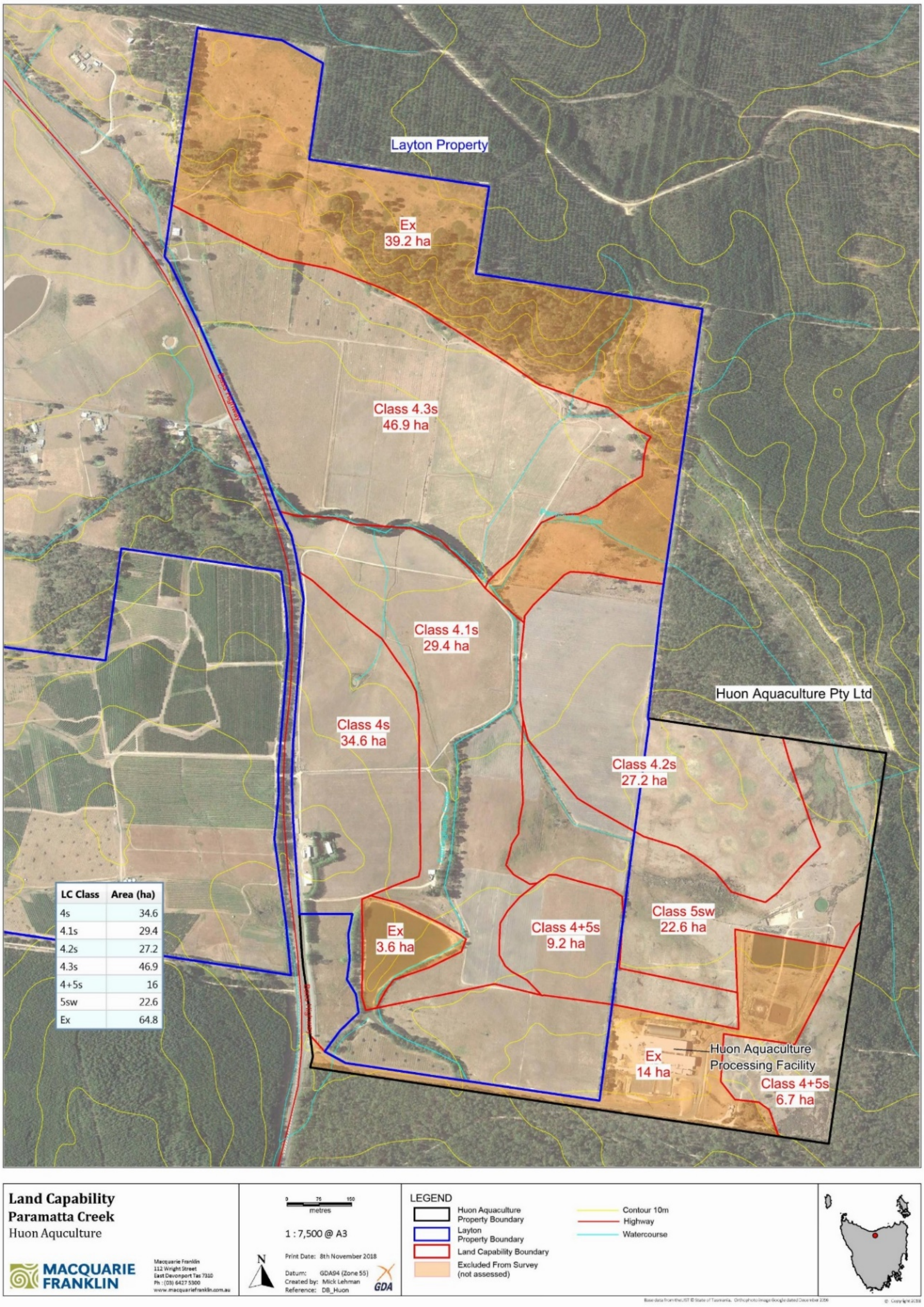

Figure 10 Land capability of the Layton's and Huon Aquaculture properties

6.2 Land suitability assessment for wastewater irrigation

6.2.1 Background

Land suitability for wastewater irrigation was assessed by reviewing previous soil mapping, environmental monitoring and site assessment reports, followed by a site visit by an experienced soil and agronomic adviser. The Huon Aquaculture property and adjoining property owned by Mr Layton were both assessed.

6.2.2 Methodology

Previous soil mapping by Agricultural Resource Management (ARM) in 2010 and Geo-Environmental Solutions (GES) in 2017 was ground-truthed by Macquarie Franklin and extended to include the remainder of the Layton property being considered for wastewater irrigation (Figure 11), as well as the topography and management requirements of the land to enable sustainable wastewater irrigation.

6.2.2.1 Huon Aquaculture property (2010)

Soils on the Huon Aquaculture property were mapped by ARM in 2010. The distribution of the soils was mapped at 1:10 000 scale using a free survey method, utilising geomorphic and landform features to identify potential changes in soil types. Soils were then noted using a series of shallow spade and auger observations to confirm their distribution. Several machine-excavated pits were then exposed to enable soils to be described in detail as well as sampling soil horizons for laboratory analysis. Soils were described using methods outlined by McDonald et. al. (1990) and mapped.

Chemical analyses of samples were conducted by the NATA accredited laboratories of Incitec Pivot Nutrient Advantage in Werribee, Victoria. All samples collected from the excavation pits received a complete soil test, which included analysis of phosphorus, sulphur, exchangeable cations, pH, chloride, electrical conductivity, organic carbon, trace elements and slaking/dispersion.

Analysis of soil physics were undertaken by GES. Measurements included saturated hydraulic conductivity, bulk density, field capacity, wilting point and soil porosity.

The assessment of potential area suitable for irrigation considered soil physical properties (soil structure, drainage, permeability), topographic position and the proximity to unsuitable areas (including poorly drained soils, drainage lines, seepage zones, watercourses/creeks and neighbouring properties).

6.2.2.2 Layton property (2017)

The GES investigation of Layton's property in February 2017 built on the previous soil investigations conducted by ARM (2010) on the Huon Aquaculture property next door. The soils mapped on both properties are consistent with soil names used by Forest Practices Authority and Forestry Tasmania's 'Soils of Tasmanian State Forests' and 'Forest Soils of Tasmania Handbook' (Grant et al 1995). Layton's Farm was identified as having two additional soil types to the area previously mapped on Huon Aquaculture's property (duplex and alluvial).

Soil cores were taken at five location on Layton's property to assess the topsoil and subsoil at these locations and verify soil type distribution. Samples were sent to (NATA accredited) Analytical

Laboratory Services (ALS) in Melbourne for chemical analysis (including phosphorus, sulphur, exchangeable cations, pH, chloride, electrical conductivity, organic carbon, trace elements and ESP).

6.2.2.3 Huon Aquaculture and Layton property (2018)

The soil mapping information presented in ARM and GES reports was ground-truthed by Macquarie Franklin in October 2018. The previously completed soil maps and relevant reports were reviewed and assessed to provide a basis for undertaking their validation in relation to taking into consideration the topography, known geology of the area, production system (i.e. dryland or irrigated) and agricultural land use activities.

Soil mapping was fine-tuned by assessing in detail the soils at 17 locations across the two properties, describing the soil type, soil profile characteristics and constraints (e.g. drainage, structure, inherent agricultural qualities etc.) and collecting samples of topsoil and subsoil for laboratory analysis (the results are provided in Appendix C).

The key soil fertility parameters on the HAC pivot are summarised as follows (based on analysis of samples collected in October 2018):

- Consistently neutral soil pH in the topsoil (average 7, no range detected) moderately acidic to moderately alkaline soil pH in the subsoil (average 6.8, range 6.2 to 7.5) pH measured as 1:5 water. This is an optimal soil pH.
- Non-saline topsoil (average 0.8dS/m, range 0.7-0.8dS/m) and non-saline subsoil (average 0.4 dS/m, range 0.3-0.4dS/m).
- Highly sodic topsoil (average 18% ESP, range 17-20% ESP) and highly sodic subsoil (average 25% ESP, range 11-40% ESP).
- Optimal phosphorus levels in the topsoil (average 47ppm, range 21-73ppm) and deficient levels in the subsoil (average 7ppm, range 5-9ppm) (measured as Colwell P).
- Low soil phosphorus buffer index in the top soil (average 130, range 120-140) and sub soil (average 151, range 91-210)
- Optimal to high levels in the topsoil (average 250ppm, range 180-320), and optimal levels in the subsoil (average 205ppm, range 140-270) (measured as available potassium).
- Marginally optimal sulphur levels in the topsoil (average 9.2ppm, range 4.5-14ppm) and very low levels in the subsoil (average 2.8ppm, range 1.7-4ppm) (measured as sulphur KCl40).
- Optimal organic carbon levels in the top soil (average 3.1%, range 2.9-4.5%), and low levels in the sub-soil (average 0.69%, range 0.57-0.82%) (measured as Walkley Black).

Based on analysis of samples collected in October 2018 key soil fertility parameters on Layton's property are as follows:

- Slightly acidic to neutral soil pH in the topsoil (average 6.6, range 6.2-7), moderately acidic to moderately alkaline soil pH in the subsoil (average 6.5, range 5.9-7.4) (measured as pH 1:5 water). This is a marginally optimal soil pH.
- Non-saline topsoil (average 0.4 dS/m, range 0.2-0.6dS/m) and non-saline in the sub-soil (average 0.3, range 0.2-0.5dS/m).
- Non-sodic top-soil (average 1.05% ESP range 0.5-3.3% ESP) and non-sodic sub-soil (average 1.9% ESP range 0.5-6.1% ESP).
- Optimal phosphorus levels in the topsoil (average 54ppm, range 20-180 ppm) and deficient levels in the subsoil (average 16ppm, range 7-22ppm) (measured as Colwell P).
- Low soil phosphorus buffer index in the top soil (average 104, range 13-220) and sub soil (average 109, range 7-240)
- Marginally optimal potassium levels in the topsoil (average 160, range 20-180ppm), and marginal levels in the subsoil (average 138ppm, range 19-570ppm) (measured as available potassium).
- Low sulphur levels in the topsoil (average 4.07ppm, range 1.8-11ppm) and low levels in the sub-soil (average 3.1ppm, range 1.1-7.5ppm) (measured as sulphur KCl40).
- High organic carbon levels in the topsoil (average 3.1%, range 2.1-3.9%), and low levels in the subsoil (average 1.2%, range 0.63-1.7%) (measured as Walkley Black).

Based on the inspection results, an updated soil map was produced to cover the full extent of the Huon Aquaculture and Layton properties (Figure 11).

6.2.3 Soil types

As described in section 6.2.2, soil types and their distribution, characteristics and limitations have been investigated in detail. The soil types identified on the property are:

- *Roebuck poorly drained (Ro-poor)*
- *Roebuck moderately well drained (Ro-mod)*
- *China*
- *Duplex*
- *Alluvial*

The characteristics of each soil type are outlined in the following sections.

6.2.3.1 Roebuck soil profile class

These soils have previously been described in the surrounding State forest and correlate to the Roebuck Soil Profile Class as described by Hill *et. al.* (1995). The drainage class of these soils varied across the survey and two distinct phases of this soil were mapped. These mapping units separated soils that were dominantly poorly drained (Ro-poor) from those that were dominantly moderately well drained (Ro-mod). Small areas of Roebuck soil were observed to have imperfect drainage, however these locations were too small to be mapped separately at this scale.

Roebuck poorly drained (Ro-poor)

The poorly drained phase is mainly located on the lower slopes through the centre of the Huon Aquaculture property, with a secondary area associated with the flats surrounding Parramatta Creek. The observed soil properties indicate that these soils are generally unsuitable for irrigation of wastewater. Currently the greatest off-site potential comes from surface run off. Their impeded drainage and slow saturated hydraulic conductivity mean that any increase to applied water will greatly increase the probability of surface water being present and the potential for off-site movement.

Roebuck moderately well drained (Ro-mod)

The moderately well drained phase was mainly located on the hillslopes situated in the northern half of the property. These soils are moderately suitable for irrigation with wastewater. Their structure and moderate drainage result in higher infiltration rates and a higher saturated hydraulic conductivity than the poorly drained phase. The higher values of organic carbon and CEC also mean these soils have a greater ability to retain any additional nutrients within the soil profile. However, the relatively shallow depth to the underlying fractured bedrock and the elevated position of these soils has the potential for water seepage to lower lying regions. Careful management of irrigation is therefore needed.

6.2.3.2 China soil profile class (Ch)

This mapping unit describes the texture-contrast profiles formed from Permian mudstone, sandstone and siltstone that were observed around the south eastern boundary of the property. Only a small area of this soil was found and it was generally located on hill slopes and slight rises. The observed China soils are moderately well drained with weakly structured topsoils overlying coarse prismatically structured subsoils.

6.2.3.3 Duplex, deep topsoil

These deep duplex soils are located on the elevated, gently sloping and undulating land on the southern area of the Layton property. The topsoil is deep (0-50cm) with a fine sandy texture, which abruptly changes to a heavy clay subsoil. The suitability of these soils for irrigation with wastewater is moderate, based on the sandy texture and depth of the topsoil and being moderate to well drained, resulting in higher infiltration rates and lower soil moisture holding capacity. These soils have a lower organic carbon content and cation exchange capacity and a lower nutrient retention capacity.

6.2.3.4 Alluvial soil

Alluvial soils are located lower in the landscape on the Layton property, on the flat and gently sloping land adjacent to Felminghams Creek and Parramatta Creek and on the foot and mid slopes on the northern area of the property. These soils vary in texture but are typically a black to brown-grey sandy loam topsoil (0-30cm) over a clay sub soil. The alluvial soils are moderately suited to irrigation with wastewater, and based on the loamy texture, depth and being imperfectly to moderately well drained, would result in moderate infiltration rates and soil moisture holding capacity.

The alluvial soils have moderate organic carbon content and cation exchange capacity and have a reasonable nutrient retention capacity. Drainage is a key factor to the productivity of these soils, and where practical, surface and cut off drains will assist in managing them for irrigation. It is important

to note that some of this land is potentially subject to inundation and care should be taken on the sensitive land directly adjacent to the waterways.

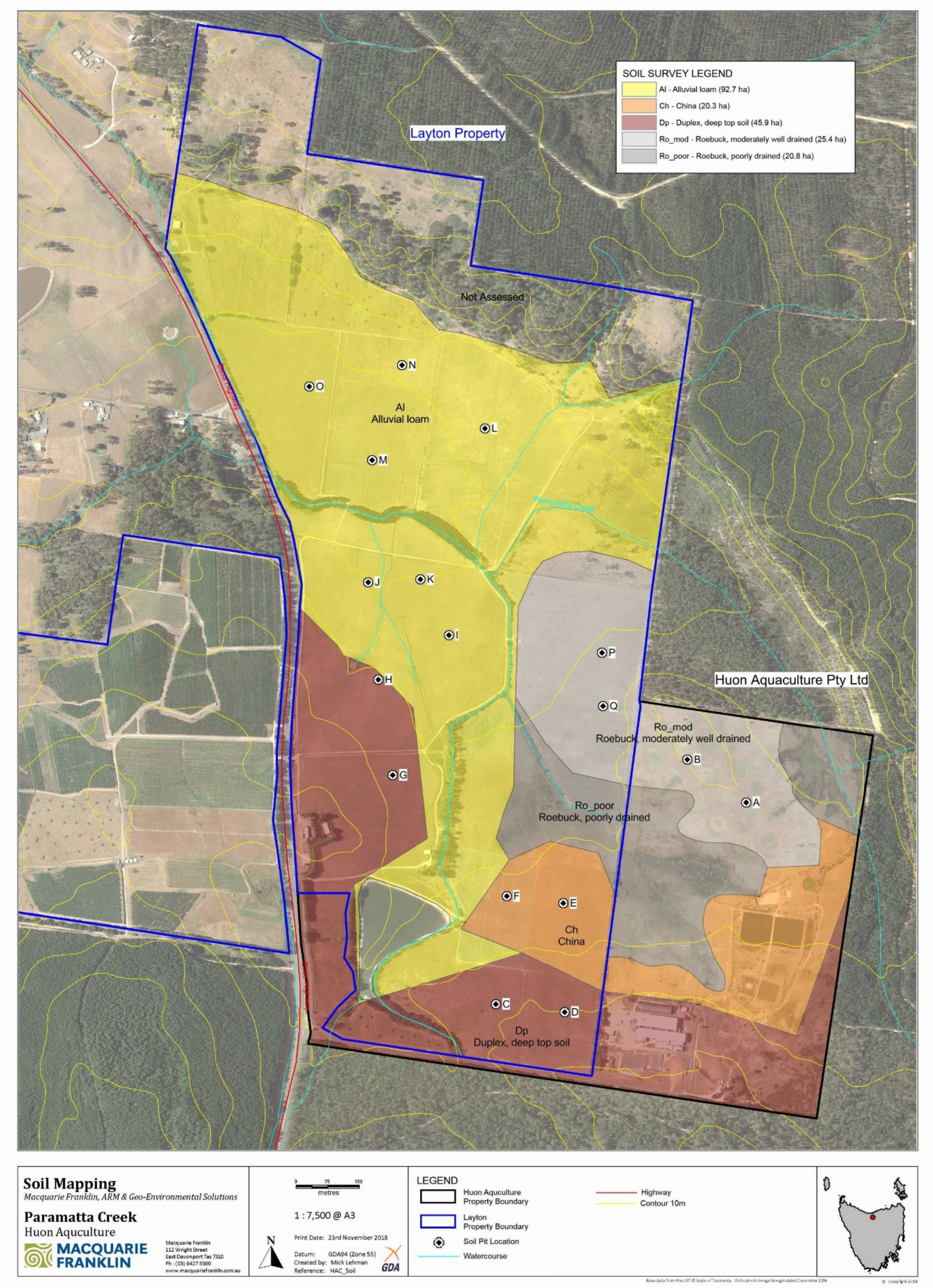

Figure 11 Soil map of both the HAC and Layton properties

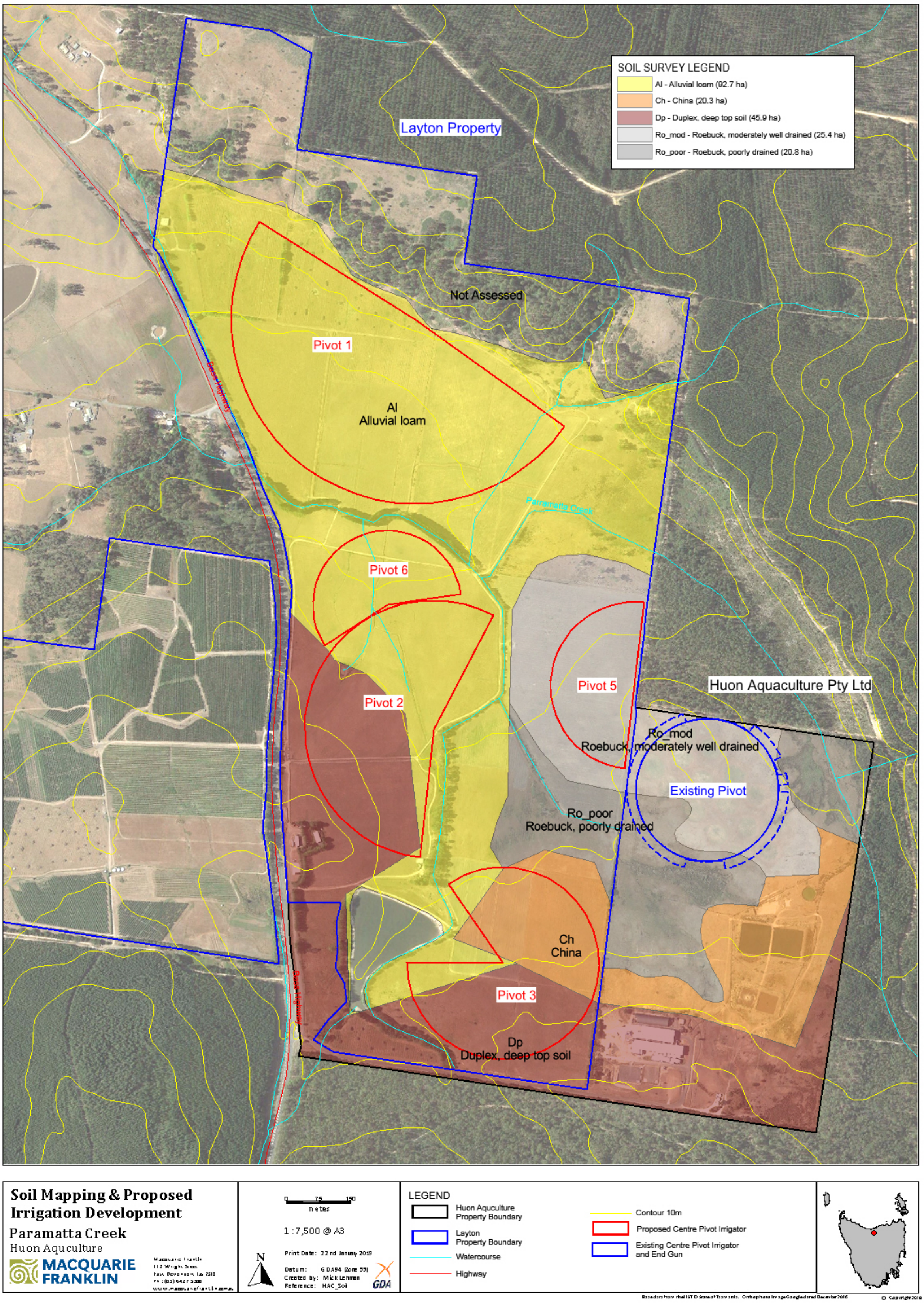

Figure 12: Soil map of both the HAC and Layton properties with proposed and existing centre pivot locations overlaid

6.2.4 Land suitability classifications

The assessed land was classified into three categories (Figure 13):

- well suited to wastewater irrigation
- marginally suited to wastewater irrigation (with shorter irrigation season due to being lower lying and more prone to lying wet)
- unsuitable for irrigation.

6.2.4.1 Well suited to wastewater irrigation

Land well suited to wastewater irrigation is on the more elevated parts of the properties where there are lighter textured soils. This land is found on the elevated southern boundary area of the Layton property, land immediately to east of the Bass Highway and mid slopes on the northern parts of the Huon Aquaculture and Layton properties. The lighter textured, deep duplex and alluvial soils are less susceptible to waterlogging and moderate to well drained. The agricultural productivity of this land would be improved by the application of irrigation and it is well suited to an extended irrigation season.

6.2.4.2 Marginally suited to wastewater irrigation

Land marginally suited to wastewater irrigation is predominantly lower lying land. This land is more susceptible to waterlogging and soil pugging, and if there has been considerable rainfall in winter months, these areas are likely to remain wet into spring, which would result in a delayed start to irrigation and a shorter irrigation season overall. The productivity of this land would be improved by the application of irrigation, however due to the expectations of a shorter irrigation season, the benefits would be constrained.

6.2.4.3 Unsuitable for irrigation

Land not suited to irrigation is lower lying and predominantly the poorly drained Roebuck (Ro-poor) soil type. The soils found here are subject to soil waterlogging for extended periods, prone to waterlogging and can be at risk of inundation. The poorly drained Roebuck (Ro-poor) soils have a high seasonal water table, are subject to waterlogging, prone to pugging, and are poor to imperfectly to well drained. The productivity of this land would not benefit from irrigation.

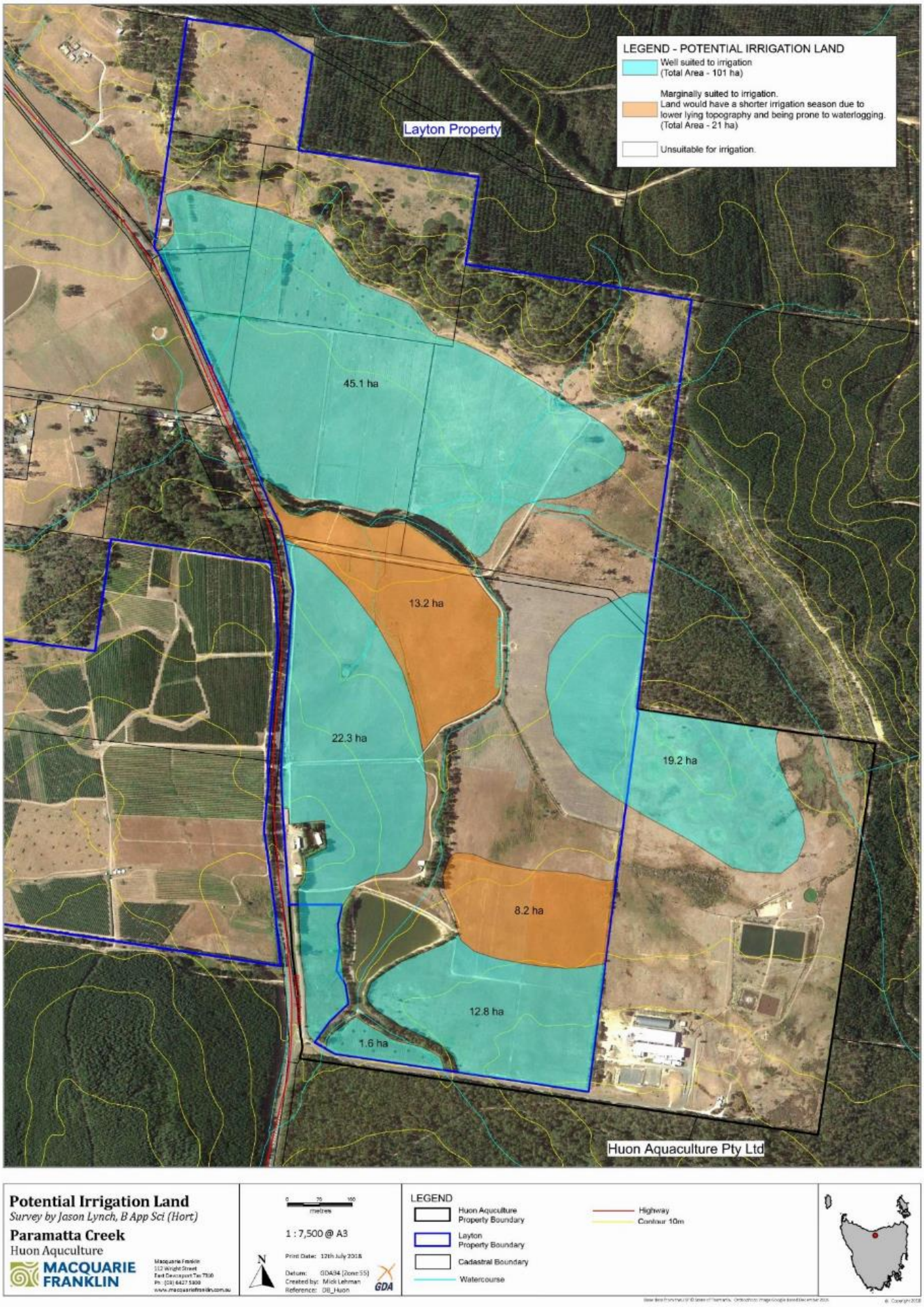

Figure 13 Map of land suitability for wastewater irrigation

6.3 Soil management

6.3.1 Risk assessment

Table 35 outlines the key risks associated with irrigating the soils found at Parramatta Creek with wastewater up to 1100µS/cm.

Table 35: Soil risk assessment

Risk	Potential Causes	Potential Impacts	Mitigation Plans	Consequence	Likelihood	Residual Risk Rating	Contingency plans
Nutrient accumulation in soils	Nutrient loading in the wastewater stream. Fertiliser budgeting by landowners doesn't take into account wastewater application. Low nutrient removal from agricultural production.	Risk of nutrient leaching/runoff and increased nutrient loads of surrounding surface or groundwater. Animal health issues. Soil structure decline. Nutrient imbalances.	Fertiliser budgets, prepared in collaboration with the landowner and agronomist, which incorporate data from the monitoring program. Pasture and grazing management support provided to landowner to ensure pastures are productive and nutrient removal is optimised. Monitor wastewater nutrient loading and dilute if required with fresh water. Monitoring program must include regular soil tests, wastewater stream, groundwater and surface water, and production data	2	2	4 Medium	Dilute inputs going in or increase removal going out (silage/hay harvesting, re-evaluate stocking rate and grazing management).

Risk	Potential Causes	Potential Impacts	Mitigation Plans	Consequence	Likelihood	Residual Risk Rating	Contingency plans
			(e.g. stocking rates, pasture harvest)				
Salt accumulation in soils	Salt loading in the wastewater stream. Ineffective dilution of wastewater with freshwater prior to irrigation (e.g. equipment malfunctions, human error). Increases in production from the factory. Excessive muriate of potash use. Drought / lower than average rainfall to flush soils.	Impaired pasture production. Soil structure decline. Poor quality surface water runoff. Leaching high salt loads to groundwater.	Monitor wastewater salt loading and reduce EC of irrigation water to <1100µS/cm. Monitoring program must include regular soil tests, wastewater stream, groundwater and surface water. Flushing soils with fresh water through irrigation system. Model likely impact of factory production increases on salt loads and determine if sustainable before any changes made. Ensure landowner is aware and does not use muriate of potash. Ensure shandying system includes safeguards.	3	2	6 Medium	If refrigerated trucks are shown to reduce the salt loads in wastewater, bring additional refrigerated trucks on-line.

Risk	Potential Causes	Potential Impacts	Mitigation Plans	Consequence	Likelihood	Residual Risk Rating	Contingency plans
Animal health impacts from high microbiology levels in irrigation water going onto pastures	Ineffective dilution of wastewater with freshwater prior to irrigation (e.g. equipment malfunctions, human error). Wastewater treatment ineffective. Fresh water source contaminated with coliforms. Withholding period between irrigation and grazing is not maintained at 48 hours	Animal health and productivity issues Stress to the landowner	Monitoring program must include regular soil tests, wastewater stream, groundwater and surface water. Monitor wastewater stream treatment methods and ensure effectiveness. Ensure shandying system includes safeguards. Increase stock withholding period to 5 days if thermotolerant coliforms >1000cfu/100ml Ensure landowner is advised of withholding periods between irrigation and grazing and grazing/irrigation scheduling programs take this into account. Monitor fresh water source.	3	1	3 Low	Quarantine affected livestock. Increase withholding periods. Stop irrigating. Increase holding time of wastewater in ponds.
Soil structure decline due to poor irrigation practices /	Low lying areas vulnerable to waterlogging.	Pasture productivity decline. Poor soil health.	Soil moisture monitoring used to schedule irrigation.	1	3	3 (Low)	Stop irrigating / review irrigation program. Reduce stocking rate.

Risk	Potential Causes	Potential Impacts	Mitigation Plans	Consequence	Likelihood	Residual Risk Rating	Contingency plans
impeded drainage (waterlogging) in areas under irrigation	Poor drainage infrastructure/planning. Inappropriate irrigation scheduling. Equipment malfunction. Increased sodicity. Lack of organic carbon.	Surface water runoff exacerbated. Erosion.	Reduced / no irrigation on poorly drained / waterlogged areas. Regular servicing of irrigation equipment, including inspecting wheel ruts for boggy areas. Growing highly productive pastures (best practice grazing management). Property drainage plan prepared. Use a feed pads or sacrifice areas during particularly wet periods to contain soil structural damage.				Re-sow pugged areas
Sodicity	Sodium salts replacing calcium in soil matrix (excessively saline irrigation water)	Pasture productivity decline. Poor soil health. Surface water runoff exacerbated. Erosion.	Monitor wastewater salt loading and reduce EC of irrigation water to <1100uS. Monitoring program must include regular soil tests, wastewater stream, groundwater and surface water. Flushing soils with fresh water through irrigation system.	1	3	3 (Low)	If refrigerated trucks are shown to reduce the salt loads in wastewater, bring additional refrigerated trucks on-line. Apply gypsum.

Risk	Potential Causes	Potential Impacts	Mitigation Plans	Consequence	Likelihood	Residual Risk Rating	Contingency plans
			Model likely impact of factory production increases on salt loads and determine if sustainable before any changes made. Ensure shandying system includes safeguards. Ensure best practice grazing management to maintain pastures with strong root systems.				
pH increase	pH level of waste water influences pH of soils	Minimal impact – pH >6 increases the availability of nutrients to plants and will improve pasture production. pH>8 may result in decreased nutrient availability	Soil pH amendments used if required to maintain soil pH in optimal range.	1	1	1 (Low)	NA

6.3.2 Salinity

6.3.2.1 Risk

An accumulation of salt in the soil could lead to poor pasture plant growth and decline in productivity and sustainability of the land due to degraded soil structure, leaching of salts into the groundwater and surface water.

6.3.2.2 Management actions

The potential for accumulation of salt in the soil will be monitored via soil tests, in conjunction with monitoring electrical conductivity in wastewater, groundwater and surface water. The modelling and calculations conducted through this WREMP development provide strong evidence that irrigation with 1100uS/cm water will not result in salt accumulation in the soils. However, if increased salt loads are observed then there is flexibility built into the system to enable further dilution of the wastewater stream below 1100uS/cm. Monitoring and the addition of a second EC meter in the irrigation system will ensure that the dilution system is operationally effective.

Through the provision of agronomic support to the land manager, as outlined in this WREMP (e.g. developing nutrient budgets, irrigation scheduling), the land manager will be discouraged from using muriate of potash and/or other fertiliser or soil ameliorants that could increase in the salt loading in the soils.

6.3.2.3 Contingency measures

In the unlikely event of management actions to reduce this risk being ineffective, the contingency measures identified is to increase the number of refrigerated trucks in service (if they are shown to reduce the salt loads in wastewater during the trial period). While HAC have a high degree of confidence the new trucks will result in decreased salinity, alternative options for disposal or reuse of the wastewater stream are continually being explored. An assessment of these options will be provided in the DPEMP. This may include additional area for irrigation of wastewater.

6.3.3 Sodicity

6.3.3.1 Risk

Accumulation of sodium in the soil structure may result in increased soil sodicity, which leads to poor soil health outcomes (e.g. reduction in soil permeability, increased risk of waterlogging and pugging, reduced soil biological activity). Decline in soil structure will result in a reduction in pasture productivity. Based on the data from the Huon Aquaculture centre pivot site, an increase in soil sodicity is possible. However, this site was subject to irrigation with highly saline water (up to 6,000uS/cm), which will not occur under this WREMP.

As demonstrated in section 5.5 a maximum wastewater electrical conductivity of 1100µS/cm has been shown by this plan to mitigate the risk of salt accumulation and soil sodicity.

6.3.3.2 Management actions

The management actions to protect against increasing sodicity of the soils being irrigated with wastewater are essentially the same as those to prevent increases in soil salinity (section 6.3.2).

6.3.3.3 Contingency measures

If the sodicity of the soil increases above trigger thresholds (as outlined in section 10.4) then the following actions would be taken:

- Additional dilution of wastewater stream prior to irrigation.
- Application of gypsum to affected areas.

6.3.4 Soil structure

6.3.4.1 Risk

Degradation of soil structure may occur if soils become waterlogged and continued stock access leads to pugging. Increased risk of waterlogging occurs as a result of poor soil drainage, or soils being at capacity at the end of summer, and quickly becoming saturated in winter. Soil structure may also be degraded as a result of increased sodicity Poor soil structure will result in a decline in the pasture sward density and overall pasture production levels, increased risk of soil erosion and possible degradation of waterways due to sediment movement.

6.3.4.2 Management actions

In order to manage the risk of soil structure decline, the following actions will be taken:

- Monitor soil moisture levels during summer and autumn to inform irrigation scheduling decisions. Closely monitor high risk (poorly drained) areas within paddocks and avoid applying more water on areas where drainage is impeded.
- Develop and implement a drainage plan for the property, which highlights high risk areas for waterlogging, and appropriate drainage solutions.
- Annual inspection of drains to ensure they are effective and to identify any areas where maintenance is required.
- Regular servicing of irrigation equipment, including inspecting wheel ruts for boggy areas.
- In situations where winters are extremely wet, livestock may be boxed up into larger mobs and in sacrifice areas (selected so that any off-site impacts such as sedimentation to surface water etc are minimised) or drier areas of the property. This will contain soil structural damage to small areas, and if necessary pastures can be renovated when conditions improve.
- Good grazing management and growing highly productive pastures will also optimise pasture utilisation of applied water.

6.3.4.3 Contingency measures

If soil structure degradation is identified the contingency measures are:

- Stop irrigation in the degraded area and review the irrigation program. This may require a reduction in the frequency and volume of irrigation water applied.

- Review the drainage plan and identify if new drainage works are necessary.
- Reduce the stocking rate.
- Re-sow areas which have become pugged (and also review the drainage of these areas before re-sowing).

6.3.5 pH

6.3.5.1 Risk

If the soil pH falls below 6 or increases above 8 the availability of macro and micro elements and soil biological activity is impaired and pasture growth and feed quality declines, and overall animal performance is limited.

Soil biology is optimised at a neutral soil pH, and this favours the growth and development of bacteria, fungi and actinomycetes, which improve the cycling of nutrients in the soil. This is especially beneficial for carbon cycling, which provides associated benefits to soil structure, moisture holding capacity and permeability.

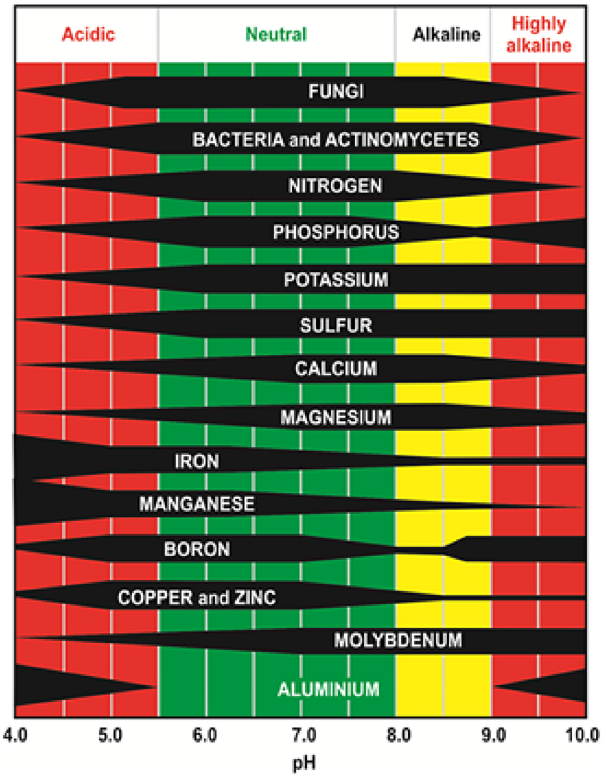

Figure 14 Soil pH and the impact on nutrient availability and soil biology
Source: [www.http://fertsmart.dairyingfortomorrow.com.au/dairy-soils-and-fertiliser-manual/chapter-7-managing-soil-limiting-factors]

In agriculture, producers make significant ongoing investment into improving soil pH to maximise plant growth and productivity. Lime, dolomite and other alkaline soil ameliorants are all used to neutralise soil pH.

A high soil pH, up to 8.0, does not pose an environmental risk and nor is it detrimental to soil health and productivity.

6.3.5.2 Management actions

- Any changes in soil pH will be monitored using soil tests.
- During preparation of annual nutrient budgets account for pH and do not apply lime, dolomite and/or other soil ameliorants that could increase in the soil pH beyond optimal levels (5.5 to 8.0).

6.3.6 Nutrients

6.3.6.1 Risk

Excessive nutrient accumulation in the soil could result in the increased risk of nutrient leaching/runoff and increased nutrient loads of surrounding surface or groundwater. There is also a risk of nutrient imbalances that could negatively impact animal health and/or result in soil structure decline. However, the risk of increased nutrient loads from the Huon Aquaculture wastewater stream is low. As an example,

Table 36 works through a phosphorous nutrient budget, that is based on:

- Soil factor - takes into consideration the phosphorous that is bound to the soil chemistry and that which is potentially leached (numbers generated based on soil texture and phosphorous buffer index and obtained from NutriMatch (Tasmanian Institute of Agriculture)).
- Nutrient removal figures from red meat obtained from NutriMatch (Tasmanian Institute of Agriculture)
- Based on irrigation of 3 ML/ha of wastewater with a concentration of 6.4mg/l per ML a total of 19.2 kg/ha will enter the system from wastewater.

Table 36 Phosphorus nutrient budget

Requirement	Phosphorus (kg/ha)
Soil factor (leaching & lock up)	20
Nutrient removal (red meat)	7
Total nutrients exported	**27**
Irrigation reuse water input (3 ML/ha)	19.2
Balance	**-7.8**

Based on these calculations, if 3 ML/ha of irrigation reuse water is applied it would result in an annual deficit of 7.8 kg/ha of phosphorus, which would deplete the soil phosphorus Colwell levels. Application of phosphorous fertiliser will be required to balance the nutrient removal and maintain the productivity of the site.

6.3.6.2 Management actions

The key risks for nutrient imbalances would result from lower than expected nutrient removal (production, in kg liveweight) or over-application of fertilisers. This risk can be very effectively managed via preparation of annual property-based nutrient budgets which takes into account actual production figures and up to date soil monitoring data from the property. This will involve an annual review of the fertiliser program by an agronomist engaged by Huon Aquaculture to support the land manager. The wastewater nutrient loading will also be monitored to ensure that the nutrients in this source are also accounted for in fertiliser programs.

Pasture and grazing management support will be provided to the land manager to ensure pastures are productive, grazing management is efficient and nutrient removal is optimised.

Further detail on the soil monitoring program is provided in section 10.7.1.5.

6.3.6.3 Contingency measures

If the soil nutrient levels show an unacceptable increase (refer to section 10.4 for more information on how this will be determined), management actions to reduce these would include harvesting the pasture for silage, removing this fodder from the production area and feeding it on non-irrigated land. For example, a modest silage harvest of 2,000 kg DM/ha (8 bales/ha) would remove 8.6 kg/ha of phosphorus and correct phosphorus accumulation.

6.4 Hydrology management

6.4.1 Risk assessment

Table 37 summarises key risks to surface and groundwater, and relevant mitigations, associated with wastewater irrigation from the Parramatta Creek facility.

Table 37 Surface and groundwater risk assessment

Risk	Potential Causes	Potential Impacts	Mitigation Plans	Consequence	Likelihood	Residual Risk Rating	Contingency plans
Nutrient-rich runoff entering Felmingham or Parramatta Creek	Nutrient loading in the wastewater stream. Fertiliser budgeting by landowners doesn't take into account nutrients in wastewater. Lower than expected nutrient removal from agricultural production.	Algal blooms in Felmingham or Parramatta Creeks. Nutrient imbalances. causing black water and anoxic conditions. Fish kills in Parramatta Creek catchment.	Fertiliser budgets, prepared in collaboration with the landowner and agronomist, which incorporate data from the monitoring program. Pasture and grazing management support provided to landowner to ensure pastures are productive and nutrient removal is optimised. Monitor wastewater nutrient loading and dilute if required with fresh water. Monitoring program must include regular soil tests, wastewater stream, groundwater and surface water, and production data	2	2	4 Low	Dilute inputs going in or increase removal going out (silage/hay harvesting, re-evaluate stocking rate and grazing management).

Risk	Potential Causes	Potential Impacts	Mitigation Plans	Consequence	Likelihood	Residual Risk Rating	Contingency plans
			(e.g. stocking rates, pasture harvest). Monitoring program must provide interpretation of results and early detection of any potential issues.				
Nutrient leaching to groundwater	Nutrient loading in the wastewater stream. Fertiliser budgeting by landowners doesn't take into account nutrients in wastewater. Lower than expected nutrient removal from agricultural production.	Impacts are likely to be to surface waters as Layton's property is a groundwater discharge area. Leaching of nutrients to groundwater will result in discharging of nutrient laden groundwater to Parramatta and Felmingham Creeks causing potential algal blooms, nutrient imbalances causing black water and anoxic conditions. Fish kills in Parramatta creek catchment.	Fertiliser budgets, prepared in collaboration with the landowner and agronomist, which incorporate data from the monitoring program. Pasture and grazing management support provided to landowner to ensure pastures are productive and nutrient removal is optimised. Monitor wastewater nutrient loading and dilute if required with fresh water. Monitoring program must include regular soil tests, wastewater stream, groundwater and surface water, and production data (e.g. stocking rates, pasture harvest). Monitoring	1	1	4 Low	Dilute inputs going in or increase removal going out (silage/hay harvesting, re-evaluate stocking rate and grazing management).

Risk	Potential Causes	Potential Impacts	Mitigation Plans	Consequence	Likelihood	Residual Risk Rating	Contingency plans
		.	program must provide interpretation of results and early detection of any potential issues.				
Salt accumulation in groundwater (leached from the soils)	Salt loading in the wastewater stream. Ineffective dilution of wastewater with freshwater prior to irrigation (e.g. equipment malfunctions, human error). Increases in production from the factory. Excessive muriate of potash use.	High salinity water discharged to creeks.	Monitor wastewater salt loading and flush irrigate with fresh water. Ensure sufficient irrigable area available for diluted wastewater irrigation. Wastewater irrigation should not exceed 1100µS/cm. Monitoring program must include regular soil tests, wastewater stream, groundwater and surface water. Monitoring program must provide interpretation of results and early detection of any potential issues. Flushing soils with fresh water through irrigation system. Model likely impact of factory production increases on salt loads and determine	3	2	6 Medium	If refrigerated trucks are shown to reduce the salt loads in wastewater, bring additional refrigerated trucks on-line.

Risk	Potential Causes	Potential Impacts	Mitigation Plans	Consequence	Likelihood	Residual Risk Rating	Contingency plans
			if sustainable before any changes made. Ensure landowner is aware and does not use muriate of potash. Ensure shandying system includes safeguards to prevent application of high salinity water.				
High salinity runoff entering surface waters	Salinity increases in the wastewater stream. Incorrect shandy ratio. Irrigating when soils are saturated.	Salinity issues in Parramatta Creek impacting on downstream users. Impacts to stream ecology through increased salinity	Monitor wastewater salt loading and ensure dilution is appropriate. Backup monitoring system on irrigator to ensure shandy rates are correct. Correct irrigation management to ensure soil moisture is optimised for plant production, reducing the risk of saturation. Monitoring program must include regular soil tests, wastewater stream, groundwater and surface water, and production data Monitoring program must provide interpretation of	3	2	6 Medium	If refrigerated trucks are shown to reduce the salt loads in wastewater, bring additional refrigerated trucks on-line.

Risk	Potential Causes	Potential Impacts	Mitigation Plans	Consequence	Likelihood	Residual Risk Rating	Contingency plans
			results and early detection of any potential issues.				
Biological/thermotolerant coliforms contaminate creeks	Irrigating when soils are saturated. Insufficient dilution of irrigation wastewater.	Health impacts to fauna and downstream users	Correct irrigation management to ensure soil moisture is optimised for plant production, reducing the risk of saturation. Monitoring program must include regular soil tests, wastewater stream, groundwater and surface water, and production data. Monitoring program must provide interpretation of results and early detection of any potential issues.	2	1	2 low	Increase retention time in storage lagoons or dams before irrigation. If refrigerated trucks are shown to reduce the salt loads in wastewater, bring additional refrigerated trucks on-line. If trucks are not effective/suitable then additional irrigation area may be an option.

6.4.2 Groundwater

6.4.2.1 Risk

The risks to groundwater identified in the risk assessment are nutrients leaching to groundwater, salt leaching to groundwater and thermotolerant coliforms entering the groundwater.

The likelihood of nutrients entering the groundwater is very low. The low levels of nutrients in the wastewater and the high-quality improved pastures will result in nutrients being utilised before leaching past the rootzone. The risk is more likely to be exacerbated by fertiliser application than wastewater irrigation, but both will be managed through annual soil sampling and consultation with a qualified agronomist.

Water-borne thermotolerant coliforms are generally at low levels in the wastewater resulting in a low risk of entering groundwater. Water-borne coliforms rely on water for transportation and irrigation will be conducted primarily through the summer months when soils are not saturated and drying times mean it is unlikely that coliforms will reach the groundwater.

Salts may over time leach to groundwater, from where they will be diluted before eventually being discharged to Parramatta Creek within Layton's property. The possible increase in salinity in the groundwater will have no impact on other landholders as the recharge and discharge zones are entirely within Layton's property.

6.4.2.2 Management actions

Nutrient budgets, prepared in collaboration with the land manager and an agronomist (commitment 17), will incorporate data from the monitoring program and significantly reduce the risk of nutrients entering the groundwater (refer to section 6.3.6.2 for more information). Wastewater nutrient and salt loading will be monitored and further diluted if required with freshwater.

The WREMP monitoring program will include regular soil tests, sampling and analysis of wastewater, groundwater and surface water, and production data (e.g. stocking rates, pasture harvest). The program will provide interpretation of results and early detection of any potential issues. Refer to section 10 for more information on the proposed monitoring program.

6.4.2.3 Contingency measures

Wastewater can be further diluted to reduce nutrient and salt additions to the property. An increase in the removal of nutrients can be undertaken through silage/hay harvesting, re-evaluate stocking rate and grazing management. Refer to section 6.3.6.2 for more details. A trial (12 months from February 2019) using a refrigerated truck is underway which may result in a reduction in salt load of the wastewater. While it is expected that the introduction of the first refrigerated truck will reduce salinity levels in the wastewater, the influence of the change on fish taste and texture is unknown. A part of the trial is an assessment of the change, if any, on taste and texture. If the trucks are shown to reduce the salt loads in wastewater, while not impacting fish quality, additional refrigerated trucks will be introduced to the fish transport fleet over time (within construction and cost time constraints).

6.4.3 Surface water

6.4.3.1 Risk

The risks to surface water identified in the risk assessment are nutrient laden runoff, salt laden runoff and thermotolerant coliforms entering surface waters.

It is possible that nutrients may enter surface water during runoff events. The risk of runoff containing excess nutrients is more likely to occur if irrigation is undertaken when the soil is saturated, if fertiliser has been applied at rates higher than required, or if rainfall events coincide with fertiliser applications.

Water borne thermotolerant coliforms are generally at low levels in the wastewater resulting in a low risk of entering surface water. Water borne coliforms rely on water for transportation, and irrigation will be conducted primarily through the summer months when soils are not saturated and drying times mean it is unlikely that coliforms will reach the groundwater.

The risk of salt entering the surface water is through two paths, one is through runoff events which coincide with wastewater irrigation and saturated soils, the other is through groundwater discharging to Parramatta Creek. While it is possible that salinity levels will increase in Parramatta Creek, the consequence is low as any increases will remain below 1500µs/cm. Australia wide data suggest that aquatic biota will be adversely affected as salinity exceeds 1000mg /L (approximately 1500µS/cm) (Hart et al. 1991, Nielsen et al. 2003). While changes in salinity can have adverse effects on freshwater biota, Parramatta Creek's historical water quality (section 3.2) suggests that salinity increases will be minimal if they do occur, with limited impacts on aquatic biota.

6.4.3.2 Management requirements

Irrigation will be timed so that soils are not saturated prior to irrigating wastewater. Nutrient budgets, prepared in collaboration with the land manager and an agronomist, will incorporate data from the monitoring program and significantly reduce the risk of nutrients entering the groundwater (refer to section 6.3.6.2 for more information). Wastewater nutrient and salt loading will be monitored and further diluted if required with freshwater.

The WREMP monitoring program will include regular soil tests, wastewater stream, groundwater and surface water, and production data (e.g. stocking rates, pasture harvest). The program will provide interpretation of results and early detection of any potential issues. Refer to section 10 for more information on the proposed monitoring program.

6.4.3.3 Contingency measures

Wastewater can be further diluted to reduce nutrient and salt loads. An increase in the removal of nutrients can be achieved through silage/hay harvesting, re-evaluate stocking rate and grazing management.

A trial is about to be undertaken utilising refrigerated fish transport trucks. If the trucks are shown to reduce the salt loads in wastewater, additional refrigerated trucks will be introduced to the fish transport fleet over time.

6.5 Crop management

6.5.1 Cropping schedule

The wastewater irrigation area will be under pasture, with the occasional fodder crop planted as part of the pasture renovation process. Salt-tolerant fodder crops that are suitable for this site include turnips, rape, annual ryegrass and oats. The pasture will be grazed by cattle and/or sheep, with best practice pasture and grazing management implemented to ensure the site is managed productively and sustainably.

6.5.2 Irrigation requirement

Table 38 shows the irrigation requirements for irrigated pasture grown in the region under different rainfall conditions. The irrigation demand per hectare is approximately 4.5ML per ha per year. This amount of irrigation water is regularly applied on well managed farms in the area (refer to section 6.5.3 for additional information). In wetter years the irrigation demand decreases, in dry years the irrigation season is extended and more irrigation is required to make up the deficit between rainfall and evaporation.

Table 38 Summary of pasture irrigation requirements under different rainfall conditions

	10th percentile rainfall	Mean rainfall	90th percentile rainfall
Irrigation demand (ML/ha/year)	6.7	4.5	2.7
Total irrigation demand (ML)	445	301	184

The total irrigation demand considers the irrigation requirements of both the well suited and marginally suited land for irrigation on the Huon Aquaculture and Layton properties. Marginally suited land has a shorter irrigation season, which is incorporated into calculations for total irrigation demand.

Calculations for pasture irrigation requirements are provided in Appendix G.

6.5.3 Pasture and grazing management

Pastures irrigated with wastewater will be grazed by cattle and/or sheep. The management practices implemented will be based on best practice to optimise livestock health and performance, pasture productivity and long-term sustainability.

Best practice pasture and grazing management will be focussed on optimising the amount of pasture grown and utilised by livestock and is characterised by a more intensive grazing system. Pasture plants have higher growth rates, as a result of optimal grazing and irrigation management, which require irrigation application rates above what is suggested in the TRWG. This grazing system is not limited to dairy operations, it is equally as applicable to sheep and cattle enterprises, and is increasingly implemented by leading red meat producers across Tasmania. Regardless of grazing enterprise (i.e. dairy, beef cattle or sheep meat), irrigation rates of 4.5ML/ha are appropriate in this region in a mean rainfall year. These irrigation figures are supported by modelling and research conducted by the Tasmanian Institute of Agriculture, regional historical pasture production 1970 to 2011 using the DairyMod simulations.

Pasture and livestock management will be predominantly managed by Mr Layton, who will be coached (as required) by an experienced pasture and grazing advisor to ensure he develops the required skills and has access to professional support to implement best practice.

Livestock will be rotationally grazed to promote optimal pasture growth, rest paddocks and soils between grazing, enable withholding periods between irrigation and livestock access to be implemented and allow land marginally suited to irrigation time to dry out without pressure from livestock.

6.5.4 Nutrient requirements

The soil data collected in October 2018 for Layton's property will be used to develop a fertiliser management program. This will be done by an appropriately experienced soils advisor in collaboration with the land manager and reviewed annually as part of the annual soil monitoring program. This will incorporate soil test results, plant nutrient requirements, nutrient loadings in applied wastewater and livestock removal of nutrients from the system. Recommendations will also consider soil amendments (e.g. liming rates etc.) and the appropriateness of fertiliser products in regard to managing any nutrient issues observed in the soil, surface water or groundwater monitoring programs.

6.5.5 Pasture suitability for wastewater irrigation

Pastures most commonly grown in the region under intensive grazing systems are predominantly perennial ryegrass based. Perennial ryegrass is classed as a moderately salt tolerant species, with no decline in production anticipated up to 3.7dS/m. A salinity level of 4.6dS/m is predicted to result in a 10% reduction in yield, while up to 5.9dS/m will result in up to 25% yield reduction (Agriculture NSW, 2016).

Under the proposed system, long term accumulation of salt in the soil is not expected to impact pastures (as outlined in section 5.5.2). Whilst there may be some temporary accumulation of salts in the soil during the irrigation season, natural flushing of salts via rainfall is sufficient to flush salts from the soil and return it to less than 1.5dS/m (non-saline) during winter. Long-term persistence and productivity of the ryegrass pastures is expected to be maintained, and will be influenced more by grazing management than irrigation water EC.

Historically, at the existing irrigation site on the Huon Aquaculture property there have been occurrences where the pasture has been impacted by wastewater salinity. This has not been due to salt accumulation in the soil, but the high salinity of the wastewater (>6,000 μS/cm) being applied, burning the pasture plants. Water of this salinity level will not be applied under the proposed system, where the maximum salinity of the water irrigated will be 1100μS/cm, well within a salinity level that will not harm productivity of ryegrass plants. As the proposed irrigation management is well-within the range of ryegrass tolerance it will support healthy, productive pastures. A search of the literature has indicated that there would not be any adverse animal performance or health impacts for cattle grazed on these pastures (Masters et al, 2016). This is supported by the fact that beef cattle have no adverse effects when provided with drinking water of salinity up to 730 dS/m (Department of Agriculture, Western Australia, 2018).

7 Irrigation system design

7.1 Irrigation area

Irrigation sites were selected to maximise the use of the land best suited to irrigation as identified by the land suitability and capability assessments (section 6.1). The proposed system will irrigate land owned by Huon Aquaculture (current irrigation area) and the adjacent property owned by the Layton family and managed by Mr Troy Layton.

Buffers of 50m from the highway and 20m from streams were applied in the design process, and irrigators configured to not cross into these exclusion zones. The option of traversing these buffer areas and using individual sprinkler control to switch off irrigation application was considered, but ultimately ruled out on the basis of little additional area gain, and potential for loss of system reliability due to potential corrosion of control valves in the future.

The total irrigated area will be around 79.81ha, plus additional area if the end gun on the existing pivot (CP4) is utilised, bringing the total to close to 80ha.

7.2 System layout

The proposed irrigation concept site plan is detailed in Figure 15 and includes five new centre pivot irrigators in addition to the existing centre pivot currently installed and operating on the Huon Aquaculture site. The details of all six irrigators are provided in Table 39.

Table 39 Proposed centre pivot irrigators

Irrigator ID	CP 1	CP 2	CP 3	CP 4 (existing)	CP 5	CP 6
Length	430m	301m	225m	168m	196m	174m
Area (ha)	28.48	15.95	13.47	10.5 (+ end gun)	6.01	5.4
Degree of Arc	176°	201°	304°	360°	180°	204°
Flow Rate @ 7mm per day	23 l/s	12.9 l/s	10.9 l/s	10 l/s	5.1 l/s	4.6 l/s

7.3 Irrigation application

Sprinkler packages are proposed to deliver 7mm per day over the entire area in a 24-hour period of continued operation. This will be adequate to meet peak irrigation water demand in most years for perennial pasture.

It should also be noted that the system does not require all pivot irrigators to be operational all of the time to meet pasture irrigation demand (see note below). The system is designed to enable withholding periods for livestock to be implemented.

7.4 System flow rate

The proposed system will have a total design maximum flow of 66.5l/s. At the initial proposed shandying ratio of wastewater to fresh water (one part freshwater to two parts wastewater), 44.3l/s of freshwater will be required to supplement the maximum flow of 22.2l/s of wastewater.

The existing water supply infrastructure to the site can't deliver this volume of fresh irrigation water, therefore the freshwater supply will need to be drawn from the existing irrigation dam located on the Layton property (referred to as Layton's dam).

7.5 Capacity to irrigate and still implement management practices

The centre pivot irrigators will be configured with 7mm sprinkler packages. The sprinkler package size (in mm per day) is an industry standard description of the application or system capacity of the irrigator and system. It means that if the irrigator was operating continuously for 24 hours and covered the entire area of the circle (i.e. travelled 360 degrees) in that time it would apply 7mm of irrigation water. Therefore, with a capacity of 7mm per day, the system could apply up to 49mm per week, which is significantly in excess of potential ET within the irrigation period, and the pasture water requirements. This allows for a significant amount of down time on each centre pivot system.

The potential wastewater volume available is 70ML, which will be diluted with freshwater at a rate of between 2:1 to 3:1, resulting in between 210 to 280ML of total water available. Including the existing centre pivot on Huon Aquaculture's land, the application area available is 80ha. With a capacity of 7mm per day, the system can apply up to 5.6 ML per day if operated continuously. Therefore, it is possible to apply the entire volume in 37 to 50 days of continuous irrigation.

However, irrigation scheduling with centre pivot systems usually involve a three to four-day irrigation interval, with the actual depth of application managed to meet pasture ET requirements for that period. For example, if the daily ET was 4mm, and the system was operating on a four-day irrigation interval, then an individual centre pivot irrigator would be slowed down to walk at a speed to cover only 90 degrees of the circle (25% of the area), in 13.7 hours, and then be stopped for the balance of the day. This would result in an application of 16mm over 25% of the area. As ET demand increases, the hours of operation increase, while the area covered remains the same, as ET demand decreases, the hours of operation decrease. A three to four-day irrigation interval is optimal for pasture production. The aim of irrigation scheduling is to apply the right amount of water at the right time and if done correctly excess soil moisture will be avoided. If any area within the site does become too wet due to rainfall, then the system can simply be turned off for an appropriate period of time.

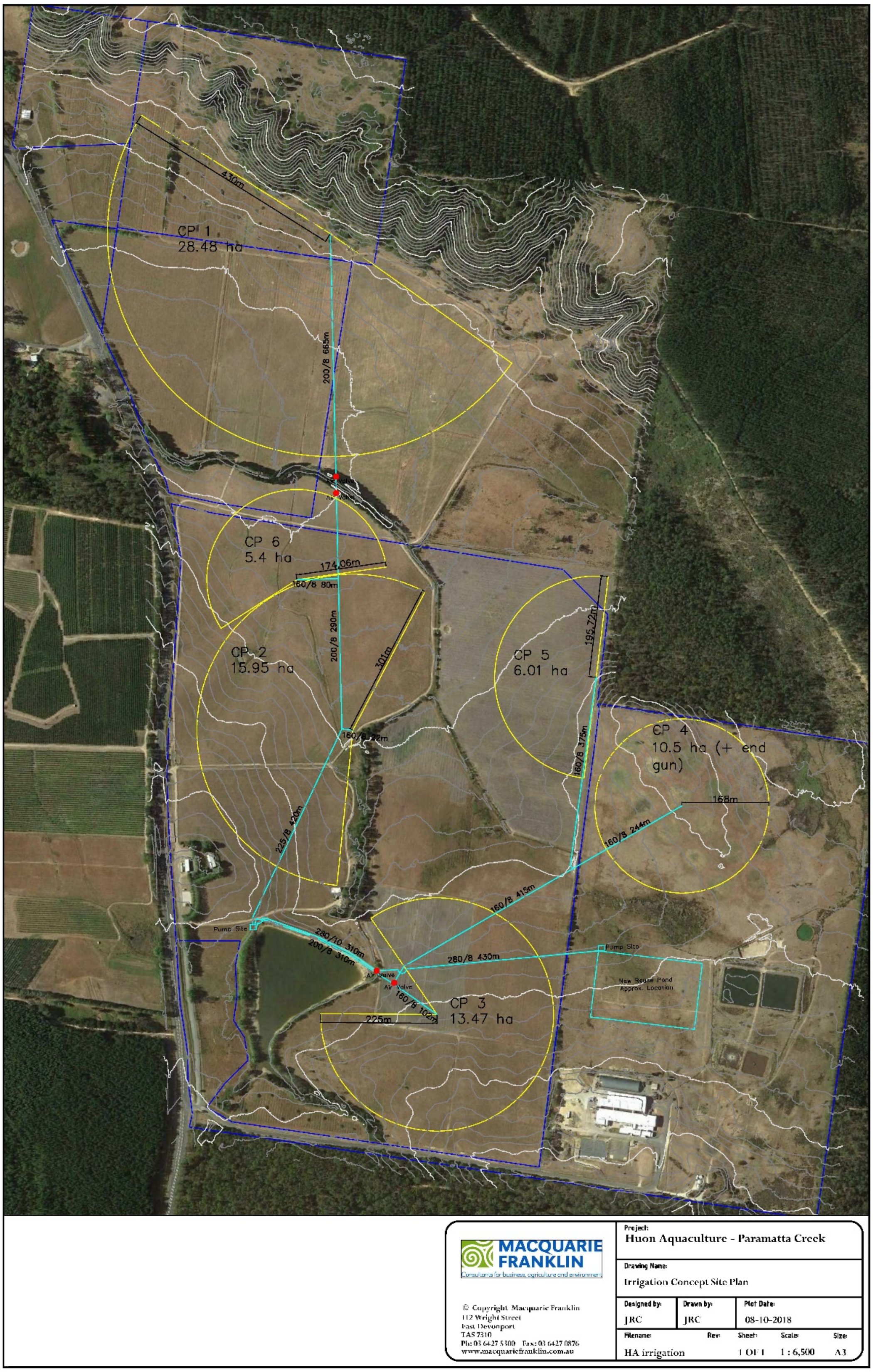

Figure 15 Proposed irrigation concept site plan for wastewater from the Parramatta Creek fish processing facility

7.6 Fresh water supply

Layton's dam (dam ID 4287, listed as being 300 ML in capacity) is supplementary filled from the Mersey River supply system during the irrigation season.

The Mersey River has not been restricted for Surety 5 takes in recent times. Surety 6 allocations have been restricted for 22 days during the 2015/16 irrigation season and 44 days during the 2017/18 season.

Huon Aquaculture hold water licence number 9538, which entitles them to 340.5ML from the Mersey River (all year) and an additional 60ML from Felminghams Creek, taken into storage during the winter period, for use during summer.

Troy Layton holds his own water allocations for both the Mersey River (water licence number 8180) and Felminghams Creek, both of which can be utilised to provide freshwater to the system. The Layton allocations total 540.75ML from the Mersey River and 60ML from Felminghams Creek. These are not currently utilised and are available for shandying of wastewater.

In addition to these water allocations, it is possible for any irrigator to purchase water from Hydro Tasmania (released from Lake Parangana) should need arise. Given the above, any restriction on direct take water from the Mersey River can be compensated via water held within Layton's dam or alternatively via the purchase of water form Hydro Tasmania. With the access to multiple reliable water sources, there is no risk that there will be insufficient freshwater in the system for shandying to occur as planned, even during drought years.

7.7 Pumping system

While it's preferred that all irrigators are run concurrently, it's likely that this won't happen all the time and as a result, the pump system has been designed to be capable of delivering water to any combination of irrigators and to accommodate the required level of in-line shandying from the wastewater dam and Layton's dam. A schematic of the proposed pump system is shown in Figure 16. This will be reviewed once the wastewater dam design is finalised.

The rate of wastewater transfer will be controlled via an automated control valve and programmable logic controller linked to an EC meter located on the discharge side of pump 1. By incorporating the wastewater supply into the system prior to pump 1 it will ensure adequate mixing of the two water supplies as they pass through pump 1, therefore ensuring correct readings from the EC meter. The target EC reading will be determined and the control valve will open and close to vary the flow to achieve the target EC.

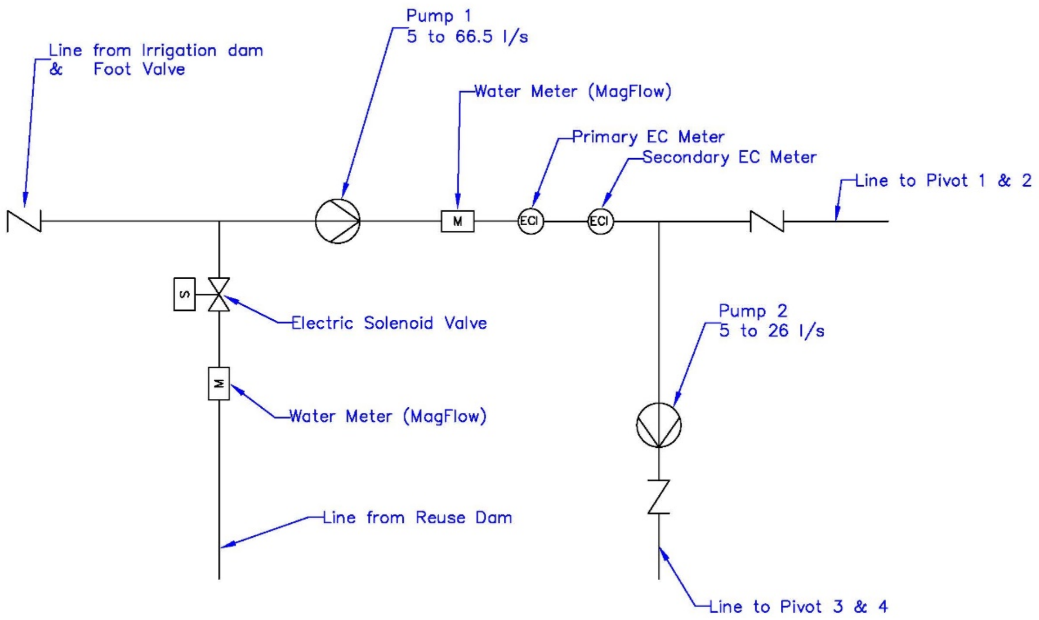

Figure 16 Schematic of pump system

As a safeguard for the system, a second EC meter will be installed downstream of the primary EC meter location. This second EC meter output will be linked to the control system and operate as safeguard. The control system will monitor the EC values of both instruments, with the primary instrument used to vary the dilution rates to achieve the target EC value. Should the EC value of the water in either instrument exceed the pre-set limit the system will shut down and irrigation will halt until the system is reset. This will prevent irrigation with highly saline water occurring in the event of an equipment malfunction at the first controller.

8 Irrigation management

8.1 Operational management

Huon Aquaculture will be the permit holder responsible for ensuring the requirements of the WREMP and environmental permit conditions are implemented.

Day-to-day irrigation of wastewater will be managed by Mr Layton. Support from Huon Aquaculture staff will be provided where required, such as overseeing maintenance of infrastructure (pipes, pumps, dams etc.), communicating supply and quality issues and at times, turning taps or pumps on and off to assist with operations. These tasks will be resourced by Huon Aquaculture as outlined in Table 40.

Table 40 Resourcing of irrigation roles performed by Huon Aquaculture

Task:	Performed by staff position at Huon Aquaculture:
Oversee maintenance of infrastructure (pipes, pumps, dams etc.)	HAC PC maintenance manager
Communicate supply and/or quality issues	HAC environmental manager and HAC PC maintenance manager
Operational assistance (e.g. turning taps or pumps on and off)	HAC environmental manager and Troy Layton
Soil moisture monitoring and irrigation scheduling	Troy Layton with support/training from appropriately qualified agronomist

All persons involved in irrigation activities will be trained in the appropriate use of the infrastructure prior to irrigation commencing by an appropriately experienced irrigation advisor.

8.2 Irrigation scheduling

Irrigation requirements of pasture will be assessed regularly to inform irrigation activities and optimise wastewater irrigation. This will be conducted using practical soil moisture monitoring equipment and ground-truthed with a shovel.

Appropriate equipment will be determined in consultation with Mr Layton (the main irrigation operator), Huon Aquaculture and an appropriately experienced external advisor. Training in its use and ongoing support from an appropriately experienced irrigation advisor / agronomist will be available to the irrigation manager.

It is envisaged that soil moisture sensors will be positioned at the depths outlined in Table 41, however this will be reviewed upon installation to ensure a site-specific approach.

Table 41 Proposed soil moisture sensor placement depth (tbc in field when installing)

Soil type	Proposed soil moisture sensor depth
Roebuck (poorly drained)	N/A not proposed for irrigation
Roebuck (moderately well drained)	0-20cm topsoil 20-40cm subsoil
China	0-20cm topsoil 20-40cm subsoil
Deep duplex	0-20cm topsoil 20-40cm subsoil
Alluvial	0-20cm topsoil 20-40cm subsoil

8.3 Shandying of wastewater

Based on the EC of the wastewater storage dam, wastewater will be shandied in-line prior to irrigation, to ensure the applied salinity level is 1100µS/cm. This process will be automated and built into the irrigation system design, with a safety mechanism (as specified in section 7).

8.4 Managing algal blooms in wastewater storage dam

As part of the ongoing water quality testing program conducted by Huon Aquaculture, treatment plant ponds and the new wastewater storage dam will be monitored for algal blooms. If an algal bloom is evident, a water sample will be sent to a NATA accredited laboratory for testing to determine if the bloom is toxic. If there is a toxicity risk to livestock during the irrigation season, then options will include suspending irrigation until the risk passes or continuing to irrigate in paddocks not required in the short term for stock feed (with contact avoidance measures in place) and withholding livestock from the affected paddocks for three weeks. Additional management advice is available in the *Guidelines for Managing Blue-Green Algae (Cyanobacteria) Blooms in Sewage Treatment Lagoons* (DPIPWE, 2011), which is available online:

https://epa.tas.gov.au/Documents/Blue-Green_Algae_Management_Guidelines_2011.pdf

8.5 Managing dam capacity

There is a low risk that the wastewater dam will reach capacity in such a way (i.e. for reasons or at a time of year) that wastewater irrigation will not be feasible to reduce the dam level. This is most likely to occur following a wet summer, when irrigation has been reduced.

A D50 gauge board will be installed near the outlet of the wastewater dam to facilitate measurement of the volume of water in the dam. With regular monitoring of wastewater dam levels against established target levels for particular times of year, this situation will be able to be predicted ahead of time and contingency plans set in place before it reaches crisis point. Additionally, if the refrigerated trucks are effective and more can be brought on-line the risk of this occurrence falls further, as less water will be coming into the system.

If wastewater dam monitoring does indicate that the dam inflows will exceed capacity, options to manage include increasing the irrigation (within 1100µS/cm limit, but beyond field capacity) on specific paddocks which are de-stocked to prevent pugging.

9 Wastewater management practices

9.1 Permitted and non-permitted uses

9.1.1 Background

Wastewater from the Parramatta Creek fish processing facility is classified as Class B recycled water, with the exception of pH, which is a little higher than the range recommended in the TRWG. For the purpose of managing the water source in this Wastewater Reuse EMP, it is treated as Class B recycled water.

Based on the TRWG, Class B recycled water is suitable for crops for human consumption to be consumed raw (providing no physical contact between recycled water and the produce, with an appropriate management plan in place on-site to manage the risk), as a processed product or for irrigation of pasture and fodder for livestock (excluding pigs and poultry).

The environmental permit conditions (No. 7894) specify that wastewater from the fish processing facility is not permitted for:

- human food crops; or
- irrigation of land to be grazed by livestock, however pasture and fodder crops may be harvested from the site and fed to livestock.

The potential risk being managed is the transfer of pathogens and disease from fish (or fish feed) to livestock, however at other sites with very similar circumstances, the risk is managed via a 48-hourwithholding period between irrigation and access to the site by livestock.

It is recommended that requirement 3.1 of condition G10 in the environmental permit conditions (No. 7894) be replaced to permit livestock grazing:

> *3. The plan must be prepared in accordance with the Environmental Guidelines for the Use of Recycled Water in Tasmania and in compliance with the following requirements:*
>
> > ***3.1 Grazing by livestock (other than pigs and poultry) requires a 48-hour withholding period post irrigation****; and*
> > *3.2 No crops other than livestock fodder crops or non-human food crops are to be grown on land subject to irrigation with effluent.*

This WREMP is based on irrigating pasture being grown for grazing by cattle and/or sheep and a 48-hour withholding period between irrigation and stock access being implemented.

9.1.2 Permitted uses

Wastewater from the Parramatta Creek fish processing facility is suitable for irrigating pasture and fodder crops for consumption by livestock (other than pigs and poultry), providing a 48-hour withholding period between irrigation and stock access is implemented.

9.1.3 Non-permitted uses

Wastewater from the Parramatta Creek fish processing facility cannot be used for the following purposes:

- human drinking water
- stock drinking water
- irrigating crops where the produce is consumed directly by humans
- irrigating pasture or fodder crops to be grazed (in situ or post-harvest) by pigs or poultry.

9.2 Withholding periods

The following minimum withholding periods apply to the use of wastewater for irrigation under this WREMP. These are in excess of the requirements as outlined in the *Environmental guidelines for the use of recycled water in Tasmania 2002.*

- 48-hour withholding period between irrigation and livestock access
- 48-hour withholding period between irrigation and harvesting of fodder crops

9.3 Buffer zones

To manage the risk of spray drift beyond the property boundaries and sensitive areas, the following buffer distances are to be implemented:

- 50m buffer distance to property boundaries (excluding the internal boundary between Huon Aquaculture and the adjoining irrigation property owned by Mr Layton)
- 50 m buffer distance to buildings (houses, factory facilities, workshops etc.)
- 20m to waterways and dams

These buffer zones are shown in Figure 18. The buffer distances are based on a site-specific approach, with the purpose being to manage the relevant risks (i.e. prevent spray drift to areas accessed by humans and prevent surface water run off to sensitive areas or other water sources/storages).

In addition, irrigation will not occur when wind conditions are such that there is a risk of spray drift leaving the property boundaries or entering a sensitive area (e.g. houses, factory facilities, workshops).

9.4 Signage

Signs will be installed to warn people that wastewater water is being used on the properties, with appropriate signs installed at the following locations:

- entry gate to the property where wastewater is being applied
- external boundary fences
- fence around wastewater storage dams
- outlets and taps where wastewater can be accessed (these should also be painted purple to indicate recycled water).

Examples of warning signs are shown in Figure 17.

Tap signage

Agricultural fence signage

Public access area signage

Figure 17 Examples of wastewater warning signs

9.5 Fencing

All wastewater irrigation areas must be fenced to stock-proof fence standard to ensure livestock access can be restricted to manage withholding periods and to ensure sufficient grazing pressure can be applied periodically (rotational grazing) to manage pasture growth and soils appropriately.

All wastewater dams must be fenced to exclude livestock access.

9.6 Preventing contact with wastewater

Contact with wastewater will be avoided by implementing the following practices:

- Access to irrigation areas is to be restricted when irrigation with wastewater is in operation.
- To prevent inhalation of wastewater particles, maintenance of irrigation infrastructure will not be conducted when the irrigation system is pressurised.
- Before conducting maintenance on irrigation infrastructure, the relevant equipment will be flushed with fresh water.
- Where there is risk of direct contact of wastewater, appropriate personal protective equipment will be worn (e.g. breathing mask and/or waterproof gloves).
- After handling irrigation equipment or wastewater infrastructure, hands should be washed with soapy water or antimicrobial solution.

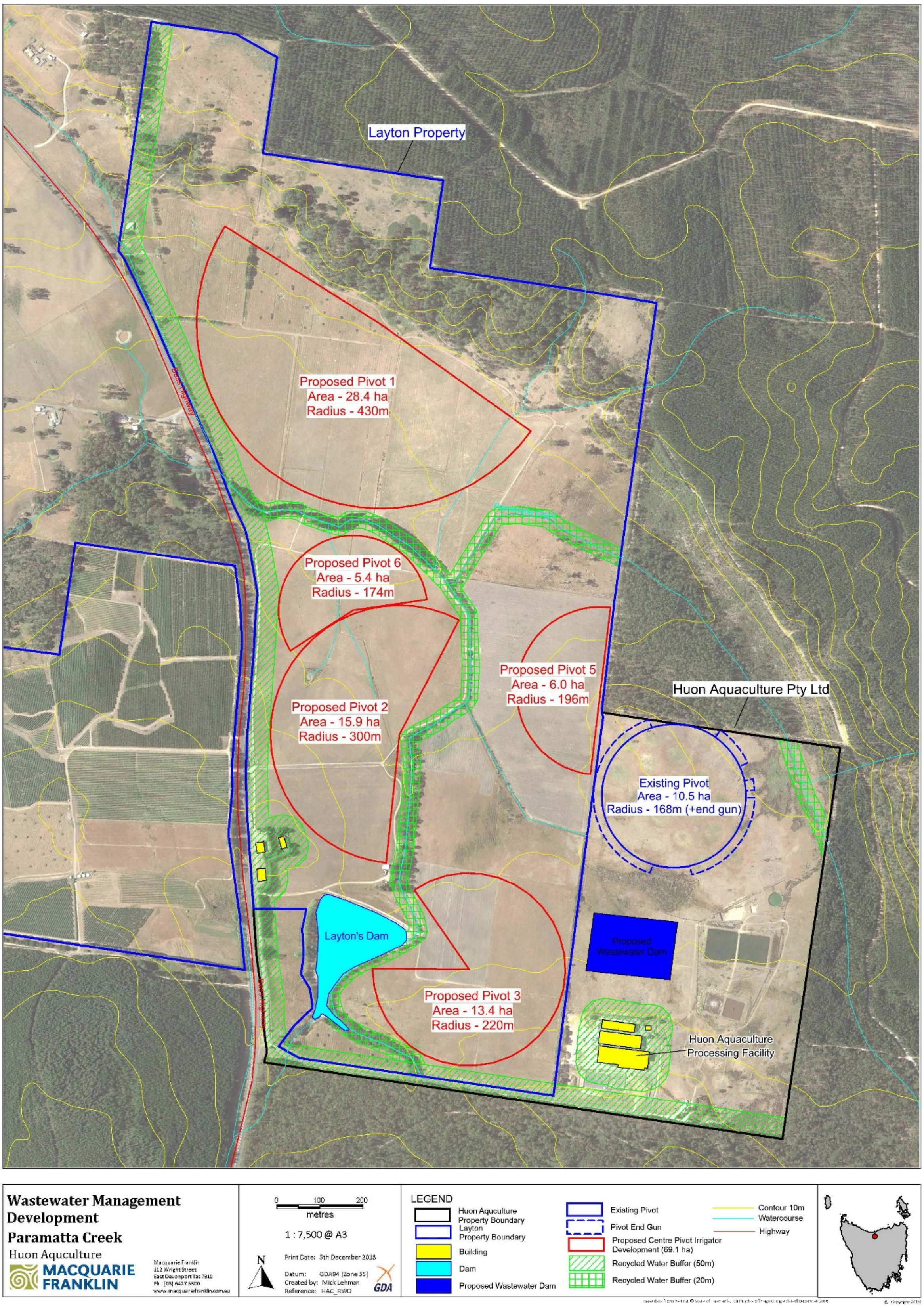

Figure 18 Map of irrigation areas and buffer zones

10 Environmental monitoring program

10.1 Overview

Monitoring programs for surface water, groundwater and soils are detailed in this section. The programs are largely consistent with historical monitoring programs however they have been updated to reflect the current environmental situation and future wastewater irrigation management practices proposed on the Huon Aquaculture and Layton properties.

As part of the annual reporting process, where the results from each individual program will be considered and relationships between them analysed, recommendations regarding the program design (sampling frequency, locations, parameters tested etc.) will be made if amendments are deemed to be required. Huon Aquaculture will progress any recommendations for changes with the EPA through the annual reporting process.

10.2 Annual compliance check

A review or “compliance check” of irrigation activities and implementation of the requirements outlined in this WREMP will be conducted annually by an appropriately experienced advisor. The findings of the compliance check will be incorporated into Huon Aquaculture’s annual reporting process.

10.3 Irrigation record keeping

Monthly records of wastewater irrigation will be maintained to enable results from the environmental monitoring program to be linked to irrigation practices. This will include monthly recording of:

- wastewater dam electrical conductivity;
- electrical conductivity of shandied wastewater applied as irrigation;
- volume of wastewater utilised for irrigation (from pump activity or dam level); and
- areas where wastewater irrigation occurred.

10.4 Trigger thresholds and response processes

In most cases trends in groundwater, surface water or soil quality (relative to baseline data) are at least as important as exceedances of guideline limits. An increasing (or decreasing) negative or undesirable trend from baseline data can provide an early-warning of potential issues, before any upper limits or trigger values are reached. This provides an opportunity for preventative actions to be implemented well before any negative environmental impacts are experienced.

A negative trend over a two-year period, where the change in parameters is greater than 20% of the baseline value and the trend is consistent in one direction, should trigger an investigation, as per Figure 16. The Parramatta Creek catchment is highly modified, with impacts from a range of land uses including agriculture, horticulture, forestry, mining and stream modification. Historic water quality data from Parramatta Creek and baseline groundwater data from Layton’s farm is variable and shows seasonal variation. Water use in the Parramatta Creek catchment is predominantly stock drinking water, accessed directly from the waterway by livestock. There is no evidence for domestic water offtakes from Parramatta Creek. Parramatta Creek does not supply a drinking water catchment.

The reference used to establish acceptable ranges for soil analytes (nutrient and physicochemical properties) is "Soil Analysis – an interpretation manual" (1999). This is the principal reference manual for soil scientists in Australia.

10.4.1 Strategy for addressing concerning results

In environmental monitoring programs there are often fluctuations in various analytes and it is not unusual to see isolated peaks in single parameters. Additionally, guideline 'limits' (e.g. ANZECC, 2000) are not always useful, as a parameter may have been in exceedance even during baseline monitoring, in which case the trend is far more important than the actual value. For these reasons, it is proposed that further investigation will only proceed when one of the following conditions are met:

1. Two consecutive chemical exceedances of recommended guideline for one or more analytes (where it hasn't exceeded previously); or
2. Increase in analyte by more than 20% in a two-year (or eight sample) period from the baseline.

Coliform levels are known to be highly variable in water samples as they are strongly influenced by a range of factors which are not related to the wastewater practices being undertaken (e.g. intensive livestock or wildlife grazing coinciding with a runoff event). Therefore, both the above points must apply when interpreting coliform test results for surface and groundwater.

The recommended process is summarised in Figure 17.

10.4.1.1 Investigation guideline values for surface water

The recommended investigation guideline values to be used when reviewing surface water quality results are based on historical baseline data collected from Parramatta creek near the confluence with the Mersey River and data collected from Layton's farm. A comparison with the trigger values for lowland rivers in south-east Australia from the Australian and New Zealand Environment and Conservation Council Guidelines for Fresh and Marine Water Quality (ANZECC 2000) has been used to ensure guideline values maintain species protection. Baseline data used to develop the investigation guideline values are from DPIPWE collected water samples from 2006, from Parramatta Creek upstream of the confluence with the Mersey River. Data collected by Macquarie Franklin from Felminghams Creek and Parramatta Creek during 2018/19 has also been used to develop investigation guideline values. The investigation guideline values are to be applied to surface water monitoring site SS3 as it is the most downstream monitoring site.

The historic salinity data for Parramatta Creek shows seasonal variation with electrical conductivity increasing through summer and autumn. Wastewater irrigation will occur through late spring, summer and autumn when there is a moisture deficit in the soil. This results in all irrigation water applied being evaporated or evapotranspirated, with runoff and leaching events of wastewater unlikely when the irrigation is managed well. Impacts from wastewater irrigation will be more likely through winter and spring when seasonal rainfall will leach or possibly cause runoff of salts. Dilution with high rainfall through winter and spring will reduce any potential impacts on receptors from salt leaching and runoff. The investigation guideline value for electrical conductivity chosen (550 µS/cm) is based on the baseline data collected in 2006, with an additional 10% increase included to account for seasonal variation. This value is well within the ANZECC lowland rivers salinity range (125-2200 µS/cm), particularly given the historical disturbance and geology of the catchment.

Nitrogen and its forms of ammonia, nitrite and nitrates will be applied through the wastewater reuse irrigation and potentially enter surface water if irrigation is not managed correctly. However, it is also possible for these nutrients to enter surface waters due to intense stock grazing and stock accessing creeks for water. The investigation guideline values for nitrates and total nitrogen are based on baseline data collected from Parramatta Creek in 2006. The ammonia (1.8mg/L @ pH7.1) investigation guideline value is based on data collected from SS3 during April 2019, this value aligns closely with the ANZECC (2000) 95% species protection value (2.1mg/L @ pH 7.1). Table 8.3.7 from ANZECC (2000) is to be used to adjust the ammonia level to the correct pH. As ammonia is an environmental toxicant. exceedance of the threshold value (>1.8mg/L) at any (one) sampling event will trigger further investigation, if it is likely to be due to wastewater quality. This will be determined by comparison of surface water test results with wastewater test result from the same date.

pH varies within the catchment, with a low pH (5.8) recorded in Felminghams Creek upstream of Laytons property and increasing to 7.54 downstream near the confluence with the Mersey River. This range (5.8-7.54) will be used to trigger investigations and is similar to the recommended ANZECC trigger values (6.5-8).

The total phosphorus investigation guideline value has been based on data collected from SS3 in April 2019, while this is double the ANZECC (2000) lowland river value, the property has a long history of horticulture and improved pastures. It is common practice for these land uses to apply phosphorus as a fertiliser, resulting in elevated phosphorus within the catchment. Phosphorus levels in the wastewater are low and therefore phosphorus in the surface water is more likely to be from historical and current agricultural practices than wastewater reuse.

Table 42 Surface water investigation guideline values for Parramatta Creek (SS3) on Layton's property

Parameter	Investigation guideline value	ANZECC (2000) Lowland river
Ammonia mg-N/L	1.8 @ pH 7.1	2.1mg/L @ pH 7.1*
Conductivity µS/cm (laboratory)	550	125-2200
Nitrate mg-N/L	0.7	0.04
Nitrogen, Total mg-N/L	1.7	0.5
pH (laboratory)	5.8-7.6	6.5-8
Phosphorus, Total mg-P/L	0.1	0.05

*95% ecosystem species protection

10.4.1.2 Investigation guideline values for groundwater

The recommended investigation guideline values to be used when reviewing groundwater quality results are based baseline data collected from six monitoring bores installed on Layton's property in 2018. Due to the spatial differences observed in the groundwater quality, investigation guideline values have been developed for each monitoring bore (MW8, MW10, MW11, MW12 and MW13) within the reuse area on Layton's property. Investigation guideline values have not been included for Huon's Parramatta Creek property, historical data will be used to monitor the trends when reviewing data from these bores (MW1, MW2, MW4, MW5, MW6, MW7 and MW9).

Data collected from three baseline monitoring events over 2018/19 has been used to develop the investigation guideline values for each bore within the reuse areas of Layton's property. The key investigation guideline value analytes include electrical conductivity, pH, ammonia, nitrates, total nitrogen and total phosphorus. These analytes have been chosen as they present the highest likelihood of being affected by wastewater irrigation. Other analytes will be assessed and appropriately investigated if trend changes are identified. An additional 10% has been added to each investigation guideline value to allow for seasonal variation and concentration during low recharge periods.

The investigation guideline values for Layton's property are to be reviewed and updated if more data is collected prior to wastewater reuse occurring on the property.

Table 43 Groundwater investigation guideline values for Layton's property

Parameter	MW8	MW10	MW11	MW12	MW13
Ammonia mg-N/L	0.11	0.11	0.11	0.33	0.11
Conductivity µS/cm (laboratory)	440	520	890	1100	340
Nitrate mg-N/L	0.14	0.25	0.59	0.04	0.07
Nitrogen, Total Kjeldhal mg-N/L	0.55	0.7	0.55	0.33	0.3
pH (laboratory)	3.9-5.9	5.7-6.2	6.2-6.8	6.2-6.9	6.2-6.8
Phosphorus, Total mg-P/L	0.21	0.21	0.37	0.23	0.30

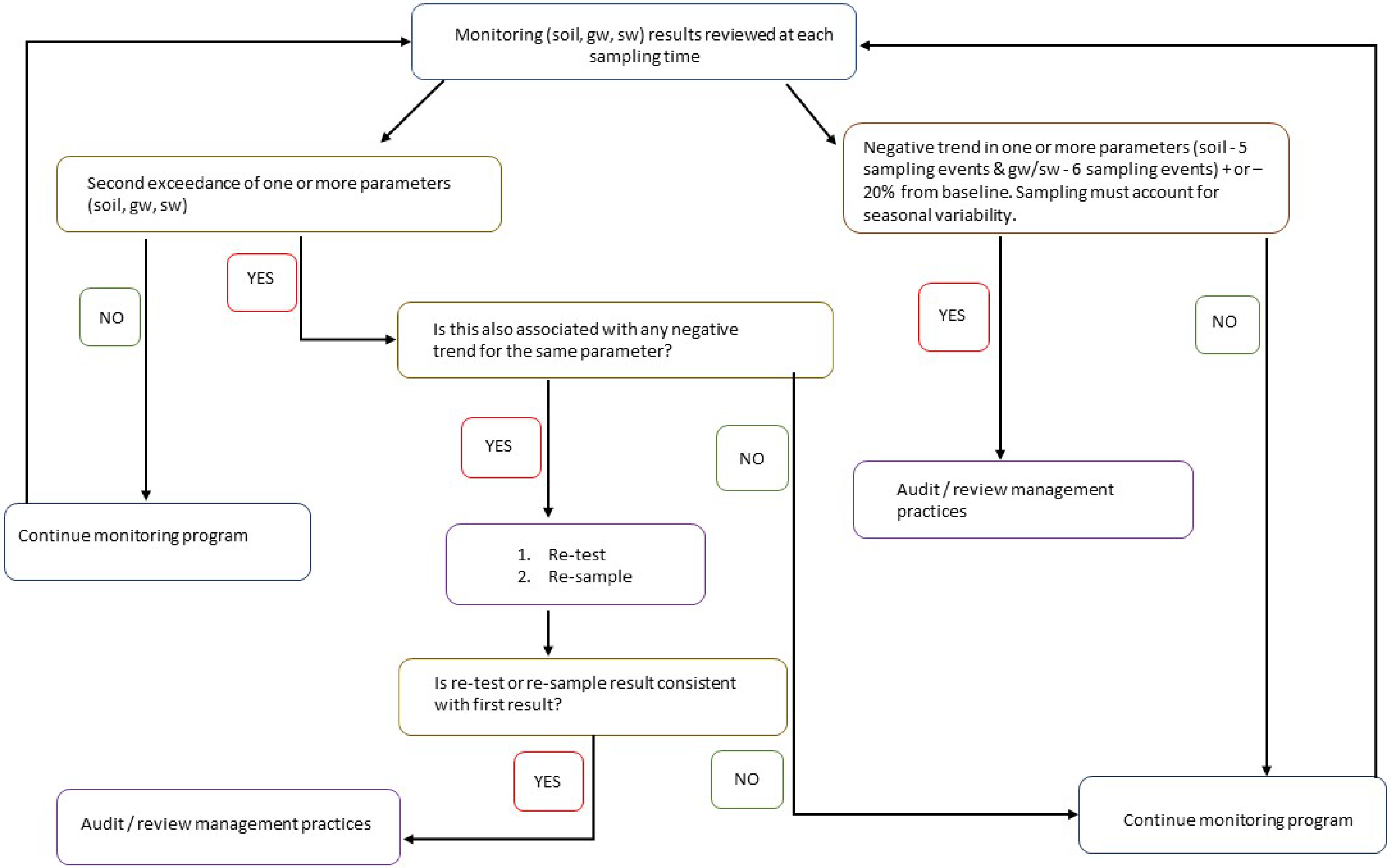

Figure 19 Process for situations where concerning analytical results are found

10.4.2 Process for assessing unusual or concerning results

There are two key result areas which may require further investigation:

1. A sample (soil, surface or ground water) analyte which exceeds the recommended guidelines (where it hasn't done before), two sampling events in a row.[1]
2. A site which is showing an upward trend (>20%) in one or more analytes compared to baseline:
    a. For soils the trend must be over a minimum of five sampling times, and samples must account for seasonal variability.
    b. For ground and surface water the trend must be over a minimum of five sampling times, and samples must account for seasonal variability.

The following is a hierarchy of steps and guidelines to follow when data from groundwater, surface water or soil triggers one of the two criteria above. The questions within each of the steps may vary depending on the actual circumstances.

Number	Step	Key questions to answer
1	If issues are being observed at one site, are they also being observed at other sites or for multiple parameters?	• Are there any concerning results at any of the other sites?
	Action 1	***If there are concerning results at other sites proceed to step 3*** ***If other sites are normal proceed to step 2***
2	Determine whether any error in sampling, testing or site contamination could have contributed to the result/s	• Has there been a change in personnel doing the sampling? • Has the same sampling method been used for sampling? • Was the sampling equipment decontaminated between samples? And by what method? • Has fertiliser application rate or timing changed in relation to time of sampling? • Has there been a change in the laboratory being used to test samples? • What were the rainfall patterns in the lead up to the sampling?

[1] Ammonia exceedance of the threshold value (>1.8mg/L) at any (one) sampling event will trigger further investigation if it is likely to be due to wastewater quality. This will be determined by comparison of surface water test results with wastewater test result from the same date.

Number	Step	Key questions to answer
		• Context – has a similar result been obtained previously at this site? If so, what were the relevant factors involved? If no, what has changed at the site? • What were the water levels in the bore and the flow rate at sampling? Were these different to those at previous samplings? • Were there any signs that the bore had been damaged or compromised (e.g. stock damage to bore, stock camp around bore, loose casing around bore etc.)?
	Action 2	***If error is likely – re-sample*** ***If error is unlikely go to step 3***
3	Could the result be influenced by wastewater application practices?	• How many parameters/analytes are affected? • What is the proximity of the sites to areas where wastewater water is being used? Or a wastewater dam? Could the dam be leaking? (organise dam sample and undertake piper plot to compare chemistry). • If dam leakage a likely source is additional assessment needed (e.g. specialist engineering assessment, infra-red or electromagnetic leakage detection). • What are the volumes of wastewater being used in the period before sampling and the amount of associated nutrients being applied? • Are there other nutrient inputs nearby that could lead to the observed results (fertilisers, chicken manure, etc)? ***Groundwater and surface water*** • What is the ground water flow system associated with the site and how might this influence the result?
	Action 3	***Determine if exceedance is likely to be associated with wastewater irrigation*** ***If no, refer information to EPA (e.g. within annual groundwater reports), with clear explanation for why wastewater is not implicated*** ***If yes, go to step 4***

Number	Step	Key questions to answer
4	Conduct a detailed site audit to determine the cause of the result and what this means for management of the site and wastewater irrigation	The outcome of this step is to determine whether a change in management or application of wastewater is required to mitigate any adverse environmental or human health impacts. Site considerations may include: • Cropping history, rotations and irrigation patterns at the property and the sampling site. • Fertiliser history at the property and the sampling site. • Potential for livestock impacts at the sampling site. • Any changes in land management that may have impacted groundwater, surface water or soils. • Where possible, general assessment of neighbouring/nearby land use activities. Once site audit complete, make a recommendation on: • Whether additional monitoring (more frequent and/or use of additional sampling sites) is necessary. • Any changes to management practices that are required
	Action 4	***Land manager advised of result and cause and updated management protocols to follow.*** ***Provide findings of site assessment to EPA and proposed contingency or mitigation measures.***

10.5 Surface water monitoring

10.5.1 Background

There are two main watercourses which flow through the Huon Aquaculture and Layton properties, Felminghams Creek and Parramatta Creek. Felminghams Creek's catchment contains a sand mine, forestry, remnant vegetation and the Bass Highway, with the headwaters of its catchment approximately three kilometres south of the proposed irrigation area. Parramatta Creek's catchment contains remnant vegetation and forestry, with its headwaters approximately one-kilometre south-east of the properties. The confluence of the two creeks is in the middle of Layton's property. Given the existing land uses within the catchments, they would be classified as slightly to moderately disturbed according to the ANZECC (2000) guidelines.

10.5.2 Methodology

10.5.2.1 Sampling locations

The proposed irrigation locations shown in Figure 18 are adjacent to Felminghams Creek and Parramatta Creek. Due to the proximity to the watercourses to irrigation activities (note buffer zones will be implemented, as outlined in section 9.3), surface water monitoring is required to detect potential environmental harm. Surface water monitoring is to be conducted at six locations (Table 44 and Figure 20) on a quarterly basis. The frequency of monitoring and the sample analysis suite will be reviewed one year after irrigation infrastructure is operational and a minimum of four sampling events have been undertaken. At each sampling time, a sample of the wastewater from the storage pond will also be collected. This will enable the cause of any exceedances to be linked to wastewater or other site environmental factors.

Table 44 Surface water monitoring locations (Datum: MGA (GDA94) zone 55)

Site name	Easting	Northing	Site description and reasoning
SS1	462,110	5,423,777	Existing monitoring site.
SS2	461,501	5,423,627	Existing monitoring site. Historically dry. Site location has been moved further downstream to ensure site has water to sample.
SS3	460,884	5,424,344	Downstream Parramatta Creek, upstream of the Bass Highway. This site will detect if salts or nutrients are leaving the wastewater reuse area.
SS4	461,341	5,424,123	Felminghams Creek upstream of the confluence with Parramatta Creek. This location will help delineate which catchment surface water contamination is being generated in.
SS5	461,214	5,423,731	Felminghams Creek between CP2 and CP3. This location will help establish which irrigation area is generating surface water contamination.
SS6	460,922	5,423,063	Reference site on Felminghams Creek to establish if any contamination is being generated by the sand mine, forestry or road infrastructure and maintenance. Located upstream of Layton's dam to ensure any impacts on the dam from the property are not captured.

10.5.2.2 Sample handling and testing requirements

Field testing will be conducted in conjunction with collecting samples for laboratory analysis.

Field testing is to include:

- pH
- electrical conductivity (EC)
- dissolved oxygen (DO)
- temperature

Laboratory testing will include the analytes listed in Table 45.

Table 45 Surface water quality analytes and trigger values

Analyte	Units	Guideline Investigation values
pH		5.8-7.6 and/or 20% change over 6 sampling events
Electrical Conductivity (EC)	µS/cm	550 and/or 20% trending increase over 6 sampling events
Total Dissolved Solids (TDS)	mg/L	20% trending increase over 6 sampling events
Chloride (Cl)	mg/L	20% trending increase over 6 sampling events
Aluminium (Al)	mg/L	20% trending increase over 6 sampling events
Boron (B)	mg/L	20% trending increase over 6 sampling events
Calcium (Ca)	mg/L	20% trending increase over 6 sampling events
Copper (Cu)	mg/L	20% trending increase over 6 sampling events
Iron (Fe)	mg/L	20% trending increase over 6 sampling events
Magnesium (Mg)	mg/L	20% trending increase over 6 sampling events
Manganese (Mn)	mg/L	20% trending increase over 6 sampling events
Phosphorus (P)	mg/L	20% trending increase over 6 sampling events
Potassium (K)	mg/L	20% trending increase over 6 sampling events
Sodium (Na)	mg/L	20% trending increase over 6 sampling events
Sulphur (S)	mg/L	20% trending increase over 6 sampling events
Zinc (Zn)	mg/L	20% trending increase over 6 sampling events
Ammonium (NH_4)	mg/L	1.8 at any sampling event
Nitrate (NO_3)	mg/L	0.7 and/or 20% trending increase over 6 sampling events
Total Kjeldahl Nitrogen (TKN)	mg/L	20% trending increase over 6 sampling events
Total Nitrogen (Total N)	mg/L	1.7 and/or 20% trending increase over 6 sampling events
Total Phosphorus (Total P)	mg/L	0.1 and/or 20% trending increase over 6 sampling events
Biochemical Oxygen Demand (BOD)	mg/L	20% trending increase over 6 sampling events
Thermotolerant coliforms	cfu/100 ml	20% trending increase over 6 sampling events

Samples are to be kept on ice until delivery to the laboratory (overnight) to ensure that the holding time of 24 hours for microbiological analysis (Thermotolerant coliforms) is not exceeded.

A series of quality assurance and quality control (QA/QC) measures will be undertaken to ensure the quality of samples taken. A field blank and rinsate blank sample will be collected to monitor contamination during sampling and to ensure no cross contamination of samples from the sampling equipment. A duplicate sample is to be collected to check the accuracy of the laboratory analysis.

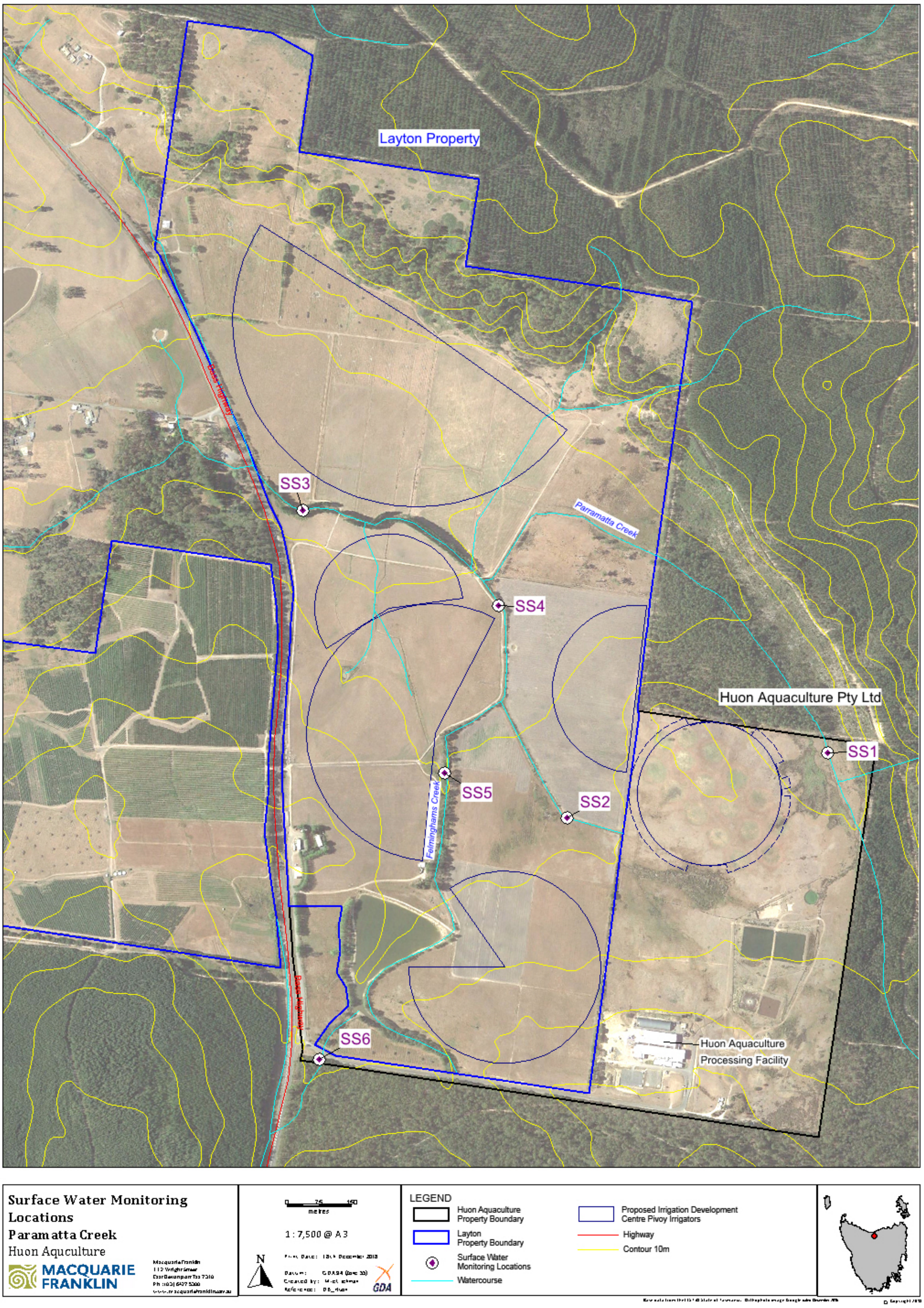

Figure 20 Surface water monitoring locations

10.6 Groundwater monitoring

10.6.1 Methodology

10.6.1.1 Sampling locations

There are currently six existing groundwater monitoring bores on the Huon Aquaculture property (Table 47). The location of the boreholes MW4 and MW5 were selected to monitor low points and boreholes MW1 and MW6 selected to monitor midpoints of the irrigation area. MW2 and MW7 monitor seepage from the wastewater ponds (Pitt and Sherry 2016).

An additional six monitoring bores have been installed on Layton's property to monitor groundwater chemistry (November 2018) (Figure 21, Table 46 and Table 47). The location of these bores was reviewed by a groundwater geologist (Appendix L).

Four of the monitoring bores (MW8, MW10, MW 11 and MW12) are within the proposed wastewater irrigation areas. These monitoring sites will monitor direct infiltration of irrigation water to the water-table beneath the centre pivots.

An additional monitoring bore (MW13) has been installed downslope of the new and existing wastewater irrigation areas. This monitoring bore will help to assess if there is any downgradient movement of contaminants from the irrigated areas.

Bore MW9 is directly down the groundwater-flow gradient from the existing wastewater ponds.

New monitoring bore (MW14) is close to the processing facility as a reference bore. The location is upslope of the proposed and existing irrigation areas.

Table 46 2018 new monitoring bore details

Bore	Depth (m bgl)	SWL (m bgl)	Screen Interval (m bgl)
MW08	4.4	2.5	1.4-4-4
MW09	3.8	0.72	1.5-3.9
MW10	6.7	1.91	1.7-6.7
MW11	4.2	0.59	1.22-4.22
MW12	6.0	1	2-6
MW13	5.35	1.4	2.35-5.35
MW14	6	3	2-6

Table 47 Groundwater monitoring locations (datum: MGA (GDA94) zone 55)

Site name	Easting	Northing	Site description and reasoning
MW1	461,769	5,423,307	Existing monitoring site.
MW2	462,116	5,423,361	Existing monitoring site.
MW4	461,669	5,423,564	Existing monitoring site.
MW5	462,106	5,423,646	Existing monitoring site.
MW6	461,882	5,423,641	Existing monitoring site.
MW7	461,965	5,423,157	Existing monitoring site.
MW8	461,488	5,423,221	Monitor potential direct infiltration of irrigation water from CP3 to the groundwater.
MW9	461,923	5,423,405	Downslope of existing wastewater ponds
MW10	461,277	5,424,070	Monitor potential direct infiltration of irrigation water from CP2 to the groundwater.
MW11	461,116	5,424,217	Downslope of CP2. This location will help to monitor if there is any lateral off-site migration of irrigation water constituents in the groundwater.
MW12	460,936	5,424,636	Monitor potential direct infiltration of irrigation water from CP1 to the groundwater.
MW13	460,899	5,424,367	Downslope of CP1. This location will help to monitor if there is any lateral offsite migration of irrigation water constituents in the groundwater. It will also help to identify if these constituents are leaving the site to the north-west along Parramatta Creek.
MW14	461,554	5,423,991	High point of Layton's/Huon Aquaculture's property to provide seasonal reference data for background groundwater quality.

10.6.1.2 Sampling procedure

Groundwater monitoring is to be undertaken quarterly. Samples are to be collected following relevant standards and guidelines outlined in:

- Geoscience Australia Record 2009/27: Groundwater Sampling and Analysis – A Field Guide.
- Environment Protection Authority Victoria 2000 - Groundwater Sampling Guidelines.

Samples are to be collected using low flow sampling methods as per industry standards. Low flow methods require field parameters to be stable prior to sample collection. This ensures consistent groundwater chemistry (Table 48). The frequency of monitoring and the sample analysis suite will be reviewed one year after irrigation infrastructure is operational and a minimum of four sampling events have been undertaken.

Table 48 Field chemistry parameters and acceptable variance

Field parameter	Acceptable variance over three consecutive reading of ≥10% of casing volume below standing water level
Groundwater level	Stable
Dissolved oxygen	+/- 10%
Turbidity	+/- 10%
Electrical conductivity	+/- 3%
Temperature	+/- 0.1°C
pH	+/- 0.05
Redox potential	+/- 10 mv

10.6.1.3 Sample handling and testing requirements

Field testing will be conducted in conjunction with collecting samples for laboratory analysis.

Field testing is to include:

- pH
- electrical conductivity (EC)
- redox (ORP)
- temperature
- Dissolved Oxygen (DO)
- standing water level (SWL)

With the exception of samples collected for microbiological analysis, all groundwater samples are to be field-filtered (0.4µm filter) during collection and before submission to the NATA-registered testing laboratory. Laboratory reports will therefore list dissolved constituents only (except for thermotolerant coliforms).

Laboratory testing is to include the analytes listed in Table 49

Table 49 Groundwater quality analytes and trigger values

Analyte	Units	Investigation trigger values
pH		Refer to Table 43 and/or 20% change over 6 sampling events
Electrical Conductivity (EC)	us/cm	Refer to Table 43 and/or 20% trending increase over 6 sampling events
Total Dissolved Solids (TDS)	mg/L	20% trending increase over 6 sampling events
Total Alkalinity	mg/L	20% trending increase over 6 sampling events
Ammonium (NH_4) (dissolved)	mg/L	Refer to Table 43 and/or trending increase over 6 sampling events
Carbonate (CO3)	mg/L	20% trending increase over 6 sampling events
Bicarbonate (HCO_3)	mg/L	20% trending increase over 6 sampling events
Aluminium (Al)	mg/L	20% trending increase over 6 sampling events
Boron (B)	mg/L	20% trending increase over 6 sampling events
Calcium (Ca)	mg/L	20% trending increase over 6 sampling events
Copper (Cu)	mg/L	20% trending increase over 6 sampling events
Iron (Fe)	mg/L	20% trending increase over 6 sampling events
Magnesium (Mg)	mg/L	20% trending increase over 6 sampling events
Manganese (Mn)	mg/L	20% trending increase over 6 sampling events
Phosphorus (P)	mg/L	20% trending increase over 6 sampling events
Potassium (K)	mg/L	20% trending increase over 6 sampling events
Sodium (Na)	mg/L	20% trending increase over 6 sampling events
Sodium Absorption Ration (SAR)		20% trending increase over 6 sampling events
Nitrate (NO_3) (dissolved)	mg/L	Refer to Table 43 and/or 20% trending increase over 6 sampling events
Total Kjeldahl Nitrogen (TKN)	mg/L	Refer to Table 43 and/or 20% trending increase over 6 sampling events
Total Nitrogen (Total N) (dissolved)	mg/L	20% trending increase over 6 sampling events
Total Phosphorus (Total P) (dissolved)	mg/L	Refer to Table 43 and/or 20% trending increase over 6 sampling events
Thermotolerant coliforms	cfu/100 ml	20% trending increase over 6 sampling events

Samples are to be kept refrigerated after collection. Overnight delivery to the laboratory will ensure that holding times are not exceeded. A series of quality assurance and quality control (QA/QC) measures are to be undertaken to ensure the quality of samples taken. A field blank and rinsate blank sample are to be collected to monitor contamination during sampling and to ensure no cross contamination of samples from the sampling equipment. A field-filtered duplicate sample is to be collected to check the accuracy of the laboratory analysis.

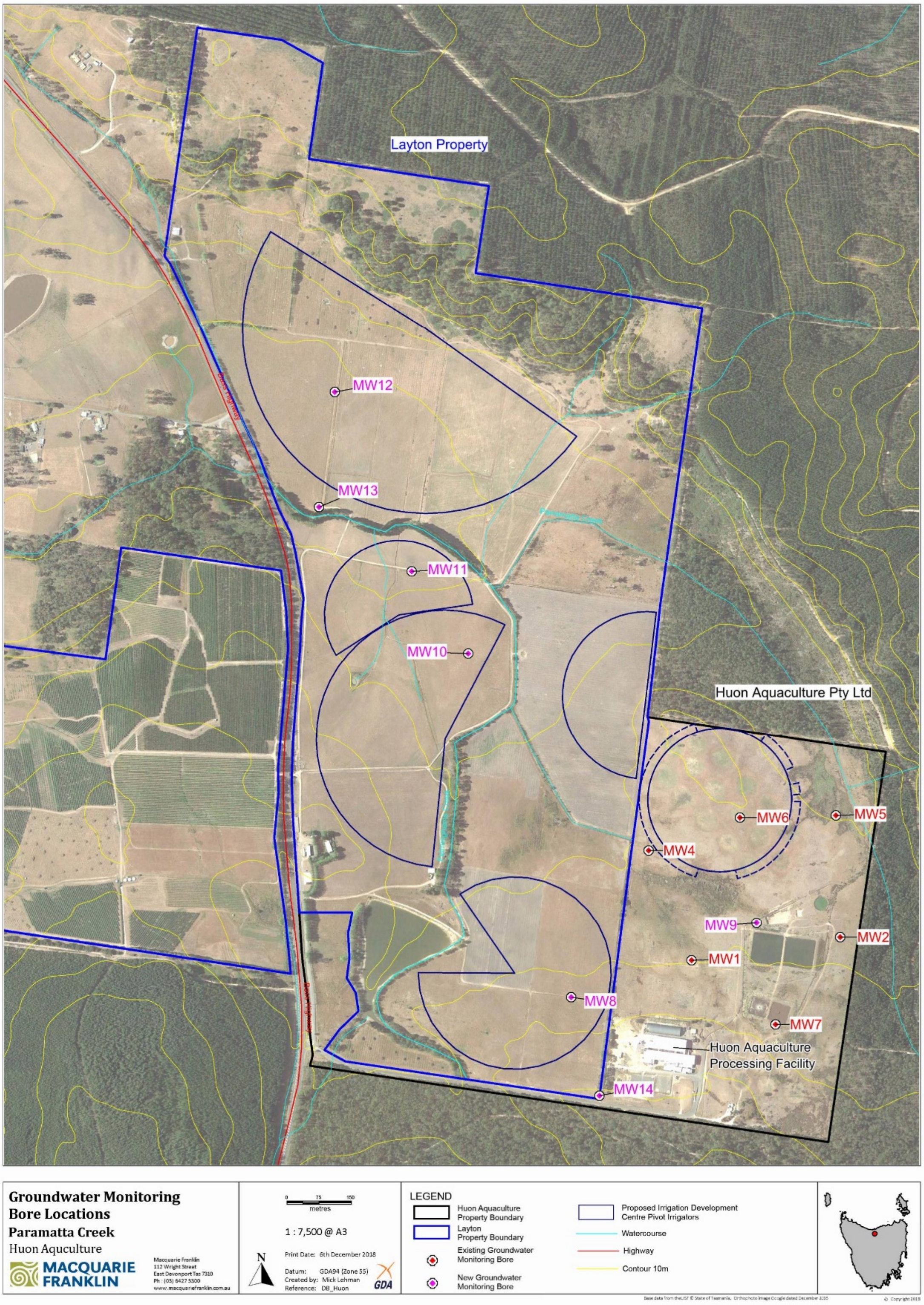

Figure 21: Groundwater monitoring locations

10.7 Soil monitoring

10.7.1 Methodology

10.7.1.1 Sampling locations

There are five existing soil sampling locations within the wastewater irrigation area on Huon Aquaculture's property. An additional eight soil sampling transects are proposed to monitor the different soil types under the five new proposed centre pivots (Figure 22, Table 50).

Transects are utilised in this soil sampling program to collect a representative sample of soil from within a specific soil type under specific management conditions. As the pivot irrigators are designed to apply wastewater irrigation evenly across the irrigated area, the location of transects under the pivot will not be prejudiced (in terms of more or less irrigation water applied) by where they run under a pivot. [2] It is important that transects reflect the predominant soil types.

[2] The sprinkler packages for each centre pivot irrigator will consist of Nelson R3000 rotators. Nelson rotators are regarded within the irrigation industry as the premium centre pivot sprinkler. Application uniformity is typically between 90 and 95% Coefficient of Uniformity (CU), which is exceptionally high. As a result, irrigation application is very uniform across the entire area. It should be noted that CU values of above 85% under pivot irrigators is generally accepted as the standard.

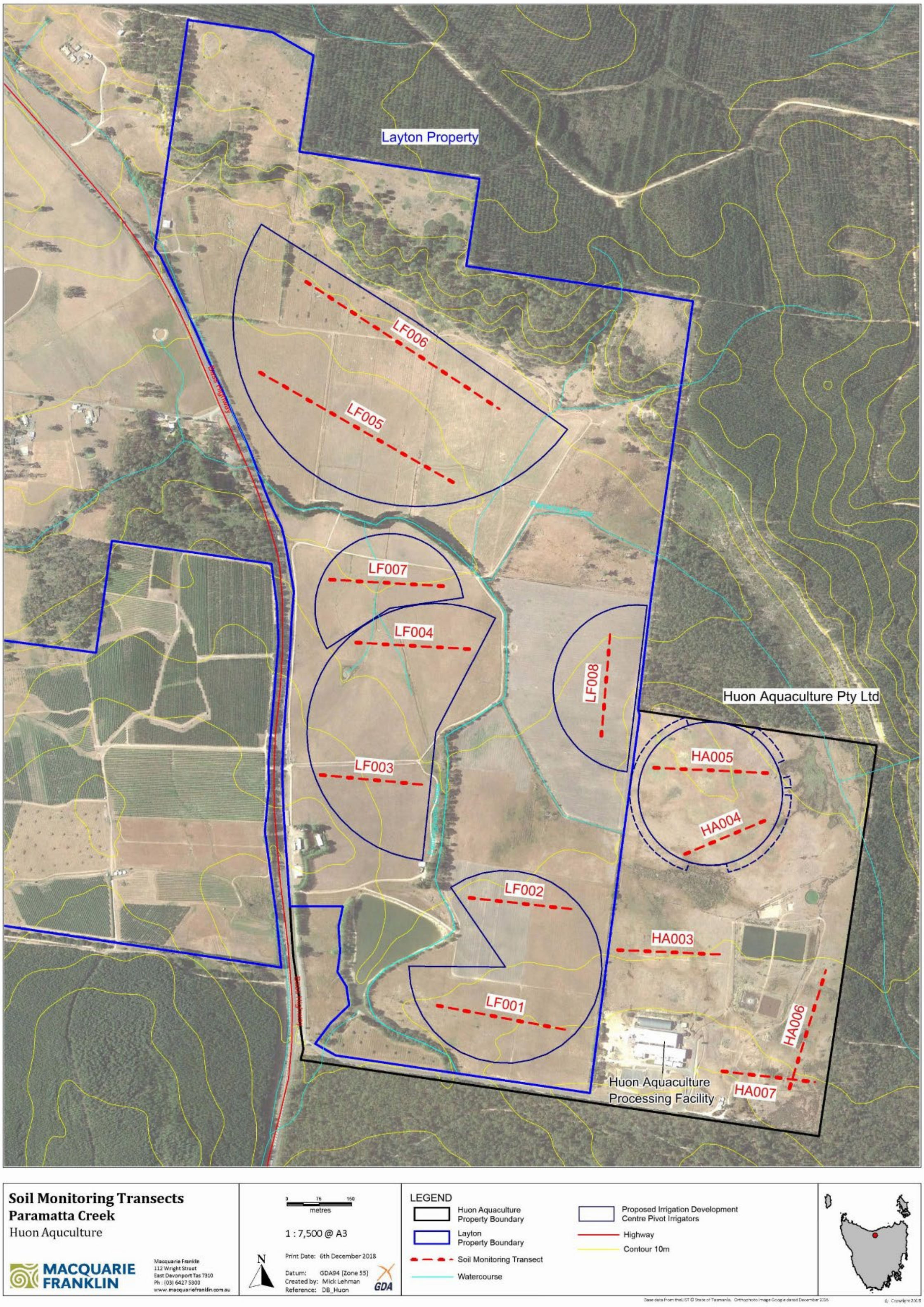

Figure 22 Soil monitoring locations

Table 50 Soil monitoring transects (Datum: MGA GDA94 zone 55)

	Start		Finish		
Site name	Easting	Northing	Easting	Northing	Site description and reasoning
HA002	461,618	5,423,316	461,871	5,423,305	Existing monitoring site.
HA004	461,775	5,423,541	461,968	5,423,621	Existing monitoring site.
HA005	461,703	5,423,742	461,970	5,423,730	Existing monitoring site.
HA006	462,019	5,422,994	462,104	5,423,269	Existing monitoring site.
HA007	461,862	5,423,034	462,079	5,423,009	Existing monitoring site.
LF001	461,199	5,423,187	461,502	5,423,129	Southern end of CP3. Transect to monitor duplex soils being irrigated with wastewater.
LF002	461,273	5,423,439	461,521	5,423,411	Northern end of CP3. Transect to monitor alluvial loams and china soils being irrigated with wastewater.
LF003	460,925	5,423,725	461,169	5,423,702	Southern end of CP2. Transect to monitor duplex soils being irrigated with wastewater.
LF004	461,008	5,424,035	461,275	5,424,020	Northern end of CP2. Transect to monitor alluvial loam soils being irrigated with wastewater.
LF005	460,783	5,424,665	461,243	5,424,404	Southern end of CP1. Transect to monitor duplex soils being irrigated with wastewater.
LF006	460,891	5,424,877	461,343	5,424,580	Northern end of CP1. Transect to monitor alluvial loams being irrigated with wastewater.
LF007	460,947	5,424,182	461,214E	5,424,167	Central area of CP6. Transect to monitor alluvial loams being irrigated with wastewater.
LF008	461,601	5,424,060	461,580	5,423,817	Central area of CP5. Transect to monitor Roebuck soils being irrigated with wastewater.

Representative soil profiles will be monitored annually (each August) to provide ongoing comparison to the baseline soil profile information obtained in October 2018. The information obtained at the soil profile assessments would include soil structure score, presence of worms, vegetation cover, presence and depth of plant roots and any other relevant observations.

Table 51 Soil profile monitoring (datum: MGA GDA94 zone 55)

Pivot site	Baseline soil profile site identifier (October 2018)	Location	
		Northing	Easting
1	M	461030.7	5424450.4
1	N	461101.8	5244676.6
2	G	461079.6	5423699.3
2	I	461213.2	5424033.9
3	C	461325.3	5423154.4
3	F	461351.2	5423411.8
4	A	461920.8	5423634.5
5	P	461577.3	5423992.5
6	K	461145.6	5424166.8

10.7.1.2 Sampling procedure

For each transect, cores of the topsoil (0-15 cm) and subsoil (nominally 30-45 cm, but to be confirmed at first sampling event to reflect subsoil depth) of the soil profile are to be taken from 10 random points along the transect. The cores are to be bulked together in clean buckets and separated into 500g sub-samples of topsoil and subsoil for each transect and are to be sent to a NATA accredited laboratory for analysis. Soil sampling is to be conducted twice a year in February and August.

10.7.1.3 Sample handling and testing requirements

Soil testing parameters are outlined in Table 52. The list of parameters tested will be reviewed after three years of data collection under the new irrigation regime, and potentially rationalised should some parameters be determined as not relevant to the program.

Table 52 Soil monitoring analytes

Parameter	Units
pH	
Electrical conductivity (EC)	µS/cm
Exchangeable calcium (Ca)	meq/100g
Exchangeable magnesium (Mg)	meq/100g
Exchangeable potassium (K)	meq/100g
Exchangeable sodium (Na)	meq/100g
Cation exchange capacity (CEC)	meq/100g
Sulfur (total as S)	%
Chloride (Cl)	mg/kg
Exchangeable Aluminium (Al)	meq/100g
Iron (Fe)	mg/kg
Boron (B)	mg/kg
Calcium (Ca)	mg/kg
Manganese (Mn)	mg/kg
Zinc (Zn)	mg/kg
Nitrate as N	mg/kg
Total kjeldahl nitrogen as N	mg/kg
Exchangeable Sodium Percentage	%
Phosphate sorption capacity	mg P orb/kg
Phosphorus (Colwell)	mg/kg
Total organic carbon	%

Soil samples will be collected and kept in cool conditions until submitted to a NATA accredited laboratory for testing.

10.7.1.4 Reporting

The annual soil monitoring report will include a nutrient balance, where soil test results, plant nutrient requirements, nutrient loadings in applied wastewater and livestock removal of nutrients from the system will be considered. A fertiliser management program will be developed by an appropriately experienced soils advisor, with recommendations considering soil amendments (e.g. liming rates etc.) and the appropriateness of fertiliser products in regard to managing any nutrient issues observed in the soil, surface water or groundwater monitoring programs.

As with both surface water and groundwater monitoring, the results from soil monitoring will not be assessed in isolation but linked with the other monitoring activities. This will provide for rigorous interpretation of all monitoring results with an ability to make appropriate recommendations which will address any issues.

10.8 Environmental monitoring program schedule

The proposed timing of sampling events is relatively consistent with historical programs conducted at the site. Environmental monitoring activities are summarised in Table 53.

Table 53 Summary of environmental monitoring and reporting activities

Environmental monitoring program activities	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Surface water sampling (biannual)				x						x		
Groundwater sampling (quarterly)	x			x			x			x		
Soil sampling (bi-annually)		x						x				
Soil profile assessment (annually)								x				
Annual compliance check [#]							x					
Annual reporting on environmental monitoring program to EPA									x			

[#] *Annual compliance check for compliance with Wastewater Reuse EMP.*

11 Commercial arrangements

Huon Aquaculture has an in-principle agreement with Mr Troy Layton to supply treated wastewater to his property for irrigation and to assist with the development of the required irrigation infrastructure, and in return, Mr Layton will manage the supply to optimise reuse and in accordance with the approved WREMP.

The agreement between Huon Aquaculture and Mr Layton will be formalised and incorporated into the Wastewater Reuse EMP once the conditions of the Wastewater Reuse EMP have been finalised with the EPA. Approval conditions will be incorporated into the agreement.

The agreement will include:

- the approved WREMP;
- the responsibilities of both parties in the supply and management of wastewater for irrigation;
- commercial arrangements regarding financial contributions to infrastructure development and ongoing operational costs (including pumping costs, freshwater use for shandying, etc.);
- ownership of infrastructure and maintenance responsibilities;
- the term of the agreement and options for renewal;
- liabilities and insurance;
- restrictions on the use of wastewater and the use and sale of the irrigated product (if any);
- property access for monitoring and compliance activities;
- minimum supply quality of wastewater; and
- reporting processes (standard and emergency situations).

12 Implementation timeline

Table 54 Timeline for implementing key actions

Action	Timeline for implementation	Notes
Rehabilitation of existing HAC irrigation sites		
Erect game proof fencing	Completed	
Apply gypsum	Completed	
Renovate pastures (year 1)	Spring 2019	
Implement rotational grazing system and continue irrigation using 1100uS/cm water	Late spring 2019	
Renovate pastures year 3 and apply gypsum	Spring 2021	
Continue rotational grazing system and irrigation as described	Ongoing	
Construction		
DPEMP and Wastewater Reuse EMP documents approved by EPA	Early 2020	Documents to be submitted in 2018, however EPA approval is not anticipated until early 2019.
Agreement between Huon Aquaculture and Mr Layton signed.	Within 2 weeks of EPA approving WREMP	Content of Wastewater Reuse EMP to first be finalised with EPA before agreement signed.
Irrigation infrastructure construction • TasNetworks application for power upgrades to new pump site • Tendering process • Irrigation system installed and operational • Irrigation operations manual developed	Complete Complete Pending EPA approval Pending EPA approval	
Wastewater storage dam construction • Dam design confirmed • Approvals process • Tendering process • Construction process • Link new wastewater storage dam to Layton's irrigation system	When DPEMP is approved Early 2020 Mid 2020 Late 2020 Late 2020	A conceptual dam design for a 75ML wastewater storage dam has been completed. Engineering for the detailed design to facilitate approval under the Water Management Act 1999 is underway.
Process changes		
Trial of refrigerated truck commences	February 2019	

Refrigerated truck trial data analysed and results reported back to EPA, with outline of plan for further trucks if trial successful	Following a 12-month trial period from trucks on-line	Trial is indicating trucks are effective for safe fish transportation, but issues arising with approvals for backfilling loads of feed and significant cost/GHG emissions implications to work through.
Monitoring activities		
Irrigation records to be completed monthly	Once irrigation commences on Laytons land	
Updated surface water, groundwater and soil monitoring program to be implemented as per WREMP.	Late 2018 onwards	Layton property included from the start to enable baseline data to be collected.
Annual compliance check conducted on irrigation activities.	Once the irrigation system is commissioned and operational	The first compliance check will be conducted as the new irrigation system comes on-line. A second compliance check will be required once the new wastewater dam is linked into the Layton's irrigation system. Annual checks thereafter during the irrigation season.
Annual reporting to EPA on environmental monitoring program.	September 2019 onwards	

13 List of commitments

Table 55 List of commitments in Wastewater Reuse EMP

Commitment number	Action	Due date
Approvals		
1	Agreement between Huon Aquaculture and Mr Layton signed, contingent upon DPEMP and WREMP approval by EPA	Complete
Rehabilitation of existing HAC irrigation sites		
2	Undertake activities to rehabilitate sodic soils under HAC pivot: • Fencing • Application of gypsum • Pasture renovation • Improved grazing management	December 2019
Construction of wastewater storage and irrigation infrastructure (pending EPA approval of DPEMP)		
3	Wastewater storage dam construction • Dam design confirmed • Approvals process • Tendering process • Construction process	When DPEMP is approved Early 2020 Mid 2020 Late 2020
4	Irrigation infrastructure construction • Tendering process • Construction process • Irrigation of wastewater commences on Layton's property	Mid 2019 Early 2020 (when DPEMP approved) Spring 2020
5	Full scale wastewater irrigation commences with irrigation scheme and new wastewater dam connected (pending DPEMP and WREMP approval by EPA by February 2020)	Late 2020
Process changes		
6	Completion of trial of suitability of refrigerated truck	12-months after trucks on-line
Wastewater quality		
7	Wastewater quality will continue to be monitored monthly, with a focus on ensuring median quality complies with Class B recycled water requirements (apart from pH, which should be maintained below 9.0 pH units).	Late 2018 onwards
8	Wastewater median electrical conductivity will be maintained at or below 3,000 μS/cm, with goal to continue to decrease electrical conductivity over time.	Late 2018 onwards
9	Wastewater will be shandied to ensure the electrical conductivity of wastewater irrigated on to land is 1,100μS/cm or less.	Once new irrigation infrastructure is operational

Commitment number	Action	Due date
10	As part of the monthly water quality testing program conducted by Huon Aquaculture, treatment plant ponds and the new wastewater storage will be monitored for algal blooms. If an algal bloom is evident, a water sample will be sent to a NATA accredited laboratory for testing to determine if the bloom is toxic.	Late 2018 onwards
Wastewater reuse irrigation activities (pending EPA approval of DPEMP)		
11	A minimum of 73ML of wastewater storage and 80ha of land will be available for irrigation of wastewater flows in a 90th percentile rainfall year (pending EPA approval of WREMP).	Late 2020 onwards
12	Irrigation infrastructure will be designed and constructed in a way that enables automated shandying of wastewater and freshwater to achieve target electrical conductivity of 1,100µS/cm or less.	Late 2020 onwards
13	All persons involved in irrigation activities will be trained in the appropriate use of the infrastructure prior to irrigation commencing by an appropriately experienced irrigation advisor.	Mid-late 2020
14	Irrigation Operations Manual developed to make clear the steps involved in delivering wastewater to the centre pivots at the permitted water quality.	Mid 2020
15	Appropriate irrigation monitoring equipment will be determined in consultation with Mr Layton (the main irrigation operator), Huon Aquaculture and an appropriately experienced external advisor.	Mid 2020
16	Training in the use of irrigation scheduling equipment and ongoing support from an appropriately experienced irrigation advisor will be available to the irrigation manager.	Mid 2020
17	Wastewater will be applied and managed in accordance with requirements outlined in the WREMP (section 9).	Mid 2020 onwards
18	The pasture and livestock manager will be coached (as required) by an experienced pasture and grazing advisor to ensure they develop the required skills and have access to professional support to implement best practice.	Late 2019 onwards
Environmental monitoring		
19	A review or "compliance check" of irrigation activities and implementation of the requirements outlined in this WREMP will be conducted annually by an appropriately experienced advisor. The findings of the compliance check will be incorporated into the annual reporting process.	Late 2019 onwards
20	Monthly records of wastewater irrigation will be maintained to enable results from the environmental monitoring program to be linked to irrigation practices	Late 2019 onwards
21	The updated monitoring programs for surface water, groundwater and soil will be implemented.	Late 2018 onwards
22	Following the first full soil sampling event, a fertiliser management program will be developed by an appropriately experienced soils	September 2019

Commitment number	Action	Due date
	advisor and reviewed annually as part of the annual soil monitoring program.	
23	Results and recommendations from the environmental monitoring program will be reported annually to the EPA in September.	September 2019 onwards

14 Glossary of terms

EC	electrical conductivity
Production	defined as product exiting the facility for sale
Sodicity (ESP%)	the percent of sodium cations in total cations
Wastewater	refers to wastewater produced as a by-product from the Huon Aquaculture Parramatta Creek fish processing facility
WREMP	Wastewater Reuse Environmental Management Plan for Huon Aquaculture Parramatta Creek fish processing facility 2018

15 References

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16 Appendices

Appendix A: Soil sampling details from Pitt and Sherry, 2009

Table 56 Summary of soil test results from Pitt and Sherry 2009 soil sampling of the Huon Aquaculture property

Analyte	Unit	LOR	HA002		HA004		HA005		HA006		HA007	
Depth (cm)			0–10	10–38	0–131	13–38	0–14	14–43	0–14	14–43	0–14	14–43
pH		0.1	4.7	4	5	4.7	4.7	4.6	4.2	3.8	5	4.2
Electrical conductivity	µS/cm	1	742	265	429	333	451	269	21	11	590	418
Exchangeable calcium	meq/100g	0.1	1.8	0.7	4.4	4.1	3.8	3.8	4.3	1.4	26	3.4
Exchangeable magnesium	meq/100g	0.1	0.8	0.9	1.6	3.2	1.1	1.8	3	2.9	2.7	4.5
Exchangeable potassium	meq/100g	0.1	0.3	0.3	0.6	0.6	0.7	0.5	0.6	0.6	0.7	0.6
Exchangeable sodium	meq/100g	0.1	1.4	1.6	3.4	2	3.8	2.5	0.3	0.3	2.5	0.7
Cation exchange capacity	meq/100g	0.1	1.4	3.5	10	9.8	9.5	8.7	8.3	5.2	11.2	9.2
Sulfur (total as S)	%	0.01	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02
Chloride	mg/kg	10	1480	450	840	630	930	530	20	<10	1240	880
Soluble calcium	mg/kg	10	<10	<10	<10	<10	<10	30	<10	<10	<10	20
Soluble magnesium	mg/kg	10	<10	<10	<10	<10	<10	80	<10	<10	<10	20
Soluble sodium	mg/kg	10	1120	320	590	440	640	36	20	<10	850	490
Soluble potassium	mg/kg	10	30	20	10	10	10	100	<10	<10	30	10
Arsenic	mg/kg	5	<5	<5	13	16	11	12	12	10	11	11
Boron	mg/kg	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Cadmium	mg/kg	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Copper	mg/kg	5	<5	<5	<5	7	5	<5	<5	6	5	7
Lead	mg/kg	5	<5	<5	9	8	9	10	12	10	11	9
Molybdenum	mg/kg	2	<2	<2	2	2	<2	<2	<2	<2	2	<2
Nickel	mg/kg	2	<2	<2	3	2	3	2	<2	<2	2	<2
Tin	mg/kg	5	<5	<5	<5	<5	<5	< 5	<5	<5	<5	<5
Zinc	mg/kg	5	6	<5	13	15	14	13	14	15	15	14
Mercury	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.02	<0.12	<0.1	15	<0.1
Nitrite + nitrite as N	mg/kg	0.1	25.9	13	23.8	9.2	25.3	17.7	14.9	10.4	32.12	16.1
Total Kjeldahl nitrogen as N	mg/kg	20	1700	280	2200	880	920	630	1570	640	2050	1200
Total nitrogen as N	mg/kg	20	1720	290	2200	890	940	650	1580	650	2080	1220
Phosphate sorption capacity	mg P sorb/kg	250	1180	1100	1580	1760	1790	1420	2090	2110	1920	2440
Bicarbonate Ext P (Colwell)	mg/kg	2	18	72	44	< 5	85	12	8	6	9	<5
Organic matter	%	0.5	5.5	1.3	4.7	1.3	7.5	1.2	4.4	1.7	6.3	1.6

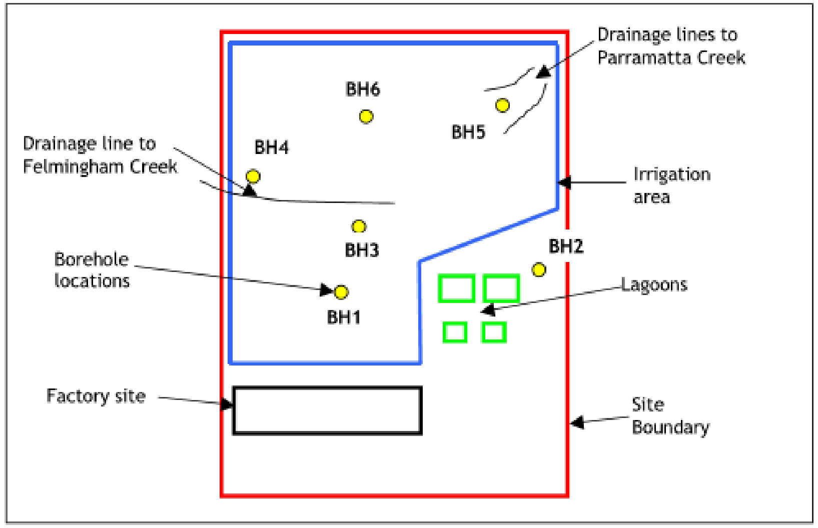
Analyte	Unit	LOR	HA002		HA004		HA005		HA006		HA007	
Total organic carbon	%	0.5	2.34	0.92	3.73	0.6	3.44	0.7	2.02	0.78	3.45	0.81

From section 3.3.4 of DPEMP (Pitt&Sherry, 2009)

A soil survey to assess the suitability of the site for irrigation and to provide baseline data in relation to the chemical and physical soil characteristics was performed. Six boreholes were constructed for groundwater sampling and soil profiling was conducted adjacent to these.

Soil sample locations and labelling: The numbering system from the groundwater bores was utilised for soil samples collected. Codes used to label samples were based on the following system:

	Irrigation area soil sample (IASS)	Sample number (next to bore number)	Topsoil (upper) or subsoil (lower)
Example: IASS1U	IASS	1	U


Drainage lines to Parramatta Creek
BH6
BH5
BH4
Drainage line to Felmingham Creek
Irrigation area
BH3
BH2
Borehole locations
Lagoons
BH1
Factory site
Site Boundary

Work Order : EM0906510
Client : PITT & SHERRY
Project : HB09244 IRRIGATION AREA SOIL MONITORING

Analytical Results

Sub-Matrix: SOIL

Compound	CAS Number	LOR	Unit	IASS1U	IASS2U	IASS3U	IASS4U	IASS5U
			Client sampling date / time	14-JUL-2009 15:00	14-JUL-2009 15:00	14-JUL-2009 15:00	14-JUL-2009 15:00	14-JUL-2009 15:00
				EM0906510-001	EM0906510-002	EM0906510-003	EM0906510-004	EM0906510-005
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.7	5.8	5.9	5.8	5.8
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	11	14	12	10	14
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	24.4	35.6	24.1	26.2	28.9
ED007: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	2.4	4.9	3.4	2.3	2.7
^ Exchangeable Magnesium	----	0.1	meq/100g	1.2	3.1	1.5	1.9	1.6
^ Exchangeable Potassium	----	0.1	meq/100g	0.6	1.7	1.2	1.6	1.2
^ Exchangeable Sodium	----	0.1	meq/100g	0.2	0.4	0.4	0.3	0.5
^ Cation Exchange Capacity	----	0.1	meq/100g	4.4	10.2	6.5	6.2	6.0
^ Exchangeable Aluminium	----	0.1	meq/100g	<0.1	0.1	<0.1	<0.1	<0.1
^ Exchangeable Sodium Percent	----	0.1	%	5.3	4.3	7.0	5.2	9.1
^ Calcium/Magnesium Ratio	----	0.1	-	2.0	1.6	2.2	1.2	1.7
ED045: Chloride								
Chloride	16887-00-6	10	mg/kg	<50	<50	120	60	50
ED093T: Total Major Cations								
Sodium	7440-23-5	10	mg/kg	100	150	150	120	170
Potassium	7440-09-7	10	mg/kg	380	610	450	660	390
Calcium	7440-70-2	10	mg/kg	790	1290	890	820	810
Magnesium	7439-95-4	10	mg/kg	240	480	280	410	300
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	4000	6660	4330	5760	4460
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Copper	7440-50-8	5	mg/kg	<5	<5	<5	<5	<5
Lead	7439-92-1	5	mg/kg	10	15	7	8	9
Molybdenum	7439-98-7	2	mg/kg	<2	<2	<2	<2	<2
Nickel	7440-02-0	2	mg/kg	<2	3	<2	<2	<2
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	<5
Zinc	7440-66-6	5	mg/kg	<5	12	<5	6	10
EK059G: NOX as N by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.100	mg/kg	0.973	0.198	0.180	<0.100	0.112
EK061G: Total Kjeldahl Nitrogen as N								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	1900	2590	1570	1760	2370
EK062: Total Nitrogen as N								
^ Total Nitrogen as N	----	20	mg/kg	1900	2590	1570	1760	2370

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Work Order : EM0906510
Client : PITT & SHERRY
Project : HB09244 IRRIGATION AREA SOIL MONITORING

Analytical Results

Sub-Matrix: SOIL			Client sample ID	IASS1U	IASS2U	IASS3U	IASS4U	IASS5U
			Client sampling date / time	14-JUL-2009 15:00	14-JUL-2009 15:00	14-JUL-2009 15:00	14-JUL-2009 15:00	14-JUL-2009 15:00
Compound	CAS Number	LOR	Unit	EM0906510-001	EM0906510-002	EM0906510-003	EM0906510-004	EM0906510-005
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	161	235	141	202	180
EK072: Phosphate Sorption Capacity								
Phosphate Sorption Capacity	----	250	mg P sorbe	----	2260	1110	1660	1440
Phosphate Sorption Capacity	----	250	mg P sorbed/kg	1550	----	----	----	----
EP004: Organic Matter								
Organic Matter	----	0.5	%	3.8	5.5	4.4	3.4	4.7
^ Total Organic Carbon	----	0.5	%	2.2	3.2	2.6	1.9	2.7

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Work Order : EM0906510
Client : PITT & SHERRY
Project : HB09244 IRRIGATION AREA SOIL MONITORING

Analytical Results

Sub-Matrix: SOIL

Compound	CAS Number	LOR	Unit	IASS6U	IASS1L	IASS2L	IASS3L	IASS4L
Client sampling date / time				14-JUL-2009 15:00	14-JUL-2009 15:00	14-JUL-2009 15:00	14-JUL-2009 15:00	14-JUL-2009 15:00
				EM0906510-006	EM0906510-007	EM0906510-008	EM0906510-009	EM0906510-010
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.9	5.8	5.8	5.7	5.7
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	15	10	14	11	8
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	23.5	22.3	36.9	23.6	25.8
ED007: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	7.1	1.8	2.7	1.6	1.8
^ Exchangeable Magnesium	----	0.1	meq/100g	2.6	1.3	3.0	1.6	2.6
^ Exchangeable Potassium	----	0.1	meq/100g	2.1	1.1	1.8	1.2	2.0
^ Exchangeable Sodium	----	0.1	meq/100g	0.2	0.2	0.4	0.4	0.4
^ Cation Exchange Capacity	----	0.1	meq/100g	12.2	4.4	7.9	4.8	6.8
^ Exchangeable Aluminium	----	0.1	meq/100g	<0.1	<0.1	0.2	<0.1	<0.1
^ Exchangeable Sodium Percent	----	0.1	%	2.1	5.9	5.5	8.1	5.9
^ Calcium/Magnesium Ratio	----	0.1	.	2.7	1.3	0.9	1.0	0.7
ED045: Chloride								
Chloride	16887-00-6	10	mg/kg	30	<20	<20	<20	<50
ED093T: Total Major Cations								
Sodium	7440-23-5	10	mg/kg	140	90	160	110	130
Potassium	7440-09-7	10	mg/kg	950	390	660	380	690
Calcium	7440-70-2	10	mg/kg	2720	500	840	420	510
Magnesium	7439-95-4	10	mg/kg	590	220	490	240	400
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	6900	3820	7590	4090	6300
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Copper	7440-50-8	5	mg/kg	<5	<5	<5	<5	<5
Lead	7439-92-1	5	mg/kg	9	6	17	7	10
Molybdenum	7439-98-7	2	mg/kg	<2	<2	<2	<2	<2
Nickel	7440-02-0	2	mg/kg	3	<2	2	<2	<2
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	<5
Zinc	7440-66-6	5	mg/kg	13	<5	14	<5	16
EK059G: NOX as N by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.100	mg/kg	2.20	0.106	0.212	0.230	0.331
EK061G: Total Kjeldahl Nitrogen as N								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	3630	1180	2100	820	1100
EK062: Total Nitrogen as N								
^ Total Nitrogen as N	----	20	mg/kg	3630	1180	2100	820	1100

A Campbell Brothers Limited Company

ALS

Analytical Results

Sub-Matrix: SOIL			Client sample ID	IASS6U	IASS1L	IASS2L	IASS3L	IASS4L
			Client sampling date / time	14-JUL-2009 15:00	14-JUL-2009 15:00	14-JUL-2009 15:00	14-JUL-2009 15:00	14-JUL-2009 15:00
Compound	CAS Number	LOR	Unit	EM0906510-006	EM0906510-007	EM0906510-008	EM0906510-009	EM0906510-010
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	615	149	159	91	119
EK072: Phosphate Sorption Capacity								
Phosphate Sorption Capacity	----	250	mg P sorbe	1820	1760	2380	1480	1710
EP004: Organic Matter								
Organic Matter	----	0.5	%	7.5	2.8	4.4	2.2	1.9
^ Total Organic Carbon	----	0.5	%	4.4	1.6	2.5	1.3	1.1

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Client : PITT & SHERRY
Project : HB09244 IRRIGATION AREA SOIL MONITORING

ALS

Analytical Results

Sub-Matrix: SOIL

Compound	CAS Number	LOR	Unit	IASS5L	IASS6L	----	----	----
Client sample ID				IASS5L	IASS6L	----	----	----
Client sampling date / time				14-JUL-2009 15:00	14-JUL-2009 15:00	----	----	----
				EM0906510-011	EM0906510-012	----	----	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.8	5.8	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	16	8	----	----	----
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	25.6	20.5	----	----	----
ED007: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	1.8	6.0	----	----	----
^ Exchangeable Magnesium	----	0.1	meq/100g	1.9	2.7	----	----	----
^ Exchangeable Potassium	----	0.1	meq/100g	1.7	1.7	----	----	----
^ Exchangeable Sodium	----	0.1	meq/100g	0.7	0.2	----	----	----
^ Cation Exchange Capacity	----	0.1	meq/100g	6.1	10.5	----	----	----
^ Exchangeable Aluminium	----	0.1	meq/100g	<0.1	<0.1	----	----	----
^ Exchangeable Sodium Percent	----	0.1	%	11.2	2.0	----	----	----
^ Calcium/Magnesium Ratio	----	0.1	-	1.0	2.2	----	----	----
ED045: Chloride								
Chloride	16887-00-6	10	mg/kg	<20	<20	----	----	----
ED093T: Total Major Cations								
Sodium	7440-23-5	10	mg/kg	180	130	----	----	----
Potassium	7440-09-7	10	mg/kg	400	810	----	----	----
Calcium	7440-70-2	10	mg/kg	550	1770	----	----	----
Magnesium	7439-95-4	10	mg/kg	260	540	----	----	----
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	4560	6660	----	----	----
Boron	7440-42-8	50	mg/kg	<50	<50	----	----	----
Cadmium	7440-43-9	1	mg/kg	<1	<1	----	----	----
Copper	7440-50-8	5	mg/kg	<5	<5	----	----	----
Lead	7439-92-1	5	mg/kg	9	10	----	----	----
Molybdenum	7439-98-7	2	mg/kg	<2	<2	----	----	----
Nickel	7440-02-0	2	mg/kg	<2	3	----	----	----
Selenium	7782-49-2	5	mg/kg	<5	<5	----	----	----
Zinc	7440-66-6	5	mg/kg	13	11	----	----	----
EK059G: NOX as N by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.100	mg/kg	0.286	<0.100	----	----	----
EK061G: Total Kjeldahl Nitrogen as N								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	1870	1630	----	----	----
EK062: Total Nitrogen as N								
^ Total Nitrogen as N	----	20	mg/kg	1870	1630	----	----	----

A Campbell Brothers Limited Company

Work Order : EM0906510
Client : PITT & SHERRY
Project : HB09244 IRRIGATION AREA SOIL MONITORING

ALS

Analytical Results

Sub-Matrix: SOIL

Compound	CAS Number	LOR	Unit	IASS5L	IASS6L	----	----	----
Client sampling date / time				14-JUL-2009 15:00	14-JUL-2009 15:00	----	----	----
				EM0906510-011	EM0906510-012	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	129	486	----	----	----
EK072: Phosphate Sorption Capacity								
Phosphate Sorption Capacity	----	250	mg P sorbe	1460	1390	----	----	----
EP004: Organic Matter								
Organic Matter	----	0.5	%	3.8	3.0	----	----	----
^ Total Organic Carbon	----	0.5	%	2.2	1.8	----	----	----

A Campbell Brothers Limited Company

Appendix B: GES soil analysis results for Layton's property (2017)

From section 5 of GES (2017) Site Suitability for Effluent Irrigation – Layton's Farm, Sassafras

Geo-Environmental Solutions Pty Ltd

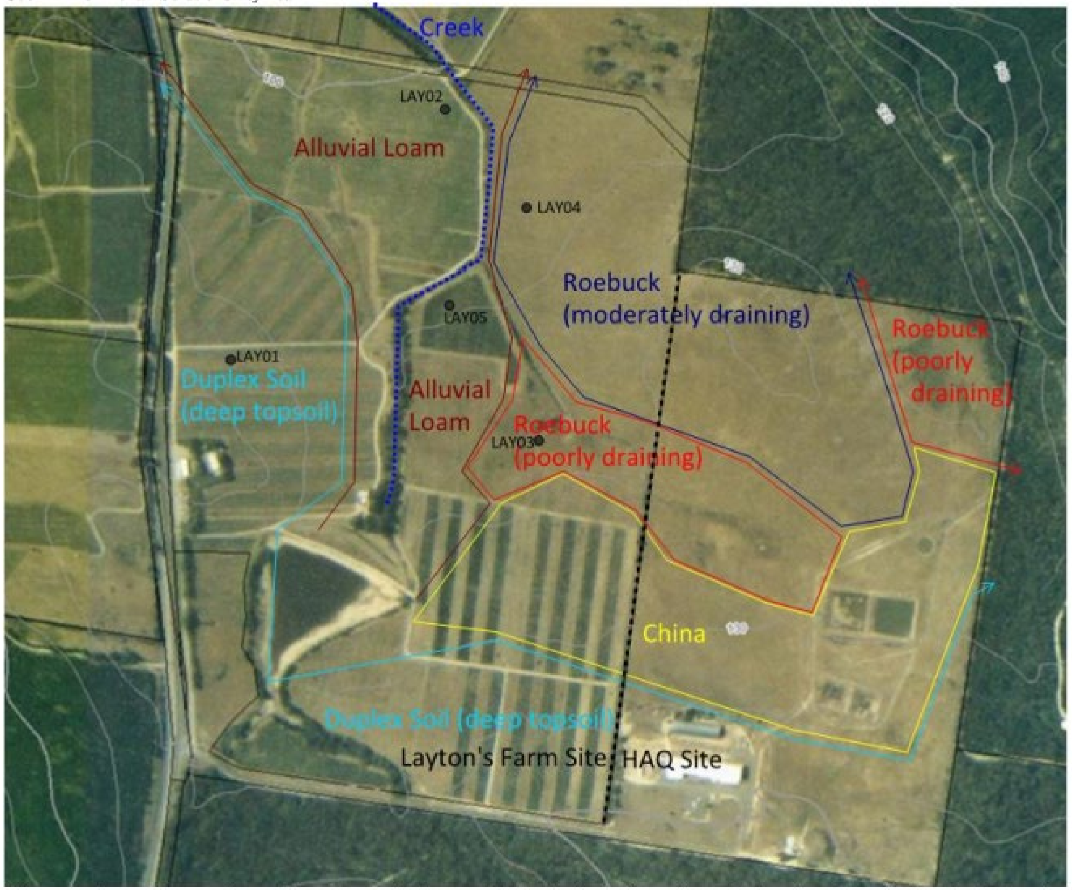

Figure 4 – Approximate soil mapping of Layton's Farm and HAC site including soil sample locations. Compiled by Mark Downie after February site investigation.

Site Suitability for Effluent Irrigation – Layton's Farm, Sassafras Page 8

Analytical Results

Sub-Matrix: SOIL
(Matrix: SOIL)

Compound	CAS Number	LOR	Unit	LAY 01 Topsoil	LAY 01 Subsoil	LAY 02 Topsoil	LAY 02 Subsoil	LAY 03 Topsoil
			Client sampling date / time	23-Feb-2017 00:00	23-Feb-2017 00:00	23-Feb-2017 00:00	23-Feb-2017 00:00	23-Feb-2017 00:00
				EM1702085-001	EM1702085-002	EM1702085-003	EM1702085-004	EM 1702085-005
				Result	Result	Result	Result	Result
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	5.1	4.0	5.8	3.9	4.6
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	63	38	75	18	72
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	3.7	14.1	13.2	12.3	24.3
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	8.2	0.7	8.6	1.5	6.4
Exchangeable Magnesium	----	0.1	meq/100g	1.6	0.6	3.4	1.7	1.4
Exchangeable Potassium	----	0.1	meq/100g	0.8	0.2	0.5	0.3	0.3
Exchangeable Sodium	----	0.1	meq/100g	0.2	0.2	0.3	0.3	0.6
Cation Exchange Capacity	----	0.1	meq/100g	10.9	3.5	12.9	3.9	8.9
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	10	50	20	20	50
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.02	0.02	0.03	0.02	0.05
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	20	10	30	20	70
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	<10	<10	40	<10	20
Magnesium	7439-95-4	10	mg/kg	<10	<10	20	20	10
Sodium	7440-23-5	10	mg/kg	<10	<10	20	10	60
Potassium	7440-09-7	10	mg/kg	80	10	30	20	20
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	730	11800	3430	4310	2690
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Iron	7439-89-6	50	mg/kg	540	11100	3390	6310	4940
Molybdenum	7439-98-7	2	mg/kg	5	<2	<2	<2	<2
Tin	7440-31-5	5	mg/kg	<5	<5	<5	<5	<5
Arsenic	7440-38-2	5	mg/kg	<5	<5	<5	<5	<5
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	<2	12	4	5	3
Copper	7440-50-8	5	mg/kg	21	<5	24	<5	7
Lead	7439-92-1	5	mg/kg	<5	<5	7	6	5
Nickel	7440-02-0	2	mg/kg	<2	<2	<2	<2	<2

Page : 4 of 8
Work Order : EM1702085
Client : GEO-ENVIRONMENTAL SOLUTIONS
Project : HAQ - Parramatta Creek

Analytical Results

Sub-Matrix: SOIL
(Matrix: SOIL)

Compound	CAS Number	LOR	Unit	LAY 01 Topsoil	LAY 01 Subsoil	LAY 02 Topsoil	LAY 02 Subsoil	LAY 03 Topsoil
			Client sampling date / time	23-Feb-2017 00:00	23-Feb-2017 00:00	23-Feb-2017 00:00	23-Feb-2017 00:00	23-Feb-2017 00:00
				EM1702085-001	EM1702085-002	EM1702085-003	EM1702085-004	EM1702085-005
				Result	Result	Result	Result	Result
EG005T: Total Metals by ICP-AES - Continued								
Zinc	7440-66-6	5	mg/kg	21	<5	40	<5	22
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.8	0.8	5.0	1.5	0.3
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	2420	330	2820	620	2960
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	2420	330	2820	620	2960
EK072: Phosphate Sorption Capacity								
Phosphate Sorption Capacity	----	250	mg P sorbed/kg	601	3000	1320	1340	1740
Phosphate Sorption Index	----	1	mgkg-1/log10 ugL-1	<1	269	23	84	36
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	46	<5	90	<5	8
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	4.13	0.34	3.00	0.79	3.57
EP004: Organic Matter								
Organic Matter	----	0.5	%	7.9	0.8	9.0	1.6	9.0

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Work Order : EM1702085
Client : GEO-ENVIRONMENTAL SOLUTIONS
Project : HAQ - Parramatta Creek

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Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)

Compound	CAS Number	LOR	Unit	LAY 03 Subsoil	LAY 04 Topsoil	LAY 04 Subsoil	LAY 05 Topsoil	LAY 05 Subsoil
Client sampling date / time				23-Feb-2017 00:00	23-Feb-2017 00:00	23-Feb-2017 00:00	23-Feb-2017 00:00	23-Feb-2017 00:00
				EM1702085-006	EM1702085-007	EM1702085-008	EM1702085-009	EM1702085-010
				Result	Result	Result	Result	Result
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	4.0	5.5	3.9	5.5	4.1
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	18	112	32	106	22
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	21.1	12.3	12.4	11.8	11.4
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	1.8	9.9	2.3	9.4	1.5
Exchangeable Magnesium	----	0.1	meq/100g	0.8	2.0	1.2	1.9	0.9
Exchangeable Potassium	----	0.1	meq/100g	0.2	0.5	0.3	0.3	0.3
Exchangeable Sodium	----	0.1	meq/100g	0.4	0.7	0.5	0.6	0.4
Cation Exchange Capacity	----	0.1	meq/100g	3.2	13.1	4.5	12.2	3.3
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	20	10	10	80	20
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.04	0.03	0.02	0.04	0.02
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	40	90	40	70	160
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	20	40	<10	40	20
Magnesium	7439-95-4	10	mg/kg	30	10	20	10	100
Sodium	7440-23-5	10	mg/kg	20	70	30	60	30
Potassium	7440-09-7	10	mg/kg	40	30	30	10	90
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	2610	5100	6480	3460	3710
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Iron	7439-89-6	50	mg/kg	2320	7000	12500	7320	6200
Molybdenum	7439-98-7	2	mg/kg	<2	<2	<2	<2	<2
Tin	7440-31-5	5	mg/kg	<5	<5	<5	<5	<5
Arsenic	7440-38-2	5	mg/kg	<5	6	7	5	<5
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	3	7	9	5	5
Copper	7440-50-8	5	mg/kg	<5	19	<5	20	<5
Lead	7439-92-1	5	mg/kg	5	12	9	8	5
Nickel	7440-02-0	2	mg/kg	<2	<2	<2	<2	<2

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Work Order : EM1702085
Client : GEO-ENVIRONMENTAL SOLUTIONS
Project : HAQ - Parramatta Creek

ALS

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	LAY 03 Subsoil	LAY 04 Topsoil	LAY 04 Subsoil	LAY 05 Topsoil	LAY 05 Subsoil
			Client sampling date / time	23-Feb-2017 00:00	23-Feb-2017 00:00	23-Feb-2017 00:00	23-Feb-2017 00:00	23-Feb-2017 00:00
Compound	CAS Number	LOR	Unit	EM1702085-006	EM1702085-007	EM1702085-008	EM1702085-009	EM1702085-010
				Result	Result	Result	Result	Result
EG005T: Total Metals by ICP-AES - Continued								
Zinc	7440-66-6	5	mg/kg	9	32	8	27	<5
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	2.4	0.7	0.6	2.0	4.7
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	930	2060	590	1850	400
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	930	2060	590	1850	400
EK072: Phosphate Sorption Capacity								
Phosphate Sorption Capacity	----	250	mg P sorbed/kg	960	1360	1670	1420	1200
Phosphate Sorption Index	----	1	mgkg-1/log10 ugL-1	32	30	79	31	36
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	49	<5	76	<5
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	1.20	2.87	0.84	2.47	0.59
EP004: Organic Matter								
Organic Matter	----	0.5	%	3.7	7.2	2.1	4.8	1.2

Page : 7 of 8
Work Order : EM1702085
Client : GEO-ENVIRONMENTAL SOLUTIONS
Project : HAQ - Parramatta Creek

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)

Compound	CAS Number	LOR	Unit	Duplicate	----	----	----	----
Client sampling date / time				23-Feb-2017 00:00	----	----	----	----
				EM1702085-011	----	----	----	----
				Result	----	----	----	----
EA001: pH in soil using 0.01M CaCl extract								
pH (CaCl2)	----	0.1	pH Unit	5.5	----	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	122	----	----	----	----
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	13.8	----	----	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	8.5	----	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	1.8	----	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	0.3	----	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	0.6	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	11.2	----	----	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	110	----	----	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.04	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	80	----	----	----	----
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	40	----	----	----	----
Magnesium	7439-95-4	10	mg/kg	10	----	----	----	----
Sodium	7440-23-5	10	mg/kg	60	----	----	----	----
Potassium	7440-09-7	10	mg/kg	10	----	----	----	----
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	3690	----	----	----	----
Boron	7440-42-8	50	mg/kg	<50	----	----	----	----
Iron	7439-89-6	50	mg/kg	10200	----	----	----	----
Molybdenum	7439-98-7	2	mg/kg	<2	----	----	----	----
Tin	7440-31-5	5	mg/kg	<5	----	----	----	----
Arsenic	7440-38-2	5	mg/kg	6	----	----	----	----
Cadmium	7440-43-9	1	mg/kg	<1	----	----	----	----
Chromium	7440-47-3	2	mg/kg	5	----	----	----	----
Copper	7440-50-8	5	mg/kg	21	----	----	----	----
Lead	7439-92-1	5	mg/kg	8	----	----	----	----
Nickel	7440-02-0	2	mg/kg	<2	----	----	----	----

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Work Order : EM1702085
Client : GEO-ENVIRONMENTAL SOLUTIONS
Project : HAQ - Parramatta Creek

ALS

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Duplicate	----	----	----	----
			Client sampling date / time	23-Feb-2017 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EM1702085-011	--------	--------	--------	--------
				Result	----	----	----	----
EG005T: Total Metals by ICP-AES - Continued								
Zinc	7440-66-6	5	mg/kg	30	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	3.2	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	2240	----	----	----	----
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	2240	----	----	----	----
EK072: Phosphate Sorption Capacity								
Phosphate Sorption Capacity	----	250	mg P sorbed/kg	1460	----	----	----	----
Phosphate Sorption Index	----	1	mgkg-1/log10 ugL-1	31	----	----	----	----
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	77	----	----	----	----
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	2.78	----	----	----	----
EP004: Organic Matter								
Organic Matter	----	0.5	%	7.4	----	----	----	----

Appendix C: 2018 soil analysis results (Huon Aquaculture and Layton's properties)

Sample ID	Sampling Site	pH (1:5 Water)	pH (1:5 CaCl2)	Electrical Conductivity	Elec. Cond. (Sat. Ext.)	Chloride	Nitrate Nitrogen	Ammonium Nitrogen	Total Nitrogen (Kjeldahl)	Phosphorus (Colwell)	Phosphorus Buffer Index
				dS/m	dS/m	mg/kg	mg/kg	mg/kg	%	mg/kg	
22033740	Site A TS	7.0	5.5	0.11	0.7	65	2.7	3.5	0.31	21	140
22033739	Site A SS	6.2	4.4	0.05	0.3	10	0.5	1.1	0.1	5	210
22033738	Site B TS	7.0	5.7	0.13	0.8	75	5.6	3.9	0.27	73	120
22033737	Site B SS	7.5	5.6	0.06	0.4	10	2.5	1.0	0.08	9	91
22033736	Site C TS	6.7	6.0	0.08	0.5	13	2.1	4.5	0.3	180	130
22033735	Site C SS	6.1	5.0	0.05	0.3	10	2.2	8.7	0.14	31	190
22033734	Site D TS	6.8	6.0	0.07	0.4	10	4.2	5.7	0.3	79	180
22033733	Site D SS	6.5	5.5	0.05	0.3	10	3.6	5.6	0.19	32	240
22033732	Site E TS	6.8	6.0	0.06	0.4	11	1.6	2.9	0.27	20	99
22033731	Site E SS	6.7	5.8	0.05	0.3	10	2.0	9.4	0.16	7	130
22033475	Site F TS	6.7	5.8	0.04	0.2	10	2.2	2.1	0.21	41	52
22033474	Site F SS	6.8	5.7	0.03	0.2	10	1.7	0.9	0.07	11	42
22033744	Site G TS	6.6	5.7	0.04	0.3	10	7.4	14.0	0.14	55	44
22033743	Site G SS	6.4	5.3	0.02	0.2	10	2.1	0.9	0.04	10	49
22033742	Site H TS	6.6	5.7	0.05	0.5	10	3.7	4.2	0.21	31	13
22033741	Site H SS	6.7	5.7	0.03	0.2	10	0.5	0.9	0.06	22	7
22033751	Site I TS	6.5	5.8	0.08	0.6	10	15.0	4.5	0.24	67	90
22033750	Site I SS	6.4	5.3	0.03	0.2	10	3.5	1.7	0.08	15	56
22033749	Site J TS	6.6	5.7	0.05	0.5	10	6.6	4.8	0.24	27	27
22033748	Site J SS	6.7	5.6	0.03	0.2	10	0.5	1.4	0.08	30	41
22033747	Site K TS	7.0	6.3	0.08	0.5	10	7.9	3.0	0.27	55	170
22033746	Site K SS	5.9	4.8	0.05	0.3	14	3.7	1.6	0.14	12	200
22033745	Site L TS	6.9	6.1	0.07	0.4	10	11.0	5.4	0.23	67	67
22033756	Site L SS	6.8	5.9	0.04	0.2	10	4.8	3.5	0.12	18	65
22033754	Site M TS	6.4	5.4	0.07	0.4	13	0.5	4.0	0.3	36	220
22033753	Site M SS	7.4	6.3	0.08	0.5	13	2.3	2.3	0.1	10	100
22033762	Site O TS	6.2	5.3	0.07	0.4	10	7.3	7.2	0.32	27	110
22033761	Site O SS	6.5	5.3	0.05	0.3	10	2.9	3.2	0.11	10	73
22033760	Site P TS	6.8	6.0	0.05	0.3	10	2.1	3.9	0.23	31	100
22033759	Site P SS	6.1	4.9	0.03	0.2	10	0.8	5.3	0.13	7	170
22033758	Site Q TS	6.8	6.0	0.07	0.4	10	4.1	3.0	0.25	45	150
22033766	Site Q SS	6.6	5.6	0.05	0.3	10	3.9	2.2	0.16	18	160
HAC TS average		7.0	5.6	0.12	0.8	70	4.2	3.7	0.29	47	130
HAC SS average		6.9	5.0	0.055	0.4	10	1.5	1.1	0.09	7	151
Laytons TS average		6.7	5.8	0.063	0.4	10.5	5.4	4.9	0.25	54	104
Laytons SS average		6.5	5.5	0.042	0.3	10.5	2.5	3.4	0.11	17	109

Sample ID	Sampling Site	Available Potassium	Calcium (Amm-acet.)	Potassium (Amm-acet.)	Magnesium (Amm-acet.)	Sodium (Amm-acet.)	Calcium/Magnesium Ratio	Aluminium (KCl)	Cation Exch. Cap.	ESP%	Aluminium Saturation
		mg/kg	cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	cmol(+)/kg		cmol(+)/kg	cmol(+)/kg	%	
22033740	Site A TS	320	7.4	0.83	2.0	2.5	3.7	0.10	12.7	20.0	1.0
22033739	Site A SS	270	2.8	0.70	2.0	1.0	1.4	2.50	9.0	11.0	28.0
22033738	Site B TS	180	7.0	0.45	0.6	1.7	11.0	0.10	9.8	17.0	1.0
22033737	Site B SS	140	2.6	0.37	0.5	2.4	4.9	0.11	6.0	40.0	1.9
22033736	Site C TS	330	12.0	0.84	3.5	0.2	3.4	0.10	16.8	0.9	1.0
22033735	Site C SS	270	6.8	0.70	2.7	0.2	2.5	0.40	10.7	1.5	3.8
22033734	Site D TS	530	15.0	1.40	4.2	0.1	3.6	0.10	20.4	0.5	1.0
22033733	Site D SS	570	9.7	1.40	4.7	0.1	2.1	0.10	16.0	0.8	1.0
22033732	Site E TS	200	8.6	0.50	4.0	0.1	2.2	0.10	13.2	0.7	1.0
22033731	Site E SS	130	5.8	0.32	3.8	0.1	1.5	0.10	10.1	1.3	1.0
22033475	Site F TS	63	6.4	0.16	2.1	0.0	3.0	0.10	8.7	0.4	1.0
22033474	Site F SS	59	3.2	0.15	1.6	0.0	2.0	0.10	4.9	0.5	1.0
22033744	Site G TS	41	5.8	0.11	1.7	0.0	3.4	0.10	7.6	0.5	1.0
22033743	Site G SS	19	1.6	0.05	0.9	0.0	1.8	0.10	2.6	1.0	1.0
22033742	Site H TS	85	6.4	0.22	1.5	0.1	4.3	0.10	8.2	0.7	1.0
22033741	Site H SS	46	3.2	0.12	0.8	0.0	4.0	0.10	4.1	1.0	1.0
22033751	Site I TS	69	9.5	0.18	2.9	0.1	3.3	0.10	12.7	0.8	1.0
22033750	Site I SS	39	3.7	0.10	1.4	0.1	2.6	0.10	5.3	1.5	1.0
22033749	Site J TS	58	8.2	0.15	2.2	0.1	3.7	0.10	10.7	1.0	1.0
22033748	Site J SS	32	4.8	0.08	1.7	0.1	2.8	0.10	6.7	1.6	1.0
22033747	Site K TS	89	9.8	0.23	3.6	0.1	2.7	0.10	13.7	1.0	1.0
22033746	Site K SS	91	4.3	0.23	2.5	0.2	1.7	0.59	7.8	3.0	7.5
22033745	Site L TS	140	9.3	0.37	1.8	0.1	5.2	0.10	11.5	0.8	1.0
22033756	Site L SS	100	6.8	0.26	1.4	0.1	4.9	0.10	8.6	0.6	1.0
22033754	Site M TS	78	8.9	0.20	3.9	0.4	2.3	0.10	13.4	3.3	1.0
22033753	Site M SS	100	8.4	0.26	6.1	1.0	1.4	0.10	15.7	6.1	1.0
22033762	Site O TS	190	7.2	0.48	2.0	0.2	3.6	0.10	9.9	2.3	1.0
22033761	Site O SS	88	4.0	0.23	1.7	0.3	2.4	0.17	6.3	4.4	2.7
22033760	Site P TS	110	10.0	0.27	2.1	0.1	4.8	0.10	12.5	1.0	1.0
22033759	Site P SS	130	4.0	0.32	2.2	0.2	1.8	0.68	7.4	2.1	9.2
22033758	Site Q TS	260	12.0	0.67	2.9	0.1	4.1	0.10	15.8	0.9	1.0
22033766	Site Q SS	260	7.6	0.65	3.3	0.2	2.3	0.10	11.7	1.3	1.0
HAC TS average		250	7.2	0.64	1.3	2.1	7.4	0.10	11.3	18.5	1.0
HAC SS average		205	2.7	0.54	1.3	1.7	3.2	1.31	7.5	25.5	15.0
Laytons TS average		160	9.2	0.41	2.7	0.1	3.5	0.10	12.5	1.1	1.0
Laytons SS average		138	5.3	0.35	2.5	0.2	2.4	0.20	8.4	1.9	2.4

Sample ID	Sampling Site	Copper (DTPA)	Iron (DTPA)	Manganese (DTPA)	Zinc (DTPA)	Boron (Hot CaCl2)	Sulphur (KCl40)	Organic Carbon (W&B)	Aluminium (KCl)	Phosphorus Environmental Risk Index	Grass Tetany Risk Index
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%	mg/kg		
22033740	Site A TS	0.2	93	23.0	1.1	0.4	4.5	3.5	9	0.15	0.09
22033739	Site A SS	0.1	36	3.5	0.2	0.2	4.0	0.8	230	0.02	0.15
22033738	Site B TS	0.2	74	21.0	1.0	0.5	14.0	2.9	9	0.61	0.06
22033737	Site B SS	0.1	25	1.8	0.1	0.2	1.7	0.6	10	0.10	0.12
22033736	Site C TS	2.8	150	26.0	5.4	1.4	4.4	3.4	9	1.38	0.05
22033735	Site C SS	1.0	88	14.0	1.3	1.0	8.0	1.4	36	0.16	0.07
22033734	Site D TS	2.3	95	24.0	6.1	1.0	2.4	3.0	9	0.44	0.07
22033733	Site D SS	1.0	41	11.0	2.0	0.8	3.4	1.7	9	0.13	0.10
22033732	Site E TS	3.2	170	1.9	4.0	1.0	2.3	3.1	9	0.20	0.04
22033731	Site E SS	1.3	120	0.6	1.2	0.8	2.6	1.8	9	0.05	0.03
22033475	Site F TS	4.3	190	1.7	7.3	0.6	1.8	2.4	9	0.79	0.02
22033474	Site F SS	0.9	130	0.4	1.5	0.3	1.1	0.9	9	0.26	0.03
22033744	Site G TS	3.1	140	1.7	6.4	0.3	3.4	2.1	9	1.25	0.02
22033743	Site G SS	0.4	130	0.3	0.5	0.2	1.0	0.6	9	0.20	0.02
22033742	Site H TS	3.2	66	4.8	16.0	0.5	3.7	3.2	9	2.38	0.03
22033741	Site H SS	0.6	40	0.8	3.2	0.2	1.5	0.9	9	3.33	0.03
22033751	Site I TS	3.8	230	3.7	11.0	0.8	7.2	3.5	9	0.74	0.02
22033750	Site I SS	0.7	160	0.6	1.8	0.4	2.5	1.1	9	0.27	0.02
22033749	Site J TS	3.0	130	2.3	20.0	0.5	2.6	3.3	9	1.00	0.01
22033748	Site J SS	0.8	180	0.4	3.8	0.2	1.1	1.1	9	0.73	0.01
22033747	Site K TS	6.2	390	3.6	6.7	1.3	6.2	3.5	9	0.32	0.02
22033746	Site K SS	1.3	260	0.8	1.4	1.1	7.5	1.7	53	0.06	0.03
22033745	Site L TS	2.8	190	5.1	6.2	0.7	2.7	2.7	9	1.00	0.03
22033756	Site L SS	1.0	110	2.2	1.5	0.5	1.4	1.3	9	0.28	0.03
22033754	Site M TS	8.3	430	20.0	16.0	1.2	11.0	3.9	9	0.16	0.02
22033753	Site M SS	1.7	100	7.6	1.8	0.8	6.6	1.1	9	0.10	0.02
22033762	Site O TS	2.0	430	11.0	4.2	0.7	5.0	3.4	9	0.25	0.05
22033761	Site O SS	0.5	170	2.8	0.5	0.5	3.2	1.1	15	0.13	0.04
22033760	Site P TS	2.7	190	2.4	5.7	0.7	1.9	3.0	9	0.31	0.02
22033759	Site P SS	0.7	160	0.5	1.0	0.7	1.8	1.5	61	0.04	0.05
22033758	Site Q TS	3.9	200	10.0	6.2	1.0	2.5	3.0	9	0.30	0.05
22033766	Site Q SS	1.8	130	6.5	3.8	0.7	2.1	1.7	9	0.11	0.06
HAC TS average		0.2	84	22.0	1.1	0.4	9.3	3.2	9	0.38	0.08
HAC SS average		0.1	31	2.7	0.1	0.2	2.9	0.7	120	0.06	0.14
Laytons TS average		3.7	214	8.4	8.7	0.8	4.1	3.1	9	0.75	0.03
Laytons SS average		1.0	130	3.5	1.8	0.6	3.1	1.3	18	0.42	0.04

Sample ID	Sample Name	Heavy Metals Analysis (mg/kg)									
		Arsenic	Cadmium	Chromium	Cobalt	Copper	Lead	Manganese	Nickel	Zinc	Mercury
EM1816536001	Site A TS	15	<1	17	<2	<5	10	643	3	15	<0.1
EM1816536002	Site A SS	16	<1	20	<2	<5	11	238	2	11	<0.1
EM1816536003	Site B TS	6	<1	8	<2	<5	6	773	3	12	<0.1
EM1816536004	Site B SS	12	<1	12	<2	<5	7	254	2	11	<0.1
EM1816536005	Site C TS	6	<1	11	<2	19	11	442	2	34	<0.1
EM1816536006	Site C SS	6	<1	11	<2	13	11	420	<2	25	<0.1
EM1816536007	Site D TS	12	<1	19	3	17	16	451	3	45	<0.1
EM1816536008	Site D SS	15	<1	23	3	11	24	392	3	36	<0.1
EM1816536009	Site E TS	10	<1	8	<2	20	12	47	<2	29	<0.1
EM1816536010	Site E SS	5	<1	8	<2	11	9	16	<2	17	<0.1
EM1816536011	Site F TS	<5	<1	4	<2	21	<5	21	<2	27	<0.1
EM1816536012	Site F SS	<5	<1	3	<2	<5	<5	<5	<2	7	<0.1
EM1816536013	Site G TS	<5	<1	<2	<2	18	<5	13	<2	17	<0.1
EM1816536014	Site G SS	<5	<1	3	<2	<5	<5	<5	<2	<5	<0.1
EM1816536015	Site H TS	<5	<1	<2	<2	20	<5	25	<2	37	<0.1
EM1816536016	Site H SS	<5	<1	<2	<2	<5	<5	<5	<2	5	<0.1
EM1816536017	Site I TS	<5	<1	3	<2	22	6	27	<2	37	<0.1
EM1816536018	Site I SS	<5	<1	2	<2	<5	<5	<5	<2	6	<0.1
EM1816536019	Site J TS	<5	<1	2	<2	18	<5	21	<2	34	<0.1
EM1816536020	Site J SS	<5	<1	3	<2	6	<5	5	<2	13	<0.1
EM1816536021	Site K TS	<5	<1	9	3	25	12	36	<2	46	<0.1
EM1816536022	Site K SS	5	<1	9	2	11	11	12	<2	21	<0.1
EM1816536023	Site L TS	9	<1	7	<2	16	13	146	<2	34	<0.1
EM1816536024	Site L SS	6	<1	6	<2	<5	11	75	<2	13	<0.1
EM1816536025	Site M TS	18	<1	22	4	27	14	276	6	56	<0.1
EM1816536026	Site M SS	<5	<1	22	3	11	11	121	5	23	<0.1
EM1816536027	Site N TS	8	<1	7	2	15	15	303	<2	29	<0.1
EM1816536028	Site N SS	12	<1	8	<2	<5	17	205	<2	13	<0.1
EM1816536029	Site O TS	<5	<1	8	2	10	13	99	<2	18	<0.1
EM1816536030	Site O SS	6	<1	7	<2	<5	11	13	<2	5	<0.1
EM1816536031	Site P TS	9	<1	10	<2	18	10	44	<2	31	<0.1
EM1816536032	Site P SS	8	<1	11	<2	<5	8	<5	<2	7	<0.1
EM1816536033	Site Q TS	14	<1	13	<2	20	13	178	6	44	<0.1
EM1816536034	Site Q SS	13	<1	15	<2	11	13	127	2	26	<0.1

Appendix D: July 2019 report to the EPA summarising wastewater quality in 2018/19

Monthly Report
Parramatta Creek
Wastewater Treatment Plant
July 2019

HUON
TASMANIA

To:	Tanya Mijak, Cindy Ong
From:	Adam Chapman
CC:	Simon Fraser, Phil Wiese, Dom O'Brien, Charles Hughes, Chris Newett, Andrew Cordwell, John Gorrie, Stephen Kent, compliance
Date:	15/08/2019
Re:	**PC WWTP Monthly Report July 2019**

1 Overview

This report has been written in response to site EPN's 7894 and 8835/1

Field data contained within was collected daily by Huon Aquaculture staff and recorded within the site and Huon Aquaculture data base (Splashback).

All laboratory results were collected utilising NATA approved collection methods and analysed at a NATA approved laboratory.

All information is therefore deemed to be correct.

Ideas, comments, opinions and assumptions are my own and not the property or opinion of the company Huon Aquaculture.

Image 1: Parramatta Creek Irrigation area Jan 2019 – Post exclusion of Wallabies

2 Contents

3 Executive Summary

Slight increases to BOD and Thermotolerant Coliforms whilst pH and the key parameter of conductivity reduced.
No irrigation occurred throughout the period.

Table 1: Summary of monthly lab results July 2019 (red = non-compliant, green=compliant)

Discharge Parameters	**Discharge Limit**	**Result**	**Difference to previous month**
Conductivity Lab uS/cm*	**3000***	**2110**	**-310**
BOD mg 02/L	**50**	**56**	**36**
Thermotolerant coliforms cfu/100ml	**1000**	**50**	**20**
Lab pH units	**5.5 - 8**	**7.5**	**-0.7**

****please note the discharge limit above for conductivity relates to the only discharge limit ever imposed on the site as an interim limit set in 2011, currently there is no EPA issued compliance limit for the site in regards to conductivity. Huon Aquaculture have utilised the 3000uS/cm as a guideline level only for salinity management.***

Table 2: Overall Performance past 12 months for key Parameters irrigation Parramatta Creek

Parramatta Creek Pond 4: 1/8/2018 – 31/7/2019						
	Max	**90th Percentile**	**Median**	**10th Percentile**	**Min**	**Sample Number**
Conductivity Lab uS/cm	3060	3030	**2380**	2060	2010	12
BOD mg/L	73	53.4	**18.5**	8.1	5	12
Thermotolerant coliforms cfu/100ml	480	391	**145**	30	10	12
pH Lab Units	8.3	8.19	**7.8**	7.5	7.5	12
Ammonia and Ammonium as N mg/L	17	16	**6.55**	0.871	0.37	12
Nitrogen (Total) as N mg/L	26	25	**21**	12.1	12	12

Table 3: Comparison Annual Median Results; red non-compliant – green compliant

	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Conductivity uS/cm*	2300	4250	NR	4520	6040	4090	3560	**2470**	**2380**
BOD mg/L	44.4	134	NR	102	130	15	31	**16**	**18.5**
Therm - coli cfu/100ml	230	150	NR	10000	800	240	250	**90**	**145**
pH Lab Units	7.6	7.3	NR	7.3	7.75	7.8	8.65	**7.75**	**7.8**

Table 3 highlights that 2018 was the first year that has achieved a compliance for all site conditions (median result) since 2011. Results for 2019 appear similar to 2018.

Upgrades to both the wastewater and salt slurry systems began in late 2015.

Conductivity improvements can be seen when comparing the same month results for previous years.
July 2016 = 3110 uS/cm
July 2017 = 2720 uS/cm
July 2018 = 2210 uS/cm
July 2019 = 2110 uS/cm

3.1 Conductivity

Figure 1: Conductivity past 12 months - Irrigation (redline 3000 uS/cm)

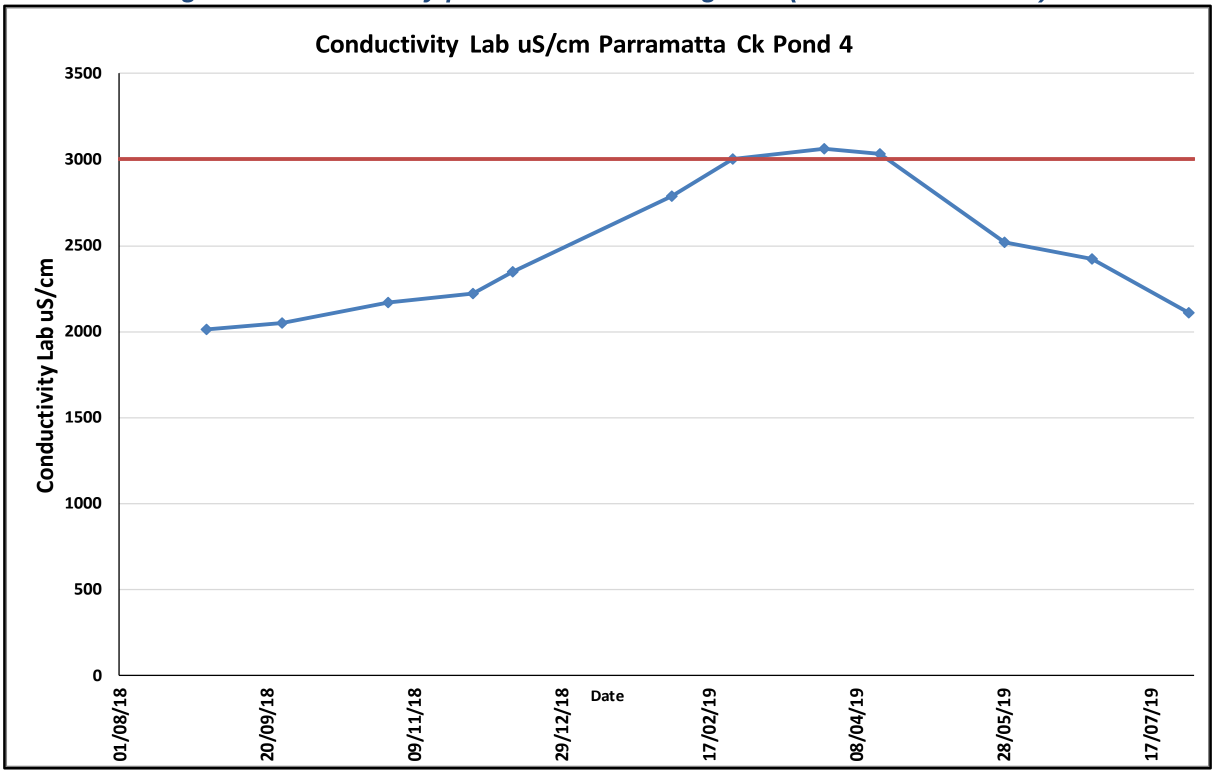
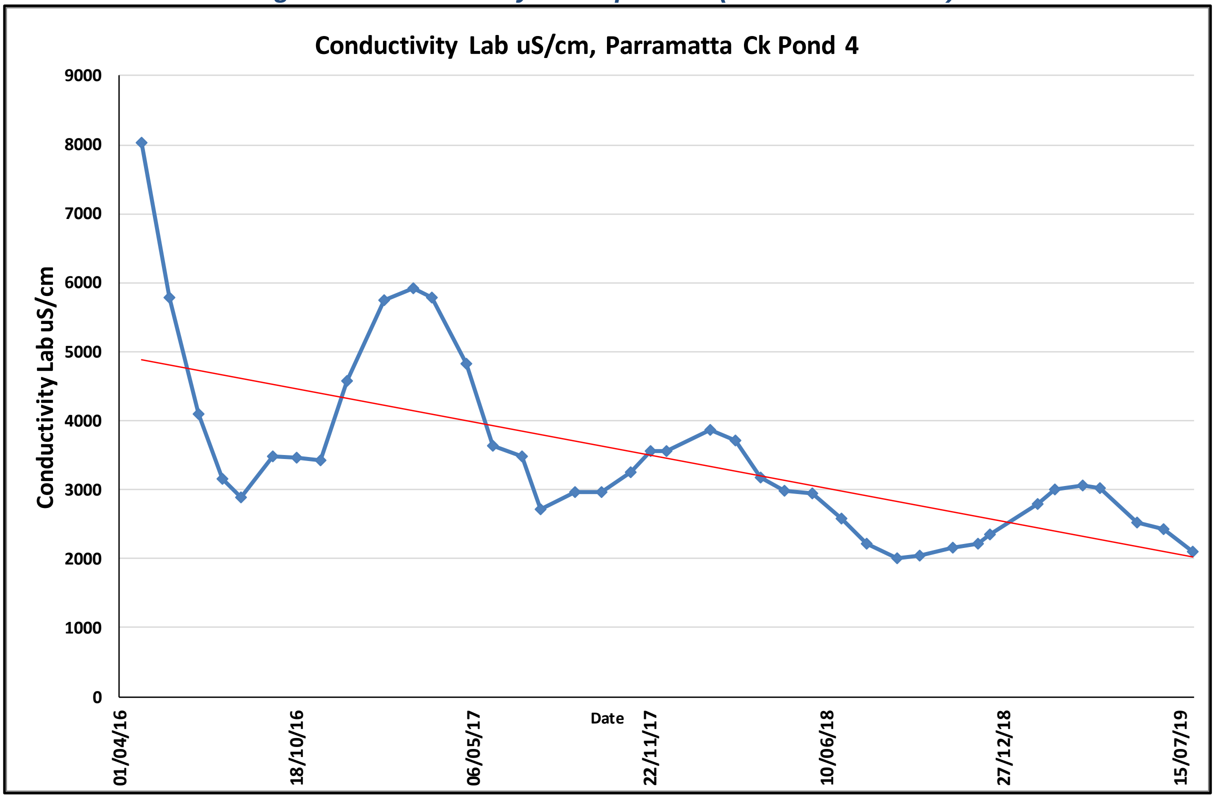


Figure 1 Conductivity is expected to remain low across the winter period.
Figure 2 Conductivity peaked at Parramatta Creek in April 2016, upgrades to the system and better management have seen conductivity reduce by ***5920uS/cm*** or 73% with improvement continuing.

Figure 2: Conductivity 2011- present (3000uS/cm in red)



3.2 Ammonia and Ammonium

High Ammonia levels (>50mg/L) are a key indicator of short circuiting or overloading of a wastewater treatment system. High Ammonia also impacts on the receiving soils and potentially on the surrounding environment. Variations will be seen as production increases each year and generally when the weather cools down as bacteria become less active.

Figure 3: Ammonia past 12 months Parramatta Creek Irrigation (Pond 4)

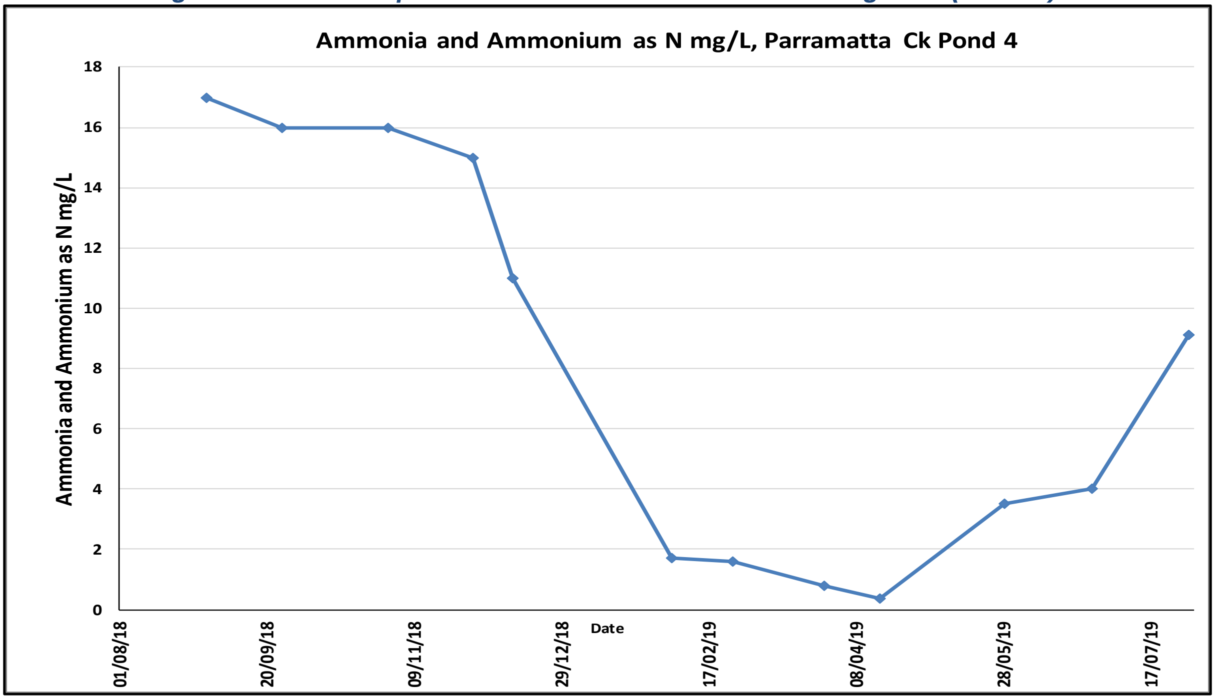
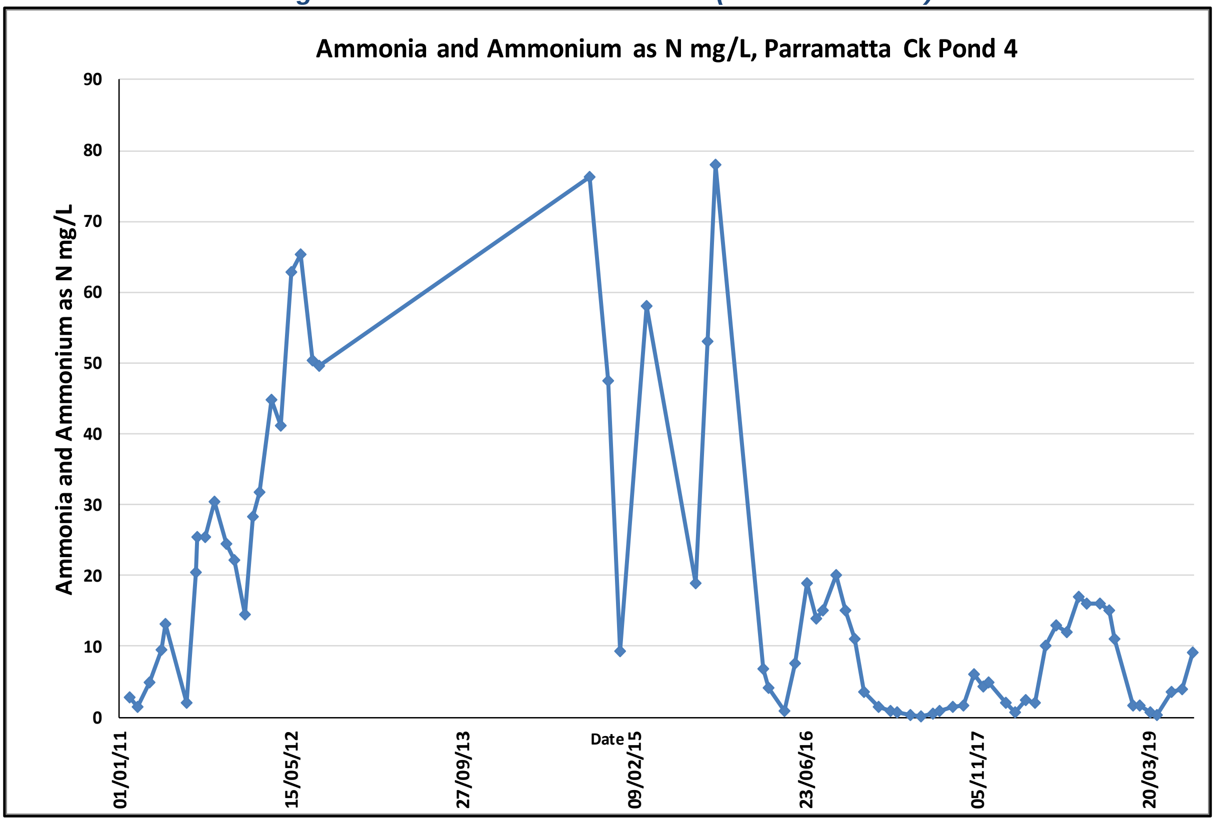


Figure 3: Highlights relatively normal Ammonia results expected from pond systems.

Figure 4: Highlights the dramatic improvement seen within Ammonia results since 2015.

Figure 4: Ammonia 2011 – Present (trend line in red)



3.3 Biological Oxygen Demand

BOD is also used as an indicator of how wastewater treatment plants are operating. High BOD is an indicator of a poor wastewater system and high organic loading. Variations will occur on occasion as the result can be influenced by Algae and floating organic material.

Figure 5: BOD- Parramatta Creek Irrigation past 12 months (redline 50 mg/L EPN condition)

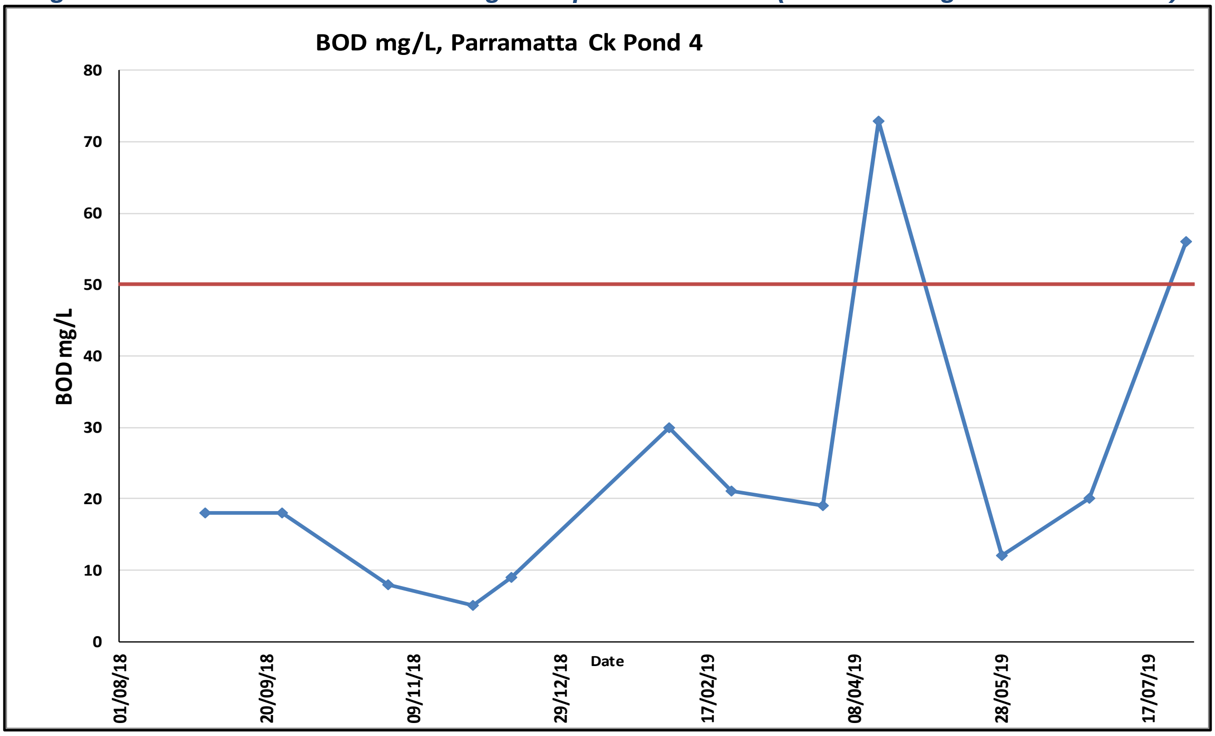
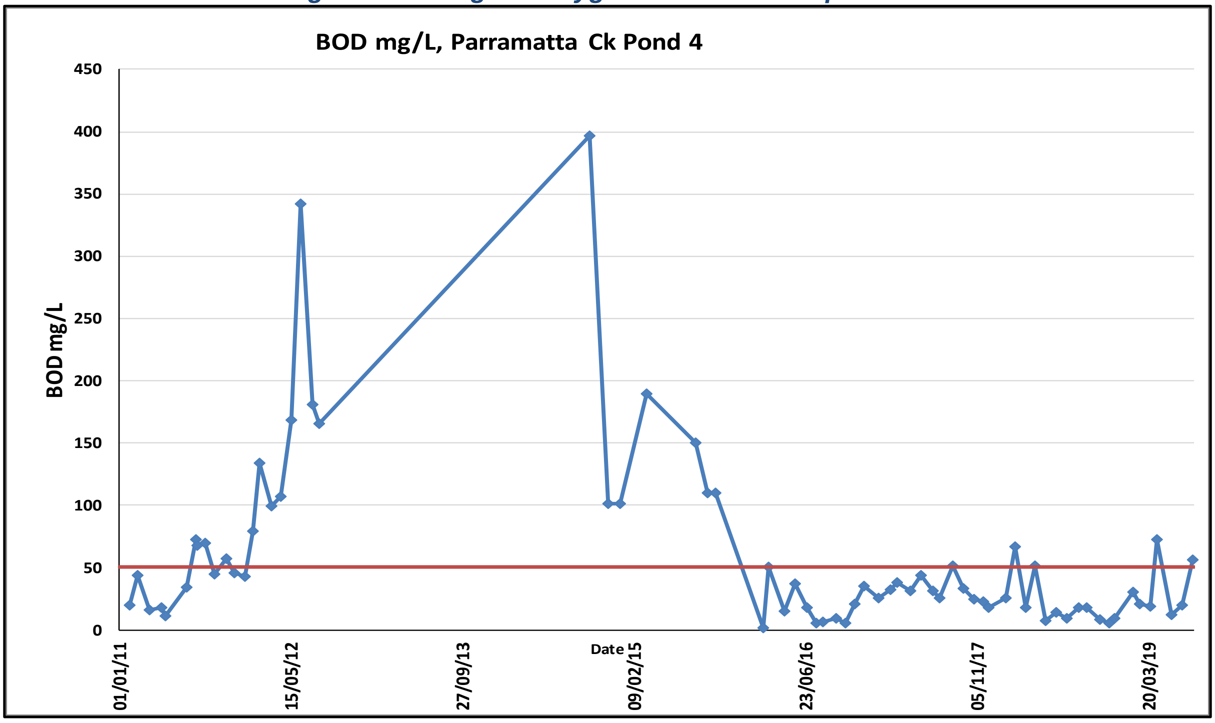


Figure 5 above highlights a stable result for the past 12 months with a jump in April post Easter production levels and another small increase possibly due to the cold weather.

Figure 6 highlights the stability within BOD across the past 2 years as upgrades and improvements have been made to the PC wastewater system.

Figure 6: Biological Oxygen Demand 2011-present



3.4 Thermotolerant Coliforms

Thermotolerant Coliforms are a useful indicator of both the efficiency of a wastewater system and are also a potential indicator of high levels of other bacteria such as E. coli

Figure 7: Thermotolerant Coliforms – PC Irrigation past 12 months (redline 1000 cfu/100mls)

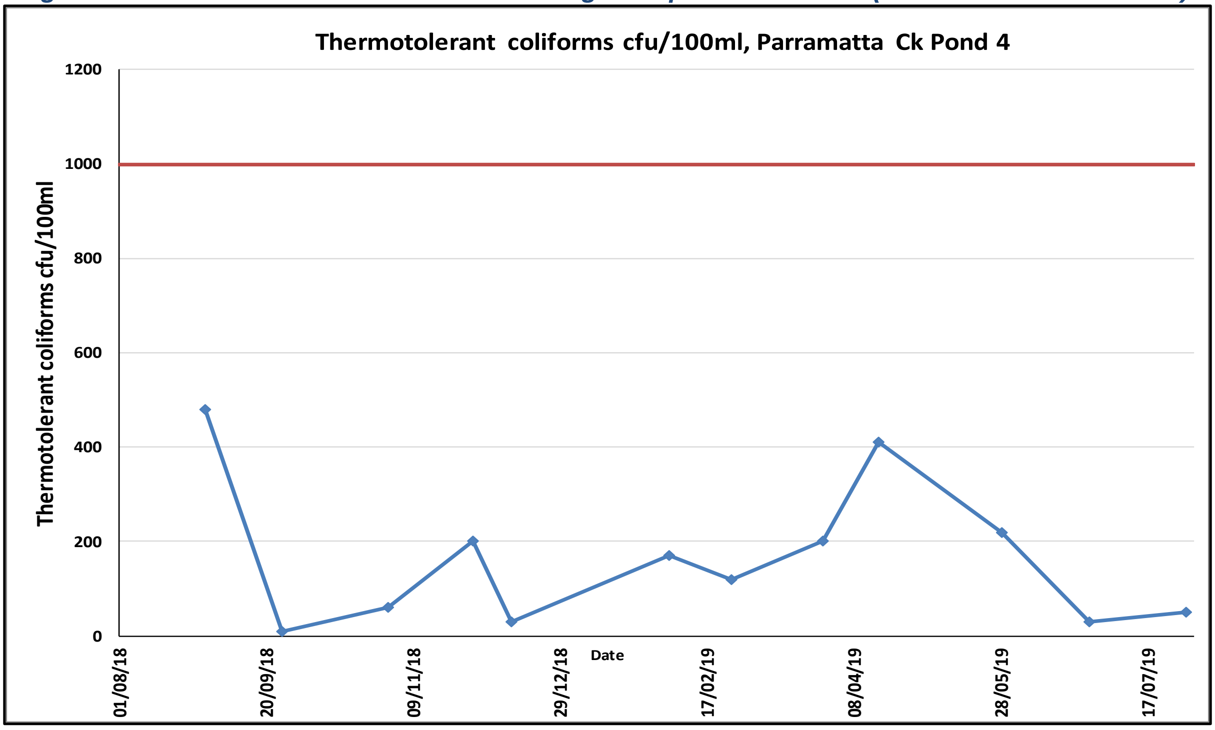
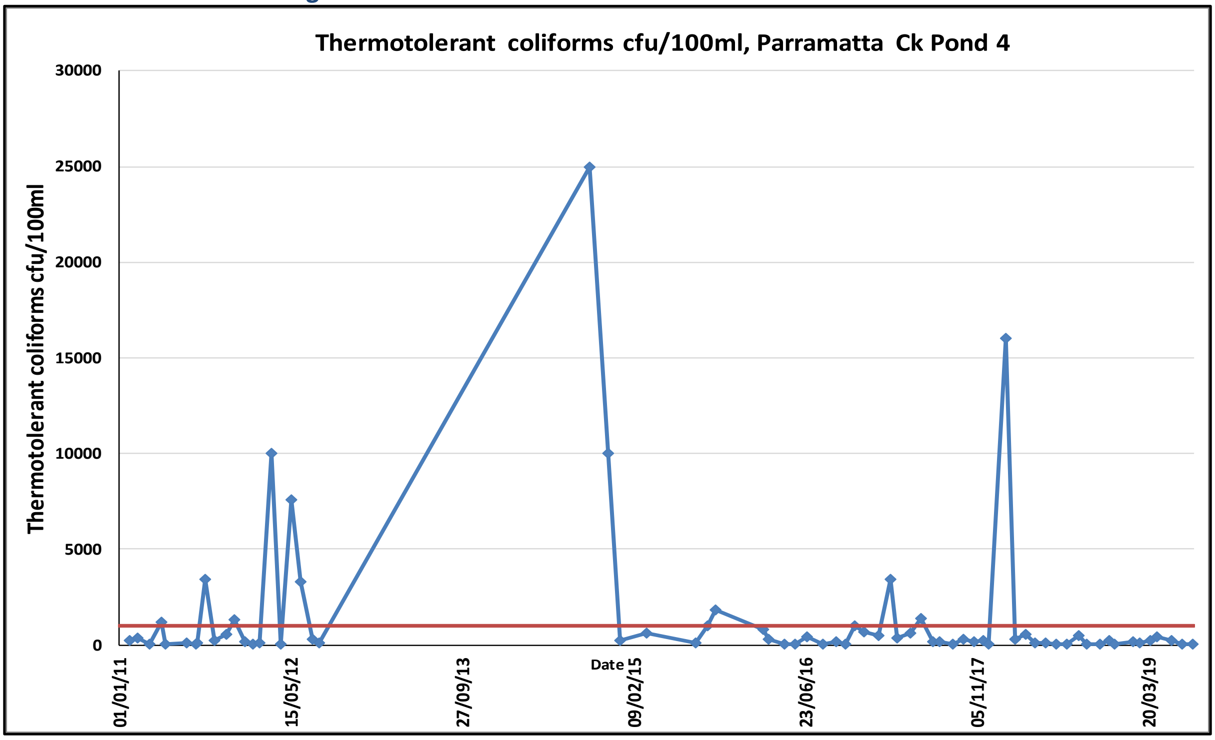


Figure 7 highlights continued low levels within the system.

Figure 8 highlights a consistently low level of Thermotolerant Coliforms indicating an effective water treatment system.

Figure 8: Thermotolerant Coliforms 2011 – Present



3.5 Laboratory pH

In waste water ponds, the aim is to consume organics placed in the pond. To achieve this mainly via solar energy, the photosynthesis will dominate over the respiration reaction. Therefore, H+ (a strong acid) and CO2, a weak acid will be consumed and the pH in the water will increase as result. It is recommended that the higher pH water be accepted as the normal operation of an effective lagoon system. (will be requested in pending DPEMP 2019)
The results below shows a stability in pH over the past twelve months with all results at or near the upper limit.

Figure 9: Lab pH – PC Irrigation past 12 months, (Redlines pH 5.5 and pH 8) (EPN conditions)

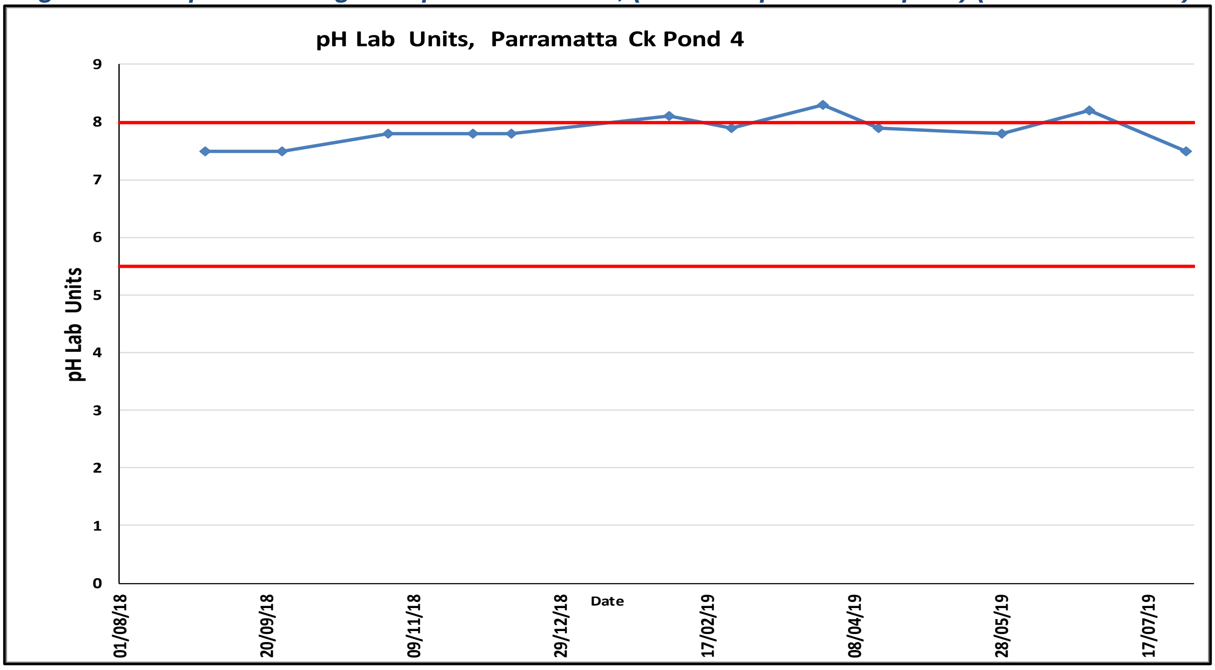
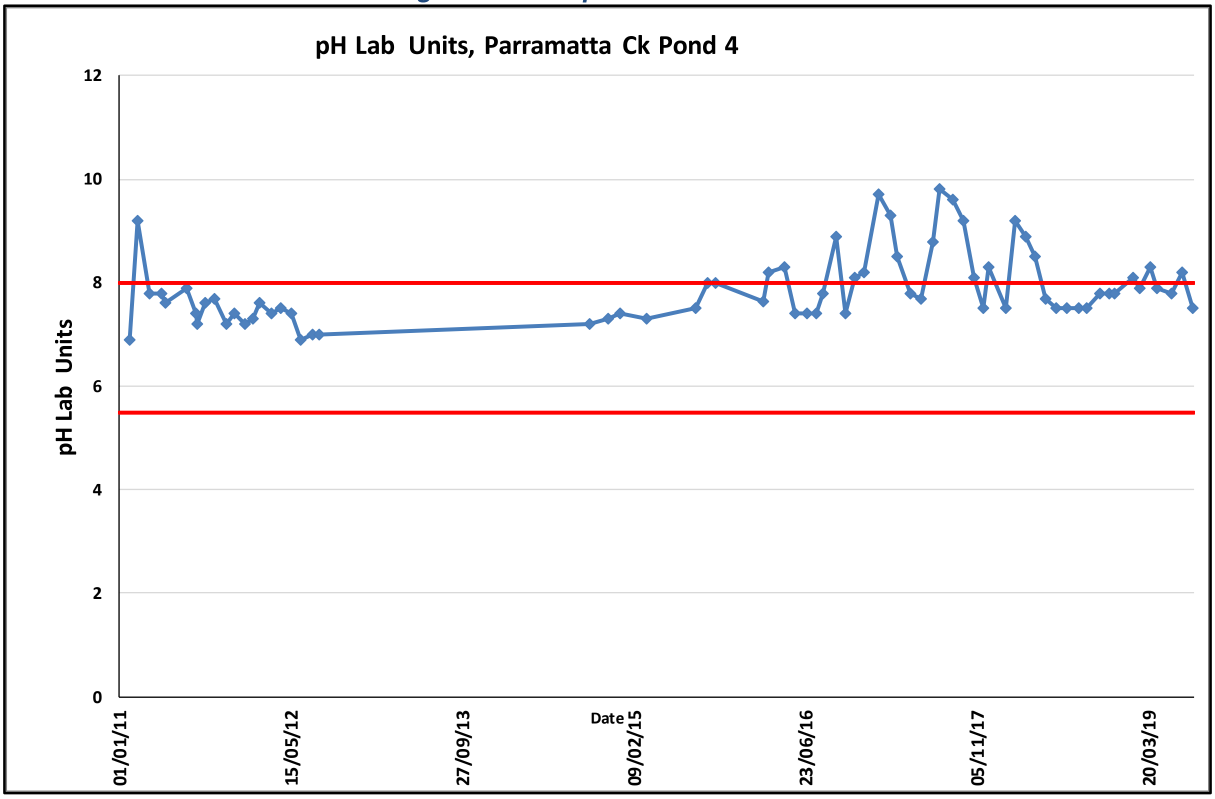


Figure 10: Lab pH 2011 – Present



3.6 Total Nitrogen

Nitrogen is valued in farming situations and some nitrogen is therefore valued within our wastewater when used for crop production.

Figure 11, highlights a stable 10mg/L variation of Total Nitrogen across the past 12 months.

Figure 11: Total Nitrogen Pond 4 (Irrigation past 12 months) (trend line in red)

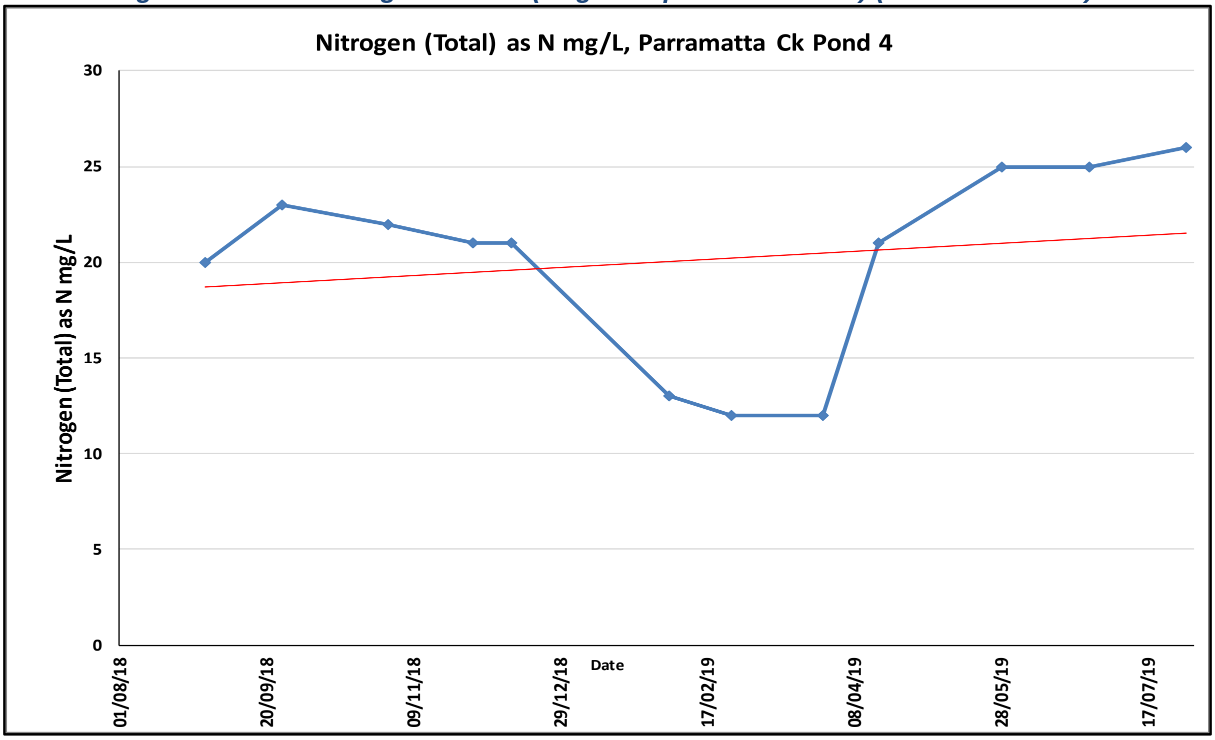
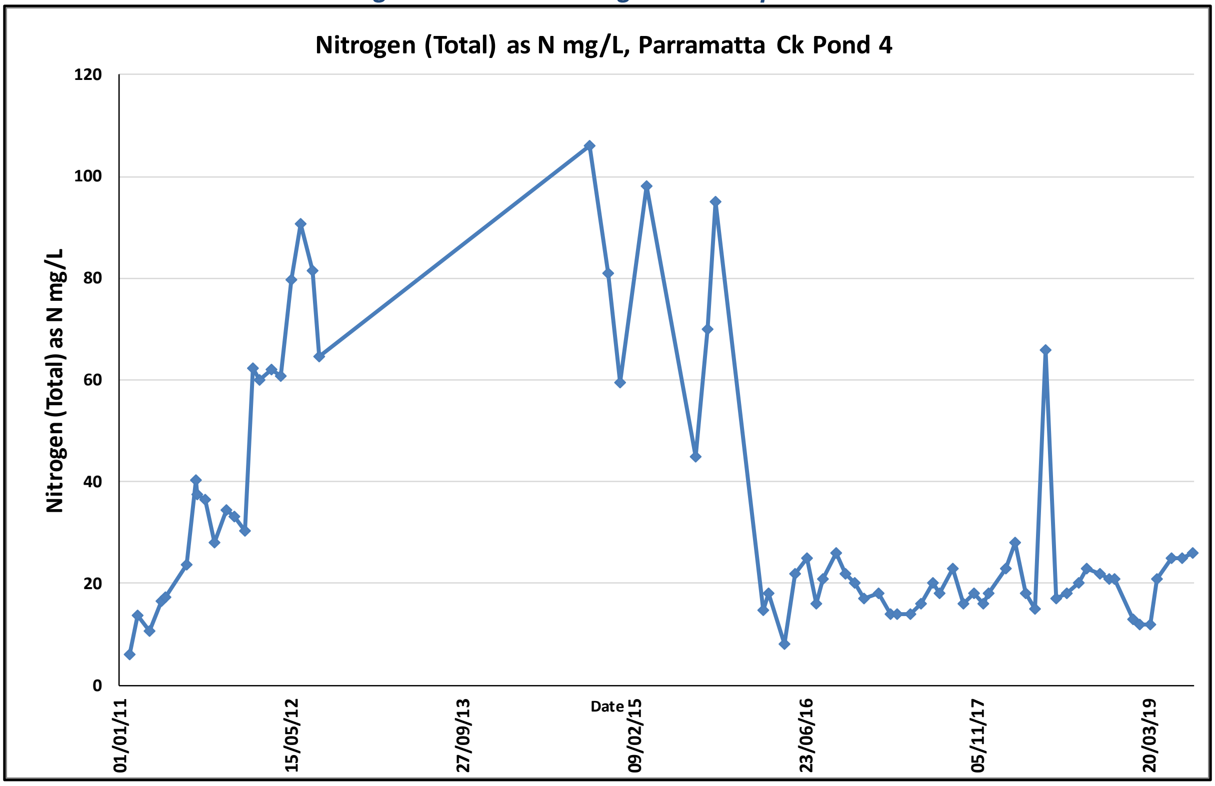


Figure 12 below highlights that Nitrogen has remained reasonably stable for a 3-year period.

Figure 12: Total Nitrogen 2011 – present



Comments

- The conductivity levels within the wastewater continued to improve

4 Chiller Truck Update

The improved salinity results can be attributed to the use of the chiller unit and also the replacement of some salt slurry with freshwater as external temperatures have reduced.

For additional information on the Parramatta Creek site please do not hesitate to contact:

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Appendix E: HAC Parramatta Creek processing facility wastewater monitoring plan

Huon Parramatta Creek wastewater salinity monitoring procedure - October 2018

Purpose

The objective of this document is to provide a procedure for monitoring wastewater salinity (electrical conductivity) at Huon Aquaculture's Parramatta Creek processing facility, while interim measures to reduce wastewater salinity are trialed, during October 2018. The interim measures to be implemented is the removal of fish receivals water from the site's wastewater stream. The purpose of the procedure is to monitor the salinity of the wastewater streams from the facility and the impact of diverting the salt slurry waste stream used to transport fish in (defined as fish receivals water).

Method

In-situ water monitoring is to be conducted at seven locations throughout the facility. It is to be completed daily when the fish receivals water is being taken offsite (with the blood water) for disposal. It is also to be completed daily when the fish receivals water is not being captured and is entering the sites pond system. Monitoring must be conducted mid-morning (approximately 10:00am) when the facility is at peak production for the day. Monitoring must be conducted in the week prior to the interim measures being implemented to establish baseline data.

In-situ monitoring is to include pH, electrical conductivity (EC µs/cm) and temperature. Data is to be recorded on the form attached. This information includes the date and time, sampler's name, pH, EC, temperature and most recent calibration date of the meter.

The water meter is to be calibrated fortnightly following the manufacturer's procedure.

Rinse the water meter with potable (fresh) water between each site. Wash the water quality meter probes after each day of use and scrub with a brush (tooth brush) to remove any solids.

Table 1 Monitoring and calibration schedule

	When fish receival water is diverted and disposed of off-site	When fish receival water enters factory wastewater stream	Water quality meter calibration
Frequency	Daily	Daily	Fortnightly

Table 2 Monitoring locations

Testing location point number:	In-situ water monitoring	Flow meters/volume
A	Fresh water	Freshwater in
B	Fish receivals water	Fish receivals tanker volume for the day
C	Processing area	WWTP meter reading
D	Pond 1 inflow	
E	Pond 2	
F	Pond 3	
G	Pond 4	Irrigation volume for the day

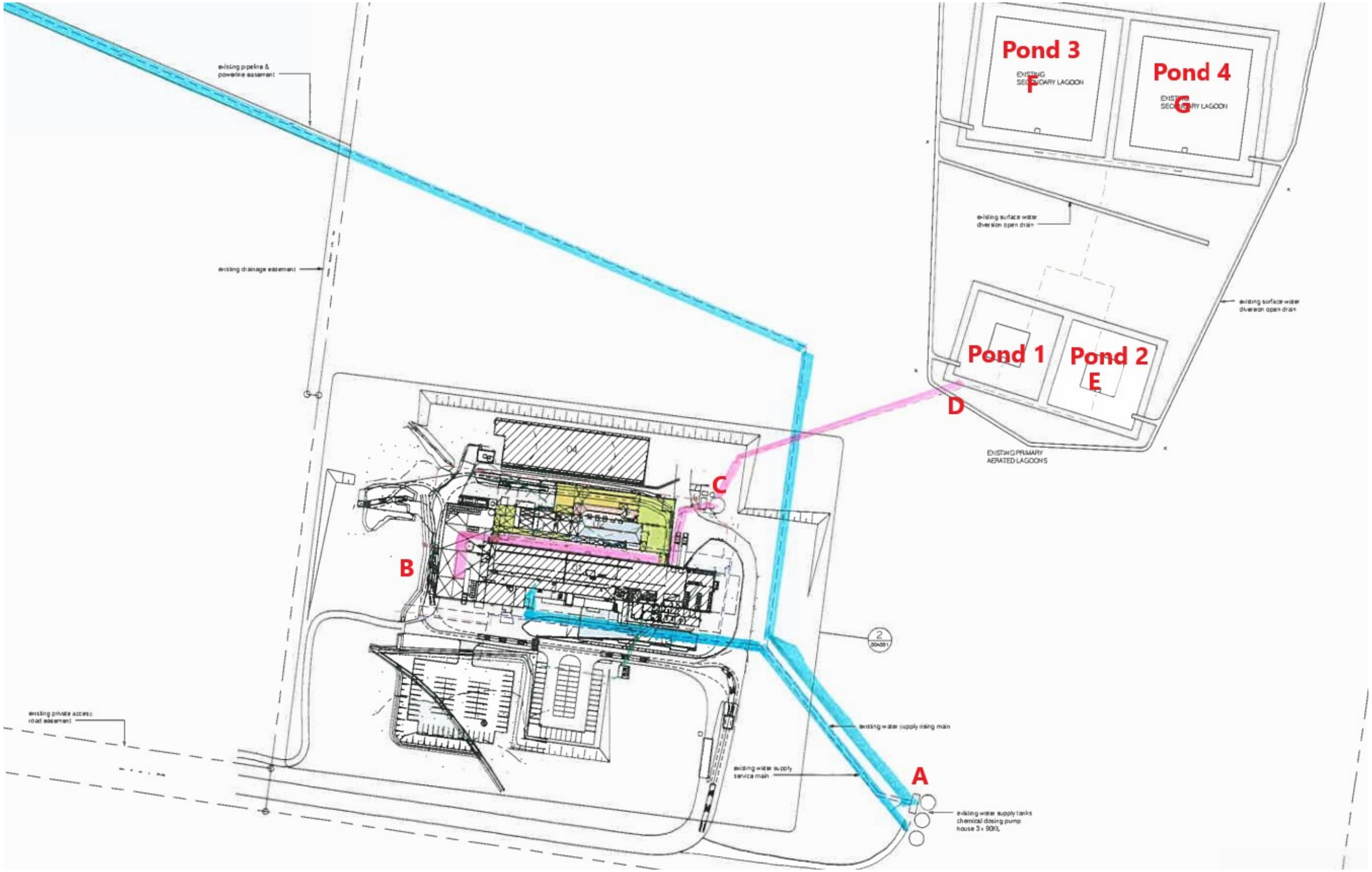

Figure 1 Monitoring locations. Letters correspond with locations in table 2

Daily water quality monitoring record sheet

Testing location point number:	Water source	Date							
		Time							
		Sampler							
A	Fresh water	pH							
		EC (µs/cm)							
		Temp. (°C)							
B	Blood water	pH							
		EC (µs/cm)							
		Temp. (°C)							
C	Process wastewater	pH							
		EC (µs/cm)							
		Temp. (°C)							
D	Pond 1 inflow	pH							
		EC (µs/cm)							
		Temp. (°C)							
E	Pond 2	pH							
		EC (µs/cm)							
		Temp. (°C)							
F	Pond 3	pH							
		EC (µs/cm)							
		Temp. (°C)							
G	Pond 4	pH							
		EC (µs/cm)							
		Temp. (°C)							
A	Fresh water meter Reading								
B	Fish receival Tanker to treatment plant volume								
C	WWTP meter Reading								
	Irrigation volume for the day								
	WQ meter calibration date								

Parramatta Creak

Printed ☐

Work Order # 98656

Manage Risks Well
Get Home Safe and Well

Asset Information

Asset ID: **Infrastructure** **Infrastructure**

Comments:

Work Instructions

Job Description: PMC - Daily Water Quality Monitoring

Instructions: Ensure sampling is conducted daily at peak production times (10:00-11:00) and all readings are detailed for reporting purposes

Job Priority:

Job Type: PM

Raised Date: 6/12/2018

Due Start: 11/12/2018

Due Finish:

Requester

Name:

Safety Notes and Alert

Safety Notes: Ensure isolation is conducted on all equipment prior to commencement of works and personal lockout - tags used

Each and every individual on any job must always lock-out and tag-out any equipment before commencing inspection, maintenance, repair or test procedure

STOP! THINK! ACT!

Tasks

No	Description	Complete	Reading Type	Reading
1	Incoming Water	☐		
2	pH	☐		
3	EC (µs/cm)	☐		
4	Temp. (°C)	☐		
5	Tanker Discharge Water	☐		
6	pH	☐		
7	EC (µs/cm)	☐		
8	Temp. (°C)	☐		
9	Wet Processing Water	☐		
10	pH	☐		
11	EC (µs/cm)	☐		
12	Temp. (°C)	☐		
13	Waste Water Plant	☐		
14	pH	☐		
15	EC (µs/cm)	☐		
16	Temp. (°C)	☐		
17	Pond 1 inflow	☐		
18	pH	☐		
19	EC (µs/cm)	☐		
20	Temp. (°C)	☐		
21	Pond 2	☐		
22	pH	☐		
23	EC (µs/cm)	☐		
24	Temp. (°C)	☐		
25	Pond 3	☐		

28 Temp. (°C) ☐
29 Pond 4 ☐
30 pH ☐
31 EC (μs/cm) ☐
32 Temp. (°C) ☐
33 Incoming water flow meter reading ☐
34 Fish receival tanker to treatment plant volume ☐
35 WWTP meter reading ☐
36 Irrigation volume for the day ☐
37 WQ meter calibration date ☐

Work and Asset Report

Details of work performed:

Total Asset Downtime: ☐ **Hours** **Asset Hours at Job Completion:** ☐ **Hours**

Additional Repairs Required? YES ☐ **NO** ☐ **Additional Parts Required? YES** ☐ **NO** ☐

Appendix F: Water balance calculation spreadsheets

Assumptions — **Mean rainfall year**

Rainfall data obtained from: Devonport Airport - BoM site no. 091126
Evaporation data obtained from: Deloraine (ATHOL) - BoM site no. 091000

Average Wastewater flow of 70 ML/year based on projected monthly and annual production levels and monthly wastewater flows by Huon Aquaculture

		unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Evaporation (Pan)	A	mm	173.6	137.2	108.5	63	40.3	27	34.1	46.5	63	96.1	120	145.7	1055
Effective Lagoon Evaporation	B	mm	138.9	109.8	86.8	50.4	32.2	21.6	27.3	37.2	50.4	76.9	96.0	116.6	844
Rainfall	C	mm	43.4	36.1	48.4	59.5	75.6	78	97.3	90.7	75.3	62.9	56.8	53.1	777
Effective Rainfall	D	mm	30.4	25.3	33.9	41.7	52.9	54.6	68.1	63.5	52.7	44.0	39.8	37.2	544
Direct Crop Coefficient	E		0.85	0.85	0.85	0.75	0.65	0.50	0.40	0.50	0.70	0.75	0.85	0.85	
Evapotranspiration (A x E)	F	mm	147.6	116.6	92.2	47.3	26.2	13.5	13.6	23.3	44.1	72.1	102.0	123.8	
Irrigation Requirement (F - D)	G	mm	117	91	58	6	0	0	0	0	0	28	62	87	449
Net Lagoon Evaporation	H	kL	1910	1473	768	-182	-867	-1128	-1400	-1070	-498	280	784	1269	1338
Wastewater Flow	I	kL	5860	5933	6935	6115	6774	6064	4275	4987	4885	5477	5861	6072	69239
Net Lagoon Inflow (I + H)	J	kL	3951	4460	6167	6297	7641	7192	5675	6057	5383	5197	5077	4803	67901
Water Used in Irrigation (G x Irrigation Area)	K	kL	17704	13801	8815	846	0	0	0	0	0	4237	9403	13095	67901
Average Daily Irrigation Rate	L	kL/d	571	493	284	28	0	0	0	0	0	137	313	422	
Cumulative Storage (Storage in Previous Month + J - K)	M	kL	11989	2648	0	5451	13092	20284	25960	32017	37400	38360	34034	25742	
Lagoon Depth	N	m	0.6	0.1	0.0	0.3	0.7	1.0	1.3	1.6	1.9	1.9	1.7	1.3	

Lagoon (reuse dam) Area	ha	2
Assume Effective Rainfall Factor		0.70
Irrigation Area Required	ha	**15.1**
Lagoon Volume Required	ML	**38.4**
Lagoon Depth	m	**1.9**

Notes:
Worksheet based on Water Budget Table "Guidelines for Wastewater Irrigation" Victorian EPA
Effective rainfall (ie that available for vegetation growth) is that which does not run off, or is intercepted by vegetation (leaves, branches etc) and is evaporated.
Direct crop coefficient is a factor relating crop water use to pan evaporation. Varies monthly and also depends on what crop is being irrigated - Pasture has been used in this scenario

Assumptions	**90th percentile rainfall (wet year)**
Rainfall data obtained from	Devonport Airport - BoM site no. 091126
Evaporation data obtained from	Deloraine (ATHOL) - BoM site no. 091000

Average Wastewater flow of 70 ML/year based on projected monthly and annual production levels and monthly wastewater flows by Huon Aquaculture

		unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Evaporation (Pan)	A	mm	173.6	137.2	108.5	63	40.3	27	34.1	46.5	63	96.1	120	145.7	1055
Effective Lagoon Evaporation	B	mm	138.9	109.8	86.8	50.4	32.2	21.6	27.3	37.2	50.4	76.9	96.0	116.6	844
Rainfall	C	mm	71.2	50.4	68.3	82.7	102.2	93.7	121.5	120.8	89.2	86.8	71.7	77.3	1003.1
Effective Rainfall	D	mm	49.8	35.3	47.8	57.9	71.5	65.6	85.0	84.5	62.4	60.8	50.2	54.1	725
Direct Crop Coefficient	E		0.85	0.85	0.85	0.75	0.65	0.50	0.40	0.50	0.70	0.75	0.85	0.85	
Evapotranspiration (A x E)	F	mm	147.6	116.6	92.2	47.3	26.2	13.5	13.6	23.3	44.1	72.1	102.0	123.8	
Irrigation Requirement (F - D)	G	mm	98	81	44	0	0	0	0	0	0	11	52	70	356
Net Lagoon Evaporation	H	kL	1354	1187	371	-647	-1399	-1441	-1884	-1672	-775	-199	487	785	-3834
Wastewater Flow	I	kL	5860	5933	6935	6115	6774	6064	4275	4987	4885	5477	5861	6072	69239
Net Lagoon Inflow (I + H)	J	kL	4507	4746	6564	6762	8173	7505	6159	6658	5660	5676	5374	5287	73073
Water Used in Irrigation (G x Irrigation Area)	K	kL	20040	16675	9115	0	0	0	0	0	0	2314	10630	14298	73073
Average Daily Irrigation Rate	L	kL/d	646	596	294	0	0	0	0	0	0	75	354	461	
Cumulative Storage (Storage in Previous Month + J - K)	M	kL	14480	2551	0	6762	14935	22440	28599	35257	40918	44280	39024	30013	
Lagoon Depth	N	m	0.7	0.1	0.0	0.3	0.7	1.1	1.4	1.8	2.0	2.2	2.0	1.5	

Lagoon (reuse dam) Area	ha	2
Assume Effective Rainfall Factor		0.70
Irrigation Area Required	ha	**20.5**
Lagoon Volume Required	ML	**44.3**
Lagoon Depth	m	**2.2**

Notes:
Worksheet based on Water Budget Table "Guidelines for Wastewater Irrigation" Victorian EPA
Effective rainfall (ie that available for vegetation growth) is that which does not run off, or is intercepted by vegetation (leaves, branches etc) and is evaporated.
Direct crop coefficient is a factor relating crop water use to pan evaporation. Varies monthly and also depends on what crop is being irrigated - Pasture has been used in this scenario

Assumptions **Mean rainfall year**

Rainfall data obtained from Devonport Airport - BoM site no. 091126
Evaporation data obtained from Deloraine (ATHOL) - BoM site no. 091000

Average Wastewater flow of 80 ML/year based on projected monthly and annual production levels and monthly wastewater flows by Huon Aquaculture

		unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Evaporation (Pan)	**A**	mm	173.6	137.2	108.5	63	40.3	27	34.1	46.5	63	96.1	120	145.7	1055
Effective Lagoon Evaporation	**B**	mm	138.9	109.8	86.8	50.4	32.2	21.6	27.3	37.2	50.4	76.9	96.0	116.6	844
Rainfall	**C**	mm	43.4	36.1	48.4	59.5	75.6	78	97.3	90.7	75.3	62.9	56.8	53.1	777
Effective Rainfall	**D**	mm	30.4	25.3	33.9	41.7	52.9	54.6	68.1	63.5	52.7	44.0	39.8	37.2	544
Direct Crop Coefficient	**E**		0.85	0.85	0.85	0.75	0.65	0.50	0.40	0.50	0.70	0.75	0.85	0.85	
Evapotranspiration (A x E)	**F**	mm	147.6	116.6	92.2	47.3	26.2	13.5	13.6	23.3	44.1	72.1	102.0	123.8	
Irrigation Requirement (F - D)	**G**	mm	117	91	58	6	0	0	0	0	0	28	62	87	449
Net Lagoon Evaporation	**H**	kL	1910	1473	768	-182	-867	-1128	-1400	-1070	-498	280	784	1269	1338
Wastewater Flow	**I**	kL	6518	5989	6402	5289	5513	4717	5809	6884	6671	6977	7133	9261	77164
Net Lagoon Inflow (I + H)	**J**	kL	4609	4515	5634	5471	6380	5845	7210	7954	7169	6698	6349	7992	75826
Water Used in Irrigation (G x Irrigation Area)	**K**	kL	19770	15412	9844	945	0	0	0	0	0	4732	10501	14623	75826
Average Daily Irrigation Rate	**L**	kL/d	638	550	318	31	0	0	0	0	0	153	350	472	
Cumulative Storage (Storage in Previous Month + J - K)	**M**	kL	15106	4210	0	4526	10906	16751	23960	31915	39084	41050	36898	30267	
Lagoon Depth	**N**	m	0.8	0.2	0.0	0.2	0.5	0.8	1.2	1.6	2.0	2.1	1.8	1.5	

Lagoon (reuse dam) Area	ha	2
Assume Effective Rainfall Factor		0.70
Irrigation Area Required	ha	**16.9**
Lagoon Volume Required	ML	**41.0**
Lagoon Depth	m	**2.1**

Notes:
Worksheet based on Water Budget Table "Guidelines for Wastewater Irrigation" Victorian EPA
Effective rainfall (ie that available for vegetation growth) is that which does not run off, or is intercepted by vegetation (leaves, branches etc) and is evaporated.
Direct crop coefficient is a factor relating crop water use to pan evaporation. Varies monthly and also depends on what crop is being irrigated - Pasture has been used in this scenario

Assumptions **90th percentile rainfall (wet year)**

Rainfall data obtained from: Devonport Airport - BoM site no. 091126
Evaporation data obtained from: Deloraine (ATHOL) - BoM site no. 091000

Average Wastewater flow of 80 ML/year based on projected monthly and annual production levels and monthly wastewater flows by Huon Aquaculture

		unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Evaporation (Pan)	A	mm	173.6	137.2	108.5	63	40.3	27	34.1	46.5	63	96.1	120	145.7	1055
Effective Lagoon Evaporation	B	mm	138.9	109.8	86.8	50.4	32.2	21.6	27.3	37.2	50.4	76.9	96.0	116.6	844
Rainfall	C	mm	71.2	50.4	68.3	82.7	102.2	93.7	121.5	120.8	89.2	86.8	71.7	77.3	1003.1
Effective Rainfall	D	mm	49.8	35.3	47.8	57.9	71.5	65.6	85.0	84.5	62.4	60.8	50.2	54.1	725
Direct Crop Coefficient	E		0.85	0.85	0.85	0.75	0.65	0.50	0.40	0.50	0.70	0.75	0.85	0.85	
Evapotranspiration (A x E)	F	mm	147.6	116.6	92.2	47.3	26.2	13.5	13.6	23.3	44.1	72.1	102.0	123.8	
Irrigation Requirement (F - D)	G	mm	98	81	44	0	0	0	0	0	0	11	52	70	356
Net Lagoon Evaporation	H	kL	1354	1187	371	-647	-1399	-1441	-1884	-1672	-775	-199	487	785	-3834
Wastewater Flow	I	kL	6518	5989	6402	5289	5513	4717	5809	6884	6671	6977	7133	9261	77164
Net Lagoon Inflow (I + H)	J	kL	5165	4802	6031	5935	6911	6158	7693	8556	7446	7177	6647	8476	80998
Water Used in Irrigation (G x Irrigation Area)	K	kL	22213	18484	10104	0	0	0	0	0	0	2565	11783	15849	80998
Average Daily Irrigation Rate	L	kL/d	717	660	326	0	0	0	0	0	0	83	393	511	
Cumulative Storage (Storage in Previous Month + J - K)	M	kL	17754	4073	0	5935	12847	19005	26698	35254	42700	47312	42175	34803	
Lagoon Depth	N	m	0.9	0.2	0.0	0.3	0.6	1.0	1.3	1.8	2.1	2.4	2.1	1.7	

Lagoon (reuse dam) Area	ha	2
Assume Effective Rainfall Factor		0.70
Irrigation Area Required	ha	**22.7**
Lagoon Volume Required	ML	**47.3**
Lagoon Depth	m	**2.4**

Notes:
Worksheet based on Water Budget Table "Guidelines for Wastewater Irrigation" Victorian EPA
Effective rainfall (ie that available for vegetation growth) is that which does not run off, or is intercepted by vegetation (leaves, branches etc) and is evaporated.
Direct crop coefficient is a factor relating crop water use to pan evaporation. Varies monthly and also depends on what crop is being irrigated - Pasture has been used in this scenario

Assumptions **Mean rainfall year**

Rainfall data obtained from Devonport Airport - BoM site no. 091126
Evaporation data obtained from Deloraine (ATHOL) - BoM site no. 091000

Average Wastewater flow of 90 ML/year based on projected monthly and annual production levels and monthly wastewater flows by Huon Aquaculture

		unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Evaporation (Pan)	**A**	mm	173.6	137.2	108.5	63	40.3	27	34.1	46.5	63	96.1	120	145.7	1055
Effective Lagoon Evaporation	**B**	mm	138.9	109.8	86.8	50.4	32.2	21.6	27.3	37.2	50.4	76.9	96.0	116.6	844
Rainfall	**C**	mm	43.4	36.1	48.4	59.5	75.6	78	97.3	90.7	75.3	62.9	56.8	53.1	777
Effective Rainfall	**D**	mm	30.4	25.3	33.9	41.7	52.9	54.6	68.1	63.5	52.7	44.0	39.8	37.2	544
Direct Crop Coefficient	**E**		0.85	0.85	0.85	0.75	0.65	0.50	0.40	0.50	0.70	0.75	0.85	0.85	
Evapotranspiration (A x E)	**F**	mm	147.6	116.6	92.2	47.3	26.2	13.5	13.6	23.3	44.1	72.1	102.0	123.8	
Irrigation Requirement (F - D)	**G**	mm	117	91	58	6	0	0	0	0	0	28	62	87	449
Net Lagoon Evaporation	**H**	kL	1910	1473	768	-182	-867	-1128	-1400	-1070	-498	280	784	1269	1338
Wastewater Flow	**I**	kL	7759	7827	8321	7339	8200	7392	5755	6990	6876	7463	7757	8079	89760
Net Lagoon Inflow (I + H)	**J**	kL	5850	6354	7553	7521	9067	8520	7155	8060	7374	7184	6973	6810	88422
Water Used in Irrigation (G x Irrigation Area)	**K**	kL	23054	17972	11479	1102	0	0	0	0	0	5518	12245	17053	88422
Average Daily Irrigation Rate	**L**	kL/d	744	642	370	37	0	0	0	0	0	178	408	550	
Cumulative Storage (Storage in Previous Month + J - K)	**M**	kL	15544	3925	0	6420	15486	24007	31162	39222	46596	48262	42990	32748	
Lagoon Depth	**N**	m	0.8	0.2	0.0	0.3	0.8	1.2	1.6	2.0	2.3	2.4	2.1	1.6	

Lagoon (reuse dam) Area	ha	2
Assume Effective Rainfall Factor		0.70
Irrigation Area Required	ha	**19.7**
Lagoon Volume Required	ML	**48.3**
Lagoon Depth	m	**2.4**

Notes:
Worksheet based on Water Budget Table "Guidelines for Wastewater Irrigation" Victorian EPA
Effective rainfall (ie that available for vegetation growth) is that which does not run off, or is intercepted by vegetation (leaves, branches etc) and is evaporated.
Direct crop coefficient is a factor relating crop water use to pan evaporation. Varies monthly and also depends on what crop is being irrigated - Pasture has been used in this scenario

Assumptions: **90th percentile rainfall (wet year)**

Rainfall data obtained from: Devonport Airport - BoM site no. 091126
Evaporation data obtained from: Deloraine (ATHOL) - BoM site no. 091000

Average Wastewater flow of 90 ML/year based on projected monthly and annual production levels and monthly wastewater flows by Huon Aquaculture

		unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Evaporation (Pan)	**A**	mm	173.6	137.2	108.5	63	40.3	27	34.1	46.5	63	96.1	120	145.7	1055
Effective Lagoon Evaporation	**B**	mm	138.9	109.8	86.8	50.4	32.2	21.6	27.3	37.2	50.4	76.9	96.0	116.6	844
Rainfall	**C**	mm	71.2	50.4	68.3	82.7	102.2	93.7	121.5	120.8	89.2	86.8	71.7	77.3	1003.1
Effective Rainfall	**D**	mm	49.8	35.3	47.8	57.9	71.5	65.6	85.0	84.5	62.4	60.8	50.2	54.1	725
Direct Crop Coefficient	**E**		0.85	0.85	0.85	0.75	0.65	0.50	0.40	0.50	0.70	0.75	0.85	0.85	
Evapotranspiration (A x E)	**F**	mm	147.6	116.6	92.2	47.3	26.2	13.5	13.6	23.3	44.1	72.1	102.0	123.8	
Irrigation Requirement (F - D)	**G**	mm	98	81	44	0	0	0	0	0	0	11	52	70	356
Net Lagoon Evaporation	**H**	kL	1354	1187	371	-647	-1399	-1441	-1884	-1672	-775	-199	487	785	-3834
Wastewater Flow	**I**	kL	7759	7827	8321	7339	8200	7392	5755	6990	6876	7463	7757	8079	89760
Net Lagoon Inflow (I + H)	**J**	kL	6406	6641	7950	7986	9598	8834	7639	8662	7652	7662	7270	7294	93594
Water Used in Irrigation (G x Irrigation Area)	**K**	kL	25668	21358	11675	0	0	0	0	0	0	2964	13616	18314	93594
Average Daily Irrigation Rate	**L**	kL/d	828	763	377	0	0	0	0	0	0	96	454	591	
Cumulative Storage (Storage in Previous Month + J - K)	**M**	kL	18442	3724	0	7986	17584	26418	34057	42719	50370	55069	48723	37704	
Lagoon Depth	**N**	m	0.9	0.2	0.0	0.4	0.9	1.3	1.7	2.1	2.5	2.8	2.4	1.9	

Lagoon (reuse dam) Area	ha	2
Assume Effective Rainfall Factor		0.70
Irrigation Area Required	ha	**26.3**
Lagoon Volume Required	ML	**55.1**
Lagoon Depth	m	**2.8**

Notes:
Worksheet based on Water Budget Table "Guidelines for Wastewater Irrigation" Victorian EPA
Effective rainfall (ie that available for vegetation growth) is that which does not run off, or is intercepted by vegetation (leaves, branches etc) and is evaporated.
Direct crop coefficient is a factor relating crop water use to pan evaporation. Varies monthly and also depends on what crop is being irrigated - Pasture has been used in this scenario

Assumptions — **Mean rainfall year**

Rainfall data obtained from: Devonport Airport - BoM site no. 091126
Evaporation data obtained from: Deloraine (ATHOL) - BoM site no. 091000

Average Wastewater flow of 100 ML/year based on projected monthly and annual production levels and monthly wastewater flows by Huon Aquaculture

		unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Evaporation (Pan)	**A**	mm	173.6	137.2	108.5	63	40.3	27	34.1	46.5	63	96.1	120	145.7	1055
Effective Lagoon Evaporation	**B**	mm	138.9	109.8	86.8	50.4	32.2	21.6	27.3	37.2	50.4	76.9	96.0	116.6	844
Rainfall	**C**	mm	43.4	36.1	48.4	59.5	75.6	78	97.3	90.7	75.3	62.9	56.8	53.1	777
Effective Rainfall	**D**	mm	30.4	25.3	33.9	41.7	52.9	54.6	68.1	63.5	52.7	44.0	39.8	37.2	544
Direct Crop Coefficient	**E**		0.85	0.85	0.85	0.75	0.65	0.50	0.40	0.50	0.70	0.75	0.85	0.85	
Evapotranspiration (A x E)	**F**	mm	147.6	116.6	92.2	47.3	26.2	13.5	13.6	23.3	44.1	72.1	102.0	123.8	
Irrigation Requirement (F - D)	**G**	mm	117	91	58	6	0	0	0	0	0	28	62	87	449
Net Lagoon Evaporation	**H**	kL	1910	1473	768	-182	-867	-1128	-1400	-1070	-498	280	784	1269	1338
Wastewater Flow	**I**	kL	8734	8799	9484	8262	9191	8309	7025	7885	7771	8404	8726	9055	101646
Net Lagoon Inflow (I + H)	**J**	kL	6824	7326	8716	8444	10058	9437	8426	8955	8269	8125	7942	7786	100308
Water Used in Irrigation (G x Irrigation Area)	**K**	kL	26153	20388	13022	1250	0	0	0	0	0	6259	13891	19345	100308
Average Daily Irrigation Rate	**L**	kL/d	844	728	420	42	0	0	0	0	0	202	463	624	
Cumulative Storage (Storage in Previous Month + J - K)	**M**	kL	17368	4306	0	7195	17252	26690	35115	44070	52339	54204	48255	36697	
Lagoon Depth	**N**	m	0.9	0.2	0.0	0.4	0.9	1.3	1.8	2.2	2.6	2.7	2.4	1.8	

Lagoon (reuse dam) Area	ha	2
Assume Effective Rainfall Factor		0.70
Irrigation Area Required	ha	**22.3**
Lagoon Volume Required	ML	**54.2**
Lagoon Depth	m	**2.7**

Notes:
Worksheet based on Water Budget Table "Guidelines for Wastewater Irrigation" Victorian EPA
Effective rainfall (ie that available for vegetation growth) is that which does not run off, or is intercepted by vegetation (leaves, branches etc) and is evaporated.
Direct crop coefficient is a factor relating crop water use to pan evaporation. Varies monthly and also depends on what crop is being irrigated - Pasture has been used in this scenario

Assumptions: **90th percentile rainfall (wet year)**

Rainfall data obtained from: Devonport Airport - BoM site no. 091126
Evaporation data obtained from: Deloraine (ATHOL) - BoM site no. 091000

Average Wastewater flow of 100 ML/year based on projected monthly and annual production levels and monthly wastewater flows by Huon Aquaculture

		unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Evaporation (Pan)	**A**	mm	173.6	137.2	108.5	63	40.3	27	34.1	46.5	63	96.1	120	145.7	1055
Effective Lagoon Evaporation	**B**	mm	138.9	109.8	86.8	50.4	32.2	21.6	27.3	37.2	50.4	76.9	96.0	116.6	844
Rainfall	**C**	mm	71.2	50.4	68.3	82.7	102.2	93.7	121.5	120.8	89.2	86.8	71.7	77.3	1003.1
Effective Rainfall	**D**	mm	49.8	35.3	47.8	57.9	71.5	65.6	85.0	84.5	62.4	60.8	50.2	54.1	725
Direct Crop Coefficient	**E**		0.85	0.85	0.85	0.75	0.65	0.50	0.40	0.50	0.70	0.75	0.85	0.85	
Evapotranspiration (A x E)	**F**	mm	147.6	116.6	92.2	47.3	26.2	13.5	13.6	23.3	44.1	72.1	102.0	123.8	
Irrigation Requirement (F - D)	**G**	mm	98	81	44	0	0	0	0	0	0	11	52	70	356
Net Lagoon Evaporation	**H**	kL	1354	1187	371	-647	-1399	-1441	-1884	-1672	-775	-199	487	785	-3834
Wastewater Flow	**I**	kL	8734	8799	9484	8262	9191	8309	7025	7885	7771	8404	8726	9055	101646
Net Lagoon Inflow (I + H)	**J**	kL	7380	7612	9113	8909	10590	9750	8909	9556	8546	8604	8239	8271	105480
Water Used in Irrigation (G x Irrigation Area)	**K**	kL	28927	24071	13157	0	0	0	0	0	0	3340	15345	20639	105480
Average Daily Irrigation Rate	**L**	kL/d	933	860	424	0	0	0	0	0	0	108	511	666	
Cumulative Storage (Storage in Previous Month + J - K)	**M**	kL	20503	4044	0	8909	19499	29249	38158	47714	56261	61524	54418	42050	
Lagoon Depth	**N**	m	1.0	0.2	0.0	0.4	1.0	1.5	1.9	2.4	2.8	3.1	2.7	2.1	

Lagoon (reuse dam) Area	ha	2
Assume Effective Rainfall Factor		0.70
Irrigation Area Required	ha	**29.6**
Lagoon Volume Required	ML	**61.5**
Lagoon Depth	m	**3.1**

Notes:
Worksheet based on Water Budget Table "Guidelines for Wastewater Irrigation" Victorian EPA
Effective rainfall (ie that available for vegetation growth) is that which does not run off, or is intercepted by vegetation (leaves, branches etc) and is evaporated.
Direct crop coefficient is a factor relating crop water use to pan evaporation. Varies monthly and also depends on what crop is being irrigated - Pasture has been used in this scenario

Assumptions **Mean rainfall year**

Rainfall data obtained from Devonport Airport - BoM site no. 091126
Evaporation data obtained from Deloraine (ATHOL) - BoM site no. 091000

Average Wastewater flow of 110 ML/year based on projected monthly and annual production levels and monthly wastewater flows by Huon Aquaculture

		unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Evaporation (Pan)	A	mm	173.6	137.2	108.5	63	40.3	27	34.1	46.5	63	96.1	120	145.7	1055
Effective Lagoon Evaporation	B	mm	138.9	109.8	86.8	50.4	32.2	21.6	27.3	37.2	50.4	76.9	96.0	116.6	844
Rainfall	C	mm	43.4	36.1	48.4	59.5	75.6	78	97.3	90.7	75.3	62.9	56.8	53.1	777
Effective Rainfall	D	mm	30.4	25.3	33.9	41.7	52.9	54.6	68.1	63.5	52.7	44.0	39.8	37.2	544
Direct Crop Coefficient	E		0.85	0.85	0.85	0.75	0.65	0.50	0.40	0.50	0.70	0.75	0.85	0.85	
Evapotranspiration (A x E)	F	mm	147.6	116.6	92.2	47.3	26.2	13.5	13.6	23.3	44.1	72.1	102.0	123.8	
Irrigation Requirement (F - D)	G	mm	117	91	58	6	0	0	0	0	0	28	62	87	449
Net Lagoon Evaporation	H	kL	1910	1473	768	-182	-867	-1128	-1400	-1070	-498	280	784	1269	1338
Wastewater Flow	I	kL	9744	9814	9772	8046	9515	8550	7922	8811	8687	9386	9734	10060	110040
Net Lagoon Inflow (I + H)	J	kL	7834	8341	9004	8228	10382	9678	9322	9881	9185	9106	8950	8791	108702
Water Used in Irrigation (G x Irrigation Area)	K	kL	28342	22094	14112	1354	0	0	0	0	0	6783	15054	20964	108702
Average Daily Irrigation Rate	L	kL/d	914	789	455	45	0	0	0	0	0	219	502	676	
Cumulative Storage (Storage in Previous Month + J - K)	M	kL	18861	5108	0	6873	17255	26933	36255	46136	55321	57644	51541	39368	
Lagoon Depth	N	m	0.6	0.2	0.0	0.2	0.6	0.9	1.2	1.5	1.8	1.9	1.7	1.3	

Lagoon (reuse dam) Area	ha	3
Assume Effective Rainfall Factor		0.70
Irrigation Area Required	ha	**24.2**
Lagoon Volume Required	ML	**57.6**
Lagoon Depth	m	**1.9**

Notes:
Worksheet based on Water Budget Table "Guidelines for Wastewater Irrigation" Victorian EPA
Effective rainfall (ie that available for vegetation growth) is that which does not run off, or is intercepted by vegetation (leaves, branches etc) and is evaporated.
Direct crop coefficient is a factor relating crop water use to pan evaporation. Varies monthly and also depends on what crop is being irrigated - Pasture has been used in this scenario

Assumptions **90th percentile rainfall (wet year)**

Rainfall data obtained from: Devonport Airport - BoM site no. 091126
Evaporation data obtained from: Deloraine (ATHOL) - BoM site no. 091000

Average Wastewater flow of 110 ML/year based on projected monthly and annual production levels and monthly wastewater flows by Huon Aquaculture

		unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Evaporation (Pan)	A	mm	173.6	137.2	108.5	63	40.3	27	34.1	46.5	63	96.1	120	145.7	1055
Effective Lagoon Evaporation	B	mm	138.9	109.8	86.8	50.4	32.2	21.6	27.3	37.2	50.4	76.9	96.0	116.6	844
Rainfall	C	mm	71.2	50.4	68.3	82.7	102.2	93.7	121.5	120.8	89.2	86.8	71.7	77.3	1003.1
Effective Rainfall	D	mm	49.8	35.3	47.8	57.9	71.5	65.6	85.0	84.5	62.4	60.8	50.2	54.1	725
Direct Crop Coefficient	E		0.85	0.85	0.85	0.75	0.65	0.50	0.40	0.50	0.70	0.75	0.85	0.85	
Evapotranspiration (A x E)	F	mm	147.6	116.6	92.2	47.3	26.2	13.5	13.6	23.3	44.1	72.1	102.0	123.8	
Irrigation Requirement (F - D)	G	mm	98	81	44	0	0	0	0	0	0	11	52	70	356
Net Lagoon Evaporation	H	kL	1354	1187	371	-647	-1399	-1441	-1884	-1672	-775	-199	487	785	-3834
Wastewater Flow	I	kL	9744	9814	9772	8046	9515	8550	7922	8811	8687	9386	9734	10060	110040
Net Lagoon Inflow (I + H)	J	kL	8390	8628	9401	8693	10913	9991	9806	10483	9462	9585	9247	9275	113874
Water Used in Irrigation (G x Irrigation Area)	K	kL	31229	25986	14205	0	0	0	0	0	0	3606	16566	22282	113874
Average Daily Irrigation Rate	L	kL/d	1007	928	458	0	0	0	0	0	0	116	552	719	
Cumulative Storage (Storage in Previous Month + J - K)	M	kL	22162	4804	0	8693	19606	29597	39403	49885	59348	65326	58008	45001	
Lagoon Depth	N	m	1.1	0.2	0.0	0.4	1.0	1.5	2.0	2.5	3.0	3.3	2.9	2.3	

Lagoon (reuse dam) Area	ha	2
Assume Effective Rainfall Factor		0.70
Irrigation Area Required	ha	**32.0**
Lagoon Volume Required	ML	**65.3**
Lagoon Depth	m	**3.3**

Notes:
Worksheet based on Water Budget Table "Guidelines for Wastewater Irrigation" Victorian EPA
Effective rainfall (ie that available for vegetation growth) is that which does not run off, or is intercepted by vegetation (leaves, branches etc) and is evaporated.
Direct crop coefficient is a factor relating crop water use to pan evaporation. Varies monthly and also depends on what crop is being irrigated - Pasture has been used in this scenario

Assumptions **Mean rainfall year**

Rainfall data obtained from Devonport Airport - BoM site no. 091126
Evaporation data obtained from Deloraine (ATHOL) - BoM site no. 091000

Average Wastewater flow of 112 ML/year based on projected monthly and annual production levels and monthly wastewater flows by Huon Aquaculture

		unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Evaporation (Pan)	A	mm	173.6	137.2	108.5	63	40.3	27	34.1	46.5	63	96.1	120	145.7	1055
Effective Lagoon Evaporation	B	mm	138.9	109.8	86.8	50.4	32.2	21.6	27.3	37.2	50.4	76.9	96.0	116.6	844
Rainfall	C	mm	43.4	36.1	48.4	59.5	75.6	78	97.3	90.7	75.3	62.9	56.8	53.1	777
Effective Rainfall	D	mm	30.4	25.3	33.9	41.7	52.9	54.6	68.1	63.5	52.7	44.0	39.8	37.2	544
Direct Crop Coefficient	E		0.85	0.85	0.85	0.75	0.65	0.50	0.40	0.50	0.70	0.75	0.85	0.85	
Evapotranspiration (A x E)	F	mm	147.6	116.6	92.2	47.3	26.2	13.5	13.6	23.3	44.1	72.1	102.0	123.8	
Irrigation Requirement (F - D)	G	mm	117	91	58	6	0	0	0	0	0	28	62	87	449
Net Lagoon Evaporation	H	kL	1910	1473	768	-182	-867	-1128	-1400	-1070	-498	280	784	1269	1338
Wastewater Flow	I	kL	9921	9993	9950	8192	9688	8705	8066	8971	8845	9556	9911	10243	112041
Net Lagoon Inflow (I + H)	J	kL	8012	8520	9182	8374	10555	9833	9466	10041	9343	9277	9127	8974	110703
Water Used in Irrigation (G x Irrigation Area)	K	kL	28863	22501	14371	1379	0	0	0	0	0	6908	15331	21349	110703
Average Daily Irrigation Rate	L	kL/d	931	804	464	46	0	0	0	0	0	223	511	689	
Cumulative Storage (Storage in Previous Month + J - K)	M	kL	19171	5190	0	6995	17549	27383	36849	46890	56233	58602	52399	40023	
Lagoon Depth	N	m	0.6	0.2	0.0	0.2	0.6	0.9	1.2	1.6	1.9	2.0	1.7	1.3	

Lagoon (reuse dam) Area	ha	3
Assume Effective Rainfall Factor		0.70
Irrigation Area Required	ha	**24.6**
Lagoon Volume Required	ML	**58.6**
Lagoon Depth	m	**2.0**

Notes:
Worksheet based on Water Budget Table "Guidelines for Wastewater Irrigation" Victorian EPA
Effective rainfall (ie that available for vegetation growth) is that which does not run off, or is intercepted by vegetation (leaves, branches etc) and is evaporated.
Direct crop coefficient is a factor relating crop water use to pan evaporation. Varies monthly and also depends on what crop is being irrigated - Pasture has been used in this scenario

Assumptions **90th percentile rainfall (wet year)**

Rainfall data obtained from Devonport Airport - BoM site no. 091126
Evaporation data obtained from Deloraine (ATHOL) - BoM site no. 091000

Average Wastewater flow of 112 ML/year based on projected monthly and annual production levels and monthly wastewater flows by Huon Aquaculture

		unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Evaporation (Pan)	**A**	mm	173.6	137.2	108.5	63	40.3	27	34.1	46.5	63	96.1	120	145.7	1055
Effective Lagoon Evaporation	**B**	mm	138.9	109.8	86.8	50.4	32.2	21.6	27.3	37.2	50.4	76.9	96.0	116.6	844
Rainfall	**C**	mm	69.34	48.97	66.27	80.20	99.44	90.83	118.02	118.24	86.27	84.62	69.57	75.33	1003.1
Effective Rainfall	**D**	mm	48.5	34.3	46.4	56.1	69.6	63.6	82.6	82.8	60.4	59.2	48.7	52.7	705
Direct Crop Coefficient	**E**		0.85	0.85	0.85	0.75	0.65	0.50	0.40	0.50	0.70	0.75	0.85	0.85	
Evapotranspiration (A x E)	**F**	mm	147.6	116.6	92.2	47.3	26.2	13.5	13.6	23.3	44.1	72.1	102.0	123.8	
Irrigation Requirement (F - D)	**G**	mm	99	82	46	0	0	0	0	0	0	13	53	71	364
Net Lagoon Evaporation	**H**	kL	1391	1216	411	-596	-1344	-1385	-1815	-1621	-717	-155	529	825	-3262
Wastewater Flow	**I**	kL	9921	9993	9950	8192	9688	8705	8066	8971	8845	9556	9911	10243	112041
Net Lagoon Inflow (I + H)	**J**	kL	8530	8777	9539	8788	11032	10090	9881	10592	9562	9711	9383	9418	115303
Water Used in Irrigation (G x Irrigation Area)	**K**	kL	31328	26050	14501	0	0	0	0	0	0	4063	16864	22498	115303
Average Daily Irrigation Rate	**L**	kL/d	1011	930	468	0	0	0	0	0	0	131	562	726	
Cumulative Storage (Storage in Previous Month + J - K)	**M**	kL	22235	4962	0	8788	19820	29910	39790	50382	59945	65593	58111	45032	
Lagoon Depth	**N**	m	1.1	0.2	0.0	0.4	1.0	1.5	2.0	2.5	3.0	3.3	2.9	2.3	

Lagoon (reuse dam) Area	ha	2
Assume Effective Rainfall Factor		0.70
Irrigation Area Required	ha	**31.6**
Lagoon Volume Required	ML	**65.6**
Lagoon Depth	m	**3.3**

Notes:
Worksheet based on Water Budget Table "Guidelines for Wastewater Irrigation" Victorian EPA
Effective rainfall (ie that available for vegetation growth) is that which does not run off, or is intercepted by vegetation (leaves, branches etc) and is evaporated.
Direct crop coefficient is a factor relating crop water use to pan evaporation. Varies monthly and also depends on what crop is being irrigated - Pasture has been used in this scenario

Appendix G: Crop irrigation requirement calculations

Crop water balance

Mean rainfall conditions

Climate Data Rainfall: Devonport Airport - BoM site no. 091126, Evaporation: Deloraine (ATHOL) - BoM site no. 091000

Mean rainfall conditions	Climatic Data (mm)												
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	TOTAL
A: Evaporation (mm)	34.1	46.5	63	96.1	120	145.7	173.6	137.2	108.5	63	40.3	27	**1055**
B: Rainfall (mm)	97.3	90.7	75.3	62.9	56.8	53.1	43.4	36.1	48.4	59.5	75.6	78	**777**
C: Effective Rainfall (mm) *(C = B x 0.7)*	68	63	53	44	40	37	30	25	34	42	53	55	544
D: Monthly Deficit (mm) *(D = A - C)*	-34	-17	10	52	80	109	143	112	75	21	-13	-28	511

Effective Rainfall: The amount of rain effectively penetrating the soil to become available to the plants. Allows for some runoff, drainage and evaporation losses.

Mean rainfall conditions	Estimated Water Requirement - **Pasture (best practice management)**												
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	TOTAL
E: Crop Factor	0.4	0.5	0.7	0.75	0.85	0.85	0.85	0.85	0.85	0.75	0.65	0.5	
F: Estimate ET *(F = A x E)*	13.6	23.3	44.1	72.1	102.0	123.8	147.6	116.6	92.2	47.3	26.2	13.5	822.3
G: Irrigation Requirement (mm) (G = F - C)	0.0	0.0	0.0	28.0	62.2	86.7	117.2	91.4	58.3	5.6	0.0	0.0	**449.4**
H: Irrigation Requirement (ML/ha)	0.0	0.0	0.0	0.3	0.6	0.9	1.2	0.9	0.6	0.1	0.0	0.0	4.5

90th percentile rainfall conditions

Climate Data Rainfall: Devonport Airport - BoM site no. 091126, Evaporation: Deloraine (ATHOL) - BoM site no. 091000

90th %ile rainfall conditions	Climatic Data (mm)												
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	TOTAL
A: Evaporation (mm)	34.1	46.5	63	96.1	120	145.7	173.6	137.2	108.5	63	40.3	27	**1055**
B: Rainfall (mm)	71	50	68	83	102	94	121	121	89	87	72	77	1003
C: Effective Rainfall (mm) *(C = B x 0.7)*	50	35	48	58	72	66	85	85	62	61	50	54	702
D: Monthly Deficit (mm) *(D = A - C)*	-16	11	15	38	48	80	89	53	46	2	-10	-27	353

Effective Rainfall: The amount of rain effectively penetrating the soil to become available to the plants. Allows for some runoff, drainage and evaporation losses.

90th %ile rainfall conditions	Estimated Water Requirement - **Pasture (best practice management)**												
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	TOTAL
E: Crop Factor	0.4	0.5	0.7	0.75	0.85	0.85	0.85	0.85	0.85	0.75	0.65	0.5	
F: Estimate ET *(F = A x E)*	13.6	23.3	44.1	72.1	102.0	123.8	147.6	116.6	92.2	47.3	26.2	13.5	822.3
G: Irrigation Requirement (mm) (G = F - C)	0.0	0.0	0.0	0.0	30.5	58.3	62.5	32.1	29.8	0.0	0.0	0.0	**213.2**
H: Irrigation Requirement (ML/ha)	0.0	0.0	0.0	0.0	0.3	0.6	0.6	0.3	0.3	0.0	0.0	0.0	2.1

10th percentile rainfall conditions

Climate Data Rainfall: Devonport Airport - BoM site no. 091126, Evaporation: Deloraine (ATHOL) - BoM site no. 091000

10th %ile rainfall conditions	Climatic Data (mm)												
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	TOTAL
A: Evaporation (mm)	34.1	46.5	63	96.1	120	145.7	173.6	137.2	108.5	63	40.3	27	**1055**
B: Rainfall (mm)	44.2	35.6	27.9	20.2	19.3	13.7	14.1	5	6.9	16.4	28.1	32.8	**264**
C: Effective Rainfall (mm) ***(C = B x 0.7)***	31	25	20	14	14	10	10	4	5	11	20	23	185
D: Monthly Deficit (mm) ***(D = A - C)***	3	22	43	82	106	136	164	134	104	52	21	4	870

Effective Rainfall: The amount of rain effectively penetrating the soil to become available to the plants. Allows for some runoff, drainage and evaporation losses.

10th %ile rainfall conditions	Estimated Water Requirement - Fodder crops												
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	TOTAL
E: Crop Factor	0.4	0.5	0.7	0.75	0.85	0.85	0.85	0.85	0.85	0.75	0.65	0.5	
F: Estimate ET ***(F = A x E)***	13.6	23.3	44.1	72.1	102.0	123.8	147.6	116.6	92.2	47.3	26.2	13.5	822.3
G: Irrigation Requirement (mm) (G = F - C)	0.0	0.0	24.6	57.9	88.5	114.3	137.7	113.1	87.4	35.8	6.5	0.0	**665.8**
H: Irrigation Requirement (ML/ha)	0.0	0.0	0.2	0.6	0.9	1.1	1.4	1.1	0.9	0.4	0.1	0.0	6.7

Land available for irrigation

	CP1	CP2	CP3	CP4	Total
Land well suitable for irrigation (ha)	28.5	10.6	10.1	10.5	59.7
Land marginally suitable for irrigation (ha)	0.0	5.3	3.4	0.0	8.7
Total irrigable land (ha)	28.5	16.0	13.5	10.5	68.4

Irrigation demand based on land available for irrigation

Mean rainfall	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	TOTAL
Land available for irrigation (ha)	0.0	0.0	0.0	59.7	68.4	68.4	68.4	68.4	68.4	0.0	0.0	0.0	
Irrigation demand (ML/ha)	0.0	0.0	0.0	0.3	0.6	0.9	1.2	0.9	0.6	0.1	0.0	0.0	4.5
Total irrigation demand (ML)	0.0	0.0	0.0	16.8	42.6	59.3	80.2	62.5	39.9	0.0	0.0	0.0	301.2

Based on marginally suited land to irrigation commencing irrigation in November

90th percentile rainfall	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	TOTAL
Land available for irrigation (ha)	0.0	0.0	0.0	0.0	59.7	68.4	68.4	68.4	68.4	0.0	0.0	0.0	
Irrigation demand (ML/ha)	0.0	0.0	0.0	0.0	0.3	0.6	0.6	0.3	0.3	0.0	0.0	0.0	2.1
Total irrigation demand (ML)	0.0	0.0	0.0	0.0	18.2	39.9	42.8	21.9	20.4	0.0	0.0	0.0	143.2

Based on marginally suited land to irrigation commencing irrigation in December

Mean rainfall	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	TOTAL
Land available for irrigation (ha)	0.0	0.0	59.7	59.7	68.4	68.4	68.4	68.4	68.4	59.7	59.7	0.0	
Irrigation demand (ML/ha)	0.0	0.0	0.2	0.6	0.9	1.1	1.4	1.1	0.9	0.4	0.1	0.0	6.7
Total irrigation demand (ML)	0.0	0.0	14.7	34.6	60.5	78.2	94.2	77.4	59.8	21.4	3.9	0.0	444.7

Based on marginally suited land to irrigation commencing irrigation in November

Summary of irrigation demand

	10th percentile rainfall	Mean rainfall	90th percentile rainfall
Irrigation demand (ML/ha)	6.7	4.5	2.1
Total irrigation demand (ML)	445	301	143

Appendix H: Layton's groundwater installation bore logs

HUON AQUACULTURE PTY LTD

PARRAMATTA CREEK GROUNDWATER MONITORING PROGRAM

SUMMARY REPORT ON BORE INSTALLATION

NOVEMBER 2018

Cover photo (6 November 2018)

View looking west over part of Layton's Farm at Parramatta Creek, showing KMR Drilling's *Explorer 50* rig drilling monitoring bore MW11 with a 150mm diameter solid auger.

Refer to this report as

Cromer, W. C. (2018). *Summary report on bore installation, Parramatta Creek Groundwater Monitoring Program.* Unpublished report for Huon Aquaculture Pty Ltd by William C. Cromer Pty. Ltd., 21 November 2018.

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1 INTRODUCTION

Huon Aquaculture Pty Ltd (Huon) is extending its groundwater monitoring program at Parramatta Creek near Devonport to include parts of Layton's Farm which adjoins its property.

William C Cromer Pty Ltd (WCC) was commissioned by Macquarie Franklin (Macfrank) on behalf of Huon to:

- visit the site and assist Macfrank's Senior Consultant Ryan Francis in the logging of the first of seven new groundwater bores,
- compile final logs sheets of the seven bores from field logs provided by Ryan Francis, and
- provide a hydrogeological summary of the drilling

2 RESULTS

Locations of existing monitoring bores, and the seven added in November 2018, are shown in the two site plans in Attachment 1. The second plan shows published geology, and inferred groundwater conditions, in relation to all bores.

Attachment 2 presents logs of the seven new bores, and photographs of drill cuttings from each.

Table 1 is a summary of relevant hydrogeological data from Attachments 1 and 2.

Table 1. Summary of the seven monitoring bores installed in November 2018

	MW8	MW9	MW10	MW11	MW12	MW13	MW14
Easting (GDA94)	461488	461923	461248	461116	460936	460899	461554
Northing (GDA94)	5423221	5423405	5424025	5424217	5424636	5424367	5422991
Date drilled	07-Nov-18	08-Nov-18	07-Nov-18	06-Nov-18	06-Nov-18	07-Nov-18	08-Nov-18
Depth (m)	4.4	3.8	6.7	4.2	6.0	5.35	6.0
Water struck (m)	c4	c3	c4	c3	c2	c2	c4
PVC casing diameter (mm)	50	50	50	50	50	50	50
PVC screen diameter (mm)	50	50	50	50	50	50	50
Screened interval (mbg)	1.4 – 4.4	1.5 – 3.9	1.7 – 6.7	1.22 – 4.22	2.0 – 6.0	2.35 – 5.35	2.0 – 6.0
Bailed volume (L) on completion)	25 in 8 mins	50 in 10 mins	ND	25 in 15 mins; bailed dry after 35L; recovery 1.1m in 3 mins	27 in 5 mins on 7 Nov 2018	70 in 20 mins	
SWL (mbg) on completion	1.9	1.9	ND	1.8	1.2	1.0	0.8
Field parameters							
EC µS/cm)	261	ND	ND	630	578	493	179
pH	5.81	ND	ND	6.0	6.1	6.36	6.3
Temperature (^{0}C)	15.4	ND	ND	16	10.9	13.9	13.3
Summary log (depths in m)	0-0.5 Clayey SILT; 0.5-1.5 Sandy CLAY; 1.5-2.2 CLAY; 2.2-4.4 CLAY with weathered mudstone chips	0 -1 CLAY; 1-2 SandyCLAY; 2-2.6 CLAY; 2.6-3.8 Sandy CLAY with weathered mudstone chips	0-0.5 SILT; 0.5-6.7 CLAY	0-0.3 Clayey SILT; 0.3-2 SiltyCLAY; 2-4.22 Sandy CLAY	0-0.5 Clayey SILT; 0.5-3.5 CLAY; 3.5-6.0 CLAY with weathered mudstone chips	0-0.5 SILT; 0.5-1 Sandy SILT; 1-1.5 Silty CLAY; 1.5-3 CLAY; 3-5.35 CLAY with weathered mudstone chips	0-0.5 SAND; 0.5-2 Sandy CLAY; 2-4 CLAY; 4-6 Silty sandy CLAY with weathered mudstone chips

Notes All holes drilled by KMR Drilling mbg = metres below ground EC = electrical conductivity

3 DISCUSSION

3.1 Geology

All bores passed through about 2m or so of unconsolidated materials, including mostly clay (with varying proportions of silt, sand and gravel) before encountering dark-coloured clay with weathered mudstone chips.

The surface two metres or so is interpreted as an in-situ weakly duplex soil profile (with perhaps an alluvial component in several low-lying bores near Parramatta Creek. The soil has developed on weathered mudstone bedrock of inferred Permian age, which would be in accord with the published geology.

3.2 Groundwater

3.2.1 Occurrence and discharge conditions

All bores encountered groundwater during drilling, at depths in the 2 – 4mbg[1] range in the soil profile and underlying weathered bedrock.

Depth to water after bore completion ranged from 0.8 – 1.9mbg. A continuous water table is probably present, and its shallowness indicates groundwater discharge (rather than recharge) conditions, as shown in Attachment 2.

3.2.1 Bore yield

Preliminary indications from bailing on hole completion are that yields in all bores are likely to be suitable for direct low-flow pumping for sampling purposes. It is understood that the bores will be further developed by pumping before (and separate from) the next groundwater monitoring event. This will provide a better indication of yield.

3.2.2 Groundwater quality

Field parameters obtained during bailing show some variability in electrical conductivity (EC).

- EC is in the 180 – 630µS/cm range in five bores, with the two lowest values (179 and 261µS/cm) from MW14 and MW8 respectively on elevated ground away from watercourses.
- pH shows relatively little variability, with a range of 5.8 – 6.4 (average 6.1).

[1] mbg = metres below ground

W. C. Cromer
Principal

This report is and must remain accompanied by the following Attachments:

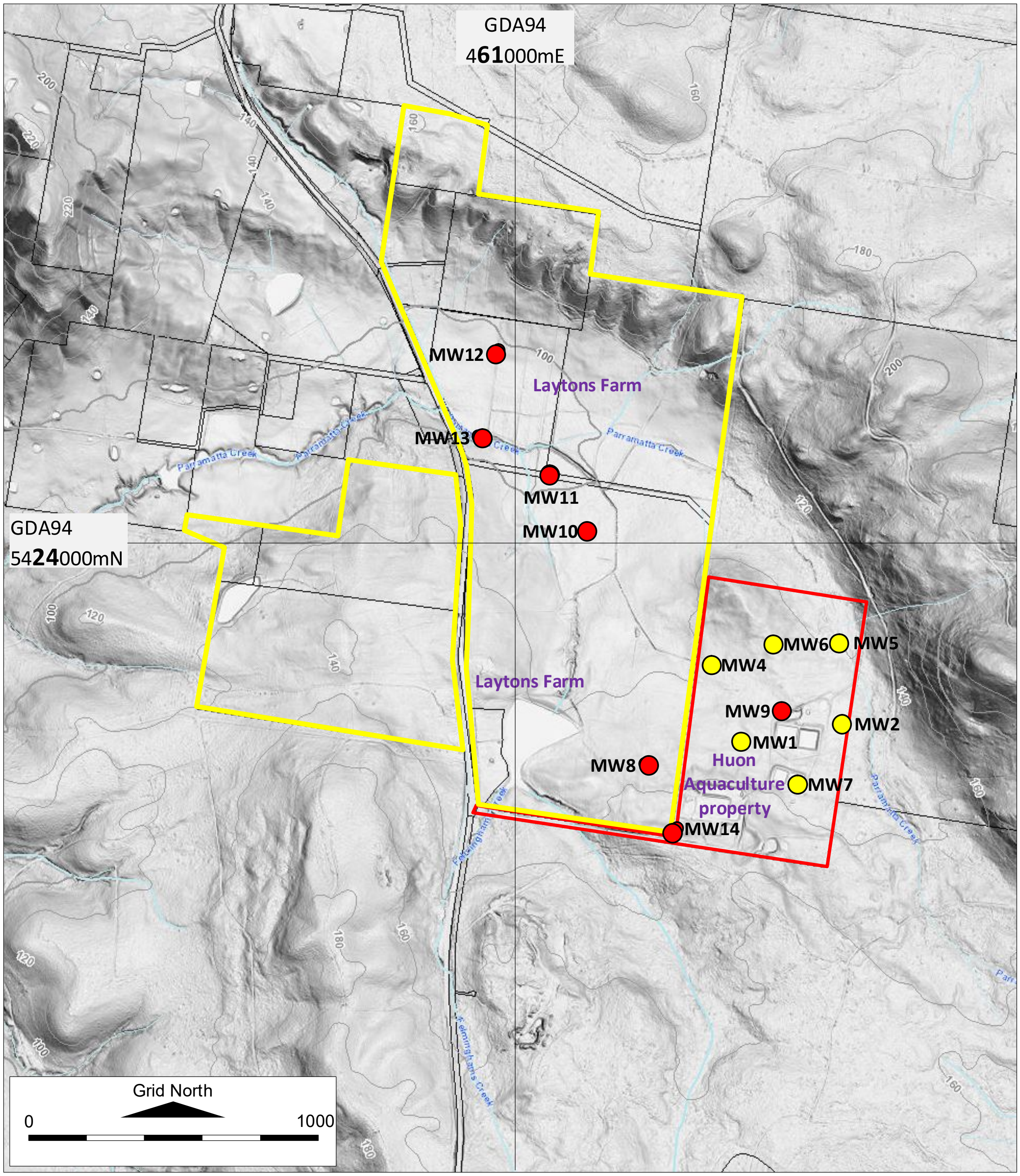
Attachment 1. Locations of existing and new monitoring bores at Parramatta Creek (1 page)
Attachment 2. Published geology, and inferred groundwater conditions, in relation to monitoring bores at Parramatta Creek (1 page)
Attachment 3. Logs and photographs of new monitoring bores MW8, MW9, MW10, MW11, MW12, MW13 and MW14 (15 pages)

Attachment 1

(1 page)

Locations of existing and new monitoring bores at Parramatta Creek

Source: www.theList.tas.gov.au



Huon Aquaculture, Parramatta Creek
Existing and proposed groundwater monitoring bores, hillside shading and cross sections A – B and C – D
William C Cromer Pty. Ltd. October 2018 Base map www.thelist.tas.gov.au

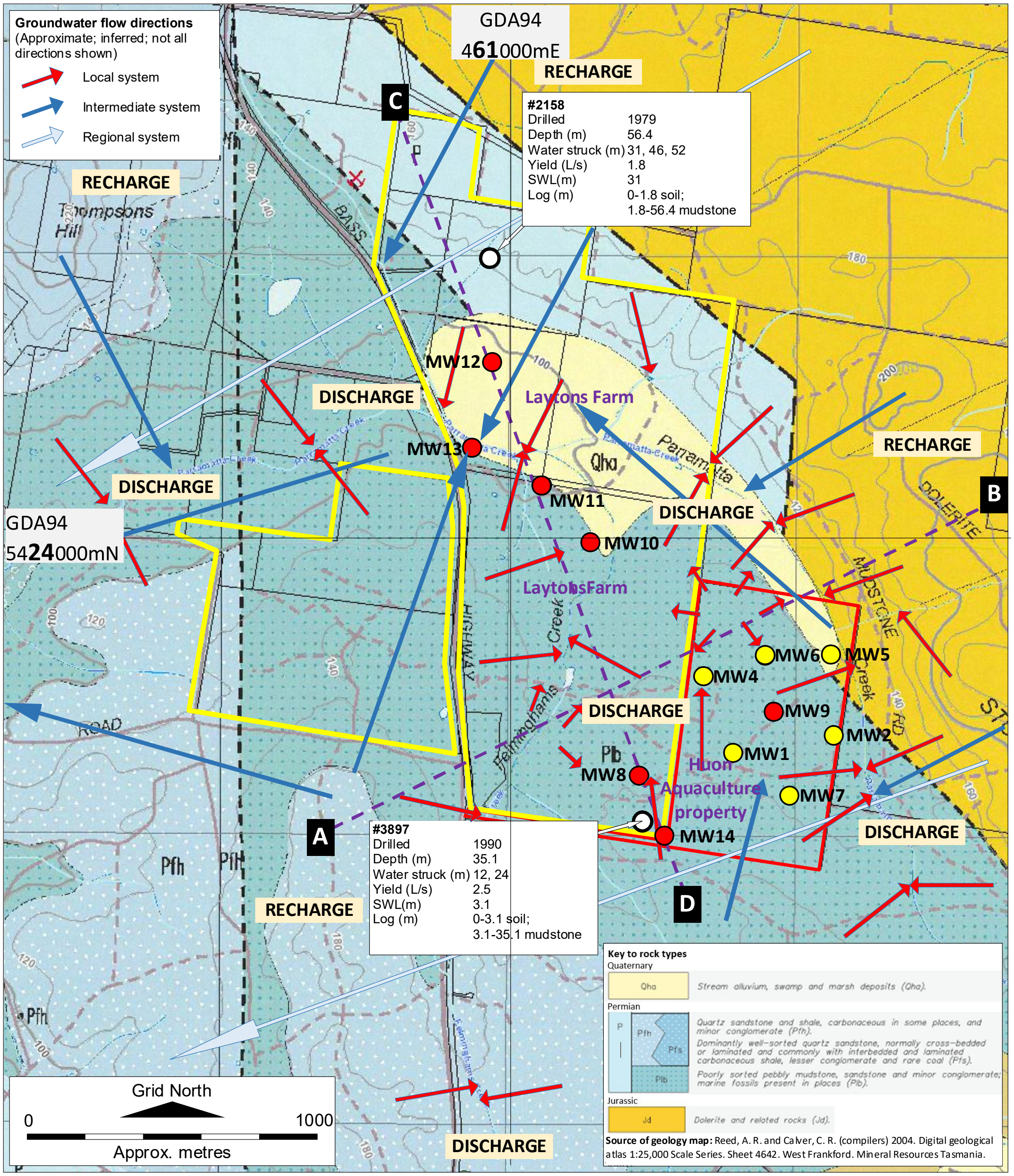
- Existing groundwater monitoring bore
- Groundwater monitoring bore installed Nov 2018

Attachment 2

(1 page)

Published geology, and inferred groundwater conditions, in relation to monitoring bores at Parramatta Creek

Source: www.theList.tas.gov.au



Huon Aquaculture, Parramatta Creek

Existing and proposed groundwater monitoring bores published geology and cross sections A – B and C – D

William C Cromer Pty. Ltd. October 2018 Base map www.thelist.tas.gov.au

- Existing groundwater monitoring bore
- Groundwater monitoring bore installed Nov 2018
- Pre-2000 private bores (location approx.)

Attachment 3

(15 pages including this page)

Logs and photographs of new monitoring bores
MW8, MW9, MW10, MW11, MW12, MW13 and MW14

These logs have been created from field logs provided by Senior Consultant Ryan Francis of Macfrank.
Mr. Francis also compiled the photographs of drill returns

William C. Cromer Pty. Ltd. Environmental, engineering and groundwater geologists

Borehole log for groundwater

ID MW8
Sheet 1 of 1

Project: Huon Aquaculture **Location: Laytons Farm**

Coordinates	461488mE, 5423221mN	**Drill type**	Explorer 50	**Hole started**	7 Nov 2018
				Hole finished	7 Nov 2018
Datum	GDA94	**Equipment**	150mm solid auger	**Drilled by**	KMR Drilling: Darren Richardson
RL	Not recorded				
Inclination	Vertical			**Logged by**	Ryan Francis
Bearing		**Drill fluid(s)**	None	**Checked by**	G. Bremner, W. Cromer

Bit type/size: Auger. Water: Water 1.9mbgl. Penetration: 1 2 3 4

Depth (m)	USCS Symbol	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency Dens Index	Structure, geology and interpretation
					+0.6magl stick-up
0–0.5	CL	Clayey SILT: grey; loamy	D	F	A horizon (topsoil) *0.3m concrete*
0.5–1.5	CH	Sandy CLAY: yellow; some gravel; medium plasticity	D - M	F - St	B horizon (subsoil) *0.9m bentonite* *1.4m start screen*
1.5–2.2	CL	CLAY: yellow; weathered mudstone angular chips	D	S	C/B horizon (weathered mudstone bedrock)
2.2–2.7	CL	CLAY; yellow-grey	D	S	
2.7–3.5	CH	CLAY: grey; weathered mudstone chips	D	S	
3.5–4.4	CH	CLAY: grey; weathered mudstone chips; high plasticity	M	F	*4.4m cap*
4.4		Refusal at 4.4mbgl in mudstone	M	H	Mudstone bedrock

CASING DETAILS:
Screen 1.4-4.4m
Sand/gravel 0.9-4.4m
Bentonite 0.3-0.9m
Concrete 0-0.3m
Collar 0.6magl

Water level: 1.9mbgl (16:10, 7/11/18)
Water bailed: 25L/8min (16:20, 7/11/18)
-pH: 5.81
-EC: 261µS
-temp: 15.4°

Casing details: *Hole completed with bottom capped screened 50mm C18 PVC casing 4.4-1.4m (slots 0.4mm); solid PVC 1.4 - 0.6magl stickup; 1-3mm gravel pack 4.4-0.9m; bentonite chips 0.9-0.3m; quick set concrete 0.3m to surface.*

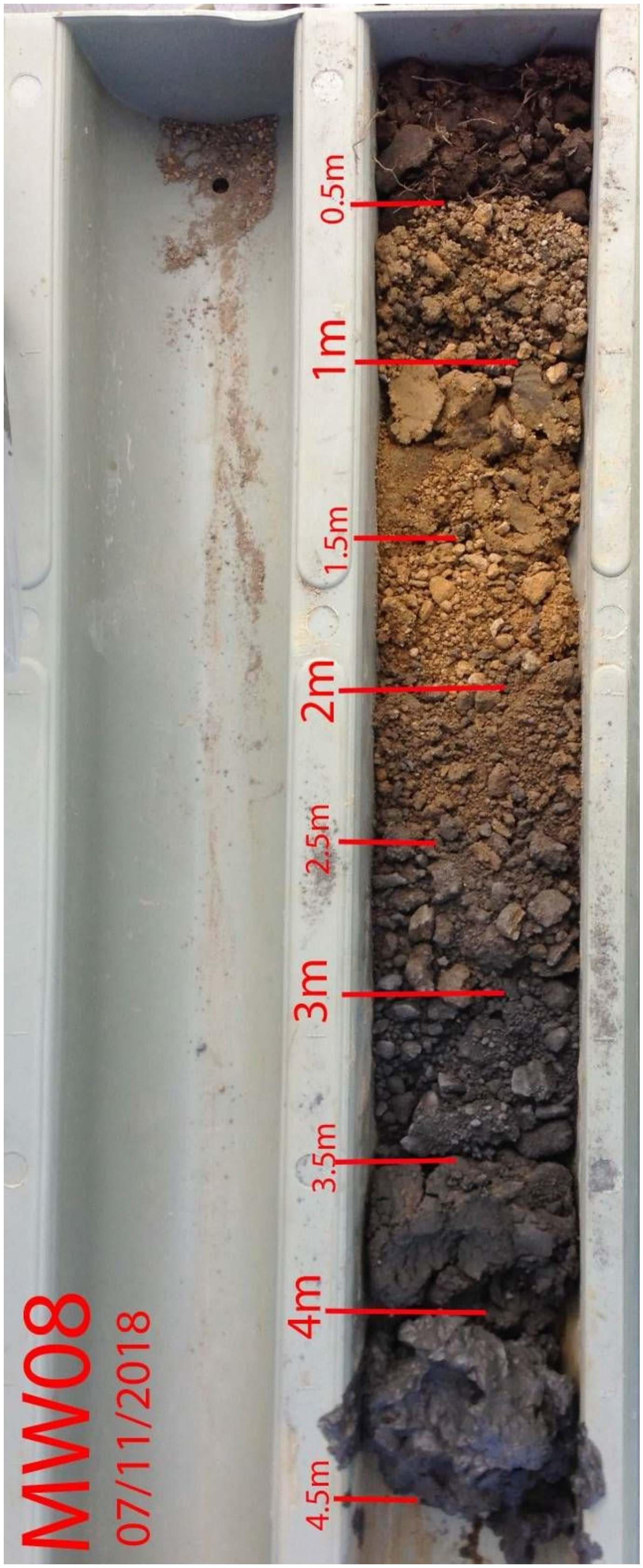
MOISTURE
D = Dry
M = Moist
W = Wet
mbgl = m below ground level
magl = m above ground level

WATER
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

PENETRATION
1 2 3 4
No resistance
Refusal

GRAPHIC LOG KEY
CLAY (CH, CI) SILT (SM) ROOTS COBBLES (63-200mm) BOULDERS (>200mm)
SAND (SP) GRAVEL (GP, GW FRACTURES

CONSISTENCY (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25 – 50kPa; easily penetrated by fist); F = Firm (50 – 100kPa; easily penetrated by thumb); St = Stiff (100 – 200kPa; indented by thumb, penetrated with difficulty); VSt = Very Stiff (200 – 400kPa; easily indented by thumbnail; H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail.
RELATIVE DENSITY (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense *picking); VD = Very dense (hard picking)


MW08
07/11/2018
0.5m
1m
1.5m
2m
2.5m
3m
3.5m
4m
4.5m

William C. Cromer Pty. Ltd. Environmental, engineering and groundwater geologists

Borehole log for groundwater

ID MW9
Sheet 1 of 1

Project: Huon Aquaculture
Location: Laytons Farm

Coordinates	461923mE, 5423405mN	**Drill type**	Explorer 50	**Hole started**	8 Nov 2018
				Hole finished	8 Nov 2018
Datum	GDA94	**Equipment**	150mm solid auger	**Drilled by**	KMR Drilling: Darren Richardson
RL	Not recorded				
Inclination	Vertical			**Logged by**	Ryan Francis
Bearing		**Drill fluid(s)**	None	**Checked by**	G. Bremner, W. Cromer

Bit type/size: Auger. Water: Water 1.9mbgl. Penetration: 1 2 3 4. Notes: Samples and tests. Metres: RL, Depth.

Depth (m)	Graphic log	USCS Symbol	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency Dens Index	Structure, geology and interpretation
						+0.6magl stick-up
0–0.4		CL	CLAY: brown; medium plasticity	M	F	0.3m concrete
0.4–1.0		CH	CLAY: grey; some sand; high plasticity	M	F	B horizon (subsoil); 1.0m bentonite
1.0–2.0		CH	Sandy CLAY: yellow; white and orange mottles; weathered mudstone chips	M - D	F - S	1.5m screen
2.0–2.6		CH	CLAY: brown; weathered mudstone chips and some sand	M - W	F	C/B horizon (weathered mudstone bedrock)
2.6–3.9		SM - CH	Sandy CLAY: grey; weathered mudstone chips	W	St	3.9m cap
3.9			Refusal at 3.9mbgl in mudstone			Mudstone bedrock

CASING DETAILS:
Screen 1.5-3.9m
Sand/gravel 1.0-3.9m
Bentonite 0.3-1.0m
Concrete 0-0.3m
Collar 0.6magl

Water level: 1.9mbgl (12:30, 8/11/18)
Water bailed: 50L (12:2\30, 8/11/18)

Casing details: *Hole completed with bottom capped screened 50mm C18 PVC casing 3.9-1.5m (slots 0.4mm); solid PVC 1.5 - 0.6magl stickup; 1-3mm gravel pack 3.9-1.0m; bentonite chips 1.0-0.3m; quick set concrete 0.3m to surface.*

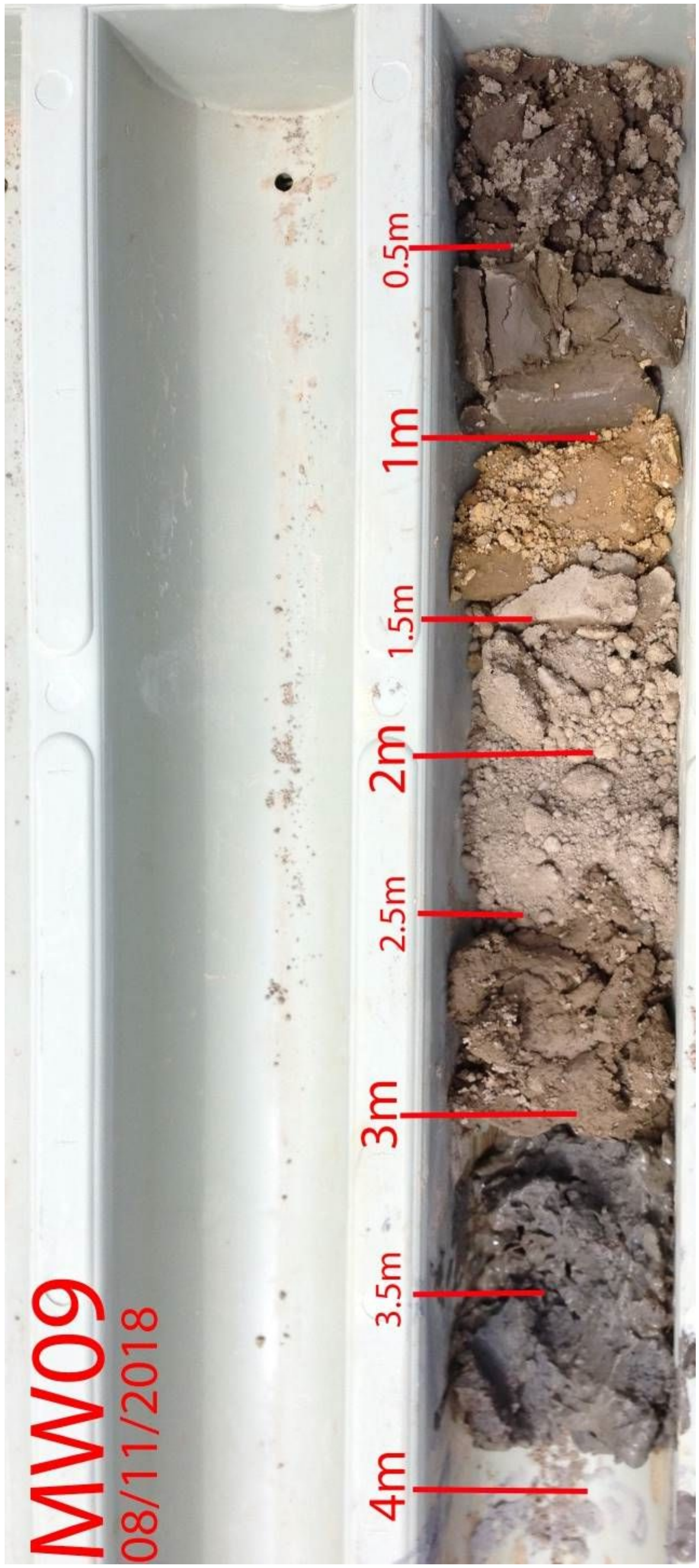
MOISTURE: D = Dry; M = Moist; W = Wet; mbgl = m below ground level; magl = m above ground level

WATER: Water level; Water inflow; Water outflow; GNE = Groundwater not encountered

PENETRATION: 1 2 3 4; No resistance; Refusal

GRAPHIC LOG KEY: CLAY (CH, CI); SILT (SM); ROOTS; COBBLES (63-200mm); SAND (SP); GRAVEL (GP, GW); FRACTURES; BOULDERS (>200mm)

CONSISTENCY (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25 – 50kPa; easily penetrated by fist); F = Firm (50 – 100kPa; easily penetrated by thumb); St = Stiff (100 – 200kPa; indented by thumb, penetrated with difficulty); VSt = Very Stiff (200 – 400kPa; easily indented by thumbnail; H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail.
RELATIVE DENSITY (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense *picking); VD = Very dense (hard picking)


MW09
08/11/2018
0.5m
1m
1.5m
2m
2.5m
3m
3.5m
4m

William C. Cromer Pty. Ltd. Environmental, engineering and groundwater geologists

Borehole log for groundwater

ID MW10
Sheet 1 of 1

Project: Huon Aquaculture | **Location: Laytons Farm**

Coordinates	461248mE, 5424025mN	**Drill type**	Explorer 50	**Hole started**	7 Nov 2018
Datum	GDA94	**Equipment**	150mm solid auger	**Hole finished**	7 Nov 2018
RL	Not recorded			**Drilled by**	KMR Drilling: Darren Richardson
Inclination	Vertical			**Logged by**	Ryan Francis
Bearing		**Drill fluid(s)**	None	**Checked by**	G. Bremner, W. Cromer

Bit type/size: Auger. Penetration scale: 1 2 3 4. Casing: +0.6magl stick-up.

Depth (m)	USCS Symbol	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency Dens Index	Structure, geology and interpretation
0–0.5	CL	SILT: grey; loamy	D	S	A horizon (topsoil) *0.3m concrete*
0.5–4.4	CL	CLAY: brown-grey; some sand and silt; high plasticity	D - M	F	Colluvium? *1.2m bentonite* *1.7m screen*
			M		
		Gravel layer near base, some quartz, angular mudstone and charcoal	M	St	Alluvial clayey gravels?
4.6–6.2	CH	CLAY; yellow-brown	M	St	Alluvial clayey gravels?
	CH	CLAY: grey; angular, weathered mudstone	W	St	
6.2–6.7	CH	CLAY: grey; weathered mudstone chips	W	St	C/B horizon *6.7m cap*
6.7		Refusal at 6.7mbgl in weathered mudstone			Mudstone bedrock

CASING DETAILS:
Screen 1.7-6.7m
Sand/gravel 1.2-6.7m
Bentonite 0.3-1.2m
Concrete 0-0.3m
Collar 0.6magl

Hole bailed by drillers. No details.

Casing details: *Screened 50mm C18 PVC casing 6.7-1.7m (slots 0.4mm); solid PVC 1.2 - 0.6magl stickup; 1-3mm gravel pack 6.7-1.2m; bentonite chips 1.2-0.3m; quick set concrete 0.3m to surface.*

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

MOISTURE
D = Dry
M = Moist
W = Wet
mbgl = m below ground level
magl = m above ground level

WATER
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

PENETRATION
1 2 3 4
No resistance
Refusal

GRAPHIC LOG KEY
CLAY (CH, CI) · SILT (SM) · ROOTS · COBBLES (63-200mm) · BOULDERS (>200mm) · SAND (SP) · GRAVEL (GP, GW · FRACTURES

CONSISTENCY (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25 – 50kPa; easily penetrated by fist); F = Firm (50 – 100kPa; easily penetrated by thumb); St = Stiff (100 – 200kPa; indented by thumb, penetrated with difficulty); VSt = Very Stiff (200 – 400kPa; easily indented by thumbnail; H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail.
RELATIVE DENSITY (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense *picking); VD = Very dense (hard picking)


MW10
07/11/2018
0.5m
1m
1.5m
2m
2.5m
3m
3.5m
4m
4.5m
5m
5.5m
6m
6.5m

William C. Cromer Pty. Ltd. Environmental, engineering and groundwater geologists

Borehole log for groundwater

ID MW11
Sheet 1 of 1

Project: Huon Aquaculture **Location: Laytons Farm**

Coordinates	461116mE, 5424217mN	**Drill type**	Explorer 50	**Hole started**	6 Nov 2018
Datum	GDA94	**Equipment**	150mm solid auger	**Hole finished**	6 Nov 2018
RL	Not recorded			**Drilled by**	KMR Drilling: Darren Richardson
Inclination	Vertical			**Logged by**	W. Cromer, Ryan Francis
Bearing		**Drill fluid(s)**	None	**Checked by**	G. Bremner, W. Cromer

Bit type/size	Water	Penetration 1 2 3 4	Notes (Samples and tests)	Metres (RL / Depth)	USCS Symbol	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency Dens Index	Casing details	Structure, geology and interpretation
Auger	Water 1.78mbgl									+0.6magl stick-up
				0	CL	Clayey SILT: orange-brown; some sand	D-M	F-St		A horizon (topsoil)
					CH	Silty CLAY: brown; some gravel; medium plasticity	M= PL	St		*0.35m concrete* B horizon (subsoil) *1.0m bentonite* *1.22m screen*
				2	CL - SC	Sandy CLAY – clayey SAND: grey; some silt; medium to high plasticity	M >PL … W	S … VS		C/B horizon (weathered mudstone bedrock)
				3	CL - SC	Sandy CLAY: light greyish yellow; some silt; patches of grey-blue and orange sandy chips				Extremely weathered mudstone and siltstone *4.22m cap*
				4.22		Close to refusal at 4.22mbgl in mudstone ***CASING DETAILS:*** *Screen 1.22-4.22m* *Sand/gravel 1.0-4.22m* *Bentonite 0.35-1.0m* *Concrete 0-0.35m* *Collar 0.6magl* Water level: 1.78mbgl (13:10, 6/11/18) Water bailed: bailed 25L/15min (12:30-12:45); bailed dry after 35L; recovery 1.1m/3mins -pH: 6.0 -EC: 630µS -temp: 16°			*Hole completed with bottom capped screened 50mm C18 PVC casing 4.22-1.22m (slots 0.4mm); solid PVC 1.22 - 0.6magl stickup; 1-3mm gravel pack 4.22-1.0m; bentonite chips 1.0-0.35m; quick set concrete 0.35m to surface.*	Mudstone bedrock
				10						

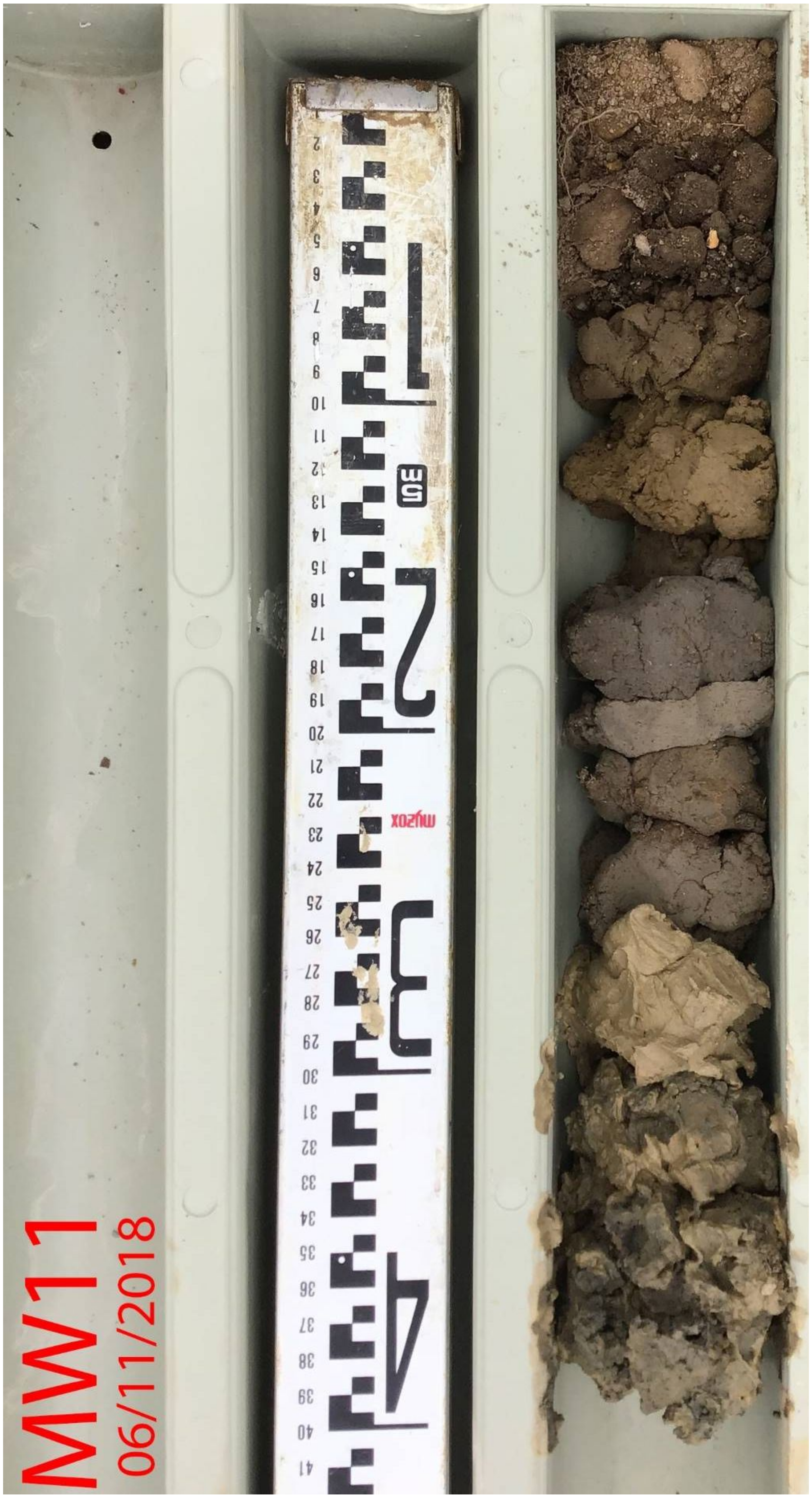
MOISTURE
D = Dry
M = Moist
W = Wet
mbgl = m below ground level
magl = m above ground level

WATER
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

PENETRATION
1 2 3 4
No resistance
Refusal

GRAPHIC LOG KEY
CLAY (CH, CI)
SILT (SM)
ROOTS
COBBLES (63-200mm)
BOULDERS (>200mm)
SAND (SP)
GRAVEL (GP, GW)
FRACTURES

CONSISTENCY (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25 – 50kPa; easily penetrated by fist); F = Firm (50 – 100kPa; easily penetrated by thumb); St = Stiff (100 – 200kPa; indented by thumb, penetrated with difficulty); VSt = Very Stiff (200 – 400kPa; easily indented by thumbnail; H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail.
RELATIVE DENSITY (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense *picking); VD = Very dense (hard picking)


MW11
06/11/2018

William C. Cromer Pty. Ltd. Environmental, engineering and groundwater geologists

Borehole log for groundwater

ID MW12
Sheet 1 of 1

Project: Huon Aquaculture **Location:** Laytons Farm

Coordinates	460936mE, 5424636mN	**Drill type**	Explorer 50	**Hole started**	6 Nov 2018
Datum	GDA94	**Equipment**	150mm solid auger	**Hole finished**	6 Nov 2018
RL	Not recorded			**Drilled by**	KMR Drilling: Darren Richardson
Inclination	Vertical	**Drill fluid(s)**	None	**Logged by**	Ryan Francis
Bearing				**Checked by**	G. Bremner, W. Cromer

Bit type/size: Auger. Water: 1.2mbgl. Penetration 1 2 3 4. Casing details: +0.6magl stick-up.

Depth (m)	USCS Symbol	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency Dens Index	Structure, geology and interpretation
0–0.5	CL	Clayey SILT: grey-brown; loamy	D	S	A horizon (topsoil) *0.3m concrete*
0.5–1.0	CH	CLAY: grey-brown; some sand; high plasticity	M=PL	St	B horizon (subsoil)
1.0–1.6	CH	CLAY: yellow; grey mottles; some sand; high plasticity	M	St	C/B horizon
1.6–2.0	CH	CLAY; yellow; high plasticity	M	St	
2.0–2.5	CH	CLAY: light yellow; some sand and gravel	W	St	*2.0m bentonite*
2.5–3.0	CH	CLAY; grey; some sand and gravel	W	St	
3.0–3.5	CH	CLAY: grey; some sand and gravel	W	St	
3.5–4.0	CH	CLAY: grey; weathered angular mudstone chips	W	St	Weathered mudstone bedrock
4.0–4.5	CH	CLAY: mottled yellow-grey; weathered angular mudstone chips	W	St	
4.5–5.0	CH	CLAY: grey-yellow; angular mudstone chips; some sand and gravel	W	St	
5.0–5.5	CH	CLAY: grey-yellow; hard layer at 5.5m; some sand and gravel	M	St	
5.5–6.0	CH	CLAY: yellow; some sand and gravel	M	St	*6.0m cap*

Refusal at 6.0mbgl in mudstone

CASING DETAILS:
Screen 2.0-6.0m
Sand/gravel 1.4-6.0m
Bentonite 0.3-1.4m
Concrete 0-0.3m
Collar 0.6magl

Water level: 1.2mbgl (07:40, 7/11/18)
Water bailed:
Bailed 16L @ 17:00 6/11/18
Bailed 27L/5min @ 08:00, 7/11/18
-pH: 6.09
-EC: 578µS
-temp: 10.9°

Hole screened 50mm C18 PVC casing 6-2m (slots 0.4mm); solid PVC 2-0.6magl stickup; 1-3mm gravel pack 6-1.4m; bentonite chips 1.4-0.3m; quick set concrete 0.3m to surface.

MOISTURE
D = Dry
M = Moist
W = Wet
mbgl = m below ground level
magl = m above ground level

WATER
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

PENETRATION
1 2 3 4
No resistance
Refusal

GRAPHIC LOG KEY
CLAY (CH, CI)
SILT (SM)
ROOTS
COBBLES (63-200mm)
BOULDERS (>200mm)
SAND (SP)
GRAVEL (GP, GW)
FRACTURES

CONSISTENCY (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25 – 50kPa; easily penetrated by fist); F = Firm (50 – 100kPa; easily penetrated by thumb); St = Stiff (100 – 200kPa; indented by thumb, penetrated with difficulty); VSt = Very Stiff (200 – 400kPa; easily indented by thumbnail; H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail.
RELATIVE DENSITY (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense *picking); VD = Very dense (hard picking)


0.5m
1m
1.5m
2m
2.5m
3m
3.5m
4m
4.5m
5m
5.5m
6m
MW12
06/11/2018

William C. Cromer Pty. Ltd. Environmental, engineering and groundwater geologists

Borehole log for groundwater

ID MW13
Sheet 1 of 1

Project: Huon Aquaculture **Location:** Laytons Farm

Coordinates	460899mE, 5424367mN	**Drill type**	Explorer 50	**Hole started**	7 Nov 2018
				Hole finished	7 Nov 2018
Datum	GDA94	**Equipment**	150mm solid auger	**Drilled by**	KMR Drilling: Darren Richardson
RL	Not recorded				
Inclination	Vertical			**Logged by**	Ryan Francis
Bearing		**Drill fluid(s)**	None	**Checked by**	G. Bremner, W. Cromer

Bit type/size: Auger | Water: 1mbgl | Penetration 1 2 3 4 | Notes (Samples and tests) | Metres (RL, Depth) | Graphic log

Casing details: +0.6magl stick-up

USCS Symbol	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency Dens Index	Structure, geology and interpretation
CL	SILT: light brown	D	S	A horizon (topsoil); 0.4m concrete
CH	Sandy SILT: light brown; loamy	D	S	B horizon (subsoil); 1.9m bentonite
CH	Silty CLAY: light brown; some sand; medium plasticity	M	St	C/B horizon
CH	CLAY: yellow; some silt and sand; medium to high plasticity	M - W	St	2.35m screen
CH	CLAY: brown with yellow mottles; some sand; gravel chips of weathered mudstone	M - W	St	
CH	CLAY: brown; some sand; weathered mudstone chips	W	F	5.35m cap
CH	CLAY: grey; weathered angular mudstone chips	W	F	Weathered mudstone

Refusal at 5.35mbgl in mudstone

CASING DETAILS:
Screen 2.35-5.35m
Sand/gravel 1.9-5.35m
Bentonite 0.4-1.9m
Concrete 0-0.4m
Collar 0.6magl

Water level: 1.0mbgl (09:55, 7/11/18)
Water volume: bailed 70L/20min (10:00)
-pH: 6.36
-EC: 493µS
-temp: 13.9°

Hole screened 50mm C18 PVC casing 5.35-2.35m (slots 0.4mm); solid PVC 2.35 - 0.6magl stickup; 1-3mm gravel pack 5.35-1.9m; bentonite chips 1.9-0.4m; quick set concrete 0.4m to surface.

Depth scale (m): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

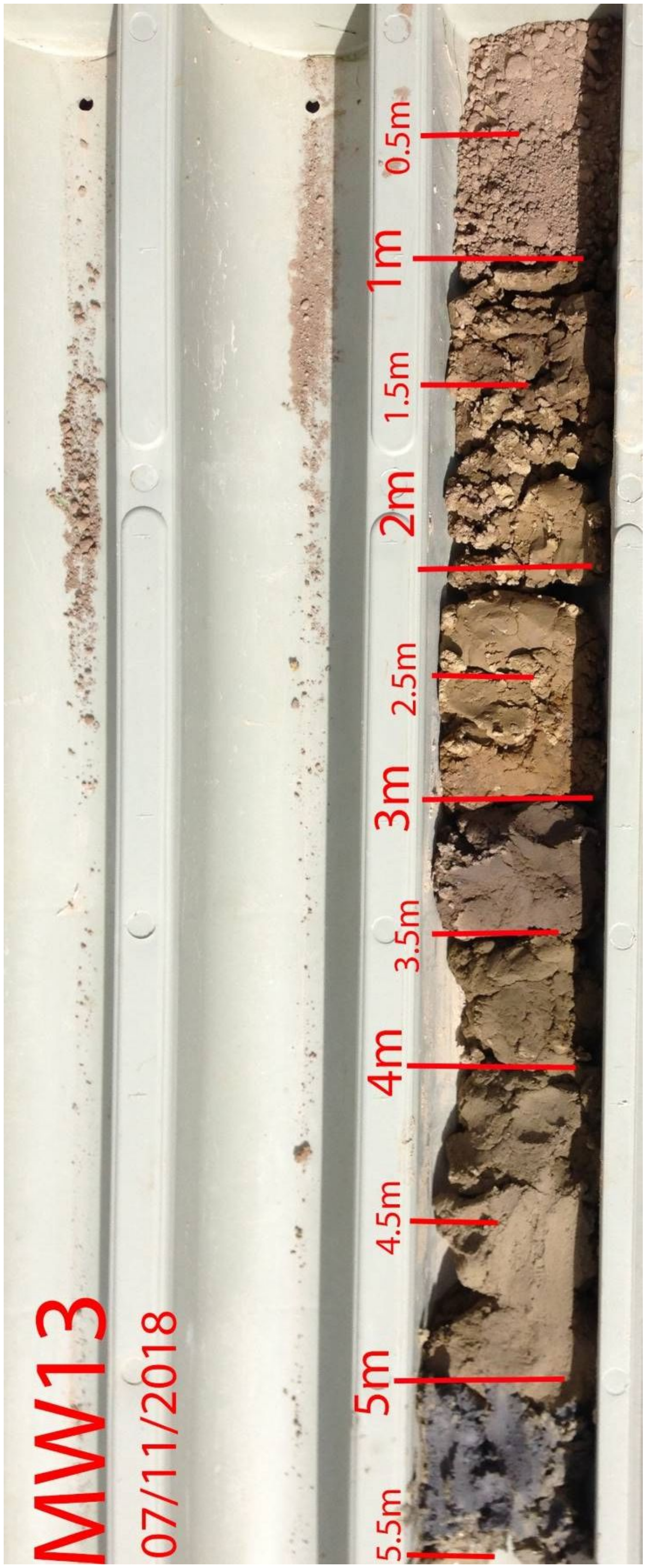
MOISTURE
D = Dry
M = Moist
W = Wet
mbgl = m below ground level
magl = m above ground level

WATER
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

PENETRATION
1 2 3 4
No resistance
Refusal

GRAPHIC LOG KEY
CLAY (CH, CI)
SILT (SM)
ROOTS
COBBLES (63-200mm)
BOULDERS (>200mm)
SAND (SP)
GRAVEL (GP, GW
FRACTURES

CONSISTENCY (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25 – 50kPa; easily penetrated by fist); F = Firm (50 – 100kPa; easily penetrated by thumb); St = Stiff (100 – 200kPa; indented by thumb, penetrated with difficulty); VSt = Very Stiff (200 – 400kPa; easily indented by thumbnail; H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail.
RELATIVE DENSITY (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense *picking); VD = Very dense (hard picking)


MW13
07/11/2018
0.5m
1m
1.5m
2m
2.5m
3m
3.5m
4m
4.5m
5m
5.5m

William C. Cromer Pty. Ltd. Environmental, engineering and groundwater geologists

Borehole log for groundwater

ID MW14
Sheet 1 of 1

Project: Huon Aquaculture
Location: Laytons Farm

Coordinates	461554mE, 5422991mN	**Drill type**	Explorer 50	**Hole started**	8 Nov 2018
Datum	GDA94	**Equipment**	150mm solid auger	**Hole finished**	8 Nov 2018
RL	Not recorded			**Drilled by**	KMR Drilling: Darren Richardson
Inclination	Vertical	**Drill fluid(s)**	None	**Logged by**	Ryan Francis
Bearing				**Checked by**	G. Bremner, W. Cromer

Bit type/size: Auger. Water: 0.8mbgl. Penetration: 1 2 3 4. Casing details: +0.6magl stick-up.

Depth (m)	USCS Symbol	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency / Dens Index	Structure, geology and interpretation
0–0.5	SP	SAND: grey-brown; fine grained	D	S	A horizon (topsoil)
0.5–1.0	CL	Sandy CLAY: dark yellow	D	S	B horizon (subsoil)
1.0–2.0	CL	Sandy CLAY: pale yellow	M	F	C/B horizon
2.0–3.0	CL	CLAY: grey-brown; sandy	M	F	
3.0–4.0	CL	CLAY: brown; some sand	M	St	
4.0–6.0	CL	Silty sandy CLAY: grey-dark grey; weathered mudstone; medium plasticity	W	St	Weathered mudstone /sandstone

Casing/interpretation annotations: 0.3m concrete; 1.5m bentonite; 2m screen; 6m cap.

Refusal at 6.0mbgl in mudstone

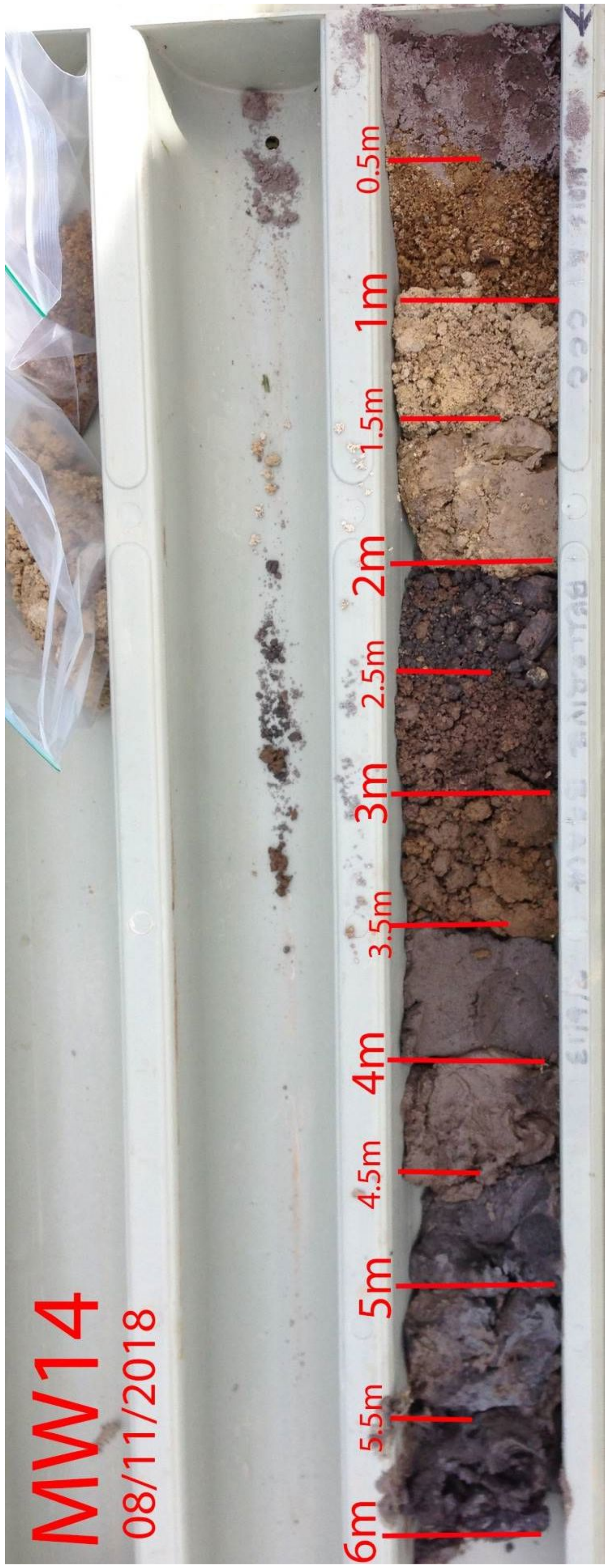
CASING DETAILS:
Screen 2-6m
Sand/gravel 1.5-6m
Bentonite 0.3-1.5m
Concrete 0-0.3m
Collar 0.6magl

Water level: 0.8mbgl (10:04, 8/11/18)
Water bailed: 45L/20min (10:20)
-pH: 6.29
-EC: 179µS
-temp: 13.3°

Capped screen 50mm C18 PVC casing 6-2m (slots 0.4mm); solid PVC 2 -0.6magl stickup; 1-3mm gravel pack 6-1.5m; bentonite chips 1.5-0.3m; quick set concrete 0.3m to surface.

MOISTURE: D = Dry; M = Moist; W = Wet
mbgl = m below ground level; magl = m above ground level
WATER: Water level; Water inflow; Water outflow
GNE = Groundwater not encountered
PENETRATION: 1 2 3 4 — No resistance to Refusal
GRAPHIC LOG KEY: CLAY (CH, CI); SILT (SM); ROOTS; COBBLES (63-200mm); SAND (SP); GRAVEL (GP, GW); FRACTURES; BOULDERS (>200mm)

CONSISTENCY (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25 – 50kPa; easily penetrated by fist); F = Firm (50 – 100kPa; easily penetrated by thumb); St = Stiff (100 – 200kPa; indented by thumb, penetrated with difficulty); VSt = Very Stiff (200 – 400kPa; easily indented by thumbnail; H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail.
RELATIVE DENSITY (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense *picking); VD = Very dense (hard picking)


0.5m
1m
1.5m
2m
2.5m
3m
3.5m
4m
4.5m
5m
5.5m
6m
MW14
08/11/2018

Appendix J: Land capability report

Land Capability Class (ha)	Land Characteristics							
	Geology & Soils	**Slope %**	**Topography & Elevation**	**Erosion Type & Severity**	**Climatic Limitations**	**Soil Qualities**	**Main Land Management Requirements**	**Agricultural Versatility**
4s (approx. 34.6 ha)	Variable duplex soils, with a black to brown sandy loam A horizon soil depth ranging from 0-20 to 50cm with a typically brown clay B horizon sub soil. Derived from mudstone and sandstone geology.	3-5	Elevated ground, gently sloping and undulating land with a north facing slope	Low erosion risk due to rill and sheet erosion caused by surface water movement on bare and exposed soils.	Minor, cool to cold winters and warm summers. With 900-1000 GDD from October to April, and 1000-1100 chilling hours (May to August), 10-20 frost days	Moderate to well drained would result in higher infiltration rates and lower soil moisture holding capacity. Occasional areas of frequent stone and rock fragments present in the soil profile.	Avoid situations that lead to the exposure of bare soil, therefore maintain sufficient ground cover, avoid over-grazing, and reduce grazing pressure during wetter periods.	Suitable for cropping with severe limitations and a restricted choice of crop options, and is suitable for pastoral use with minimal limitations. On the Layton's property this Land is under active pastoral land use management.

4.1s (approx. 29.4 ha)	Duplex soils, with a black sandy loam A horizon soil depth ranging from 0-30 with a typically grey clay B horizon sub soil. Derived from alluvium sediments	3-5	Lower lying land, gently sloping and undulating land with a north facing slope	Low erosion risk due to rill and sheet erosion caused by surface water movement on bare and exposed soils.	Minor, cool to cold winters and warm summers. With 900-1000 GDD from October to April, and 1000-1100 chilling hours (May to August), 20-40 frost days	Moderate to well drained would result in higher infiltration rates and lower soil moisture holding capacity. Occasional areas of frequent stone and rock fragments present in the soil profile.	Avoid situations that lead to the exposure of bare soil, therefore maintain sufficient ground cover, avoid over-grazing, and reduce grazing pressure during wetter periods.	Suitable for cropping with severe limitations and a restricted choice of crop options, and is suitable for pastoral use with minimal limitations. On the Layton's property this Land is under active pastoral land use management.
4.2s (approx. 27.2 ha)	Gradational soil, grey and grey/brown A horizon 0-20/30cm over a brown clay B horizon, as per the Roebuck soil type.	2-5	Elevated ground, gently sloping rolling land, ranging from a south to westerly facing aspect	Low erosion risk due to rill and sheet erosion caused by surface water movement on bare and exposed soils.	Minor, cool to cold winters and warm summers. With 900-1000 GDD from October to April, and 1000-1100 chilling hours (May to August), 20-30 frost days	Moderate to well drained would result in higher infiltration rates and lower soil moisture holding capacity. Occasional areas of frequent stone and rock fragments present in the soil profile.	Avoid situations that lead to the exposure of bare soil, therefore maintain sufficient ground cover, avoid over-grazing, and reduce grazing pressure during wetter periods.	Suitable for cropping with severe limitations and a restricted choice of crop options, and is suitable for pastoral use with minimal limitations. On the Layton's property this Land is under active

	Derived from Quaternary alluvium.							pastoral land use management, whilst on the HAC property this land is used for re-use water application.
4.3s (approx. 34.ha)	Dermosol soils, with a brown loamy A horizon soil 0-30/40, over a brown clay B horizon. Derived from Quaternary alluvium.	3-5	Elevated ground, gently sloping and undulating land with a south facing slope.	Low erosion risk due to rill and sheet erosion caused by surface water movement on bare and exposed soils.	Minor, cool to cold winters and warm summers. With 900-1000 GDD from October to April, and 1000-1100 chilling hours (May to August), 10-20 frost days	Moderate to well drained would result in higher infiltration rates and lower soil moisture holding capacity.	Avoid situations that lead to the exposure of bare soil, therefore maintain sufficient ground cover, avoid over-grazing, and reduce grazing pressure during wetter periods.	Suitable for cropping with severe limitations and a restricted choice of crop options, and is suitable for pastoral use with minimal limitations. On the Layton's property this Land is under active pastoral land use management.

Appendix K: Soil pit descriptions

			Slope (%)	Aspect	Soil Type	Drainage	Runoff Risk	Permeability	Vegetation	Worms Present	Soil Profile Description				Soil Structure Score	Additional Notes
		Description									Depth (cm)	Horizon	Texture	Colour		
A	461920.8 5423634.5	CP4 Pivot SE	3 to 5	South	Roebuck	MW	M	M	Degraded weedy pasture, plant roots depth to 30cm	N N	0-10 10+	A B	Clay loam Clay	Brown grey Olive brown	7 to 8 6 to 7	Existing HAC pivot site, weak orange mottles in sub soil, gravel present (3-5mm)
B	461780.4 5423737	CP4 Pivot SE	3 to 5	West	Roebuck	MW	M	M	Degraded weedy pasture, plant roots depth to 30cm	N N	0-10 10+	A B	Clay loam Clay	Brown grey Olive brown	7 to 8 7 to 8	Existing HAC pivot site, weak orange mottles in sub soil, gravel present (3-5mm)
C	461325.3 5423154.4	CP3 Pivot SW	3 to 5	West	Duplex	M	M	M	Improved grass & clover pasture, plant roots depth to 30cm	Y Y	0-30 20+	A B	Sandy loam Clay	Grey brown Light grey brown	6 to 7 7 to 8	Ex-orchard site, weak orange mottles in sub soil, stone & gravel present (3-20mm)
D	461488.3 5423135.4	CP3 Pivot SW	3 to 5	North	Duplex	M	M	M	Failed lucerne pasture, plant roots depth to 30cm	N N	0-30 30+	A B	Clay loam Clay	Grey brown Brown	5 to 6 5 to 6	Ex-orchard site, nil mottling in sub soil, stone & gravel present (5-40mm)
E	461485.1 5423395.6	CP3 Pivot SE	1 to 3	North	China	M	M	M	Improved grass & clover pasture, plant roots depth to 30cm	Y N	0-15 15+	A B	Clay loam Clay	Grey Brown	6 to 7 6 to 7	Ex-orchard site, moderate orange mottling in sub soil, stone & gravel present (5-20mm)
F	461351.2 5423411.8	CP3 Pivot NW	1 to 3	North	China	MH	M	M	Improved grass & clover pasture, plant roots depth to 30cm	Y Y	0-20 20+	A B	Sandy loam Clay	Grey Light grey	7 to 8 6 to 7	Ex-orchard site, weak orange mottling in sub soil, stone & gravel present (5-10mm)
G	461079.6 5423699.3	CP2 Pivot S	5	East	Duplex	M	M	H	Improved grass & clover pasture, plant roots depth to 30cm	Y Y	0-20 20+	A B	Sandy loam Clay	Grey Light grey	7 to 8 6 to 7	Ex-orchard site, moderate orange mottling in sub soil, stone & gravel present (5-20mm)
H	461045.2 5423927.2	CP2 Pivot Middle	3 to 5	North	Duplex	MH	M	H	Improved grass & clover pasture, plant roots depth to 30cm	Y Y	0-25 25+	A B	Sandy loam Clay	Grey Light grey	7 to 8 6 to 7	Ex-orchard site, moderate orange mottling in sub soil, stone & gravel present (5-20mm)
I	461213.2 5424033.9	CP2 Pivot N	1 to 3	North	Alluivial loam	MH	M	H	Improved grass & clover pasture, plant roots depth to 30cm	Y Y	0-30 30+	A B	Sandy loam Clay	Grey Light grey	7 to 8 6 to 7	Ex-orchard site, moderate orange mottling in sub soil, stone & gravel present (5-20mm)
J	461020.9 5424159.7	CP6 Pivot W	3 to 5	North	Alluivial loam	MH	M	H	Improved grass & clover pasture, plant roots depth to 30cm	Y Y	0-15 15+	A B	Sandy loam Clay	Grey Light grey	7 to 8 6 to 7	Ex-orchard site, weak orange mottling in sub soil, stone & gravel present (5-20mm)
K	461145.6 5424166.8	CP6 Pivot E	1 to 3	North	Alluivial loam	MH	M	MH	Improved grass & clover pasture, plant roots depth to 30cm	Y Y	0-15 15+	A B	Clay loam Clay	Grey brown Brown	6 to 7 6 to 7	Ex-orchard site, weak orange mottling in sub soil, no stone & gravel present
L	461298.9 5424526.4	CP1 Pivot E	3 to 5	South	Alluivial loam	MH	M	MH	Improved grass & clover pasture, plant roots depth to 30cm	Y Y	0-20 20+	A B	Sandy loam Clay	Brown Brown	6 to 7 5 to 6	Ex-orchard site, weak orange mottling in sub soil, stone & gravel present (2-20mm)
M	461030.7 5424450.4	CP1 Pivot S	1 to 3	South	Alluivial loam	M	M	MH	Improved grass & clover pasture, plant roots depth to 30cm	Y N	0-15 15+	A B	Clay loam Clay	Grey brown Blue grey	5 to 6 4 to 5	Ex-orchard site, strong orange mottling in sub soil, no stone & gravel present
N	461101.8 5244676.6	CP1 Pivot N	3 to 5	South	Alluivial loam	MH	M	MH	Improved grass & clover pasture, plant roots depth to 30cm	Y Y	0-20 20+	A B	Sandy loam Clay	Brown Brown	6 to 7 5 to 6	Ex-orchard site, weak orange mottling in sub soil, stone & gravel present (2-20mm)
O	460880.6 5424625.8	CP1 Pivot W	1 to 3	South	Alluivial loam	MH	M	MH	Improved grass & clover pasture, plant roots depth to 30cm	Y Y	0-20 20+	A B	Sandy loam Clay	Brown Brown	6 to 7 5 to 6	Ex-orchard site, weak orange mottling in sub soil, stone & gravel present (2-20mm)
P	461577.3 5423992.5	CP5 Pivot N	1 to 3	North	Roebuck	M	M	M	Improved grass & clover pasture, plant roots depth to 30cm	Y N	0-15 15+	A B	Clay loam Clay	Brown grey Olive brown	6 to 7 6 to 7	Ex-orchard site, weak orange mottling in sub soil, stone & gravel present (2-20mm)
Q	461579.7 5423865.4	CP5 Pivot S	1 to 3	North	Roebuck	M	M	M	Improved grass & clover pasture, plant roots depth to 30cm	Y N	0-15 15+	A B	Clay loam Clay	Brown grey Olive brown	6 to 7 6 to 7	Ex-orchard site, weak orange mottling in sub soil, stone & gravel present (2-20mm)

Drainage; M: moderate, MH: moderate high, H: high
Runoff risk; M: moderate
Permeability; M: moderate, MH: moderate high, H: high
Worms present; Y: yes, N: no

Appendix L: Desktop assessment of groundwater conditions at Huon Aquaculture and Layton properties

Desktop assessment of groundwater conditions at Huon Aquaculture and Layton properties at Parramatta Creek, Tasmania

Bill Cromer
Groundwater geologist

Hydrogeological fundamentals

Figures 1 and 2 depict fundamental principles in a gravity-driven groundwater system[1] like that at Parramatta Creek. The system is part of the hydrogeological cycle[2].

It is important to distinguish between local, intermediate and regional flow patterns, and between groundwater recharge and discharge areas.

In recharge areas, groundwater is replenished by net rainfall (rain less evapotranspiration) infiltrating from above. Water table (unconfined) conditions apply. Groundwater flow lines are down and away from the recharge area. Hydraulic heads are relatively high and decrease with depth. The only source of groundwater is from direct infiltration.

In discharge areas, groundwater may or may not be replenished by infiltration from above (so local water table conditions may or may not apply). The main supply of groundwater is from a recharge area some distance from the discharge area. In the discharge area, groundwater flow lines are up towards the surface, and hydraulic heads increase with depth. Discharge areas are often indicated by swamps and lagoons at least partly fed from below, and by shallow water tables. Importantly, since groundwater flow is upwards in discharge areas, irrigation water (and any contained contaminants) applied at the surface has restricted vertical downward flow, and typically either runs off or evapotranspires without entering the groundwater systems.

In the field, distinguishing between recharge and discharge conditions is achieved by observing water levels in two closely-separated bores (or a nested pair in the same hole) with short screened sections at different depths, as shown in the lower two diagrams in Figure X.2.

Aquifers and groundwater conditions at Parramatta Creek

Permanent groundwater at Parramatta Creek occurs in and moves through intersecting fractures in Permian-age sedimentary rocks (mudstone, siltstone, sandstone) and in nearby Jurassic-age dolerite to the northeast. These are called hard-rock unconfined aquifers. Groundwater also occurs in the veneer of Quaternary-age alluvium along Parramatta Creek, and, to a lesser extent, along Felminghams and smaller tributary drainage lines. These unconsolidated sediments are intergranular unconfined aquifers.

[1] Sophocleous (2004) cited in Figure 2 defines a groundwater system as "a set of groundwater flow paths with common recharge and discharge areas. Flow systems are dependent on the hydrogeologic properties of the soil/rock material, and landscape position. Areas of steep or undulating relief tend to have dominant lo*cal flow systems* (discharging to nearby topographic lows such as ponds and streams). Areas of gently sloping or nearly flat relief tend to have dominant *regional flow systems* (discharging at much greater distances than local systems in major topographic lows or oceans)." A three-dimensional closed groundwater flow system that contains all the flow paths is called the *groundwater basin*.

[2] The *hydrological cycle* is the circulation of water in various phases through the atmosphere, over and under the earth's surface, to the oceans, and back to the atmosphere. The cycle is solar-powered. Because water is a solvent it dissolves elements, and geochemistry is a fundamental part of the cycle, which is a flux for water, energy, and chemicals.
Water enters the land-based cycle as precipitation; it leaves as surface streamflow (runoff) or evapotranspiration. The route which groundwater takes from a recharge point to a discharge point is a *flow path*.

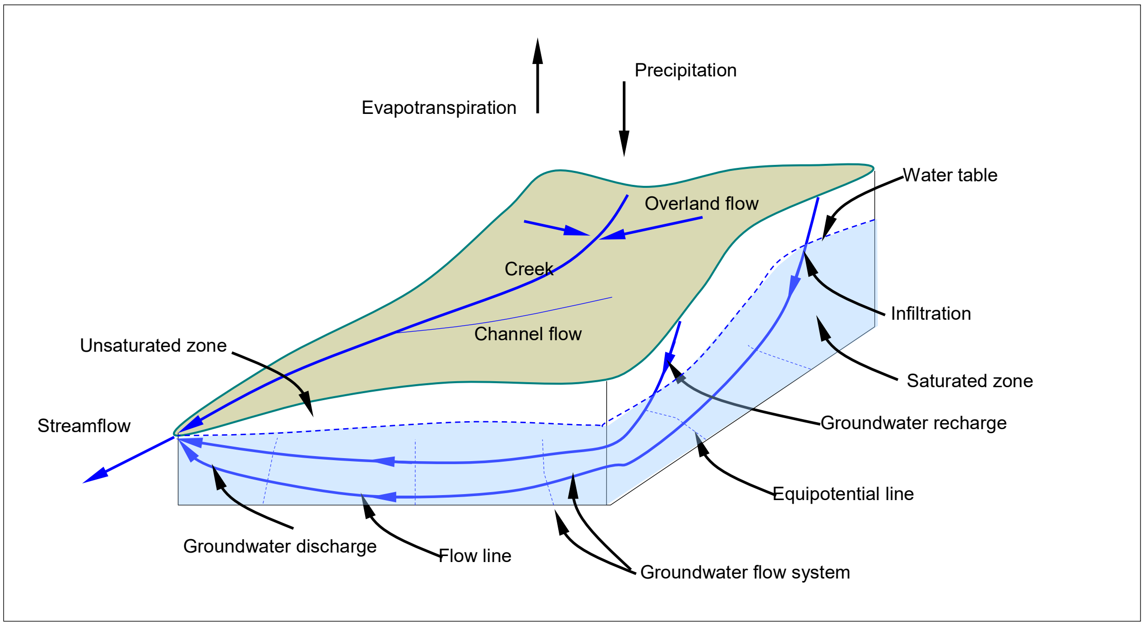
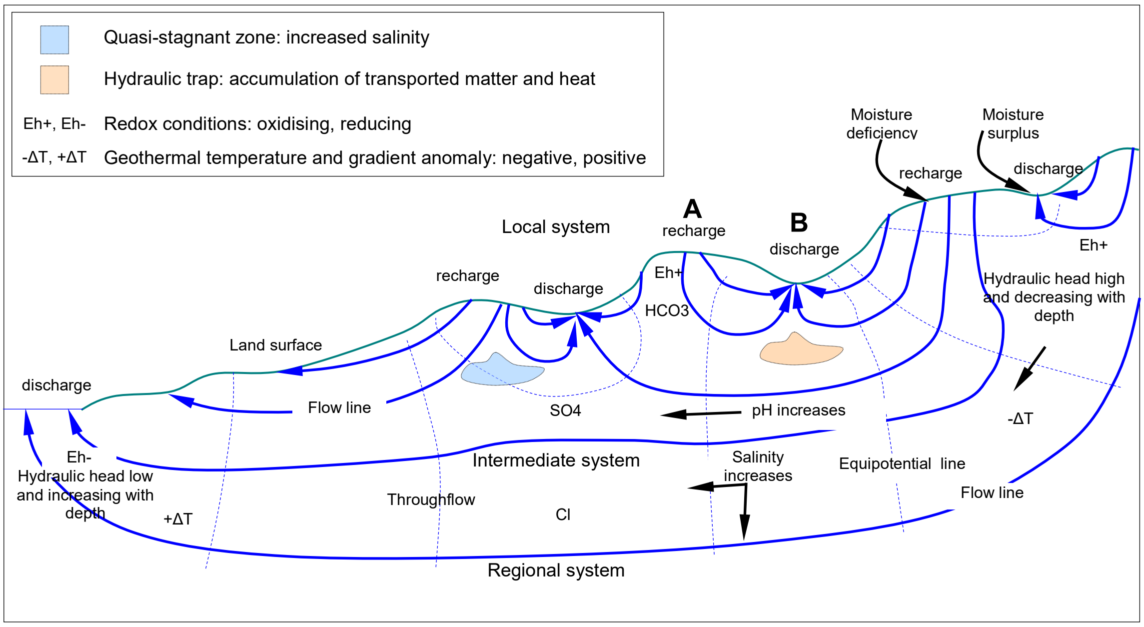
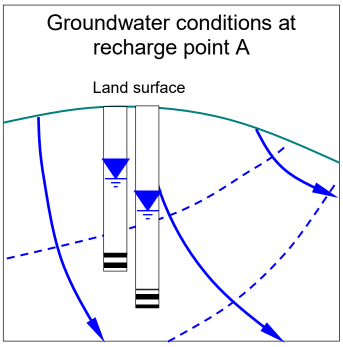


Figure 1. Aspects of the land-based hydrological cycle.





In recharge areas (at left), the hydraulic heads are relatively high and decrease with depth, as shown by the water levels in two adjacent piezometers. In discharge areas (at right), the energy and flow conditions are reversed: heads are low and increase with depth.

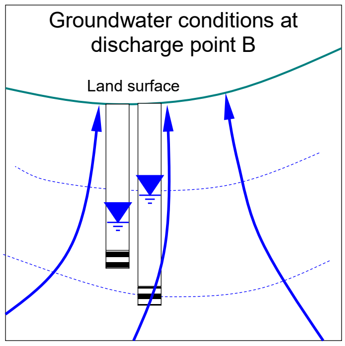


Figure 2. Schematic sections showing fundamentals of groundwater hydrology in a gravity-driven groundwater system. Adapted from Sophocleous (2004). Groundwater recharge, in *Groundwater*, [Eds. Luis Silveira, Stefan Wohnlich and Eduardo J. Usunoff] in *Encyclopaedia of Life Support Systems* (EOLSS), *Developed under the Auspices of the UNESCO, Eolss Publishers, Oxford, UK, [www.eolss.net)*

The relatively low-lying areas adjacent to and including Parramatta and Felminghams Creeks are groundwater discharge areas, where upward-moving groundwater is discharged to the surface via evapotranspiration and streamflow. The water table is close to the surface (within a metre or so in monitoring bores on the Huon Aquaculture property) and it fluctuates in response to changing evapotranspiration rates, rainfall and irrigation.

Discharge and recharge areas, and existing and proposed monitoring bores, and shown in Figures 3 and 4, and in the conceptual hydrogeological cross sections in Figures 5 and 6.

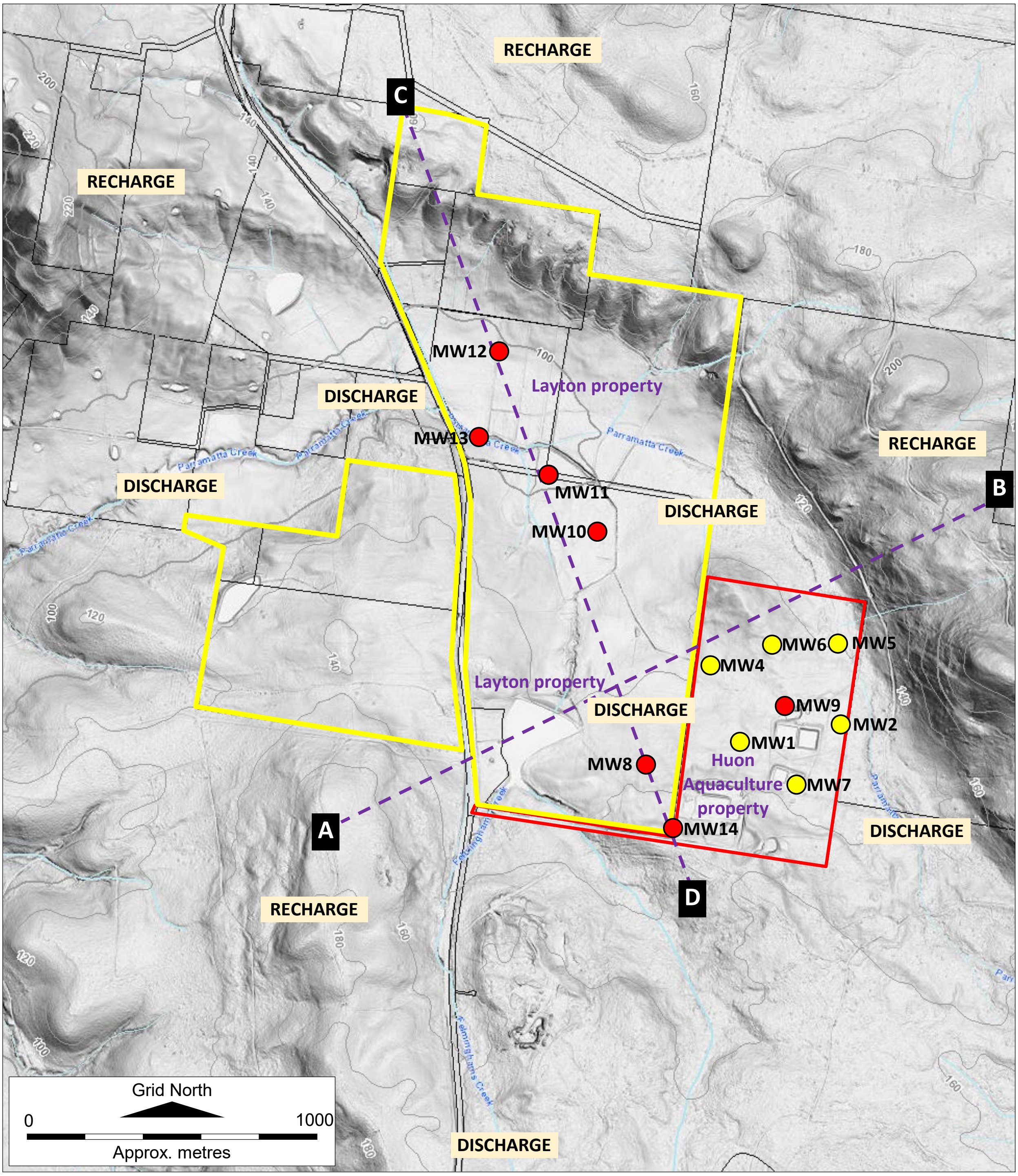
Potential effects of Huon Aquaculture irrigation on groundwater

Irrigation water applied in discharge areas cannot migrate to deeper parts of the aquifer and so does not join intermediate and regional flow directions.

Irrigation water applied in excess of evapotranspiration (ET) at any time will remain in the soil profile (until ET removes it), or it may move vertically downwards towards the water table, and contained constituents may be detected in monitoring bores located within the irrigation area itself. However, the upward groundwater movement inhibits off-site migration in groundwater, so that the effects of irrigation ought to be undetected in off-site “downgradient” monitoring bores.

The only way applied net irrigation water (irrigation less ET) can move off-site is via streamflow. Accordingly, surface water sampling in Parramatta Creek upstream and downstream of the irrigation areas ought to be a component of water monitoring.

Depending on time of year and irrigation rates, ET may be a significant component of the local water budget. It typically ranges from about 1mm/day in winter (0.01ML/ha/day) to over 5mm/day (0.05ML/ha/day) in summer (Figure 7).



Huon Aquaculture, Parramatta Creek
Existing and proposed groundwater monitoring bores, hillside shading and cross sections A – B and C – D
William C Cromer Pty. Ltd. October 2018 Base map www.thelist.tas.gov.au

- Existing groundwater monitoring bore
- Proposed groundwater monitoring bore
- Section line

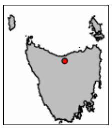


Figure 3. Hillshade map of the Parramatta Creek area

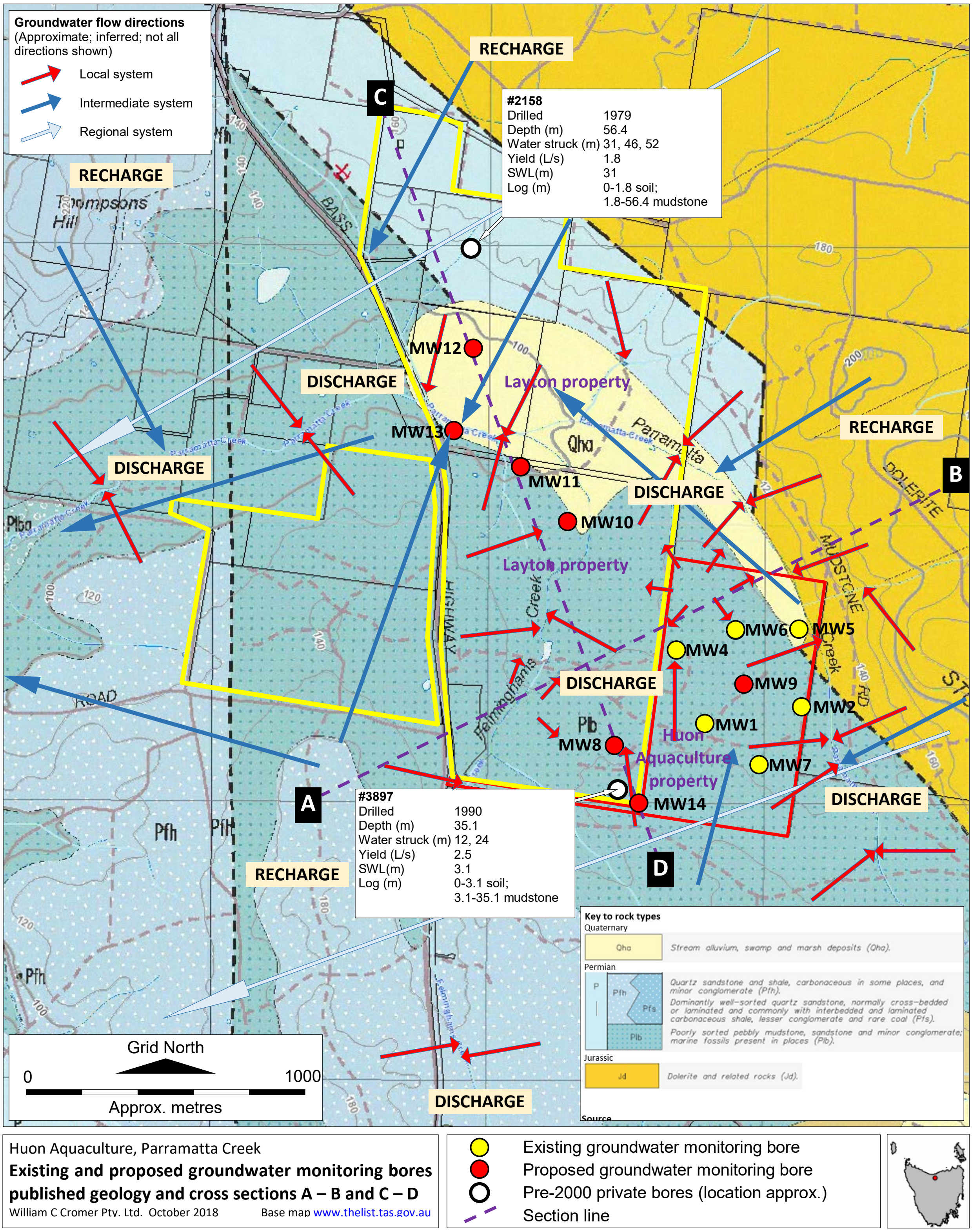


Figure 4. Published geology of the Parramatta Creek area, showing interpreted recharge and discharge areas, and groundwater flow directions for local, intermediate and regional flow systems.

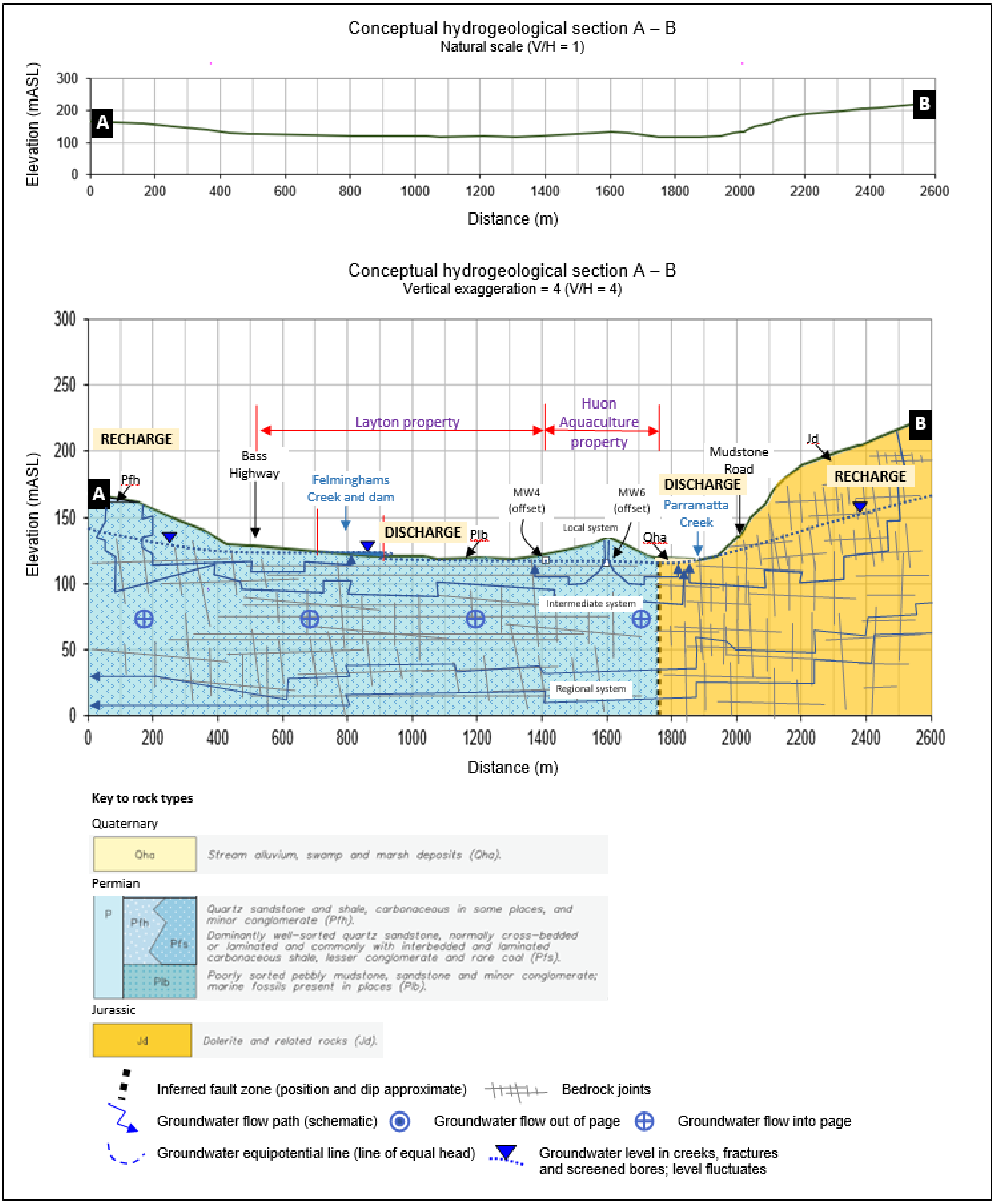


Figure 5. Conceptual hydrogeological cross section A – B in the Parramatta Creek area, showing interpreted recharge and discharge areas, and groundwater flow directions for local, intermediate and regional flow systems. See Figures 3 and 4 for the location of the cross section.

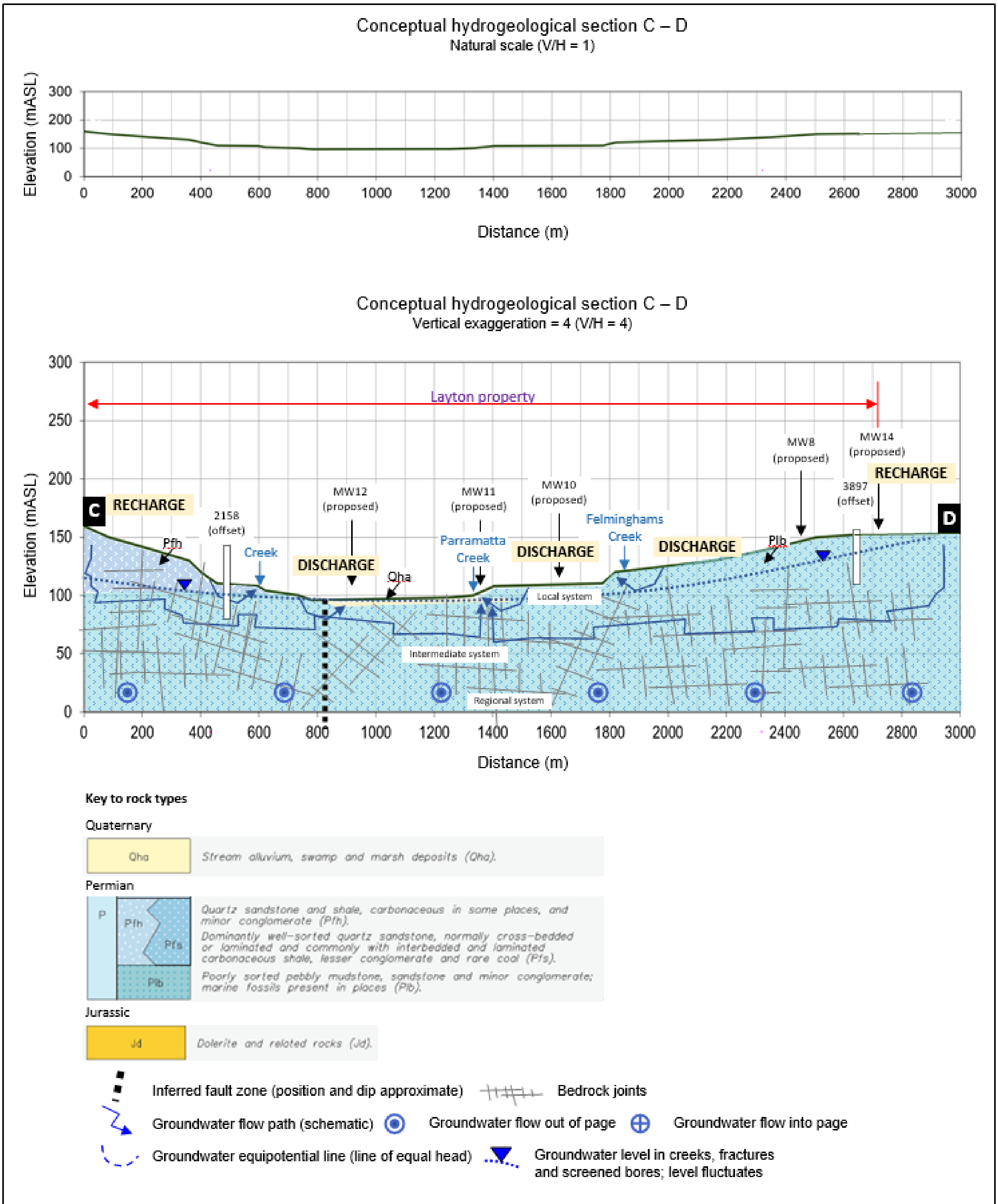


Figure 6. Conceptual hydrogeological cross section C – D in the Parramatta Creek area, showing interpreted recharge and discharge areas, and groundwater flow directions for local, intermediate and regional flow systems. See Figures 3 and 4 for the location of the cross section.

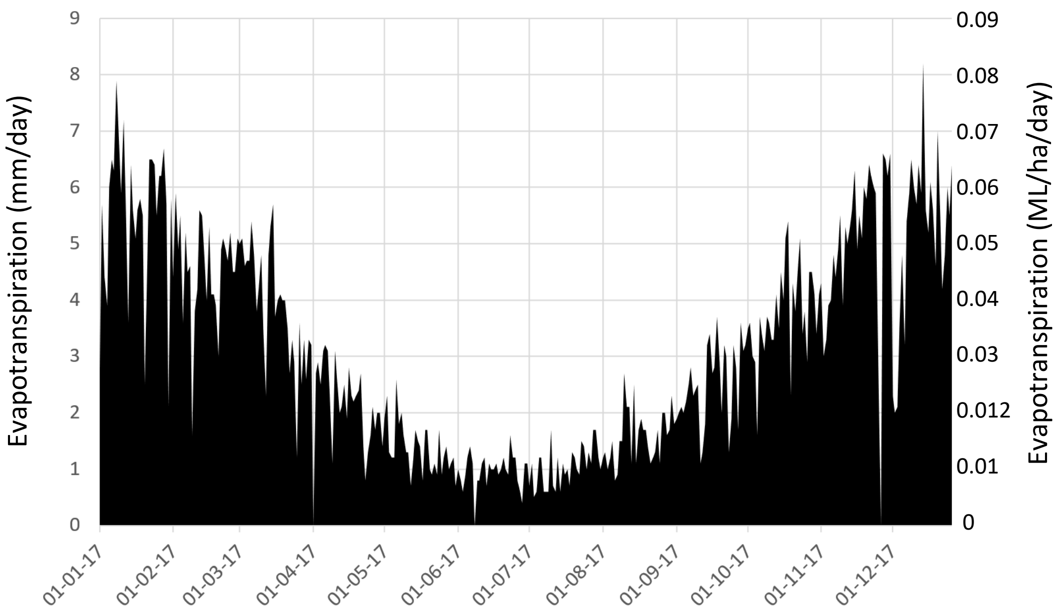


Figure 7. Evapotranspiration at Launceston Airport (2017)
Source: http://www.bom.gov.au/watl/eto/tables/tas/launceston_airport/launceston_airport.html

Appendix M: AusRivAS final report, Kannunah Consulting April 2018

AusRivAS (Australian Rivers Assessment System) Surveys at Huon Aquaculture sites.

Bridport, Meadowbank, Millybrook, Mountain Stream, Parramatta Creek and Springfield sites

Final Report

Prepared by Kanunnah Pty Ltd.

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Report production: Todd Walsh

Base data for mapping: TasMap/The List

Disclaimer

Except where otherwise stated, the opinions and interpretations of legislation and policy expressed in this report are the authors' own and may not necessarily reflect those of the relevant agency. It is the client's responsibility to confirm management prescriptions with the relevant agency before acting on the content and recommendations of this report

Contents

1 Introduction

Various Huon Aquaculture sites were AusRivAS surveyed in March 2018 to determine the health of the waterways upstream and downstream of where the aquaculture operations were situated.

The samples were taken from areas known as riffles where possible. A riffle is a shallow section of a stream or river with a rapid current, and a surface broken by gravel, cobble or boulders. A riffle sample is generally preferred, as it produces a larger sample due to the higher amount of available habitat. Where no riffle existed (Derwent River), an edge sample was taken. Edge sampling is taken from the vegetation that is hanging or growing in the stream. Tasmania has many areas where there is a significant lack of available habitat for an edge sample. The Derwent site was an example of minimal habitat.

AUSRIVAS is a rapid procedure to quantify impact on the in-stream biota. At present, this is achieved by predicting the occurrence of families of macro invertebrates at test sites from environmental variables and a large database of high-quality reference sites. The raw output from this procedure is a list of the families of invertebrates expected in a standard sample from the site, the probability of occurrence of each family in that sample and a tally of which of those families did occur in an actual sample.

O/E (Observed/Expected) score is a ratio relating the number of families of macro invertebrates recorded in a sample to the number of families expected in that sample according to the predictions of the model for least-disturbed conditions.

Sites are scored as follows:

Autumn Riffle sampling scoring

O/E Score	Band	Explanation
>1.14	X	Richer than reference. More macroinvertebrate families found than expected
0.86-1.14	A	Similar to reference. Most or all the expected families were found at the site
0.58-0.85	B	Significantly impaired. Several expected families not found
0.30-0.57	C	Severely impaired. Many expected families not found
0.00-0.29	D	Extremely impaired. Extremely few of the expected macroinvertebrate families found

Autumn Edgewater sampling scoring

O/E Score	Band	Explanation
>1.19	X	Richer than reference. More macroinvertebrate families found than expected
0.82-1.19	A	Similar to reference. Most or all the expected families were found at the site
0.45-0.81	B	Significantly impaired. Several expected families not found
0.08-0.44	C	Severely impaired. Many expected families not found
0.00-0.07	D	Extremely impaired. Extremely few of the expected macroinvertebrate families found

Table .1 Scoring systems for AusRivAS

The sites suitable for sampling were as follows: (riffle sample unless otherwise indicated)

Code	Name	Northing	Easting
HUONBRIDPORT01	Brid River upstream of Huon Aquaculture	5459575	533344
HUONMEADOWBANK01	Derwent River upstream of Huon Aquaculture (Edge)	5280063	488345
HUONMEADOWBANK02	Derwent River downstream of Huon Aquaculture (Edge)	5279469	488379
HUONMEADOWBANK03	channel downstream of Huon Aquaculture at Meadowbank	5279476	488355
HUONMILLYBROOK01	South Esk River upstream of Huon Aquaculture	5412774	560550
HUONMILLYBROOK02	South Esk River downstream of Huon Aquaculture	5412380	560874
HUONPARRAMATTA01	Parramatta creek downstream of Huon Aquaculture	5424443	460730
HUONSPRINGFIELD01	Myrtle Creek upstream of Huon Aquaculture	5431824	542163
HUONSPRINGFIELD02	Myrtle Creek downstream of Huon Aquaculture	5432135	541969
HUONSTPATRICKS01	St Patricks River upstream of Huon Aquaculture	5427814	531951
HUONSTPATRICKS02	St Patricks River downstream of Huon Aquaculture	5427610	531618

Table .2 AusRivAS sampling/surveying Site and coordinates

2 Results

Code	Autumn	Spring	Autumn	Spring	Autumn	Autumn
	2016	2016	2017	2017	2018	2018
	Score	Score	Score	Score	Score	Rating
HUON BRIDPORT01	0.89	0.64	0.79	0.58	0.66	B
HUON MEADOWBANK01	0.12	N/A	0.48	N/A	0.48	B
HUON MEADOWBANK02	0.24	N/A	0.60	N/A	0.36	C
HUON MEADOWBANK03	0.38	0.47	0.42	0.34	0.59	B
HUON MILLYBROOK01	1.22	1.05	1.07	1.20	1.07	A
HUON MILLYBROOK02	0.94	1.05	0.82	0.82	1.04	A
HUON PARRAMATTA01				0.46	0.36	C
HUON SPRINGFIELD01	1.15	1.13	1.15	0.93	1.09	A
HUON SPRINGFIELD02	0.75	0.76	0.69	0.76	0.81	B
HUON STPATRICKS01				1.03	1.00	A
HUON STPATRICKS02				0.95	1.14	X

Table .3 AusRivAS Results autumn 2018

3 Discussion of results

The Meadowbank artificial channel (03) improved slightly. The channel is a man-made drain and, should not be compared to a natural waterway.

The scores at Millybrook were almost identical, with both sites recording an "A" rating. The site below the farm has improved considerably.

The scores at Springfield remained very consistent with the previous results, suggesting that there is some impact from the operation.

The St Patricks site recorded an excellent score below the farm, higher than above.

Todd Walsh