ATTACHMENT C – RDAgritech Limited Effluent Pond Design Report

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DAIRY EFFLUENT POND DESIGN REPORT

JOB TITLE	SCHRADER #2 EFFLUENT
ADDRESS	514 RIMU SEAWARD DOWNS ROAD OTERAMIKA
JOB NUMBER	50193
	19 June 2015

Client:	Schrader Mains Ltd 514 Rimu Seaward Downs Road RD1 Invercargill 9871
Planner:	Landpro PO Box 302 Cromwell 9342

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Prepared by	Reviewed by
Deborah Capper-Starr	David Rider
BSc (Earth)	BSc (Geol)
Engineering Geologist	Farm Dairy Effluent Design Specialist
	Senior Engineering Geologist/Geoprofessional

Schrader #2 Effluent Design Report REV2.docx

1. SYSTEM DESIGN SUMMARY

The Shed roof water will be excluded from the effluent system at all times.

Yard stormwater will be diverted from the effluent system into a field drain or channel during the months when cows are not being milked.

Farm Dairy Effluent (FDE) from the yard and shed will drain under gravity to a new 4 m x 3 m HYNDS precast stonetrap.

Solids removed from the stonetrap will be dried in a 6 m x 3 m concrete bunker to be constructed adjacent to the stonetrap. A dish drain will be installed at the front of the solids bunker, to direct the liquid fraction back into the stonetrap and allow the solids to dry adequately, prior to being applied to the effluent area.

Concrete aprons and hard fill will be installed to allow for all weather vehicle access to the stonetrap and solids drying bunker, and to prevent effluent contamination of the surrounding areas. The walls of the stonetrap will be extended up a nominal 300mm to prevent surface water from entering the trap and to prevent splashing of effluent during cleaning.

FDE will drain under gravity from the stonetrap to a new, 930 m^3 FDE deferred storage pond. The fill material for the pond construction will be mainly from the proposed pond excavation, with any shortfall being carted from the property's existing borrow pit.

FDE in the pond will be well mixed prior to discharge, using a horizontal thrust stirrer. This re-suspends and breaks up solids that would otherwise block the irrigation system and can either be shore or wharf mounted. At this stage the client's preference is for a wharf mounted DeLaval foot stirrer.

When conditions are appropriate for discharge, FDE will be applied to the land via a low application Larall Smart Hydrant. [1]

Table 1: Summary of the pond system information.

Type of distribution system proposed:	Low application:	Larall Smart Hydrant
Type of effluent to be distributed		Stirred, Raw
Coordinates of proposed pond (NZTM)	1264721 mE:	4851049 mN
Maximum expected for design		320
Type of dairy shed		Herringbone
Water use expected for design (two milkings/day)	60	Litres/cow/day
Daily volume FDE expected	19	m^3
Stormwater catchment area of yard & other areas	1,000	m^2
Total catchment area of proposed pond	690	m^2
Total catchment area for inclusion in pond design	1,690	m^2
Massey Pond Calculator design requirement (30 years)	940	m^3
TOTAL OPERABLE STORAGE volume of proposed pond	930	m^3
ESCOP Calc. 60 day storage requirement	918	m^3
Length of pond at top of bank	34.5	m
Width of pond at top of bank	20.0	m
Average depth of pond	2.5	m

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[1] Monaghan RM, Hedley MJ, DI HJ, McDowell RW, Cameron KC, Ledgard SF (2007) *Nutrient Management in New Zealand Pastures – Recent Developments and Future Issues*

[1] RM Monaghan, DJ Houlbrooke and LC Smith (2010) *The use of low-rate sprinkler application systems for applying farm dairy effluent to land to reduce contaminant transfers*

[1] D J Houlbrooke (2006) *An assessment of soil aeration and K-line irrigation technology as management strategies to prevent overland flow of land applied farm dairy effluent.*

4 D J Houlbrooke, R M Monaghan & M McLeod (2010) *Matching farm dairy effluent storage requirements & management practices to soil & landscape features, AgResearch*

2. INTRODUCTION

2.1. SCOPE

This report describes the design and assessment conducted for a proposed dairy farm conversion at the above site, within the next five years. The farm is designing their dairy effluent systems to the current Farm Dairy Effluent (FDE) deferred storage requirements. This report has been produced utilizing the Massey Dairy Effluent Storage Volume Calculator, the Landcare Research website, Dairy NZ (FDE) Code of Practice, IPENZ Practice Note 21 and 27 and current industry best management practices.

The Client has engaged LandPro for consent processing and RDAgritech have been engaged to provide reporting for the design and construction of the FDE storage pond and effluent system, suitable for inclusion in the consent applications.

3. SITE ASSESSMENT

3.1. SITE CONSIDERATIONS

The farm is situated to the northeast of the Waituna Catchment and is made up of mainly flat land, with some sloping land along the waterway that flows diagonally through the centre of the property. The prevailing winds are from the west.

The property has been run as a dry stock and dairy support unit, with some existing infrastructure including an entrance lane and concreted stockyard, which could be converted for dairying purposes, with minimal adjustments being required. A 30 or 32 aside Herringbone shed and associated yards are proposed, with capacity for a maximum of 320 cows. These numbers were derived from the the Conversion Proposal completed by Roslin Cunsultancy Ltd, which states that the total number of cows to be milked will vary throughout the milking season as follows;

August	September	October	November	December
320	315	306	306	306
January	February	March	April	May
306	300	300	270	240

This results in an average of 306 cows across the milking season.

It is proposed that all young stock will be grazed off the property, with 70% of the dairy herd (~210 cows) being wintered off and approximately 4 Ha of kale grown on farm to be grazed by the remaining ~90 cows during June to September.

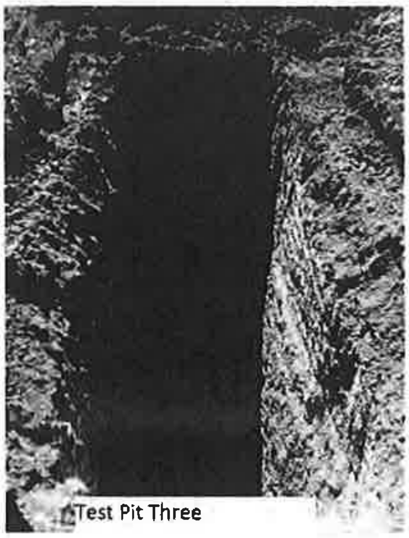
At this stage, no standoff pads or feedpads are planned, however allowance has been made in the pond sizing to accommodate a nominal 300 m^2 of extra catchment in the future.

3.2. SOILS INVESTIGATION

A soils investigation was undertaken on the 2rd December 2014, which included three (3) test pits and three (3) saturated conductivity (Ksat) tests and a site walkover to inspect existing soil exposures. A desktop study was also undertaken to identify soil types from the Environment Southland Topoclimate database.

Test Pit One

Test Pit Two



Test Pit Three

Two test pits were conducted at the proposed pond site, with an extra one being conducted at an alternative site on the northern side of the existing lane. The test pits encountered topsoil overlying Woodland soils, which are generally a SILT with small amounts of clay and some gravel. Alluvial gravels underlay the Woodland soils. Groundwater was encountered at 3.5 m in test pit 1 and perched groundwater was present in test pit 2 at 2.5 m. Groundwater was not encountered in test pits 3, however there was evidence of water at 2.4 m. The test log sheets in Appendix C describe soil types and depths in more detail. As it is not uncommon to encounter under-runners in the farm's locale, should any be encountered during construction of the FDE deferred storage pond, cutoff drains are to be installed to direct any subsurface water away from the pond; please refer to the Design Drawings in Appendix D.

Site soils investigations confirmed the soil characterisations arrived at from the desktop review.

Environment Southland's soil database identified two soil types across the farm and effluent application area; the technical data sheets for these soils are contained within Appendix C. Woodlands soils, which respond well to aeration and are the main soil type, cover the majority of the farm. Thin strips of Dacre soils are present in stream riparian margins however; as effluent will not be applied within 20 m of surface waterways these soils are not expected to receive effluent. For this reason, we have not included the Dacre soils in our discharge area assessment. We have however included the data sheets in Appendix C

From the Topoclimate soils information technical data sheets;

- Woodlands soils have a Landscape Classification of "B" – Impeded drainage or low infiltration rate. These soils are classed as HIGH risk for effluent application at an application depth less than the soil water deficit and not exceeding 25mm per application using a low rate irrigator, or 10mm per application for a travelling irrigator. Woodlands soils are known for slight nutrient leaching.
- Dacre soils have a Landscape Classification of "C" – Sloping land (>7°) or hump and hollow drainage

Table 2: Each of the soils identified by the database and some of their relevant properties.

SOIL NAME	APPROX AREA (Ha)	STRUCTURAL COMPACTION	WATERLOGGING	SOIL RISK (flat terrain)	MEASURED Ksat (mm/hr)
Dacre	16	moderate	severe	high	-
Woodlands	87	moderate	moderate	high	1, 1, 16

Profile Available Water (PAW) for the property was based on information obtained from the Landcare Research website, and was estimated to be high across the Woodlands soils. A map generated from the Landcare Research website is contained in Appendix C.

Current industry research and accepted practice would suggest that deferred irrigation systems at low application rates would suit this particular farm and the soils present. Pulse/very low application irrigation can be utilised during the wetter months of autumn, winter and spring to keep the pond level low to maintain the deferral storage capacity if required. This irrigation should be balanced with the recommended soil monitoring to avoid irrigation on saturated soils.

3.3. RAINFALL

The Massey Pond Calculator is able to analyse the last 30 years of rainfall data and provide calculations on the maximum pond size that would have been required based on the depth of application and the volume of effluent discharged. The rainfall site of Waimahaka (1,149 mm) was used, rather than the closer site at Woodlands Garvie Road (1,031 mm), to bring the annual rainfall total closer to that used in the farm's nutrient budget (1,152 mm) that was undertaken by Roslin Consultancy Ltd. When rainfall events of high intensity or long duration occur these will cause surface water runoff and drainage through the soil. When FDE application is not appropriate, in situations such as this, deferred storage is required. We have checked the pond size against the woodlands site and the pond as designed is larger with the current site.

While we have allowed for irrigation to occur below field capacity, if extreme events occur outside the design capacity of this system (which require irrigation on soil above field capacity to prevent overtopping of the pond), then provided irrigation rates lower than the infiltration capacities (saturated conductivities) are used, research indicates that minimal, to no overland flow or leaching of nutrients would be expected.

4. DESIGN

The stonetrap and solids drying bunker will be installed in an existing area at the intersection of three laneways. This will allow for easy access by machinery for cleaning purposes. An all weather accessway and concrete apron will be installed to prevent effluent from flowing onto the surrounding area. The stonetrap inlet and outlet will be installed in such a way as to increase the residence time of the effluent. This will be achieved by placing both pipes at a 45-degree angle from the walls of the trap, causing the effluent to circulate before exiting the trap and allowing the heavier fraction to drop out of suspension.

Making use of the gravity available onsite will minimise the on-going time and monetary cost of maintenance, while constructing the FDE storage pond partially in-ground will reduce construction time and costs. The small amount of fill that may need to be brought in will be taken from the farm's existing, consented gravel pit.

A nominal 300m^2 has been included in the pond sizing undertaken for the farm. This allows for the possibility of a feedpad or silage pad in the long-term operation of the farm.

In order to know what the soil moisture conditions are prior to effluent discharge and as part of best management practice, we recommend the installation of soil moisture and temperature monitoring equipment (not aquaflex strips) and a weather station to record rainfall and ambient temperature across the effluent irrigation area. High and low level alarms in pump sumps and irrigator monitors and alarms are to be installed as needed. Proprietary monitoring systems such as Smart Farm and Regen systems would be ideal.

Local pump suppliers have quoted a maximum 8 hour response time should pumps fail and for a replacement to be installed. However in the mean time, backup generators and/or pumps could be used to ensure effluent is still able to be transferred to the pond or paddock.

A synthetic liner has been specified as the most robust solution for containing liquid in of the pond. For the purpose of providing clear drawings a 1.5mm HDPE liner has been shown on the drawings. Other products would be allowed only if the Design Engineer gives prior written approval. A 100mm thick, concrete based, sump hole in the pond is proposed to ensure no damage to the base where pumps and stirrers are to be fitted. The pump pontoons, suction intake or stirrer support will be able to rest on the base if necessary.

If pumps and stirrers are to be fitted at other locations in the pond then RDAgritech must be advised prior to pond construction.

Liner suppliers will need to provide a minimum 20-year warranty on durability, with installation of their systems in full accordance with their installation instructions. The liner installer is to install a uPVC inlet pipe as per the plans even if the shed pipe work is not installed at the time of installation.

Under the concrete pad in the pond sump is a non-welded square of liner to act as a slip joint to protect the main liner from damage. It is essential that no stones or foreign objects be between the two contact surfaces.

4.1. DESIGN RATIONALE

The current pond sizing selected is based on the Massey calculator utilising a 1 in 30 year capacity limit, and we have used this as a more accurate measure of storage requirement than the ESCOP. As can be seen on the Summary Table, we have not taken the maximum pond size but rather a 1 in 30 year overtopping event. The Dairy NZ COP only requires a 1 in 10 year event to be considered, however we do not consider this suitable for these types of ponds. The calculator also doesn't currently give an output for the amount of stormwater included in the design on the summary report. However, it is accounted for in the design sizing.

If the instantaneous irrigation rate is higher than the Ksat value, the soil cannot absorb it fast enough. This will instigate ponding at the surface or drainage/sheet flow on the surface.

During the wetter parts of the year, the system can be pulsed to 1mm depth application rates. These low application depths allow a greater opportunity to irrigate during wetter times when the soil water deficit is likely to be low. These irrigation regimes will be utilised to maintain storage as required. Typically irrigation would occur until the nutrient limit for the soil is reached or the depth application specified in the Discharge Permit for an event is reached, whichever occurs first. On reaching this trigger level the pods would be moved to the next area. The irrigation contractor will determine the irrigation rationale in more detail and provide onsite training of staff to ensure they are suitably trained on its use.

Generally the creation of deferred storage in the form of ponds will allow the farmer to discharge when conditions suit to avoid having to irrigate using such a regime. However the pond and discharge parameters have been set to allow the above worst-case situation to be sustainably managed.

The storage pond should be irrigated from daily or when conditions allow and should not be used to defer irrigation when irrigation potential is present. The current design does not allow for deliberate storing of effluent in the pond outside the already excluded times as specificed in the pond design summary report from Massey. This includes holding effluent over winter and 5 days emergency storage. If irrigation potential is available outside these times, then irrigation should occur on every available day. This includes the winter months when, if irrigation potential exists then irrigation should occur to create storage for the impending spring.

Ponds of this size will stagnate and cause nuisance odour, as well as Biological Oxygen Demand problems when applied to the soil resulting in increased de-nitrification in the soil, unless oxygenated by means of mechanical stirring, or aeration of the fluid is conducted. This is also another reason why it is important to keep the pond as empty as possible. Pumped outlet nozzles discharging into sumps or ponds should be flared to provide a flat stream to maximise aeration.

Pond safety systems in accordance with The Department of Labour and best practice safety systems for a pond hazard of this type should be installed as part of the farm's health and safety policy, and management program. As a minimum, the wharf structure is to be fenced where it extends over the pond and have a buoy with 30 m of rope attached, the pond is to be suitably fenced and safety access ropes installed at the same locations as the safety stairs. The safety ropes should be inspected at least annually to ensure they have not been deteriorated by sun and moisture. All accessable areas with a health and safety risk shall be appropriatly signeposted.

4.2. IRRIGATION RATIONALE

Approximately 26 Ha of effluent disposal area is being utilised at this stage to allow the farmer the greatest potential to irrigate when possible.

During the spring and autumn wet months the irrigation system will be set to low application depths and utilising the pulsing 6 ports of the Larral system to distribute the effluent over a large area. These application rates will be adjusted by the farmer to suit the conditions. During the summer months the rate will be increased to the averaged maximum achievable by the low application irrigation setup.

While daily effluent of up to 18.9 m^3 is expected for the design we have specified an irrigation volume of 82 m^3 and 170 m^3 as the system must be capable of these outputs (within a 24 hour period) in order to reduce any deferred volume. The successful irrigation supply company will be providing the irrigation system details and components to meet the volume required. At this stage a Larall Smart Hydrant effluent irrigator is proposed and is subject to design by the irrigation contractor.

On no account should FDE be applied when surface water is ponding or during, 6 hours before, or 12 hours after heavy rainfall intensities of greater than 5 mm/hr. Combined with the soil moisture monitoring information, visual inspection of the proposed application areas must be conducted before each application to ensure conditions are suitable. Irrigation is to cease or be moved to a new area, if adverse conditions are present.

4.3. CLEANING AND REMOVAL OF SOLIDS

Solids from the stonetrap will be spread on the paddocks as required, observing best practice separation distances from sensitive areas and avoiding spreading of solids during adverse climatic conditions.

Prior to emptying the stonetrap, it should be agitated by using the yard wash down hose to mix the organics to a slurry and flush them out. This will greatly reduce the organics that need to be removed from the stonetrap. These solids can then be cleaned out and dumped into the new solids drying bunker to dry before spreading on paddocks. The heavier stones/sand should remain in the stonetrap. Once the milking season finishes, the stonetrap should be hosed to remove any FDE remaining, then the stones/sand that have built up can be removed and drained, prior to spreading on lanes.

A water hydrant connection is to be installed near the pond crest to allow washing down of any sludge that may build up, into the sump in the base of the pond.

The frequency of cleaning is dependent on use. It may take a few seasons to establish a suitable cleaning regime.

Ideally, prior to the stonetrap being cleaned the stored sludge on the stone dump area should be spread to paddock if conditions are suitable.

5. RECOMMENDATIONS FOR PASTURE MANAGEMENT AND IRRIGATION

As part of best management practice, a pasture management regime involving aerating of effluent paddocks should be introduced, particularly if pugging and/or waterlogging of the soils has occurred in paddocks. As shown in the research reporting mentioned above, aeration greatly improves the soil's ability to hold and process nutrients from FDE, which also provides for a 'healthier' soil matrix.

RDAgritech recommend that aeration, or re-pasturing, of the topsoil profile should be carried out immediately on any effluent paddocks that have suffered compaction, or pugging, due to stock. This will re-establish the permeability of the soil and reduce overland drainage runoff.

6. HEALTH AND SAFETY

All work must be in compliance with the Health and Safety in Employment Act. The following table from *IPENZ Practice Note 21: Farm Dairy Effluent Ponds* summarizes minimum hazard mitigation required around FDE ponds.

HAZARD MITIGATION AROUND FDE PONDS	
Fencing	Permanent and secure fencing to prevent stock and children from accessing FDE pond areas.
Gates	Lockable Access gates
Emergency Escape options	Permanent ladders and escape ropes.
Rescue buoy	A rescue buoy or similar on a rope that can be thrown to a person in the pond to help them keep afloat.
Anchor points	Anchor points to attach floating pontoons (if used) to improve stability.
Signage	Hazards on site clearly shown

The pond and any sumps including stonetraps that pose a health and safety hazard of falling, drowning and/or entrapment shall be fully fenced as deemed appropriate by the principle's Health and Safety Policy on farm. The fencing should be appropriate for the hazards, stock, personnel and accessibility by the type of individuals likely to enter the site. Guidance on fencing systems can be obtained on the Dairy NZ website.

7. APPLICABILITY

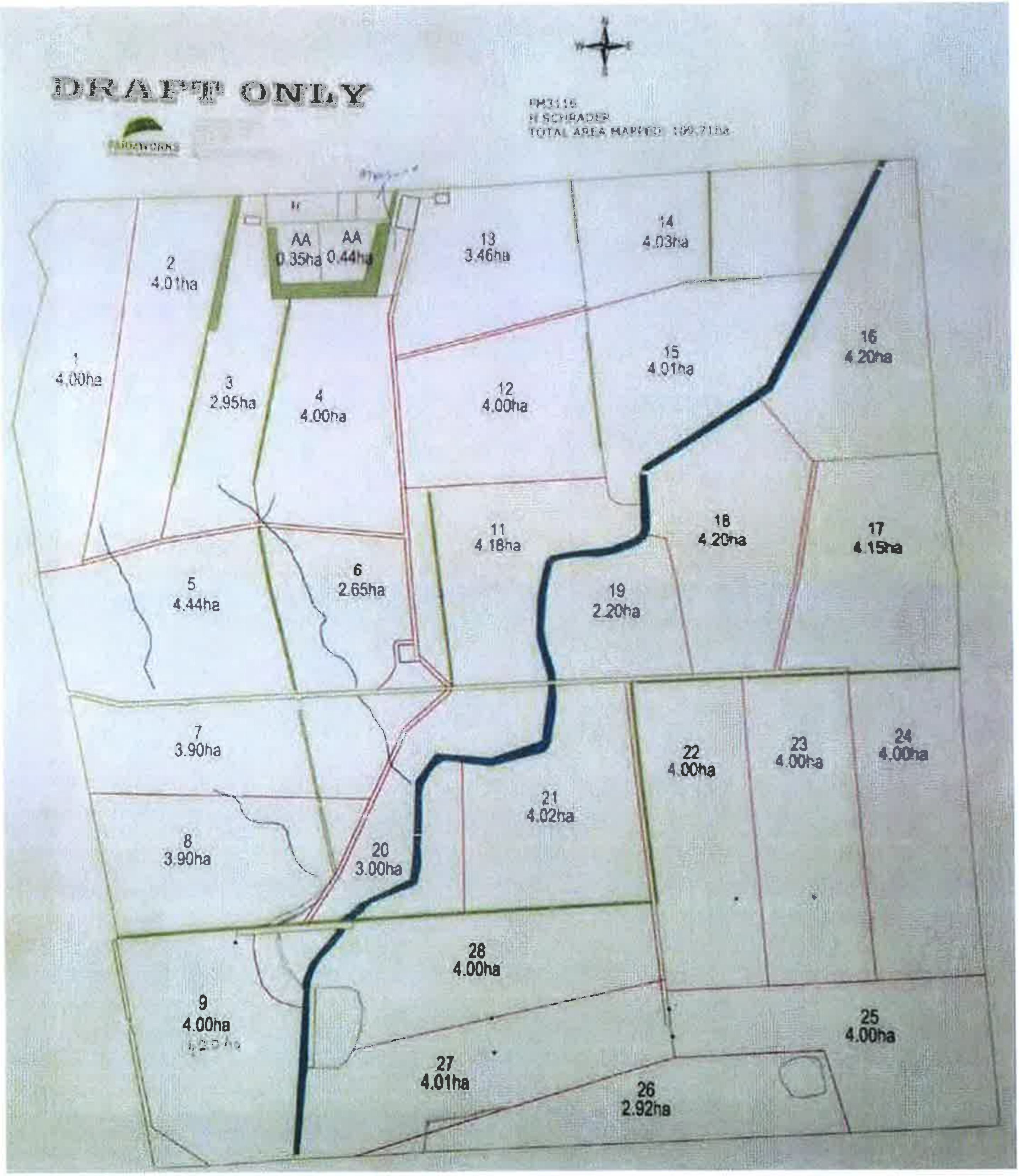
This report has been prepared based on the information provided to us by the Client or their representative. The design is iterative whereby changes can affect the entire design outcome. We must be notified of any potential changes to confirm the design is not compromised.

While we have exercised due care in assessing the pond size, we take no responsibility for the Massey pond calculator results. This is a proprietary software package still under development and is subject to vetting by its developers and reviewers.

This report is only to be used by the parties named above for the purpose that it was prepared and shall not be relied upon or used for any other purpose without the express written consent of RDAgritech Ltd

APPENDIX A. SITE PLANS

1. Proposed Farm Map


DRAFT ONLY
FARMWORKS
N
W
E
FM3115
H SCHRADER
TOTAL AREA MAPPED 109.71ha
H
AA 0.35ha
AA 0.44ha
1 4.00ha
2 4.01ha
3 2.95ha
4 4.00ha
5 4.44ha
6 2.65ha
7 3.90ha
8 3.90ha
9 4.00ha
4.20 Ha
11 4.18ha
12 4.00ha
13 3.46ha
14 4.03ha
15 4.01ha
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17 4.15ha
18 4.20ha
19 2.20ha
20 3.00ha
21 4.02ha
22 4.00ha
23 4.00ha
24 4.00ha
25 4.00ha
26 2.92ha
27 4.01ha
28 4.00ha

APPENDIX B. MASSEY DAIRY EFFLUENT STORAGE CALCULATOR REPORT

Note:

The Massey Pond Calculator is able to analyse the last 30 years of rainfall data and provide calculations on the maximum pond size that would have been required based on the depth of application and the volume of effluent discharged. When rainfall events of high intensity or long duration occur, these will cause surface water runoff and drainage through the soil. When FDE application is not appropriate in situations such as this, deferred storage is required.

The current pond sizing selected is based on the Massey Pond Calculator, utilising a 1 in 30 year capacity limit and RDAgritech have used this as a more accurate measure of storage requirement than the ESCOP. As can be seen on the summary sheet, we have not taken the maximum pond size but rather a 1 in 30 year overtopping event. The new DairyNZ COP only requires a 1 in 10 year event to be considered, however we do not consider this suitable for these types of ponds. The calculator also does not currently give an output for the amount of stormwater included in the design on the summary report, however it is accounted for in the design sizing.

Dairy Effluent Storage Calculator
Summary Report

Regional authority:	Environment Southland
Authorised agent:	RDAgritech - DCS
Client:	Schrader Mains Ltd
Program version:	1.44
Report date:	Wednesday, 10 June 2015
General description:	

A maximum of 320 cows and a wash down water volume of 60 litres/cow/day was assumed. The actual volumes were based on the Roslin Consultancy Ltd Conversion Proposal, which details the number of cows per month.

The rainfall site of Waimahaka (1,149 mm) was used rather than the closer site at Woodlands Garvie Road (1,031 mm), to bring the annual rainfall closer to that used in the farm's nutrient budget (1,152 mm). This translates to a larger pond than if the closer site was used.

The area of effluent block is also as detailed in the Roslin Consulting Ltd Conversion Proposal.

The catchment area of the proposed milking shed yard is estimated to be 700 m^2. The yard is to be diverted from the 1st of June to the 31st of July.

The milking shed roof (~243 m^2) is to be permanently diverted from the pond.

A low rate Larral Smart Hydrant system is proposed. The flow rate for this system is approximately 20 m^3/hour. The system will run for around 10 hours each day (a volume of 200 m^3) with a maximum daily depth of 20 mm, based on a 6 port Larral applying 2 mm depth per hour.

To allow for possible future expansion, a nominal 300 m^2 has been included in the design for a future feedpad and the pond size was increased to 930 m^3 which is achieved through a 34.5 m x 20 m x 2.5 m pond with a 2:1 batter on the embankments.

This volume is calculated on the assumption that no irrigation occurs from the 1st of June until the 31st of July. An additional 5 days of storage has been allowed for emergencies such as pump break down. The pond also has a freeboard allowance of 300 mm.

The consent will need to provide for the ability to irrigate all year round to ensure that in adverse years, some irrigation may occur over winter to enable storage to be available for spring.

Climate

Rainfall site: Waimahaka
Mean annual rainfall: 1149 mm/year

Effluent Block

Area of low risk soil: 0.0 hectares
Minimum area of high risk soil: 26.0 hectares
Surplus area of high risk soil: 0.0 hectares

Wash Water

Yard wash:

- Na. of cows milked in spring: 320 cows
- Milking time: 5 hrs/day
- Yard wash volumes: Custom average daily values (cubic metres/day)
- Season start: 10 August
- Season end: 31 May

Month	Wash Volume (cubic metres)
January	18.4
February	18.0
March	18.0
April	16.2
May	12.0
June	0.0
July	0.0
August	16.0
September	18.9
October	18.4
Navember	18.4
December	18.4

Irrigation

Winter-spring depth: 2 mm
Spring-autumn depth: 20 mm
Winter-spring volume: 82 cubic metres
Spring-autumn volume: 170 cubic metres
Irrigate all year? No
Don't irrigate start: 01 June
Don't irrigate end: 31 July

Catchments

Yard area: 700 square metres
Diverted? Yes
- diversion start: 01 June

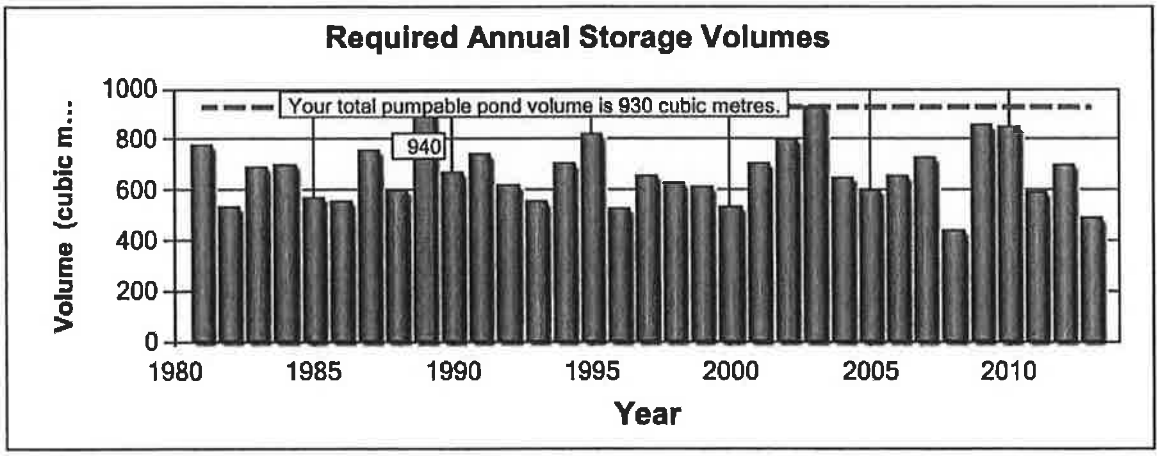
- diversion end:	01 August
Shed roof area:	243 square metres
Diverted?	Yes
Feedpad area:	0 square metres
Covered?	No
Diverted?	No
Other areas:	300 square metres

Storage

Pond/s present?	Yes
No. of ponds:	One pond
Includes irregular ponds?	No
Pond 1	
- total volume:	1127 cubic metres
- pumpable volume:	930 cubic metres
- surface area:	690 square metres
- pumped?	Yes
Emergency storage period:	5 days

Outputs

Maximum required volume:	940 cubic metres
90 % probability volume:	834 cubic metres
During the period from:	01 July 1980
To:	30 June 2013



RDAgritech Deferred Irrigation Rationale

The Pond Storage Calculator (PSC) will only irrigate on days when a soil water deficit (SWD) equal to, or greater than the depth entered in the depth field is available. RDAgritech has found that areas of Southland have very low available SWD during autumn, winter & spring.

RDAgritech has concluded (in agreement with the scientific research available) that with good management practice and our deferred irrigation approach (as described above) nutrient leaching will be mitigated even if the soil is above field capacity, provided only low depth, low rate irrigation occurs.

Guidance on application of FDE to various soil types is presented in "Matching Farm Dairy Effluent Storage Requirements and Management Practices to Soil and Landscape Features" by DJ Houlbrooke, et al. Relevant concepts from this report regarding FDE application on soils at field capacity are paraphrased below.

- Low application rates increase the likelihood of matrix flow and allow a greater volume of Farm Dairy Effluent (FDE) to move through smaller pores in the soil. This allows greater attenuation of nutrients in the root zone.
- Fine-grained "High-Risk" soils typically have a high water holding capacity. If infiltration through the soil is primarily via matrix flow, soils with a higher water holding capacity will require greater application depths to instigate drainage below the root zone.
- During matrix flow, surface water inputted at the surface of the soil will primarily displace water situated deeper in the root zone. Thus FDE applied will remain in the root zone with sufficient residence time for nutrient attenuation and direct losses of nutrients should be negligible.

RDAgritech's standard practice is to map the soils on farm and assess soil type and infiltration across the farm's effluent block.

APPENDIX C. SOILS INFORMATION

1. Permeameter Log Sheets SK1-SK3
2. Test Pit Log Sheets TP1-TP3
3. Soils Types & Classifications Map
4. Landcare Research PAW Map
5. Soil Testing Location Plan
6. Soils Data Sheets
    a. Dacre Soils
    b. Woodlands Soils

Field Auger/Permeameter Test Sheet

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Project:	Schrader #2 Effluent		
Site Location:	514 Rimu Seaward Downs Road		
Test Number:	SK-1 in BH-1	Test Date:	2-Dec-14
Operator:	DCS	Test Time:	12:46 pm
Auger Ø:	10 cm	Permeameter Ø ID:	4.2 cm
Depth of Auger Hole:	0.5	Average Hole Ø:	11.5 cm

Auger Log E 1262584 N 4847864

DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PARTICLE SIZE CHARACTERISTICS,PLASTICITY, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	MOISTURE CONDITION	SOIL / ROCK TYPE, ORIGIN, DEFECTS, STRUCTURE, FORMATION	GROUND WATER
0.1 0.2 0.3	ΨΨΨΨΨΨ ΨΨΨΨΨΨ ΨΨΨΨΨΨ ΨΨΨΨΨΨ ΨΨΨΨΨΨ ΨΨΨΨΨΨ	SILT; organics; friable; mid-brown; no worms	D/M	Topsoil	none
0.4 0.5	xxx..xxx..xxx xxx..xxx..xxx xxx..xxx..xxx xxx..xxx..xxx	SILT; very minor clay; very minor plasticity; orangey grey/brown		Woodlands Soils	
0.6 0.7		End of Borehole; no groundwater encountered			

$$K_{sat} = \frac{4.4Q\left[0.5\sinh^{-1}\left(\frac{H}{2r}\right) - \sqrt{\left\{\left(\frac{r}{H^2}\right)+0.25\right\}} + \frac{r}{H}\right]}{2\pi H^2}$$

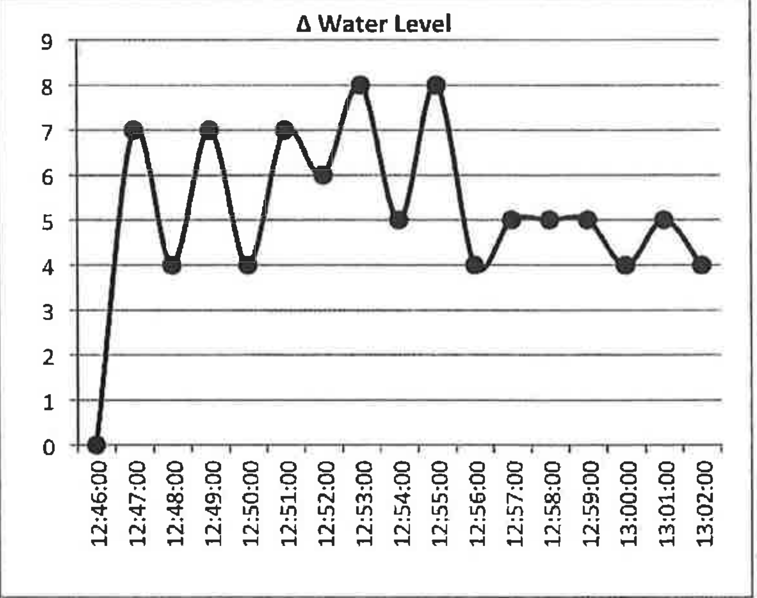
Ksat = 1 mm/hr

Permeameter Readings

Permeameter test was conducted between 0.2m and 0.5m

Water Level in hole 300mm

Time	Δ Time (hr)	Water Level (mm)	Δ Water Level (mm)
12:46:00	0	612	0
12:47:00	0:01:00	619	7
12:48:00	0:01:00	623	4
12:49:00	0:01:00	630	7
12:50:00	0:01:00	634	4
12:51:00	0:01:00	641	7
12:52:00	0:01:00	647	6
12:53:00	0:01:00	655	8
12:54:00	0:01:00	660	5
12:55:00	0:01:00	668	8
12:56:00	0:01:00	672	4
12:57:00	0:01:00	677	5
12:58:00	0:01:00	682	5
12:59:00	0:01:00	687	5
13:00:00	0:01:00	691	4
13:01:00	0:01:00	696	5
13:02:00	0:01:00	700	4



Field Auger/Permeameter Test Sheet

RDAgritech
ENGINEERED BY NATURE

Project:	Schrader #2 Effluent		
Site Location:	514 Rimu Seaward Downs Road		
Test Number:	SK-2 in BH-2	Test Date:	2-Dec-14
Operator:	DCS	Test Time:	1:39 pm
Auger Ø:	10 cm	Permeameter Ø ID:	4.2 cm
Depth of Auger Hole:	0.5	Average Hole Ø:	11.5 cm

Auger Log E 1262584 N 4847864

DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PARTICLE SIZE CHARACTERISTICS,PLASTICITY, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	MOISTURE CONDITION	SOIL / ROCK TYPE, ORIGIN, DEFECTS, STRUCTURE, FORMATION	GROUND WATER
0.1 0.2 0.3	ψψψψψψ ψψψψψψ ψψψψψψ ψψψψψψ ψψψψψψ ψψψψψψ	SILT; organics; friable; mid-brown; some worms	D/M	Topsoil	none
0.4 0.5	xxx..xxx..xxx xxx..xxx..xxx xxx..xxx..xxx xxx..xxx..xxx	SILT; very minor clay; very minor plasticity; orangey grey/brown		Woodlands Soils	
0.6 0.7		End of Borehole; no groundwater encountered			

$$K_{sat} = \frac{4.4Q\left[0.5\sinh^{-1}\left(\frac{H}{2r}\right) - \sqrt{\left\{\left(\frac{r}{H^2}\right) + 0.25\right\}} + \frac{r}{H}\right]}{2\pi H^2}$$

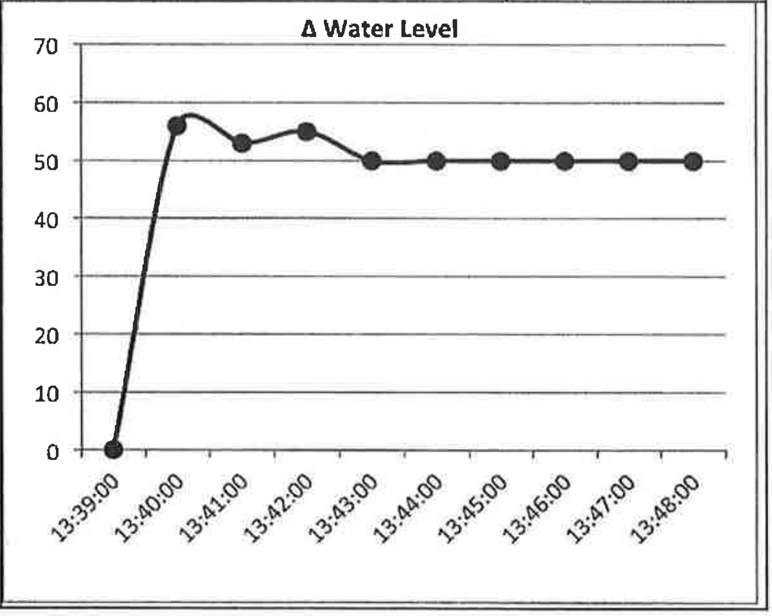
Ksat = 16 mm/hr

Permeameter Readings

Permeameter test was conducted between 0.2m and 0.5m

Water Level in hole 300mm

Time	Δ Time (hr)	Water Level (mm)	Δ Water Level (mm)
13:39:00	0	156	0
13:40:00	0:01:00	212	56
13:41:00	0:01:00	265	53
13:42:00	0:01:00	320	55
13:43:00	0:01:00	370	50
13:44:00	0:01:00	420	50
13:45:00	0:01:00	470	50
13:46:00	0:01:00	520	50
13:47:00	0:01:00	570	50
13:48:00	0:01:00	620	50



Field Auger/Permeameter Test Sheet

Project:	Schrader #2 Effluent		
Site Location:	514 Rimu Seaward Downs Road		
Test Number:	SK-3 in BH-3	Test Date:	2-Dec-14
Operator:	DCS	Test Time:	2:32 pm
Auger Ø:	10 cm	Permeameter Ø ID:	4.2 cm
Depth of Auger Hole:	0.5	Average Hole Ø:	11.5 cm

RDAgritech
ENGINEERED BY NATURE

Auger Log E 1262584 N 4847864

DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PARTICLE SIZE CHARACTERISTICS, PLASTICITY, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	MOISTURE CONDITION	SOIL / ROCK TYPE, ORIGIN, DEFECTS, STRUCTURE, FORMATION	GROUND WATER
0.1	ψψψψψψ ψψψψψψ	SILT; organics; friable; mid-brown; no worms	D/M	Topsoil	none
0.2	ψψψψψψ ψψψψψψ				
0.3	ψψψψψψ ψψψψψψ				
0.4	xxx..xxx..xxx xxx..xxx..xxx	SILT; very minor clay; very minor plasticity; orangey grey/brown		Woodlands Soils	
0.5	xxx..xxx..xxx xxx..xxx..xxx				
0.6		End of Borehole; no groundwater encountered			
0.7					

$$K_{sat} = \frac{4.4Q\left[0.5\sinh^{-1}\left(\frac{H}{2r}\right) - \sqrt{\left\{\left(\frac{r}{H^2}\right) + 0.25\right\}} + \frac{r}{H}\right]}{2\pi H^2}$$

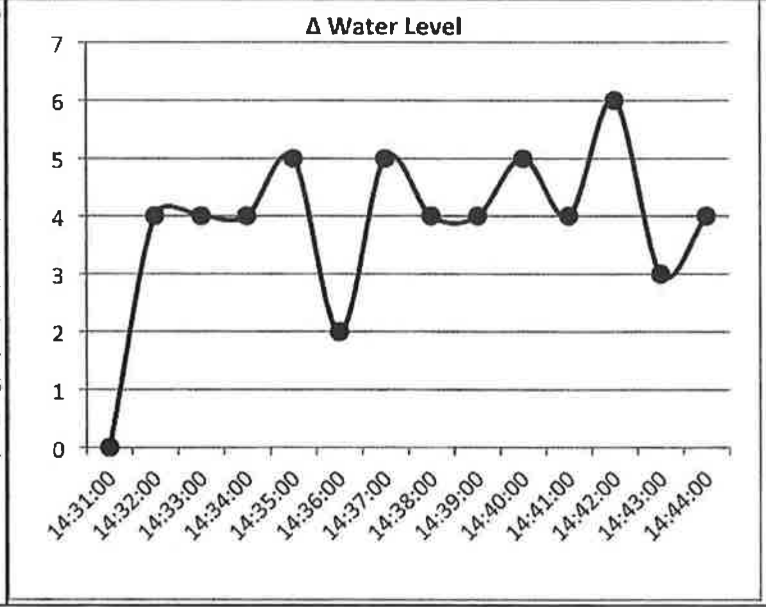
Ksat = 1 mm/hr

Permeameter Readings

Permeameter test was conducted between 0.2m and 0.5m

Water Level in hole 300mm

Time	Δ Time (hr)	Water Level (mm)	Δ Water Level (mm)
14:31:00	0	163	0
14:32:00	0:01:00	167	4
14:33:00	0:01:00	171	4
14:34:00	0:01:00	175	4
14:35:00	0:01:00	180	5
14:36:00	0:01:00	182	2
14:37:00	0:01:00	187	5
14:38:00	0:01:00	191	4
14:39:00	0:01:00	195	4
14:40:00	0:01:00	200	5
14:41:00	0:01:00	204	4
14:42:00	0:01:00	210	6
14:43:00	0:01:00	213	3
14:44:00	0:01:00	217	4



TP-1	TEST PIT LOG		RDAgritech ENGINEERED BY NATURE
JOB NUMBER: 50193	PROJECT:	Schrader #2 Effluent	
	LOCATION:	514 Rimu Seaward Downs Road	
CO-ORDINATES:	HOLE STARTED:	2-Dec-14	
Refer Investigation Site Plan	HOLE FINISHED:	2-Dec-14	
ELEVATION:	OPERATOR:	Michael Kollat	
DATUM:	COMPANY:	Cameron Contracting Ltd	EQUIP.: SH210

ENGINEERING DESCRIPTIONS							GEOLOGICAL
STRENGTH TESTING	GROUNDWATER	SAMPLES	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PARTICLE SIZE CHARACTERISTICS,PLASTICITY, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	MOISTURE CONDITION	SOIL / ROCK TYPE, ORIGIN, DEFECTS, STRUCTURE, FORMATION
				ψψψψψψ	SILT; organics, dark brown	M	Topsoil
				ψψψψψψ			
				ψψψψψψ			
			0.4	xxoxxoxxo	SILT; Gravelly; very minor clay; friable		Woodlands Soil
				xxoxxoxxo			
				xxoxxoxxo			
				xxoxxoxxo			
			0.8	xxoxxoxxo			
				xxoxxoxxo			
				OoOooOoo	GRAVEL; ~0.1 m thick layer of white, rounded gravels		Alluvial Gravels
				xoxoxxoxx	SILT; gravelly; gravel sub-rounded to rounded, some cobbles up		
			1.2	xoxoxxoxx	to 150 mm; greyish		
				xoxoxxoxx			
				xoxoxxoxx			
				xoxoxxoxx	Perched water entering pit at 1.5 m		
			1.6	oo-Ooo-oo	GRAVEL; fine to medium; some gravel to 100 mm; some clay; orangey	M/W	
				oo-Ooo-oo			
				oo-Ooo-oo			
				oo-Ooo-oo			
			2.0	oo-Ooo-oo			
				oo-Ooo-oo			
				oo-Ooo-oo			
				oo-Ooo-oo			
			2.4	oo-Ooo-oo			
				oo-Ooo-oo			
				oo-Ooo-oo			
				oo-Ooo-oo			
			2.8	oo-Ooo-oo			
				oo-Ooo-oo			
				oo-Ooo-oo			
				oo-Ooo-oo			
			3.2	oo-Ooo-oo			
				oo-Ooo-oo			
				oo-Ooo-oo			
	▼			oo-Ooo-oo	Groundwater entering pit at 3.5 m	W	
			3.6	oo-Ooo-oo			
				oo-Ooo-oo			
				oo-Ooo-oo			
				oo-Ooo-oo			
			4.0	oo-Ooo-oo			
				oo-Ooo-oo			
				x.-.-xo.-.xo	SAND; silty, clayey; moderate amount of medium, rounded gravel		
				x.-.-xo.-.xo	End of test pit at 4.5 m depth		

OTHER COMMENTS:	Logged By:	DCS
	Checked Date:	10-Feb-15
PHOTO REF.:	Sheet:	1 of 1

TP-2

TEST PIT LOG

RDAgritech
ENGINEERED BY NATURE

JOB NUMBER: 50193
PROJECT: Schrader #2 Effluent
LOCATION: 113B Cotter Ave
CO-ORDINATES: Refer Investigation Site Plan
HOLE STARTED: 2-Dec-14
HOLE FINISHED: 2-Dec-14
ELEVATION: m
OPERATOR:
DATUM:
COMPANY: Cameron Contracting Lt
EQUIP.: SH210

ENGINEERING DESCRIPTIONS							GEOLOGICAL
STRENGTH TESTING	GROUNDWATER	SAMPLES	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PARTICLE SIZE CHARACTERISTICS,PLASTICITY, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	MOISTURE CONDITION	SOIL / ROCK TYPE, ORIGIN, DEFECTS, STRUCTURE, FORMATION
				ψψψψψψ	SILT; organics, dark brown	M	Topsoil
				ψψψψψψ			
				xxoxxoxxo	SILT; Gravelly; very minor clay; friable		Woodlands Soil
			0.4	xxoxxoxxo			
				xxoxxoxxo			
				xoxoxxoxx	SILT; gravelly; gravel sub-rounded to rounded, some cobbles up		Alluvial Gravels
				xoxoxxoxx	to 150 mm; greyish		
			0.8	xoxoxxoxx			
				xoxoxxoxx			
				xoxoxxoxx			
				xoxoxxoxx			
			1.2	xoxoxxoxx			
				xoxoxxoxx			
				xoxoxxoxx			
				xoxoxxoxx			
			1.6	oo-Ooo-oo	GRAVEL; fine to medium; some gravel to 100 mm; some clay; orangey	M/W	
				oo-Ooo-oo			
				oo-Ooo-oo			
				oo-Ooo-oo			
			2.0	oo-Ooo-oo			
				oo-Ooo-oo			
				oo-Ooo-oo			
				oo-Ooo-oo			
			2.4	oo-Ooo-oo			
				oo-Ooo-oo	Perched water entering the pit at 2.5 m	W	
				oo-Ooo-oo			
				oo-Ooo-oo			
			2.8	oo-Ooo-oo			
				oo-Ooo-oo			
				oo-Ooo-oo			
				oo-Ooo-oo			
			3.2	oo-Ooo-oo			
				oo-Ooo-oo			
				oo-Ooo-oo			
				oo-Ooo-oo			
			3.6	oo-Ooo-oo			
				oo-Ooo-oo			
				oo-Ooo-oo			
				oo-Ooo-oo			
			4.0	oo-Ooo-oo			
				oo-Ooo-oo			
				oo-Ooo-oo			
				oo-Ooo-oo	End of test pit at 4.5 m depth		

OTHER COMMENTS:

PHOTO REF.:

Logged By: DCS
Checked Date: 10-Feb-15
Sheet: 1 of 1

TP-3

TEST PIT LOG

RDAgritech
ENGINEERED BY NATURE

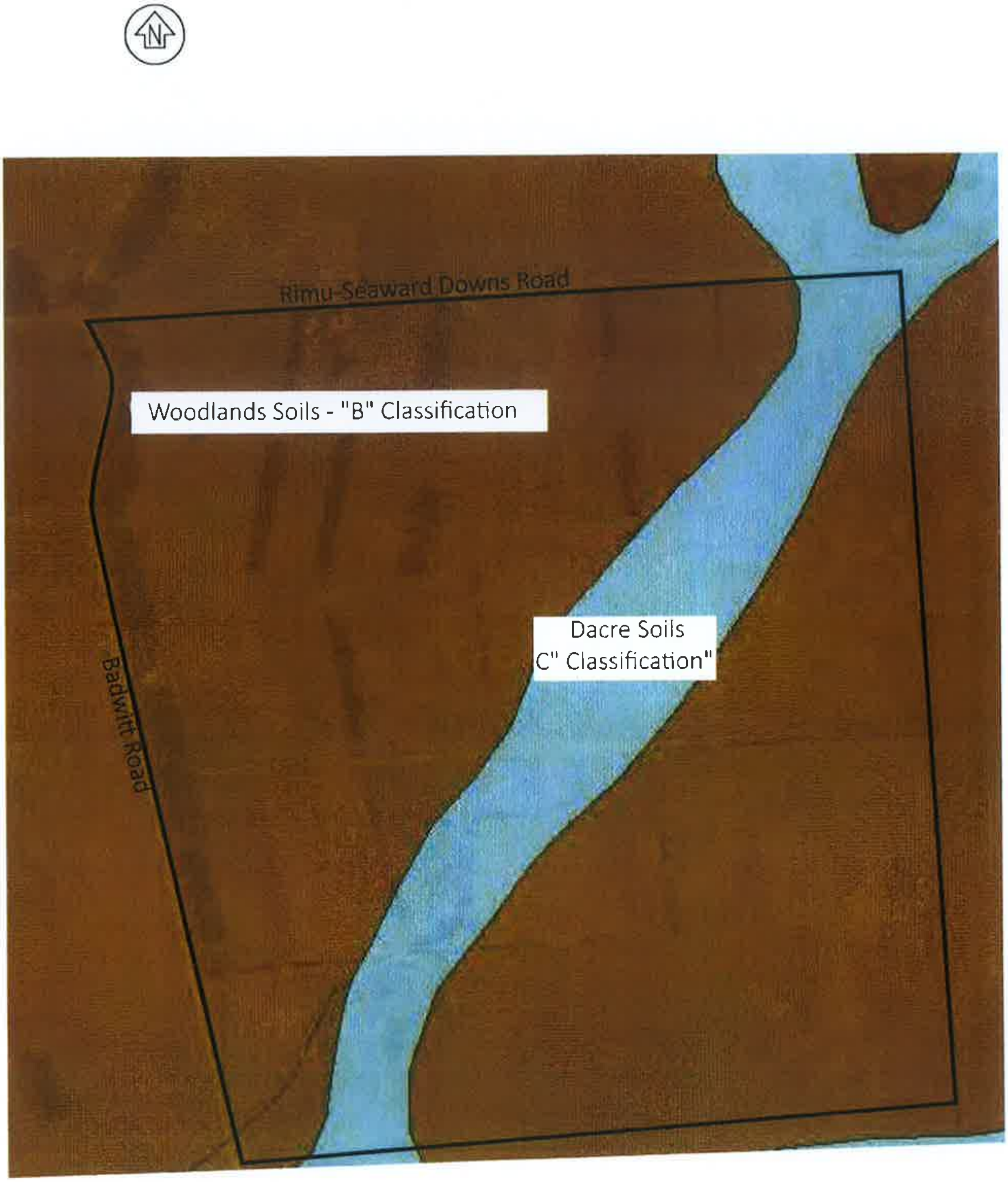
JOB NUMBER: 50193
PROJECT: Schrader #2 Effluent
LOCATION: 113B Cotter Ave
CO-ORDINATES: Refer Investigation Site Plan
HOLE STARTED: 2-Dec-14
HOLE FINISHED: 2-Dec-14
ELEVATION: m
OPERATOR:
DATUM:
COMPANY: Cameron Contracting Lt
EQUIP.: SH210

ENGINEERING DESCRIPTIONS							GEOLOGICAL
STRENGTH TESTING	GROUNDWATER	SAMPLES	DEPTH (m)	GRAPHIC LOG	SOIL / ROCK CLASSIFICATION, PARTICLE SIZE CHARACTERISTICS,PLASTICITY, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	MOISTURE CONDITION	SOIL / ROCK TYPE, ORIGIN, DEFECTS, STRUCTURE, FORMATION
				ψψψψψψ ψψψψψψ	SILT; organics, dark brown	M	Topsoil
			0.4	xxoxxoxxo xxoxxoxxo xxoxxoxxo	SILT; Gravelly; very minor clay; friable		Woodlands Soil
			0.8 1.2 1.6	xoxoxxoxx xoxoxxoxx xoxoxxoxx xoxoxxoxx xoxoxxoxx xoxoxxoxx xoxoxxoxx xoxoxxoxx xoxoxxoxx xoxoxxoxx xoxoxxoxx xoxoxxoxx	SILT; gravelly; gravel sub-rounded to rounded, some cobbles up to 150 mm; greyish		Alluvial Gravels
			2.0	oo-0oo-oo oo-0oo-oo oo-0oo-oo oo-0oo-oo oo-0oo-oo oo-0oo-oo	GRAVEL; fine to medium; some gravel to 100 mm; some clay; orangey	M/W	
	▼		2.4 2.8 3.2 3.6	oo-0oo-oo oo-0oo-oo oo-0oo-oo oo-0oo-oo oo-0oo-oo oo-0oo-oo oo-0oo-oo oo-0oo-oo oo-0oo-oo oo-0oo-oo oo-0oo-oo oo-0oo-oo oo-0oo-oo oo-0oo-oo oo-0oo-oo	Evidence of water at 2.4 m		
			4.0	oo-0oo-oo oo-0oo-oo oo-0oo-oo oo-0oo-oo	Groundwater entering pit at 3.9 m	W	
					End of test pit		

OTHER COMMENTS:

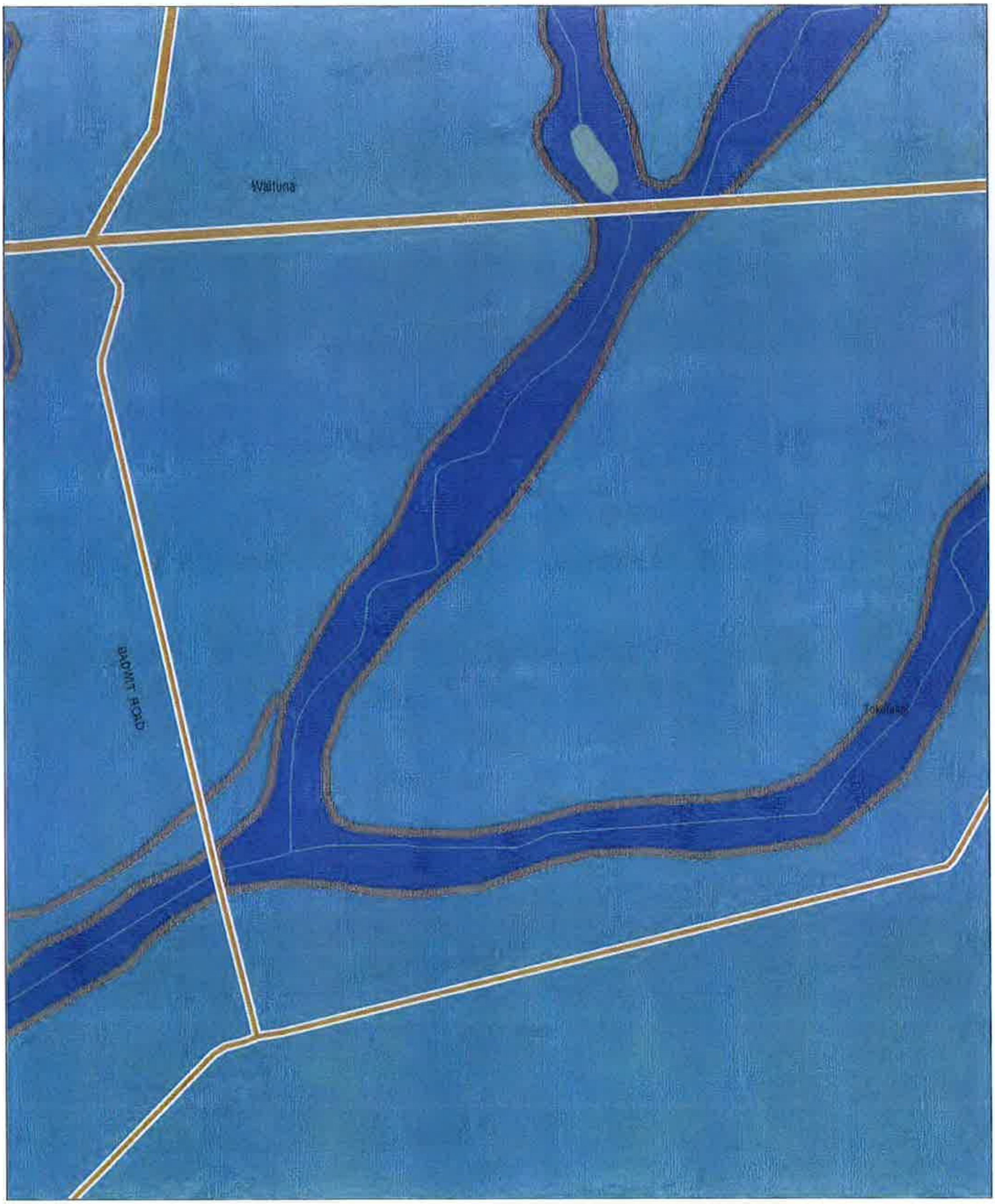
PHOTO REF.:

Logged By: DCS
Checked Date: 10-Feb-15
Sheet: 1 of 1



SOILS TYPES AND CLASSIFICATONS MAP
not to scale

Schrader #2 Effluent PAW Map



S-mapOnline
Fast, simple access to New Zealand soils data

Landcare Research
Manaaki Whenua

Scale: 1:10,000

Printed: 15:40:00 PM Thu, 5 Feb 2015

Legend

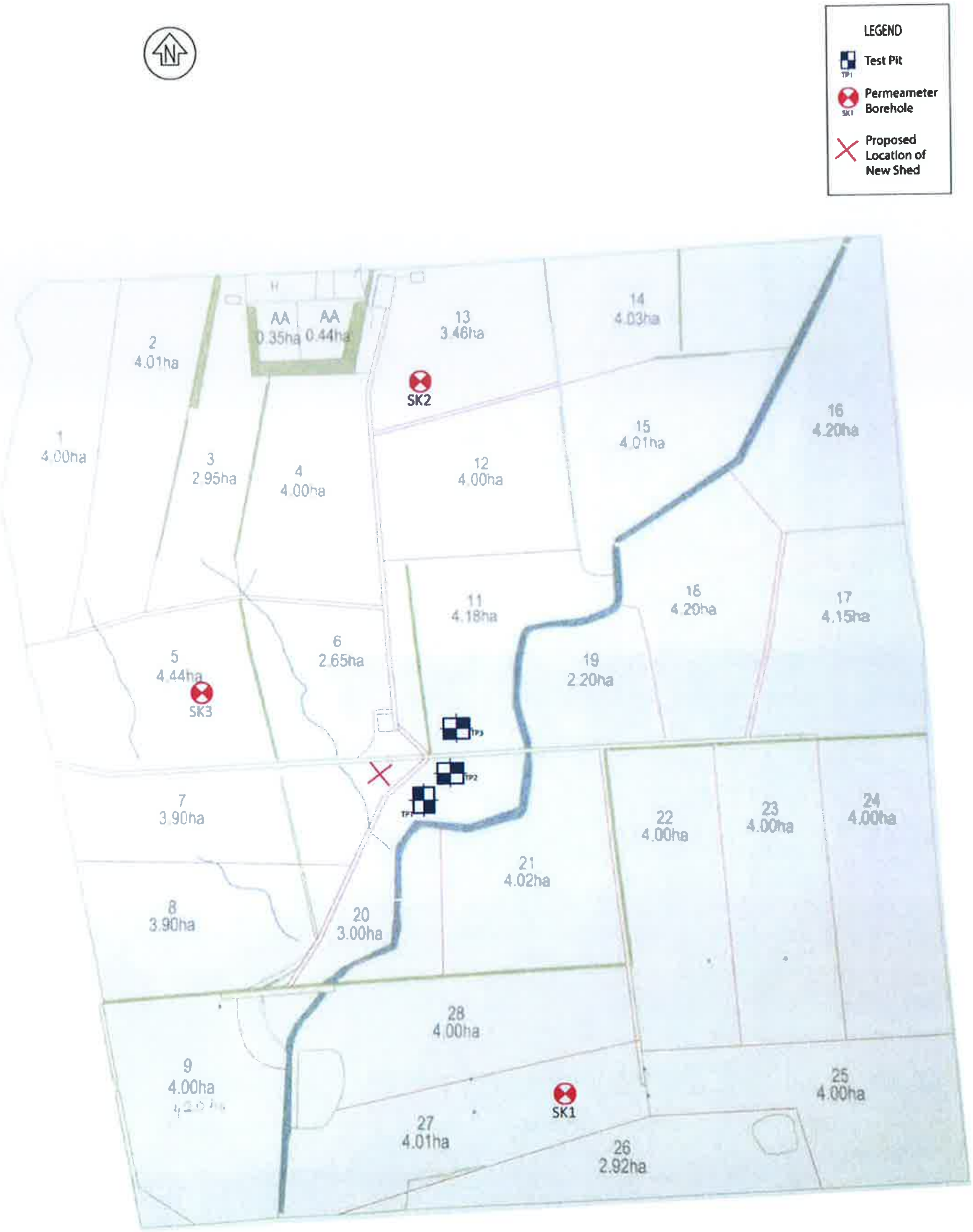
Soil Moisture - Profile Available Water in 1m (mm)

🟦 High

🟦 Very High

S-mapOnline
Fast, simple access to New Zealand soils data

Landcare Research
Manaaki Whenua



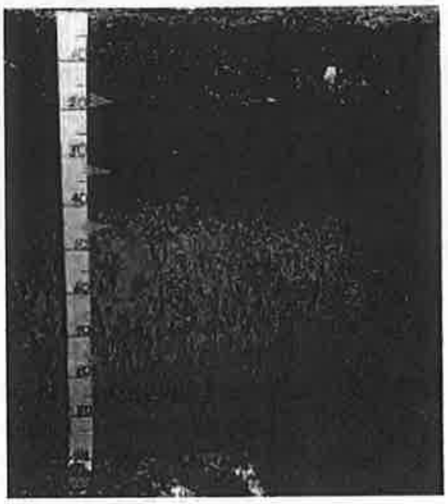
INVESTIGATION LOCATION PLAN
not to scale

Topoclimate Southland Soil Information Sheet No. **33**

Soil name: Dacre

Overview

Dacre soils occupy about 13,200ha on floodplains of minor steams of the Southland plain between the Oreti River and Tokanui. They are formed into fine alluvium from rewashed loess. These soils are moderately deep to deep, poorly drained, and have silty textures. They are used in association with adjacent well drained soils for intensive pastoral farming with sheep, dairy and deer. Climate is cool temperate with regular rain, so soils are often wet.



Dacre profile

Physical properties

Dacre soils have a deep rooting depth and high available soil water, although the rooting depth may be limited by poor aeration during wet periods due to the poor drainage and slow subsoil permeability. Texture is typically silt loam and topsoil clay content is 20–30%. The soils are typically stone free, although the moderately deep phase will have gravels between 45–90cm depth.

Fertility properties

Topsoil organic matter levels are variable and range from 6 to 16%; P-retention values 25–50%; pH values moderate and low in the subsoil. Cation exchange values are moderate, grading to low in the subsoil, while base saturation values are high in the subsoil. Available magnesium and potassium are low, as are soil reserve phosphorus levels. Micro-nutrient levels are generally adequate.

Associated and similar soils

Some soils that commonly occur in association with Dacre soils are:

- Otanomomo: very poorly drained peat soils
- Otepuni: shallow, poorly drained soil on quartz gravels
- Tisbury: poorly drained gley soil, formed in loess on terraces
- Woodlands: imperfectly drained soil formed in loess on terraces.

Some soils that have similar properties to Dacre soils are:

- Titipua: has over-thickened slightly peaty topsoils
- Jacobstown: has a more developed structure with silty textures
- Caroline: has a cemented ironpan in the subsoil.
- Makarewa: has a clayey subsoil with greater structural development.

Sustainable management indicators

Note: the vulnerability ratings given in the table below are generalised and should not be taken as absolutes for this soil type in all situations. The actual risk depends on the environmental and management conditions prevailing at a particular place and time. Specialist advice should be sought before making management decisions that may have environmental impacts. Where vulnerability ratings of Moderate to Very severe are indicated, advice may be sought from Environment Southland or a farm management consultant.

Vulnerability factor	Rating	Vulnerability compared to other Southland soils
Structural compaction	moderate	These soils have a moderate vulnerability to structural degradation by long-term cultivation, or compaction by heavy stocking and vehicles. This rating reflects the poor drainage, that is offset by the moderate topsoil organic matter and P-retention levels.
Nutrient leaching	slight	These soils have a slight vulnerability to leaching to groundwater. This rating reflects the high water holding capacity and slow subsoil permeability.
Topsoil erodibility by water	slight	Due to the medium organic matter and clay content, the topsoil erodibility of these soils is slight. Erodibility is highly dependent on management, particularly when there is no vegetation cover.
Organic matter loss	slight	Vulnerability to long-term decline in soil organic matter levels is partly dependent on soil properties, and highly dependent on management practices (e.g., crop residue management and cultivation practices).
Waterlogging	severe	These soils have a severe vulnerability to waterlogging during wet periods. This rating reflects the poor drainage and slow subsoil permeability.

General landuse versatility ratings

Note: The versatility ratings in the table below are indicative of the major limitations for semi-intensive to intensive land use. These ratings differ from those used in the past in that sustainability factors are incorporated in the classification. Refer to the Topoclimate district soil map or property soil map to determine which of the soil symbols listed below are applicable, then check the versatility ratings for that symbol in the appropriate table.

DcU1 (Dacre undulating deep)
DcU2 (Dacre undulating moderately deep)

Versatility evaluation for soil DcU1, DcU2		
Landuse	**Versatility rating**	**Main limitation**
Non-arable horticulture	Limited	Inadequate aeration during wet periods; risk of short-term waterlogging after heavy rain.
Arable	Limited	Inadequate aeration during wet periods; risk of short-term waterlogging after heavy rain.
Intensive pasture	Moderate	Inadequate aeration during wet periods; risk of short-term waterlogging after heavy rain.
Forestry	Limited	Inadequate aeration during wet periods; potential flood risk.

Management practices that may improve soil versatility

- Careful management after heavy rain and wet periods will reduce the impact of short-term waterlogging. Intensive stocking, cultivation and heavy vehicular traffic should be minimised during these periods.
- Installation and maintenance of subsurface mole and tile drains will reduce the risk of short-term waterlogging.
- If compaction occurs, aeration at the correct moisture content and depth can be of benefit.

Topoclimate Southland Soil Information Sheet No. 24

Soil name: Woodlands

Overview


Woodlands profile

Woodlands soils occupy 24,500 ha on intermediate and high terraces of the lower Southland Plain between the Mataura River and Otautau. They are formed in deep wind-deposited loess derived from greywacke and schist rocks. Woodlands soils are imperfectly drained, have a deep rooting depth, high water holding capacity and silt loam textures. They are high-producing soils currently used for intensive sheep, dairy and deer production, with limited cropping. They have a cool temperate climate and receive regular rain over the year and seldom dry out.

Physical properties

Woodlands soils have a deep rooting depth and high plant-available water, meaning there is no major physical barrier to root growth, although high bulk density in the lower subsoil may restrict root penetration. The compact subsoil is slowly permeable, and may cause short-term waterlogging and limit aeration after heavy rainfall. Texture is silt loam in all horizons, with topsoil clay content of 20-30%. Woodlands soils are typically stone free, although the moderately deep phases have gravel between 45 and 90cm depth that may restrict rooting depth and available water to moderately high.

Fertility properties

Topsoil organic matter levels are 5-7%; P-retention values 30-60%; pH values are moderate, with some profiles below 5.5. Cation exchange and base saturation values are moderate and available magnesium and potassium low. Soil reserves of phosphorus are low and available sulphate sulphur high in the subsoil. Micronutrient levels are generally adequate.

Associated and similar soils

Some soils that commonly occur in association with Woodlands soils are:

- Waikiwi: occurs on the same landforms, but is well drained
- Dacre: poorly drained soil on floodplains of streams and minor drainage channels.
- Oteramika: shallow soil occurring on shoulder and side slopes where loess has been eroded away
- Pukemutu: poorly drained soil, due to water perching on a dense subsoil fragipan.

Some soils that have similar properties to Woodlands soils are:

- Mokotua: occurs on the same landforms, but is more severely mottled, with the imperfect drainage tending towards poorly drained. The soils lack the structureless horizon, having a structured subsoil to 90cm.
- Arthurton: imperfectly drained Brown soil associated with Pallic soils of northern Southland, reflected in P-retentions of 20-40%
- Aparima: imperfectly drained Brown soil with a fragipan, associated with Pallic soils (Pukemutu series) on the Southland Plains, west of the Oreti River
- Fortrose: imperfectly drained soil occurring in near-source loess east of the Mataura River, west to south of Fortrose; has pale coloured subsoils with loamy silt textures.

Sustainable management indicators

Note: the vulnerability ratings given in the table below are generalised and should not be taken as absolutes for this soil type in all situations. The actual risk depends on the environmental and management conditions prevailing at a particular place and time. Specialist advice should be sought before making management decisions that may have environmental impacts. Where vulnerability ratings of Moderate to Very severe are indicated, advice may be sought from Environment Southland or a farm management consultant.

Vulnerability factor	Rating	Vulnerability compared to other Southland soils
Structural compaction	moderate	These soils have a moderate vulnerability to structural degradation by long-term cultivation, or compaction by heavy stocking and vehicles. This rating reflects the moderate topsoil clay and P-retention values, but is offset by the imperfect drainage.
Nutrient leaching	slight	These soils have a slight vulnerability to leaching to groundwater. This rating reflects the imperfect drainage, high water holding capacity and slow subsoil permeability .
Topsoil erodibility by water	slight	Due to the topsoil clay percentage, the topsoil erodibility is slight. Erodibility is highly dependent on management, particularly when there is no vegetation cover.
Organic matter loss	slight	Vulnerability to long-term decline in soil organic matter levels is partly dependent on soil properties, and highly dependent on management practices (e.g., crop residue management and cultivation practices).
Waterlogging	moderate	These soils have a moderate vulnerability to waterlogging during wet periods. This rating reflects the imperfect drainage and slowly permeable subsoil.

General landuse versatility ratings

Note: The versatility ratings in the table below are indicative of the major limitations for semi-intensive to intensive land use. These ratings differ from those used in the past in that sustainability factors are incorporated in the classification. Refer to the Topoclimate district soil map or property soil map to determine which of the soil symbols listed below are applicable, then check the versatility ratings for that symbol in the appropriate table.

WdU1 (Woodlands undulating deep); WdU2 (Woodlands undulating moderately deep)

Versatility evaluation for soil WdU1, WdU2		
Landuse	**Versatility rating**	**Main limitation**
Non-arable horticulture	Moderate	Inadequate aeration during wet periods; risk of short-term waterlogging after heavy rain.
Arable	Moderate	Inadequate aeration during wet periods; risk of short-term waterlogging after heavy rain.
Intensive pasture	Moderate	Inadequate aeration during wet periods; risk of short-term waterlogging after heavy rain.
Forestry	Moderate	Vulnerability to sustained waterlogging.

WdR1 (Woodlands rolling deep); WdR2 (Woodlands rolling moderately deep)

Versatility evaluation for soil WdR1, WdR2		
Landuse	**Versatility rating**	**Main limitation**
Non-arable horticulture	Moderate	Inadequate aeration during wet periods; rolling slopes
Arable	Limited	Rolling slopes.
Intensive pasture	Moderate	Inadequate aeration during wet periods; rolling slopes.
Forestry	Moderate	Vulnerability to sustained waterlogging.

WdH1 (Woodlands hilly deep); WdH2 (Woodlands hilly moderately deep)

Versatility evaluation for soil WdH1, WdH2		
Landuse	**Versatility rating**	**Main limitation**
Non-arable horticulture	Unsuitable	Hilly slopes
Arable	Unsuitable	Hilly slopes
Intensive pasture	Limited	Hilly slopes
Forestry	Moderate	Vulnerability to sustained waterlogging; hilly slopes.

Management practices that may improve soil versatility

- Careful management after heavy rainfall and wet periods will reduce the impact of short-term waterlogging. Intensive stocking, cultivation and vehicular traffic should be minimised during these periods.
- Installation and maintenance of subsurface drainage with moles and tiles may reduce the risk of short-term waterlogging
- If compaction occurs, aerating at the correct depth and moisture content can be of benefit.

APPENDIX D. DESIGN DRAWINGS

1. Deferred Storage Pond Drawings

APPENDIX E. SPECIFICATIONS

1. Earthfill Specification

SCHRADER #2 EARTHWORKS AND EARTHFILL SPECIFICATION

1 SCOPE

This specification consists of the excavation and bulk earth fill requirements for the site including the stripping of topsoil, controlled filling, cut to waste, topsoiling and re-vegetation, excavation of open drains and other related work for the placement of bulk earth fill. This Specification shall be read in conjunction with all other documents.

The specification will form the basis of works to enable the Pond to be certified in accordance with the Environment Southland Land use consent issued for the works.

All works shall be in accordance with the issued consent documents for the property, design drawings, specifications and any other documents or variations issued as part of the works to be completed.

2 RELATED DOCUMENTS

In this Specification, reference is made to the following documents:

- New Zealand Building Code
- NZS 4431:1989 Code of practice for earthfill for residential development
- NZS 4402: 1986 Methods of testing of soils for civil engineering purposes (Suite)

3 QUALITY ASSURANCE

The work shall be carried out by a reputable Earthworks Contractor, In accordance with best trade practice of sound repute by competent craftsmen using equipment, materials and processes that are best suited for the purpose and shall be of the very highest standard.

No Change or Variation is permitted unless the Engineer provides appropriate written instructions.

Dimensions and details shall be read in conjunction with the Engineer's drawings. The Contractor shall check all dimensions before construction commences.

The Contractor shall fully comply with all the provisions of the New Zealand Building Code, including all requirements for site and worker safety.

Ensure that all contract insurances are in place before starting work on site. Insurances shall remain in place for the full duration of the project until practical completion.

Any additional permits, consents or notifications required by any authorities shall be obtained and paid for and all necessary deposits, plans and specifications lodged as required before any work is commenced.

Any tests and inspections required by any of the above regulations or authorities shall be made at the appropriate time. Any works covered up before such required tests or inspections have been made shall be uncovered and opened up for testing and inspection at the Contractor's expense.

4 GENERAL REQUIREMENTS

4.1 DRAINAGE AND EROSION CONTROL

All bulk Earthworks shall be carried out in fully drained conditions with no free water on the working surfaces. Where it is impractical to maintain excavations of unsuitable material deposits in a fully drained condition, the Engineer will have discretion to relax this requirement to the degree that is necessary.

Cut areas shall be sloped and graded adequately so that they do not pond water or allow water to infiltrate, and drains shall be installed or pumping carried out as necessary on a regular basis to remove water from the areas of operations, or to drain water as soon as it is seen to develop.

Any filling, which has been allowed to become too wet or soft, shall be removed and dried, or replaced. All fill surfaces shall be rolled off at the end of each day's work to prevent erosion. Prior to commencement of the filling operations the following day, the smooth surface shall be scarified by approved plant to ensure a good bind to the lower surface is achieved.

4.2 DUST CONTROL

Earthmoving shall be carried out and maintained so that dust is not raised near or blown over the working area and existing buildings. The Site shall be kept watered as necessary to meet this requirement until covered by dust-free materials.

4.3 SILT CONTROL

The Contractor is responsible for all silt control and discharge from the site of works. Silt control measures installed must not allow untreated sediment laden water to enter waterways downstream. The engineer has the discretion to order cessation of works to remedy any non-compliance or what the engineer considers inadequate silt control measures.

As a minimum

- Upslope stormwater diversion channels shall be installed around the fill areas to suit
- Silt fences and hay bales at regular intervals as required to prevent uncontrolled discharge of sediment laden water to the surrounding area.

Ideally a sediment collection pond and decanting pipework would be installed to provided appropriate detention times for suspended sediments, guidance can be found in Auckland Regional Council Technical Publication TP90 here:

http://www.aucklandcouncil.govt.nz/EN/planspoliciesprojects/reports/technicalpublications/Pages/technicalpublications51-100.aspx

4.4 SEQUENCE OF OPERATION

In the event that a particular sequence of operation is required by the Principal or the Engineer, or because of the nature of the Works, then the Contractor shall submit with their original programme, a Methodology Statement that will include their preferred sequence of carrying out the Works. Any such statement shall be subject to the approval of the Engineer and shall comply with any internal completion dates or order of carrying out the Works set out in the contract. The Methodology Statement shall be updated from time to time as required by the Engineer.

4.5 PRESERVATION AND MAINTENANCE

The Contractor shall preserve and maintain all Earthworks, including partly completed Earthworks, and make good at no cost to the Principal any Earthworks that have deteriorated below the specified standards for whatever reason.

4.6 TOLERANCES

All Earthworks shall be carried out to the lines levels and grades shown on the Drawings and specifications. Finished level tolerances shall be as follows:

– Batters	±0 mm to 100 mm
– Other surfaces	±0 mm to 50 mm
– Pipe inverts	±0 mm to 10 mm

5 REMOVAL OF VEGETATION

The Contractor shall remove all vegetation from the site of Earthworks, and shall clear all obstructions from the Site of the Works. Clearing shall mean the removal of all growth (other than grass and weeds), extraction of stumps, and other items remaining above the surface of the ground, and the complete disposal of all items. Extraction of stumps (if any) shall remove all roots greater than 25mm diameter. The removal of grass and weeds shall be provided for under topsoil stripping.

6 EXCAVATION

6.1 REMOVAL OF TOPSOIL

All turf and organic topsoil shall be stripped from the areas subject to Earthworks before other operations commence in these areas. All topsoil shall be stockpiled for future reuse in the locations shown on the drawings or areas otherwise approved on Site by the Engineer or principle. If stockpiled slopes shall not be steeper than 1 vertical to 1.5 horizontal and have all changes of grade rounded to conform generally to the surrounding landscape.

The stockpile should be track rolled during formation as with the outer surface, to minimise organic decay during stockpiling. The location of the stockpile shall be such that no water can pond or be impounded by the stockpile.

The depth of topsoil stripping shall be sufficient to remove all organic material, turf and significant plant roots. Except where limited by boundaries, existing works or other limiting features, stripping shall extend 3 metres beyond the limits of areas subject to Earthworks or construction. The Contractor shall cooperate with the Engineer ahead of and during stripping operations to determine the stripping depth and shall avoid unnecessary over excavation.

6.2 OVER EXCAVATION

The Contractor shall direct their operations to avoid excavating beyond designated profiles. Any excavation beyond these profiles carried out without express instruction by the Engineer shall be made good to the direction of the Engineer with compacted fill of equal quality to that designated to cover the excavated profile. This reinstatement work shall be at no cost to the Principal.

6.3 CUT TO WASTE

All cut material other than topsoil and that required for fill or backfill shall be carted to the Principal's nominated dump or removed from Site and disposed of. The dumped material shall be track rolled and levelled to the level of the surrounding ground or as directed. Any material to be carted offsite will need the principles approval prior to commencing.

6.4 EXCAVATE TO FILL

The location of the borrow area at this stage is the main excavation area as shown on the supplied earthworks drawings. Should this need to be varied it is to be determined during discussions with the successful Contractor and principle. The Engineer or Principle shall advise other areas as required. At this stage any shortfall is expected to be obtained from the existing gravel extraction area previously consented.

The Contractor shall exclude all organic matter from fill excavations.

7 UNDER DRAINS

Under drainage will be required under the sump base of the pond and will be trenched downhill at a minimum grade of 1 in 100. It will be day lighted at an approved sump/wing wall and be protected from stock damage. A drain and sump detail is provided in the design report drawings.

The underdrain beneath the sump is to be perforated drain coil and then connected to a solid uPVC pipe with a concrete collar as per the drawings.

The drainage aggregate must be clean washed, well-graded gravels. TNZ F6 is a suitable drainage material. The entire drainage trench is to be wrapped with geotextile cloth. Engineering approval must be sought prior to any substitutions.

8 INSPECTION SCHEDULE

The following inspection schedule is the MINIMUM number of inspections required. Failure of the contractor to give sufficient notice (48 hours) or covering of works prior to inspection will result in any and all costs to test or inspect the works to the sole satisfaction of the engineer to be born by the contractor.

A schedule of inspection check sheet is supplied with the tender documents and a summary list is detailed below.

- Inspection by the engineer is required post topsoil stripping to confirm adequate removal of organics and topsoil.
- All subgrade areas must be inspected, tested and approved by the engineer or their representative prior to fill placement.
- All under runners shall be subject to engineers' inspection and approved mitigation.
- The engineer will inspect the works during construction to confirm compliance with the drawings and specification as required, with at least 5 visits during construction.
- in-situ density testing in accordance with section 9.3 test 4B (NDM) below would be conducted by Central Testing Laboratories, or their local agent with Central Testing used for any laboratory testing required, the results will need to be forwarded to RDAgritech within 24 hours of results being available or a verbal call as a minimum.
- in-situ density testing in accordance with section 10.0 below would be conducted by RDAgritech Ltd, with central testing used for any laboratory and a subcontracted company for NDM testing if required would be specified by RDAgritech Ltd.

9 FILL PLACEMENT

9.1 GENERAL

Prior to compaction, all fill material shall be broken into fragments of less than 200mm. The material shall be spread uniformly in layers of less than 200mm thickness, and conditioned to appropriate average water content.

New fill shall not be spread over surfaces that have deteriorated from their specified condition. Where necessary, the old surface shall be scarified, conditioned, re-compacted and retested before placing new fill.

The Contractor shall exclude all organic matter from fills.

Where the fill surface has been subject to freezing then no fill shall be placed until the surface has adequately thawed and the surface reconditioned to acceptable for fill placement.

Fill placed in the anchor liner trench needs to be compacted carefully to the following standards due to the risk of liner puncture.

All fill batters will be overfilled and then cut back to the final shape. Compaction shall not occur on sloping surfaces.

9.2 EQUIPMENT

The Contractor shall employ sufficient compaction equipment to achieve the specified compaction. The number and type of plant necessary shall be confirmed by trials. No subsequent changes shall be introduced without the prior approval of the Engineer.

9.3 CONTROL OF WATER CONTENT

When soil is to be dried the Contractor shall disc the soil and allow it to dry uniformly to its full depth. Alternative other dry soils may be mixed to a uniform consistency to help with the reduction of water content on the whole.

When the soil is to be wetted, this shall be done with sprinkling equipment ensuring uniform and controlled distribution of water in conjunction with blading and discing.

Any costs of drying or wetting will be deemed to be included in the fill rate or other scheduled items. No extra payments will be made.

9.4 COMPACTION REQUIREMENTS

The maximum dry density will be determined by the methods of NZS: 4402 where these are appropriate.

The compaction requirements for embankment fill material shall be as follows:

- Cohesive material such as bulk fill to the finished levels sourced from the excavation or borrow pit (Silts/Clays etc.) shall be placed in uniform layers not greater than 200mm loose thickness. Fill shall achieve the following standards:
    - The in-situ dry density shall be not less than 95% of the maximum dry density (MDD), and/or
    - Average vane strength over 10 consecutive readings shall not be less than 100kPa with no individual reading less than 80kPa.
    - For onsite correlative testing the Scala Penetration Resistance SPR (number of blows to drive the Scala penetrometer 150 mm) below the fill surface shall be not less than 8. The upper 150 mm may be ignored for the purpose of this test. This is to be recorded by adding the blows per 50 mm for a consecutive 150 mm depth with the SPR for each 50mm the addition of the preceding three 50mm intervals. Ideally the target depth would be 900mm for each test point.
- Cohesionless material such as onsite or imported gravels, sands and hard fill shall be placed in uniform layers not greater than 200mm loose thickness. Compaction on each layer of fill materials so placed shall be sufficient to obtain the following standards:
    - The SPR will be a minimum of 12, or
    - The in-situ dry density shall be not less than 95% of the maximum dry density (MDD), and
    - No undue deflection occurs when tracked with a fully loaded 6-wheel dump truck.

The base of the excavation shall also be compacted/conditioned to achieve an SPR minimum of 8 or in-situ shear vane of 100kPa.

9.5 COMPACTION TRIALS

Before filling is started the Contractor shall demonstrate to the Engineer the adequacy of the equipment to be used by spreading and compacting a minimum of three individual superimposed layers of soil (200mm thickness before compaction) in which tests of the standard of compaction shall be conducted.

The required standards of compaction shall be as defined in Clause 9.4. During the compaction trials the Contractor may develop, in conjunction with the Engineer, ad hoc tests, which the Contractor may use himself as an approximate guide to the standard of compaction being achieved at any time.

Should differing kinds of soil be uncovered during the course of subsequent work, further trials shall be conducted at the direction of the Engineer.

At the time of writing the specific fill borrow was not known, when the Contractor is made aware of the area then compaction samples should be taken and sent to the lab for processing, this usually takes 7 days for a result so preplanning is essential.

10 TESTING

10.1 GENERAL

Were a subcontracted testing agency for onsite NDMs is engaged, the Contractor will be responsible for coordinating and paying for all testing of the fill to meet the requirements of the specification. The results of which will be forwarded to the Engineer daily.

The Engineer or testing agency (Inspector) may carry out check tests of compaction at any time. The Contractor shall stop or divert their machines as required by the inspector to allow the tests to be carried out.

Where field tests indicate that the specified standard of compaction has not been achieved, the inspector may order cessation of work and/or removal of the fill, subject to the nature of the fill concerned.

All costs associated with the re-testing of any fill areas that fail to meet the specified standards, will be charged to the Contractor and will be deducted from Progress Payments.

Such costs will include all related supervision and administration time incurred by the Inspector or Engineer and their staff in determining the extent of compacted fill failing to meet the specified standards, its subsequent re-testing and the effecting of the appropriate advice to all parties concerned.

At any time either prior to or during the course of construction, the Inspector may direct modifications to the compaction methods, with the object of ensuring that the optimum compaction criteria for the particular materials and conditions being encountered or likely to be encountered are achieved.

Where no compaction curves are available in the specification or reporting, or the Contractor feels he does not have sufficient information within the pond extents to successfully complete the contract, it is the Contractor's responsibility to notify the Engineer as well as conducting their own investigation of the pond area and obtaining appropriate compaction samples or additional information as they deem necessary.

10.2 TESTING PROCEDURE

The Contractor shall be responsible for ensuring that the specified compaction parameters are achieved and shall carry out such testing as is needed to ensure the consistent quality of the fill. Approximate test methods may be employed to obtain rapid indicative results, but approximate methods shall not be used for acceptance purposes where the adequacy of materials, processing or workmanship is in doubt or the amount by which the test result fails, falls within the confidence limits of the approximate test result.

The tests described and defined in Clause 10.3 will be used to determine the classification and compaction standards of fill materials.

The Contractor shall interrupt or divert their operations as necessary to permit the Inspector to conduct any verification tests required with complete safety.

10.3 TESTS AND TEST METHODS

Test No.	Test	Test Method
2	Vane Shear*	Test Method for Determining the Vane Shear Strength of a Cohesive Soil using a Hand Held Shear Vane, NZ Geotechnical Society, 2001
3	Sieve Analysis	NZS 4402:1980 (Test 2.98.2)
4A	In-situ Density*	ASTM D2922 (& D3017) (Nuclear Densometer) may be used
4B	Water Content	NZS 4402:1986 Test 2.1
4C	Solid Density	NZS 4402:1986 Test 2.7
6	Scala Penetrometer	NZS 4402:1988 Test 6.5.2

* Test method qualified by following notes.

Vane Shear Tests:

The vane shear strength of the soil at any test position shall be taken as the mean of the results of a set of tests. A set of shear tests shall comprise four or more individual tests made within an area of 1m2.

- Before a new shear vane is first used it should be calibrated to obtain values of torque vs. spring deflection. It should be recalibrated at intervals of not more than 12 months.
- The vane shear strength of the soil must be derived in accordance with the Test Method for Determining the Vane Shear Strength of a Cohesive Soil using a Hand Held Shear Vane New Zealand Geotechnical Society 2001.
- Vane shear strengths based on vane manufacturer's empirical calibrations shall not be used.
- During penetration or testing with the shear vane, every effort shall be made to avoid any gravels present in the fill. If it can be demonstrated that any single test is influenced by the presence of gravels, that single test shall be noted but the result disregarded for acceptance purposes.

10.4 TEST FREQUENCY

The frequency of testing will depend on the consistency of fill operations and materials used, but the testing rate will be generally as follows:

Test	Location/purpose	Frequency
In-situ density	Bulk fill and lining materials	1 set per 250 m^3 or every 0.5 m lift for the first 1.5 m lift, then as required by the engineer.
Water content	In-situ density air voids	As per in-situ density
Solid density	For use in measuring air voids	One per soil type
Shear Vane	Shear strength	As required
Scala Penetrometer	Soil strength	As required

As soon as the Engineer is satisfied that materials are consistent and work is being carried out in a systematic and consistent manner, they may reduce the frequency of testing as they judge to be appropriate.

11 TOPSOILING AND GRASSING

11.1 GENERAL

Topsoil shall not be handled or worked when plastic (mouldable), unless directed by the Engineer. Where it is necessary to place the topsoil when plastic, the soil shall be loosely deposited across the site, and then allowed to dry before being worked. All traffic shall be kept off the topsoil when plastic.

Unless otherwise instructed, the Contractor shall use the stockpiled material removed during site preparation. Should there be a shortage of stockpiled materials, the Contractor shall obtain the approval of the Engineer and principle for the importation of topsoil from sources external to the Site. Such imported topsoil shall be clean friable soil, free from excessive amounts of sand, gravel and stones, and shall be capable of supporting the vegetation specified.

Topsoil shall be spread over all areas to be revegetated to a minimum thickness of 200mm. Spreading shall not be done when the ground or the topsoil is excessively wet or otherwise in a condition detrimental to the work.

Should excess soil be available it may be used on the outside of the embankments as buttress and to reduce the slope of the external batters. The soil should be shaped to conform with natural contours and be as smooth as possible with a gentle transition.

All topsoil shall be smoothed with a chain harrow towed by a light tractor or similar to eliminate all minor depressions and wheel marks and to produce a smooth evenly graded open textured surface that will not hold water.

The seed and fertiliser shall be uniformly distributed and harrowed into the topsoil to a depth of 15 - 20mm, leaving a smooth, evenly graded, open textured surface which will not hold water. The Contractor shall not compact the topsoiled surface.

The Contractor shall maintain, dress up and re-sow as necessary, the topsoiled and revegetated surfaces until all surfaces are completely covered with a good strike of revegetation and free from runnels.

The Principle shall specify and supply the pasture type and mix.

11.2 MARGINAL AREAS

Marginal areas between roads, security fences and buildings shall be covered with not less than 100mm of topsoil, and sown and fertilised with a grass seed and fertiliser mix suited to the soil and climate of the District or as specified.

12 SYNTHETIC LINER

The synthetic liner proposed is a 1.5 mm HDPE. Alternative liner systems will require approval from RDAgritech Ltd.

The licensed installer of the product will undertake all installation requirements for placement in accordance with the design/build components supplied by them. All instructions and requirements for them to provide their 20 year warranty must be complied with. Liner installers have advised that the liner is to be placed on a sand, or less than 10mm gravel, blinding layer of 20 mm thickness or a geotextile cloth protection layer. All batter edges and corners are to have a minimum 0.5 m radius rounded edge to prevent liner damage.

Sand bags are to be provided by the principle for use as anchor weights during construction. A nominal 30 bags are required at this stage. The liner supplier can supply these at a cost if required.

Safety stairs are to be provided in the locations as shown on drawings. The anchor trench detail is as per the drawings.

The anchor trench is to be excavated after the main pond earthworks are complete to ensure a stable batter slope.

An inlet pipe connection is to be installed through the liner using the proprietary compression connection details supplied by the liner installer.

Fill placement into the anchor trench is to be conducted by suitably sized plant so as to provide even placement of fill without damaging the liner. The fill in this trench is to be compacted to a minimum 93% MDD.

Gas Venting is required to be installed beneath the liner as per the Liner installer's recommendations.

The liner installer is to inspect and approve the final surface prior to installation of the liner, Liner installation results in the liner installer accepting the subgrade/shape and condition as suitable.

13 Health & Safety

All work must be in compliance with the Health and Safety in Employment Act. The following table from *IPENZ Practice Note 21: Farm Dairy Effluent Ponds* summarizes minimum hazard mitigation required around FDE ponds.

HAZARD MITIGATION AROUND FDE PONDS	
Fencing	Permanent and secure fencing to prevent stock and children from accessing FDE pond areas.
Gates	Lockable Access gates
Emergency Escape options	Permanent ladders and escape ropes.
Rescue buoy	A rescue buoy or similar on a rope that can be thrown to a person in the pond to help them keep afloat.
Anchor points	Anchor points to attach floating pontoons (if used) to improve stability.
Signage	Hazards on site clearly shown

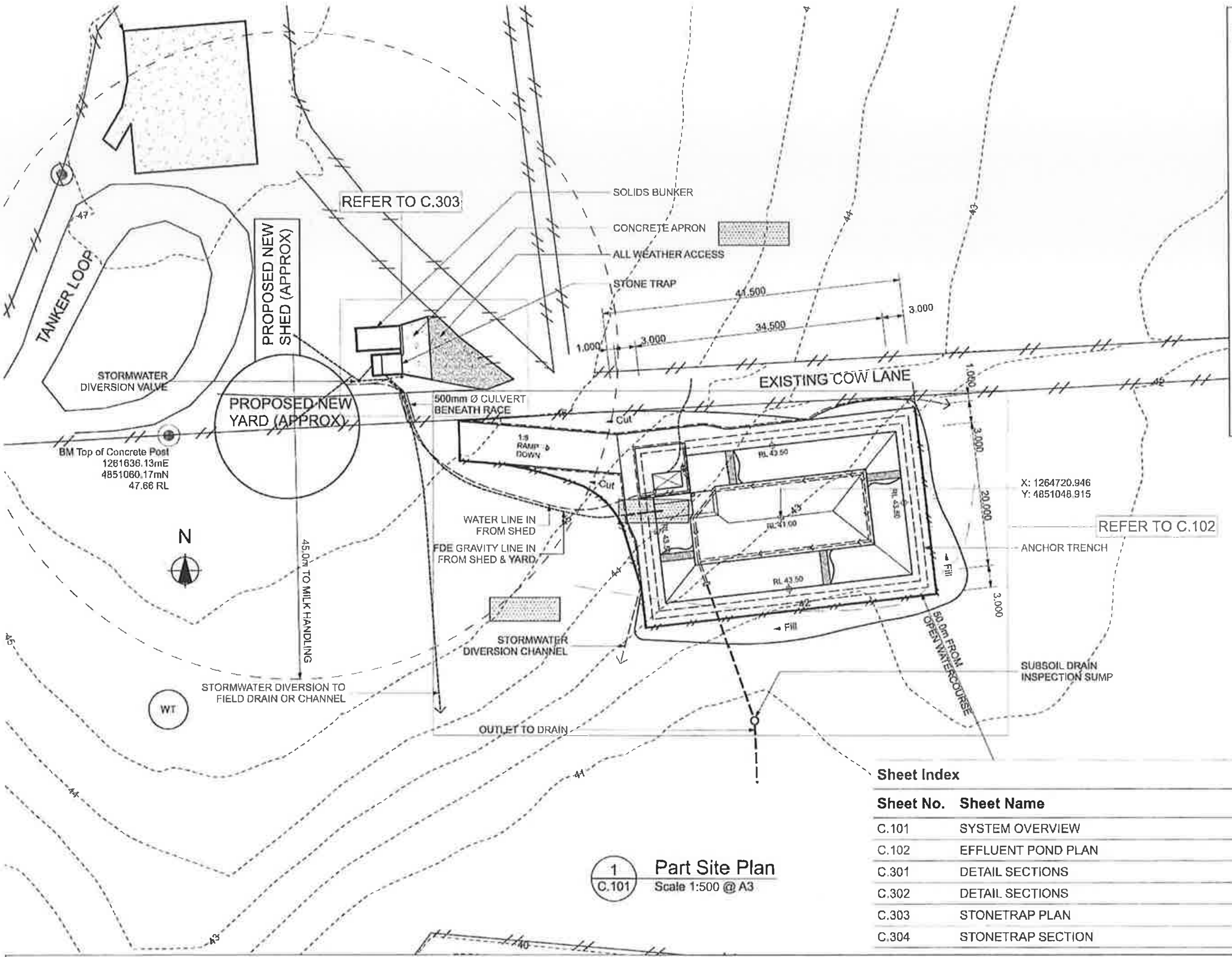
The pond and any sumps that pose a health and safety hazard of falling, drowning and/or entrapment shall be fully fenced as deemed appropriate by the principles health and safety policy on farm. The fencing should be appropriate for the hazards, stock, personnel and accessibility by the type of individuals likely to enter the site. Guidance on fencing systems can be obtained on the Dairy NZ website.

Revision History

rev	date	issue
01	04/02/2015	RESOURCE CONSENT

Notes:

1. Check all dimensions on site.
2. All drawings to be read in conjunction with RDAgritech Design Report and Specifications.
3. Cut / Fill volumes solid measure, approximate only, and based on typical pond section. Contractor to confirm volumes.
4. Any variations from the design drawings are to be confirmed by the Engineer in writing.
5. Irrigation Contractor to confirm new watermain details.
6. Coordinates in NZTM.
7. **Effluent Line out of Pond to be determined** by Irrigation Contractor.
8. All Pipework to have 1:100 grade unless stated otherwise, and to be fully sealed and glued to prevent leaks.
9. All Safety Stairs to have Safety Ropes Installed as well.
10. Pond Area to be Fully Fenced (Client to Arrange).
11. Gas Venting to be Installed Under the Liner, with vents installed at top of embankment.
12. Engineer to inspect once pond is fully excavated to assess whether additional subsurface flow drains are required.
13. All concrete work to be in accordance with IPENZ practice note 27.
14. All excavation work to comply with health and safety requirements for working in trenches and pits and the specific site hazards.
15. Safety Bouys to have min 30.0m rope length **and to be mounted on Fence Post.**



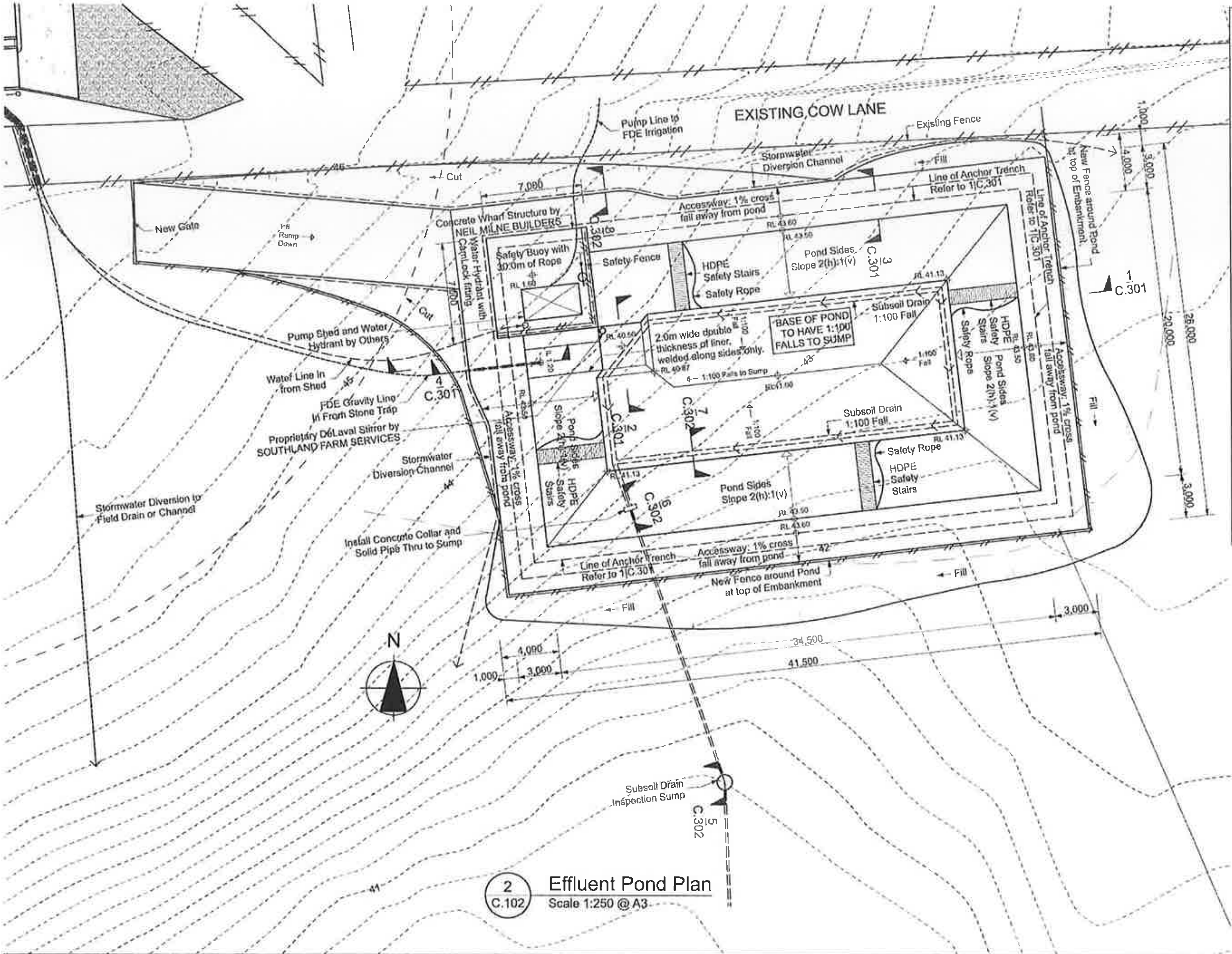
1
C.101

Part Site Plan
Scale 1:500 @ A3

Sheet Index

Sheet No.	Sheet Name	Published	Rev No.
C.101	SYSTEM OVERVIEW	☒	01
C.102	EFFLUENT POND PLAN	☒	01
C.301	DETAIL SECTIONS	☒	01
C.302	DETAIL SECTIONS	☒	01
C.303	STONETRAP PLAN	☒	01
C.304	STONETRAP SECTION	☒	01

RDAgritech ENGINEERED BY NATURE	Engineering Firm RDAgritech Ltd P.O. Box 1711 Invercargill 9840	Project Manager	Client SCHRADER MAINS LTD 514 RIMU SEAWARD DOWNS ROAD OTERAMIKA	SCHRADER #2 EFFLUENT POND DESIGN	Sheet Title: SYSTEM OVERVIEW Printed: 4/02/15	Scale: as shown Job No. 50193	Drawing No. C.101 Revision 01



2 C.102

Effluent Pond Plan

Scale 1:250 @ A3

Revision History

rev	date	issue
01	04/02/2015	RESOURCE CONSENT

Notes:

1. Check all dimensions on site.
2. All drawings to be read in conjunction with RDAgritech Design Report and Specifications.
3. Cut / Fill volumes solid measure, approximate only, and based on typical pond section. Contractor to confirm volumes.
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5. Irrigation Contractor to confirm new watermain details.
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9. All Safety Stairs to have Safety Ropes Installed as well.
10. Pond Area to be Fully Fenced (Client to Arrange).
11. **Gas Venting to be Installed Under the Liner, with vents installed at top of embankment.**
12. **Engineer to inspect once pond is fully excavated to assess whether additional subsurface flow drains are required.**
13. All concrete work to be in accordance with IPENZ practice note 27.
14. All excavation work to comply with health and safety requirements for working in trenches and pits and the specific site hazards.
15. Safety Bouys to have min 30.0m rope length and to be mounted on Fence Post.

KEY:

- - - - - - - - Existing Contours

Solid Measures (Approximate)

Topsoil Strip:	585m³
Cut:	290m³
Fill:	495m³
Borrow to Fill:	205m³

RDAgritech
ENGINEERED BY NATURE

Engineering Firm
RDAgritech Ltd
P.O. Box 1711
Invercargill 9840

Project Manager

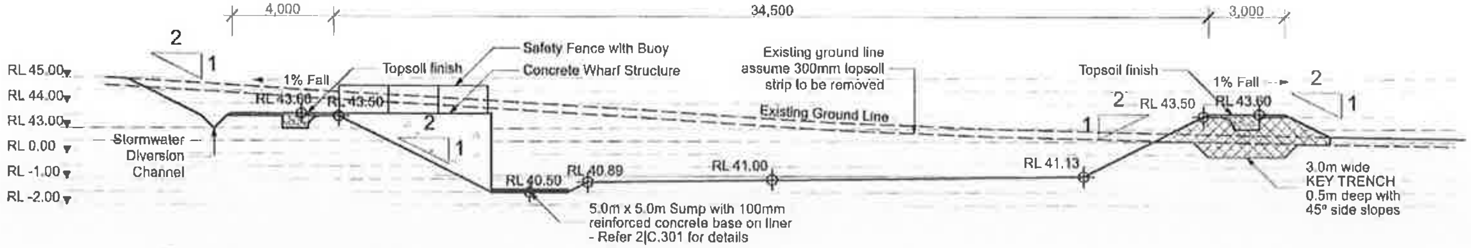
Client
SCHRADER MAINS LTD
514 RIMU SEAWARD DOWNS ROAD
OTERAMIKA

SCHRADER #2
EFFLUENT POND
DESIGN

Sheet Title:
EFFLUENT POND PLAN
Printed 4/02/15

Scale: as shown
Job No. 50193

Drawing No. C.102
Revision 01



1 C.102 TYPICAL POND SECTION
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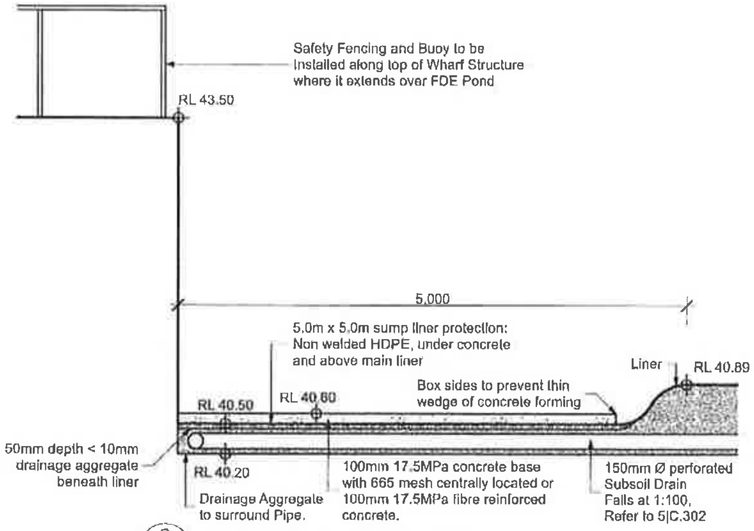

2 C.102 PUMP SUMP SECTION
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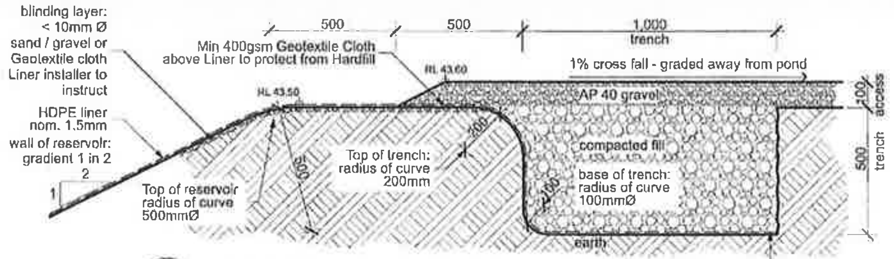
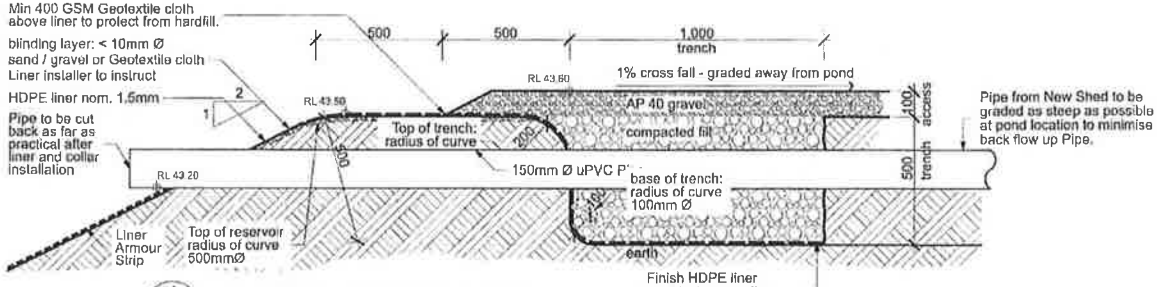


3 C.102 ANCHOR TRENCH DETAIL
Scale 1:20 @ A3



4 C.102 EFFLUENT PIPE IN DETAIL
Scale 1:20 @ A3

Revision History

rev	date	issue
01	04/02/2015	RESOURCE CONSENT

Notes:

1. Check all dimensions on site.
2. All drawings to be read in conjunction with RDAgritech Design Report and Specifications.
3. Cut / Fill volumes solid measure, approximate only, and based on typical pond section. Contractor to confirm volumes.
4. Any variations from the design drawings are to be confirmed by the Engineer in writing.
5. Irrigation Contractor to confirm new watermain details.
6. Coordinates in NZTM.
7. Effluent Line out of Pond to be determined by Irrigation Contractor.
8. All Pipework to have 1:100 grade unless stated otherwise, and to be fully sealed and glued to prevent leaks.
9. All Safety Stairs to have Safety Ropes installed as well.
10. Pond Area to be Fully Fenced (Client to Arrange).
11. Gas Venting to be Installed Under the Liner, with vents installed at top of embankment.
12. Engineer to inspect once pond is fully excavated to assess whether additional subsurface flow drains are required.
13. All concrete work to be in accordance with IPENZ practice note 27.
14. All excavation work to comply with health and safety requirements for working in trenches and pits and the specific site hazards.
15. Safety Bouys to have min 30.0m rope length and to be mounted on Fence Post.

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ENGINEERED BY NATURE

Engineering Firm
RDAgritech Ltd
P.O. Box 1711
Invercargill 9840

Project Manager

Client
SCHRADER MAINS LTD
514 RIMU SEAWARD DOWNS ROAD
OTERAMIKA

SCHRADER #2
EFFLUENT POND
DESIGN

Sheet Title
DETAIL SECTIONS
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Scale
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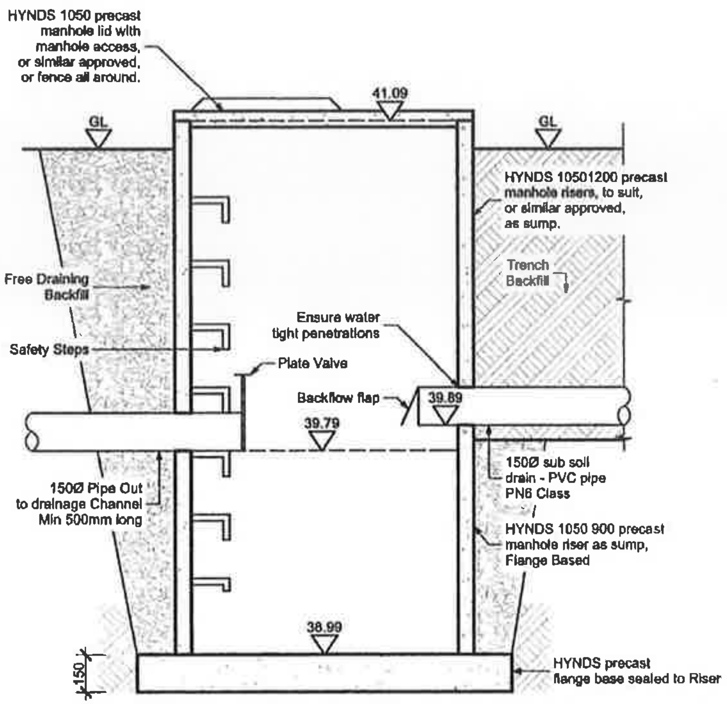
Job No.
50193

Drawing No.
C.301
Revision
01



5
C.102

SUBSOIL DRAIN INSPECTION SUMP DETAIL

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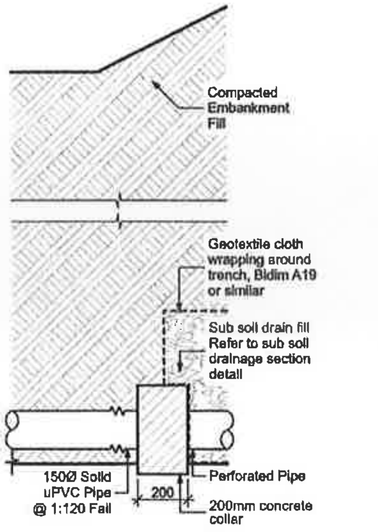

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C.102

SUBSOIL DRAIN PIPE TRANSITION DETAIL

Scale 1:20 @ A3

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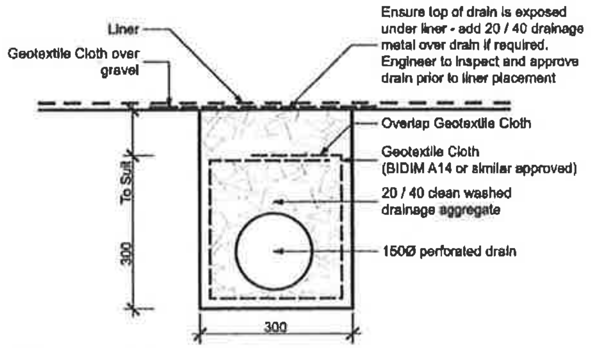

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C.102

SUBSOIL DRAIN SECTION

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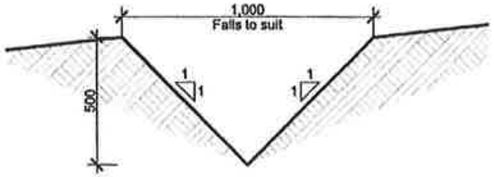

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C.102

STORMWATER DIVERSION CHANNEL

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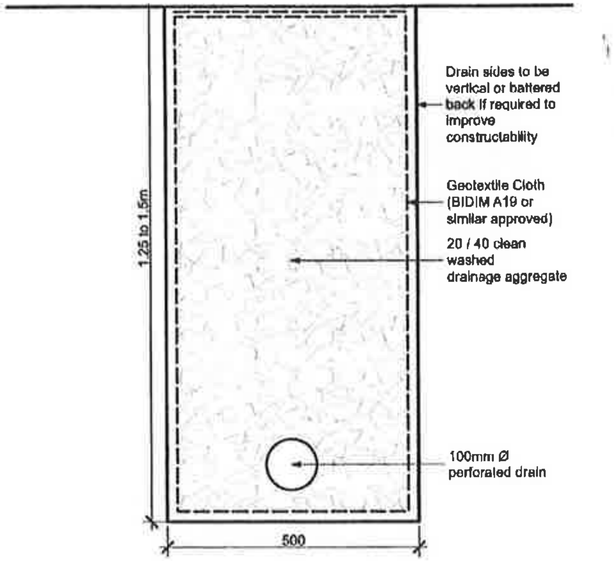

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COUNTERFORT DRAIN SECTION

Scale 1:10 @ A3

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Engineering Firm
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P.O. Box 1711
Invercargill 9840

Project Manager

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C.302

Revision
01

Revision History

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01	04/02/2015	RESOURCE CONSENT

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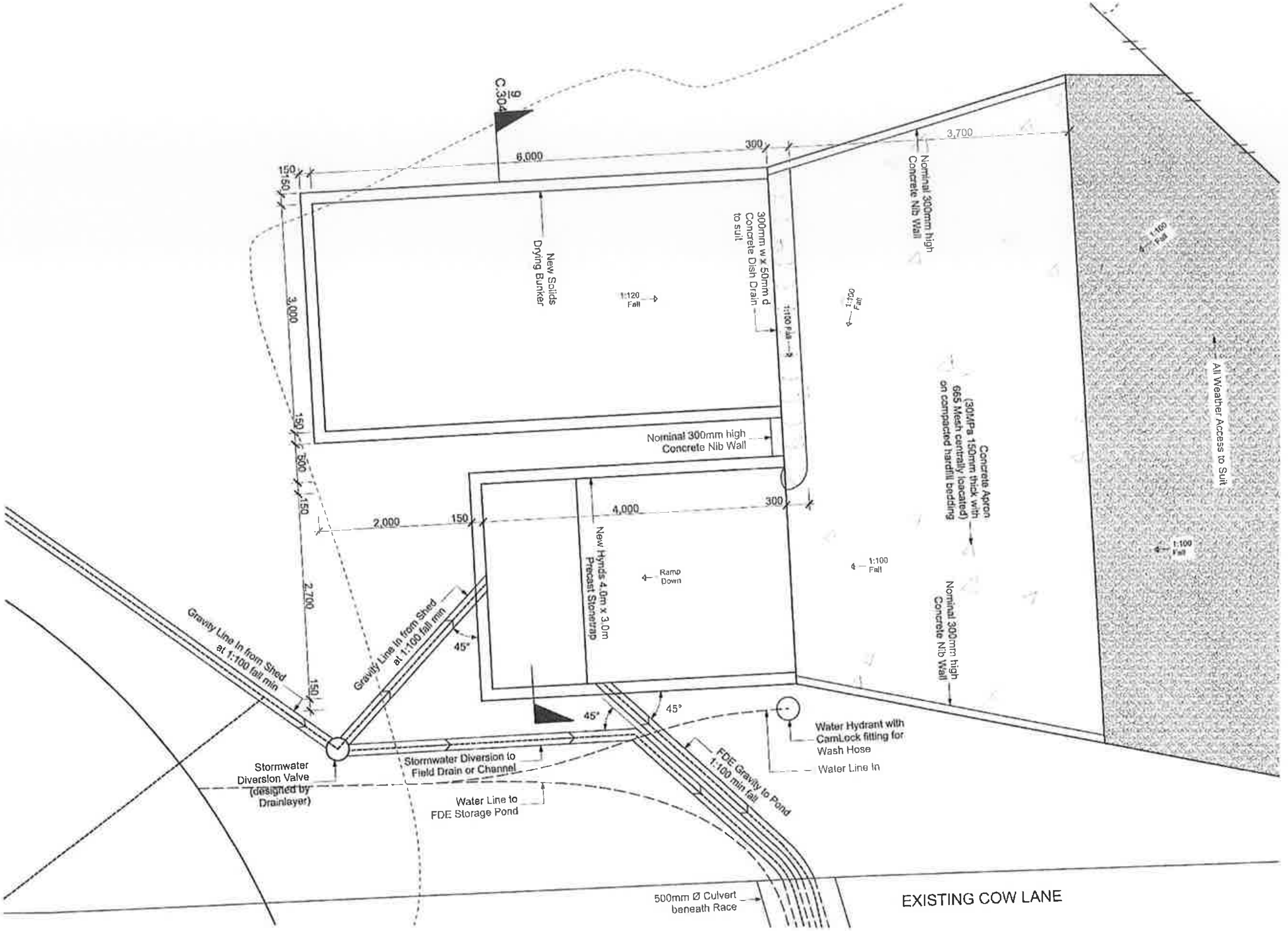

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C.303

Stonetrap Plan

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RDAgritech Ltd
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Invercargill 9840

Project Manager

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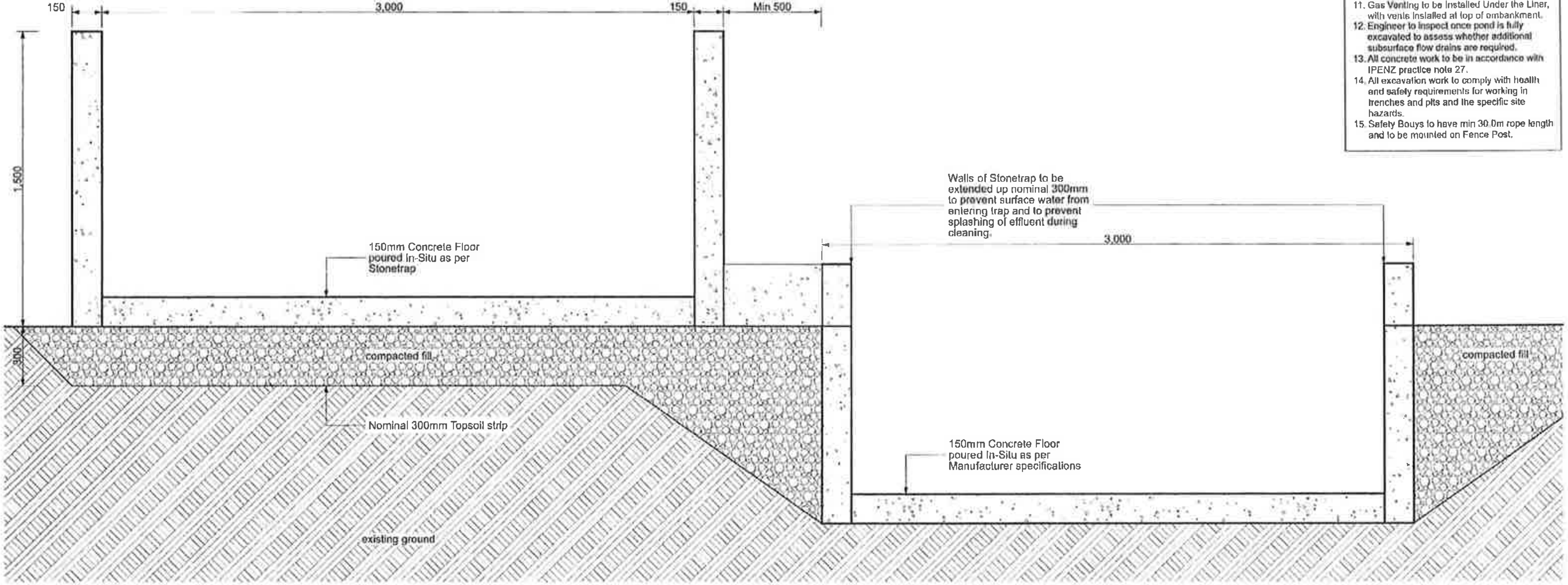

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C.303

STONETRAP / SOLIDS BUNKER SECTION

Scale 1:20 @ A3

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Engineering Firm
RDAgritech Ltd
P.O. Box 1711
Invercargill 9840

Project Manager

Client
SCHRADER MAINS LTD
514 RIMU SEAWARD DOWNS ROAD
OTERAMIKA

SCHRADER #2
EFFLUENT POND
DESIGN

Sheet Title
STONETRAP SECTION

Printed 4/02/15

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Job No.
50193

Drawing No.
C.304

Revision
01

ATTACHMENT D – Receiving Environment/Water Quality Report

TECHNCIAL COMMENT

Date: 18th June 2015 File Ref: S14083

To: Rebecca Gibson, Resource Planner

From: Karen Wilson, Senior Environmental Scientist

Subject: **Water quality assessment for a Waituna dairy conversion**

1 Background

A resource consent application for a dairy conversion at 514 Rimu-Seaward Downs Road is being prepared for lodgement with Environment Southland. As part of the consent process, an assessment of the potential ecological and water quality effects of the proposed activity has been prepared for the purposes of supporting information for the applicant.

Figure 1: *General site location map*

[Source: NZ Topo Map website]

Cromwell
Unit 7, Cromtrade, 2 McNulty Road
PO Box 302, Cromwell 9342, New Zealand

Gore
23 Medway Street
Gore 9710, New Zealand

0800 023 318
info@landpro.co.nz
www.landpro.co.nz

2 Receiving Environment

2.1 Receiving Water Bodies

The property is located in the Waituna catchment[1] and has unnamed tributaries to Waituna Creek flowing in a northeast to southwest direction through the applicants' property, as shown in Figure 2. The Waituna Creek discharges into the Waituna Lagoon which is an intermittently closed and open coastal lake and lagoon (ICOLL) located approximately 10 kilometres (km) east of Invercargill.

Figure 2: *Property map with key topographical features*

[Source: Google earth]

The key receiving environments from the property are:

- an un-named tributary to Waituna Creek which runs through the centre of the property;
- groundwater underneath the property which is part of the Waihopai groundwater management zone and has been characterised as being part of the Northern Waituna Zone. This groundwater discharges into Waituna Creek with a likely minor component providing throughflow into the lower reaches of the Waituna catchment;

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[1] The 'Waituna catchment' refers to the catchment area that drains into the Waituna Lagoon (i.e. Waituna, Moffat and Curran's Creeks) while the 'Waituna Creek catchment' refers solely to the drainage area associated with Waituna Creek.

- the Waituna Creek which receives groundwater discharge and flow from the tributary running through the property; and,
- the Waituna Lagoon which is an ICOLL that drains the Waituna, Moffat and Curran's Creek catchments.

2.2 Values and Objectives

The Regional Water Plan for Southland 2010 (henceforth referred to as the Regional Water Plan) and the Regional Coastal Plan for Southland, 2013 (henceforth referred to as the Regional Coastal Plan) describe the values and objectives for freshwater and coastal water bodies in the Southland Region, respectively. These values establish the desired condition of the receiving environments and underpin the water quality standards used to assess the impact of land use activities.

Under the Regional Water Plan, the surface water bodies on the property are classified as lowland soft bed streams. Table 1 summarises the values associated with this water body type as specified in the Regional Water Plan.

Table 1: *Summary of Regional Water Plan values (from Objective 3) for the Waituna Creek Tributary*

Classification	*Values specified in the Regional Water Plan*
Lowland soft bed	- Bathing in those sites where bathing is popular; - Trout where present, otherwise native fish; - Stock drinking water; - Ngāi Tahu cultural values, including mahinga kai; - Natural character including aesthetics.

The Regional Water Plan establishes only one groundwater quality objective (Objective 8) that essentially states all groundwater quality must be maintained or enhanced to potable standards except for those aquifers where ambient water quality is naturally less than the Drinking Water Standards for New Zealand (DWSNZ). It is noted that Section 3.2 in the Regional Water Plan includes a Groundwater Outcome that specifies groundwater discharge should not have any adverse effect on surface water quality, aquatic life or recreational values however this does not appear to follow through to any Objectives, Policies or Rules.

In 2010 a National Policy Statement for Freshwater Management[2] (NPS-FM) was introduced requiring all regional councils and unitary authorities to establish freshwater quality and quantity objectives and to set 'limits' to achieve these. The NPS-FM was revised in 2014 and specifically directs councils to safeguard fresh water's life supporting capacity, ecosystem processes and indigenous species and to prevent adverse effects on human health. It also sets a deadline for full implementation of the NPS-FM by 2025. Environment

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[2] Ministry for the Environment, 2014. National Policy Statement for Freshwater Management 2014. New Zealand Government, July 2014.

Southland have released a schedule for rolling out freshwater limits in the Southland Region and it is understood that the Waituna catchment limit setting process will occur in conjunction with the Mataura catchment in July 2017 to 2019[3]. Although the NPS-FM does not apply to coastal waters, the NPS-FM does require Councils to improve integrated management of freshwater and coastal environments.

Section 3.10 in the Regional Coastal Plan describes the key values for the coastal environment between Tiwai Point and Fortrose, including the Waituna Lagoon. These have been reproduced in Table 2 and in summary, the key values relevant to this application are the natural wild character, bird and waterfowl habitat, recreational and heritage values. It is noted that the Regional Coastal Plan does not identify any particular issues with water quality in the Waituna Lagoon unlike other coastal environments in the Regional Coastal Plan where the effects of water quality on values are discussed in some detail. The water quality of the Waituna Lagoon is discussed in Section 3.3.

Table 2: *Regional Coastal Plan values for Tiwai Point to Fortrose, including Waituna Lagoon*

Value	*Description*
Areas containing significant values	The coastal strip adjacent to Fortrose Spit and extending one kilometre seaward from the mean high water mark springs, has been identified by the Department of Conservation as an area of conservation value (see ACSV 14-07 in Appendix 5).
Natural character and landscape values	The dominant landscape elements in this reach are the extensive shingle beaches, gravel bars, dunelands and their associated native vegetation, and the adjoining peat bogs, lagoons, estuaries, salt marshes and tidal flats, most of which are largely unmodified. The lack of modification results in the area having very high natural character of a type not found elsewhere in the region (see Appendix 4, Landscape Unit 5). The combination of open coastal and estuarine water bodies separated by intact indigenous vegetation gives rise to a landscape which, while not picturesque in the usual sense, has its own desolate and remote beauty. This attracts people on a regular and ongoing basis, but perhaps not in the same numbers as elsewhere. Access can be a limiting factor.
Heritage and archaeological values	While the mainland is not renowned for its archaeological or heritage values, the coastal waters and Ruapuke Island are. In the early 1800s, there was a thriving Maori community on Ruapuke. It was also an early mission station and an important provisioning point for early whalers, sealers and traders as well as a significant provider to mainland Southland. A smaller Maori community was located near the Toetoes Estuary. There was also a pre-European adze factory and Tiwai Point. The

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[3] http://es.govt.nz/environment/water-and-land-2020-and-beyond/

	Dog Island lighthouse is also significant as it is the tallest in New Zealand (36 metres) and was built in 1865. The wreck of the 'Waikouaiti' (1939) also lies off Dog Island.
Coastal landforms and associated processes	Tiwai peninsula, Waituna Lagoon and Fortrose Spit are all geologically recent landforms connected to changes in sea level and the Mataura River. Submarine lignite deposits found in Toetoes Bay are rated as being of regional geological significance because the illustrate sea level rise and tectonism since early Quaternary time. While the relief of the peninsulas, spits and barrier beaches along this reach is low, they have strong, yet soft, horizontal lines. The dune system on the Fortrose Spit has been identified as containing a diverse and natural community of dune species which is rated as nationally important. The interaction between the sea and inland waters Is evident by the natural closing of the Waituna Lagoon outlet and the instability of the bar at the mouth of the Toetoes Estuary. The nearshore and foreshore protect these landforms from the action of waves. Sediments, especially quartz gravels are derived from local sources. Past coastal monitoring has suggested a trend towards accretion but this is possibly not indicative of every location within this reach. Almost all of the beach contains deposits of gold and platinum.
Recreational and amenity values	To some extent the recreational values are limited by a lack of access to this reach. For some, the lack of easy access is a challenge largely overcome by the se of three for four wheel motorcycles, while others use rough tracks created on the shallow peats and pea gravels and the mean high water mark. Direct access to the coast is available at the east end of Waituna Lagoon, and for those with prior written permission from New Zealand Aluminium Smelter, access is available through the smelter grounds to the beach behind. The west end of this beach is relatively sheltered and marks the change from beach to rocky shore. The wild, wilderness character of the beach can be an attraction in itself. Trout fishing at the mouth of the Waituna Lagoon is very popular, the spot being renowned for very large sea-run trout. Generations of people are drawn year after year to the lagoon for trout fishing and gamebird hunting. Surfcasting from the beach is an occasional activity and scuba diving and snorkelling are undertaken around the rocks at the western end. Although the soft and sometimes steep gravels make the beach tiring to walk, it does attract people who seek to beachcomb or enjoy the wilderness experience. Further out to sea, recreational diving for paua, crayfish and to a lesser extent oysters and fishing are popular activities for people on pleasure boars launched at Bluff or Fortrose.

Marine mammals and birds	While right whales are occasionally observed from the shore and dolphins more frequently so, the area has no particular significance for marine mammals. Some birds, especially black-billed gulls, oyster catchers and banded dotterel, nest on the gravel platform at the top of the beach. The rocks east of Tiwai Point are a roosting area for Stewart Island shags.
Ecosystems, vegetation and fauna habitats	The vegetation on Tiwai Peninsula landward of the beach includes a small area of *Oleria nummularifolia* (coin-leafed daisy) which is normally a subalpine shrub, and the southern limits of other subalpine species such as the *Donatianovae-sealandiae* (a cushion plant) matagouri and speargrass. The peninsula is regarded as a fine example of recovering vegetation subsequent to the cessation of burning, and grazing by domestic animals. There is also significant invertebrate fauna, especially moths, many of which are usually only found in subalpine areas. Further to the east, Waituna Wetlands Scientific Reserve adjoins the coastal marine area. This 10 kilometre long, 3,500 hectare reserve, has been designated as a Wetland of International Importance, the values of which are more particularly documented in the Oceania Wetland Inventory, a copy of which is available from the Department of Conservation. A three kilometre strip of coastal farmland separates the scientific reserve from the Fortrose Spit, which contains nationally significant dune communities. In this reach, while the foreshore and nearshore are not particularly significant in terms of vegetation and fauna, the land adjoining it is quite the opposite. The foreshore can tolerate considerable use so long as those activities do not adversely impact on adjoining land. The waters off Ruapuke and Green Islands are productive rock lobster and paua fisheries, commercial paua fishing being prohibited from within one nautical mile of their shoreline.
Commercial values	The seas of this coast are commercially important for crayfish, blue cod and paua, and is also important for dredge oysters. All of the foreshore (and some of the seabed) is subject other either mining or prospecting licenses for gold. Recent history has seen a few mining operations come and go but there are signs of continuing and renewed interest.
Navigational safety	Dog Island is owned by the Maritime Safety Authority who operates a lighthouse on the island. Another smaller light is located in this area on land at Bushy Point and together with lights at Waipapa and Slope Points further to the east, and a lighthouse at Centre Island west of Bluff, ships are guided through Foveaux Strait.
Principal issues	1. Lack of access to the area and consequent need to preserve access along the beaches.

	2. Threat of activities in the coastal marine area adversely affecting the natural values of adjoining coastal environment.

3 Receiving Environments Sensitivity, Susceptibility and Existing Water Quality

3.1 Waihopai Groundwater Zone

The Regional Water Plan has delineated groundwater management zones for the Southland Region and the applicants' property is located in the Waihopai groundwater zone. Generally groundwater quality within the Waihopai groundwater zone complies with limits set in the Drinking Water Standards for New Zealand (DWSNZ). The 2010 State of the Environment (SOE) monitoring report[4] showed that of the 78 bores sampled in the Waihopai groundwater zone, the median nitrate concentration was 0.25 mg/L which is well below the DWSNZ maximum acceptable value of 11.3 mg/L. This indicates groundwater quality in this zone is very good which is interpreted to reflect the relatively large assimilative capacity of groundwater resources in this zone due to denitrification and/or attenuation processes. Only two sites sampled in this zone (i.e. 3% of all sites sampled) had an exceedance of the maximum acceptable value for nitrate, most likely in response to point source discharges or poor well head protection. Trend analysis of the three long term SOE monitoring sites showed no statistically significant trend in two sites and an improving nitrate trend in the remaining site.

Groundwater quality in the area around Waituna has been modelled by Environment Southland as having low to very low denitrification potential based on geology, sediment geochemistry and geomorphology (Rissmann 2011[5]) which suggests shallow groundwater is sensitive to nitrate accumulation. Environment Southland (Rissmann 2012[6]) have identified groundwater quality on the property as having nitrate levels which reflect pristine, pre-European background levels (i.e. nitrate (as NO_3-N) between 0.01 – 0.4 mg/L) and minor to moderate land use impacts (i.e. nitrate between 1.0 – 3.5 mg/L) reflecting minimal impact of land use.

Regional time lag analysis (Chanut, 2014[7]) shows the Waituna catchment has a total vertical travel time for nitrate of 3 to 5 years and eigenmodelling by Lincoln Ventures[8] suggested Waituna has a very rapidly draining

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[4] Hughes, B. N., 2010. State of the Environment: Groundwater quality technical report. Prepared for Environment Southland by Liquid Earth Limited.

[5] Rissmann, C. 2011. Regional mapping of groundwater denitrification potential and aquifer sensitivity. Environment Southland publication number 2011-12, Invercargill.

[6] Rissmann, C., 2012. The extent of nitrate in Southland groundwaters: Regional 5 year median (2007-2012 (June)). Environment Southland publication number 2012-09, Invercargill.

[7] Chanut, P., 2014. Estimating time lags for nitrate response in shallow Southland groundwater. Environment Southland publication number 2014-03, Invercargill.

[8] Burbery, L., 2012. Analysis of groundwater level data: Waituna Lagoon. Prepared for Environment Southland by Lincoln Ventures Limited, report number 1008-2-R1. Funded by Envirolink Advice Grant ESRC1S2. 17p.

groundwater system with mean hydraulic storage residence times in the region of 1 to 8 weeks across the catchment.

3.1.1 *Waituna Zones*

Environment Southland have broadly categorised groundwater resources in the Waituna catchment into three zones[9]:

- The Northern Waituna Zone which covers the northern section of the Waituna Creek catchment (north of Mokotua) and is characterised by thick, stoneless brown soils which buffer groundwater quality from the effects of land use due to cation exchange and chemical sorption processes which are aided by longer mean residence times (months). Shallow groundwater quality in this area shows little impact from land use with the main risk to water quality being from artificial drainage.
- The Mokotua Infiltration Zone which is in the central section of the Waituna Creek catchment (between Mokotua and Caesar Road) and is characterised by rapid infiltration of soil water with little or no attenuation of contaminants from overlying land use due to the reworking of soil and aquifer materials during a former sea level highstand during the last interglacial period (approximately 70,000 – 100,000 years ago). The movement of water through this zone is rapid (1-2 week mean residence time) and appears to contribute to the deterioration in water quality in Waituna Creek south of Mokotua. Because groundwater movement is so rapid, the risk of nitrate accumulating in the aquifer to excessive levels is relatively low.
- The Southern Waituna Zone includes the southern section of the Waituna Creek catchment as well as Curran's Creek and Moffat Creek catchments. This area is dominated by reducing groundwater conditions due to the abundance of organic carbon associated with wetland peat deposits and to a lesser extent lignite measures. Soil water drainage is relatively rapid and this area is susceptible to high phosphate solubility and mobility[10].

Figure 3 shows that the applicants' property is located in Northern Waituna Zone which has identified artificial drainage as posing the greatest risk to water quality.

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[9] Rissmann, C., Wilson, K., and Hughes, B., 2012. Waituna catchment groundwater resource technical report. Environment Southland publication 2012-04, Invercargill. 93p.

[10] Adapted from Rissmann, C. 2011. Regional mapping of groundwater denitrification potential and aquifer sensitivity. Environment Southland publication number 2011-12, Invercargill.

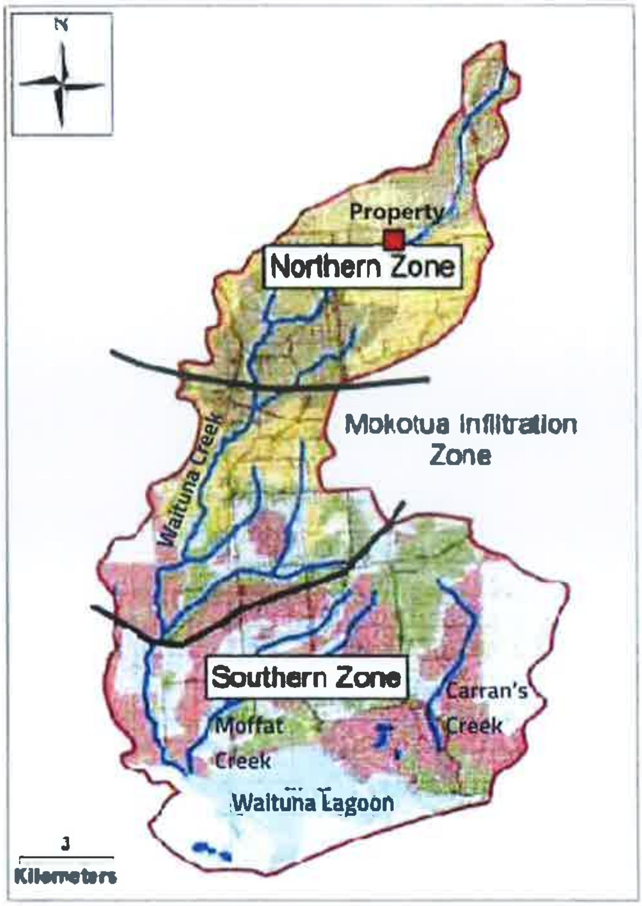

Figure 3: *Groundwater quality zones of the Waituna catchment as defined by natural variation in hydrological and hydrogeological properties, soil and aquifer types and hydrochemical variation*
[Adapted from: Environment Southland, 2012[7]]

Overall, based on the hydrogeological characteristics of the Waituna catchment described above, there is relatively low risk of nitrate concentrations accumulating in groundwater to levels that exceed the maximum acceptable value (excluding point-source discharges).

3.2 Waituna Creek

The nearest Environment Southland surface water quality SOE monitoring site to the applicants' property is located approximately 4.5 km downstream (i.e. to the southwest) in the Waituna Creek 1 metre upstream of Waituna Road[11]. There is also another SOE monitoring located in the downstream reaches of Waituna Creek at Marshall Road. The available water quality monitoring data from the Waituna Creek catchment has been summarised in Tables 3, 4, 5 and 6 and in Attachment A and B. These results show that when compared to other SOE sites across New Zealand, the water quality in the Waituna Creek is amongst the worst 25% of like sites for elevated phosphorous and nitrogen levels (Table 3). A comparison of all monitoring sites in the

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[11] It is noted that the SOE monitoring site is referred to as the Waituna Creek at Mokotua in the 2010 SOE report however the site has since been renamed to the Waituna Creek 1m upstream of Waituna Road. Monitoring at this site ceased in July 2014.

Waituna catchment against other catchments in the Southland Region shows the Waituna catchment has the largest proportion of parameters in the lowest water quality category (Table 4)[12].

Table 3: *Summary of Waituna Creek Water Quality Results Compared Nationally*

[Source: LAWA website]

Parameter	All NZ sites	All lowland rural sites	10 year trend	5 year trend
Waituna Creek 1m upstream of Waituna Road				
Bacteria (*e.coli*)	Worst 25% of like sites	Worst 25% of like sites	No trend	No trend
Clarity (black disc)	Worst 50% of like sites	Worst 50% of like sites	Meaningful improvement	No trend
Nitrogen (total N)	Worst 25% of like sites	Worst 25% of like sites	Meaningful degradation	No trend
Phosphorous (total P)	Worst 50% of like sites	Worst 50% of like sites	No trend	Meaningful improvement
Waituna Creek at Marshall Road				
Bacteria (*e.coli*)	Worst 50% of like sites	Worst 50% of all sites	No trend	No trend
Clarity (black disc)	Worst 25% of like sites	Worst 50% of all sites	Meaningful improvement	No trend
Nitrogen (total N)	Worst 25% of like sites	Worst 25% of all sites	No trend	No trend
Phosphorous (total P)	Worst 25% of like sites	Worst 25% of all sites	No trend	No trend

Table 4: *Summary of Waituna Catchment Water Quality Results Compared Regionally*

[Information derived from LAWA website]

Catchment	Number of monitoring sites	Number of Water Quality Parameters in Each Category			
		Worst 25%	Worst 50%	Best 50%	Best 25%
Aparima	5	0	3	4	2
Mataura	26	2	4	1	2
Mokotua	1	2	1	3	3
Oreti	16	2	5	0	2
Pourakino	4	0	3	4	2
Tokonui	1	6	2	0	1
Waiau	10	0	0	2	7
Waihopai	2	4	4	1	0
Waikawa	1	3	5	0	1
Waikopikopiko	1	0	3	5	1
Waimatuku	2	6	2	0	1
Waituna	**5**	**8**	**0**	**1**	**0**

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[12] The median concentration from the site/catchment for a given parameter is compared to the quartiles for all sites/all like sites across New Zealand (based on a total of 945 monitoring sites).

Under the Regional Water Plan the Waituna Creek is classified as a lowland soft bed waterbody and it is noted that this distinguishes it from the other tributaries in the Waituna catchment (i.e. Moffat and Carran's Creeks are classified as lowland hard bed water bodies). When water quality data from the Waituna Creek is compared against the Regional Water Plan values and objectives for lowland soft bed waterbodies, it can be seen in Table 5 that water quality is regularly exhibiting compromised condition, particularly with respect to macroinvertebrates which are a biological marker, and excessive nitrogen and phosphorous concentrations which are indicators of ecological condition. However for most parameters water quality trends are improving or are showing no trend. It is also noted that periphyton, which is only monitored downstream of the property, is well within the Regional Water Plan standards.

Table 5: *Summary of SOE Surface Water Quality Results Compared Against Regional Water Plan Standards*[13]

Parameter	ES Standard	Min*	Median*	Max*	Samples breeched* (%)	Trend Magnitude* (% per year)
Waituna Creek 1m upstream of Waituna Road						
Dissolved Reactive Phosphorous (mg/L)	**<0.010**	0.005	0.015	0.057	30	Improving (9.3%)
Nitrate Nitrite Nitrogen (mg/L)	**<1.7**	0.400	1.65	4.40	49	Deteriorating (3.2%)
Unionised ammonia (mg/L)	**<0.344**	0.0150	0.046	0.166	0	No Trend
Visual clarity (m)	**>1.3**	0.05	1.08	3.00	33	No Trend
Faecal bacteria (CFU/100 ml)	**<1,000**	33	500	110,000	25	No Trend
Water temperature (°C)	**<23**	4.7	10.9	15.6	0	N/A
Waituna Creek at Gorge Road						
Macroinvertebrate community index	**>80**	64	80	89	60	No Trend
Ash free dry weight (g/m²)	**<35**	8.4	19.3	22.4	0	N/A
Chlorophyll-*a* (mg/m²)	**<120**	38.6	39.2	50.9	0	N/A
Waituna Creek at Marshall Road						
Dissolved Reactive Phosphorous (mg/L)	**<0.010**	0.005	0.015	0.057	78%	Improving (4.5%)
Nitrate Nitrite Nitrogen (mg/L)	**<1.7**	0.027	1.28	4.50	34%	Deteriorating (2.8%)
Unionised ammonia (mg/L)	**<0.344**	0.0087	0.031	0.324	0%	Improving (15.9%)
Visual clarity (m)	**>1.3**	0.08	0.78	1.5	50%	Improving (4.5%)
Faecal bacteria (CFU/100 ml)	**<1,000**	20	320	69,000	23%	No Trend

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[13] Source: Wilson, K, Meijer, K, Larkin, G, and Hicks, A, 2012. Water quality methodology for Southland Water 2010 report. Environment Southland publication number 2012-05, Invercargill.

Water temperature (°C)	**<23**	4.2	11.2	18.6	0%	N/A
Macroinvertebrate community index	**>80**	64	76	82	80%	Deteriorating (1.6%)

*Monitoring period is 2005 – 2010

+Monitoring period is August 2000 – 30 June 2010

Water quality in the Waituna Creek has also been assessed against the National Bottom Lines in the NPS-FM. Time-series plots of water quality in the Waituna Creek at Marshall Road are included in Attachment A and Waituna Creek 1 metre upstream of Waituna Road in Attachment B. Table 6 compares 1st July 2013 to 30th June 2014 (i.e. the 2013/14 hydrological year) water quality results from both Waituna Creek SOE monitoring sites. Overall, the results suggest that while water quality in the Waituna Creek may be considered to be compromised in comparison to other SOE monitoring sites across New Zealand and Southland, the Waituna Creek has not breeched the National Bottom Lines in the last 12 years of monitoring and in most instances can be categorised as being good to fair (i.e. falls within the 'B' and 'C' attribute states).

Table 6: *Summary of Waituna Creek 2013/14 Results Compared to National Bottom Lines*

[Information derived from Environment Southland and the Ministry for the Environment (2014)]

	Nitrate (Toxicity) *(mg NO_3-N/L)*		*Ammonia (Toxicity)* *(mg NH_4-N/L)*		*E. coli (Recreation)* *(E. coli/100 mL)*
	Annual Median	Annual 95th Percentile	Annual Median	Annual Maximum	Annual Median
National Bottom Line	**6.9**	**9.8**	**1.30**	**2.20**	**1,000**
Waituna Creek 1m upstream Waituna Rd	1.96	4.08	0.04	0.13	385
Waituna Creek at Marshall Road	1.26	2.94	0.05	0.12	460

In summary, the available data suggests the state of water quality in the Waituna Creek catchment is generally fair with the main contaminants of concern being excessive levels of nutrients, especially in the downstream reaches. These results suggest water quality is being driven by a relatively complex combination of overland and lateral flow (i.e. soil drainage and discharge from artificial drains) being the primary transport mechanisms. Nitrate concentrations may also be affected by groundwater discharge, particularly in the middle to lower stream reaches.

Freshwater resources in the Southland Region have been recently stratified according to their water quality issues and disproportionate contaminant source areas. As part of this study, a map was developed looking at water quality risk to future development. As is shown in Figure 4, the applicants' property appears to be located in an area of slight risk meaning there are few downstream water quality issues where source loads could increase significantly.

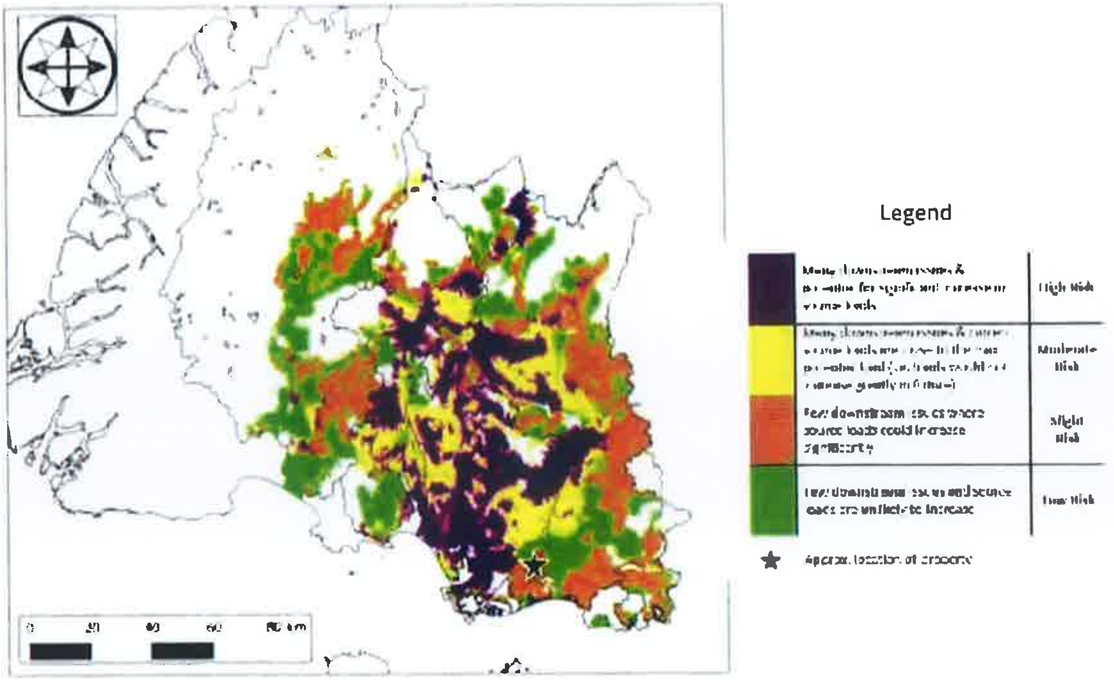

Figure 4: *Water quality stratification of the Southland Region demonstrating future development risk*

[Source: Aqualinc 2014[14]]

3.3 Waituna Lagoon

The Waituna Lagoon is a relatively large ICOLL that is separated from the sea by a barrier beach. The lagoon is fed by three freshwater streams, the largest of which is the Waituna Creek, and drains to the sea through an artificially managed opening. Historically, the lagoon was surrounded by a peat bog wetland about 20,000 ha in size whose drainage gave the lagoon water its characteristic clear brown humic stain, low nutrient status and low pH. Today the catchment is dominated by agricultural land use (intensive sheep, beef and dairying) resulting in increased nutrient inputs into the lagoon. Because the lagoon is largely unmodified and its remaining coastal wetland is largely intact, it was designated as being of international significance under the RAMSAR Convention in1976[15].

A coastal risk assessment undertaken by Wriggle Coastal Management in 2008 [16] shows that while eutrophication and sedimentation is an issue in the lagoon, overall vulnerability and susceptibility ranges from very low to high, as shown in Table 7.

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[14] Aqualinc, 2014. Regional Scale Stratification of Southland's Water Quality – Guidance for Water and Land Management. Prepared for Environment Southland, report number C13055/02.

[15] Adapted from Wriggle Coastal Management, 2008. Southland Coast Te Waewae Bay to the Catlins: Habitat mapping, risk assessment and monitoring recommendations. Prepared for Environment Southland, August 2008.

[16] Wriggle Coastal Management, 2008. Southland Coast Te Waewae Bay to the Catlins: Habitat mapping, risk assessment and monitoring recommendations. Prepared for Environment Southland, August 2008.

Table 7: *Risk assessment for the Waituna Lagoon*

[Source: Wriggle Coastal Management, 2008]

	Existing Condition Rating	*Susceptibility Rating*	*Vulnerability Rating*
Sedimentation	Fair	High	High
Eutrophication	Fair	High	High
Disease Risk	Very Good	Moderate	Low
Contaminants	Very Good	Moderate	Low
Habitat Loss	Good	Moderate	Low
Invaders	Good	Moderate	Low
Shellfish	Very Good	Very Low	Very Low

In 2010, it was identified that the last ten years of monitoring data highlighted a rapid decline in the ecological condition of the lagoon to the point it had deteriorated from a high value seagrass (*Ruppia*) dominated state to a more degraded condition with nuisance epiphyte and algal blooms and sediment anoxia causing stress to the keystone *Ruppia* species. Expert opinion at the time was that unless urgent intervention occurred, the lagoon could undergo a rapid transition to an even more degraded phytoplankton dominated state which would change the fundamental values and character of the lagoon[17]. A multi-agency and community response was initiated that incorporated a range of scientific investigations and catchment works along with changes to the opening regime and land management within the catchment. Although the nature of the response has changed over time, the response to water quality issues in the Waituna catchment are still on-going[18].

The dynamics of ICOLL's are less well understood than their estuarine or coastal lake counterparts and their shifts between freshwater infill and seawater ingress make them highly dynamic and complex environments. The ecology and water quality in ICOLL's are driven by complex interactions between the opening regime, climate and catchment nutrient loads. In terms of management, there is a "trade-off" between the salinity and desiccation pressures on macrophytes from artificial opening events versus the potential for these events to flush nutrient-laden freshwater and organically-enriched sediments from the lagoon. Modelling results by the University of Waikato show that "*under current catchment nutrient loads it is not possible to maintain a "healthy" Ruppia population in the lagoon with changes to the opening regime alone.*" However the amount of nutrient load reductions required to sustain persistent and productive *Ruppia* beds are dependent on the opening

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[17] Roberston, B., Stevens, L., Schallenberg, M., Roberston, H., Hamill, K., Hicks, A., Hayward, S., Kitson, J., Larkin, G., Meijer, K., Jenkins, C., and Whaanga, D. 2011. Interim recommendations to reduce the risk of Waituna Lagoon flipping to an algal-dominated state. Prepared for Environment Southland by the Lagoon Technical Group. Environment Southland, Invercargill. 16p.

[18] It is noted that the Interim Recommendations by the Lagoon Technical Group has been subsequently revised however this document is not in the public domain and has therefore not been used in this report.

regime adopted[19]. At this point in time, it appears no opening regime and nutrient load reduction targets have been formally adopted by Environment Southland.

4 Water Quality Effects of the Proposed Activity

4.1 Proposed Activity

The proposed activity consists of changing the existing land use of beef and dairy support (young stock and cow wintering) to a dairy milking platform. The proposed maximum herd size is 306 cows which equates to a stocking rate of 2.97 cows/ha (based on a maximum effective farm area of 103 ha). The dairy operation will winter off 70% of the mature dairy cows and all young stock will be grazed off. The farm dairy effluent is to be discharged to land using a low rate irrigation system (pods) at appropriate times (i.e. when soil moisture conditions are below field capacity which means storage will be required). A nutrient management plan for the proposal has been prepared by Roslin Consultancy Ltd along with a nutrient budget of the current land use.

4.2 Water Quality Effects

Nutrient loss from the existing land use (i.e. beef and dairy support) and the proposed land use (i.e. dairy milking platform) have been estimated for the property using the Overseer® model (version 6.2.0) by Roslin Consultancy Ltd. The modelled outputs have been summarised in Table 8 and indicate the proposal will reduce the average nitrogen load lost from the property from 35 kg N/ha/year to 29 kg N/ha/year (or 17%) while phosphorous loss will increase from 0.4 to 0.6 kg P/ha/year (or 50%).

Table 8: *Modelled Whole Farm Nutrient Losses (using Overseer® version 6.2.0)*
[Source: Roslin Consultancy Ltd, 2015]

Scenario	*Farm System*	*Nitrogen Loss (kg N/ha/yr)*	*Phosphorous Loss (kg P/ha/yr)*
Existing land use	Beef and dairy support	35	0.4
Proposed land use	Dairying of 306 cows with >70% wintered off	29	0.6

It is noted that under the proposed land use, the modelled nitrogen loss of 29 kg N/ha/year is in the lower range for New Zealand dairy farms (i.e. average between 24 – 42 kg N/ha/year) and the average nitrate concentration in drainage water across most of the property is modelled as ranging between 4.1 and 7.4 mg/L.

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[19] Adapted from Hamilton, D., P., Jones, H. F. E., Özkundakci, D., McBride, C., Allan, M. G., Faber, J., and Pilditch, C. A., 2012. Waituna Lagoon Modelling: Developing quantitative assessments to assist with lagoon management. Prepared for Environment Southland by the University of Waikato, ERI report number 004, Hamilton. 93p.

This is below the DWSNZ maximum acceptable value of 11.3 mg/L. The exception being the kale crop block where the average nitrate concentration in drainage water is estimated to be 14.4 mg/L. As this area represents only 4% of the total effective farm area, the average nitrate concentration in drainage water from across the total effective farm area is 6.7 mg/L. This is less than the farm average nitrate concentration from the current land use which is modelled as being 7.5 mg/L. It is further noted the modelled nutrient losses represent losses from farm before any attenuation, dilution or accumulation that may occur in the receiving environments and are therefore not an estimate of the environmental effect on water quality.

No phosphorous concentrations have been estimated however the modelled phosphorous loss from the property is expected to increase from 0.4 to 0.6 kg P/ha/year. Given the environmental setting, the main transport mechanism of phosphorous loss is inferred to be via runoff in the form of phosphorous bound to soil particles entering surface water and by fertiliser and effluent being washed off the land during heavy rainfall creating overland flow or sub-surface flow after application.

With respect to microbiological contamination from pastoral farms, research by AgResearch[20] shows that late autumn until mid-spring is the high risk period as this is when surface runoff and mole-pipe drainage is most likely to occur. They also note that *"not all areas of the landscape contribute to flow pathways of loss. Those that do are termed critical source areas and are characterised as being directly "connected" to water bodies".* AgResearch suggest that improved effluent management, stock exclusion and the elimination of stock crossings will have the greatest impact in reducing microbiological contamination from pastoral farms and after that, large populations of waterfowl are likely to be the next highest contributor. This is illustrated in Figure 5 below.

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[20] Monaghan, R. M., Semadeni-Davies, A., Muirhead, R. W., Elliott, S and Shankar, U., 2010. Land use and land management risks to water quality in Southland. Prepared for Environment Southland, April 2010.

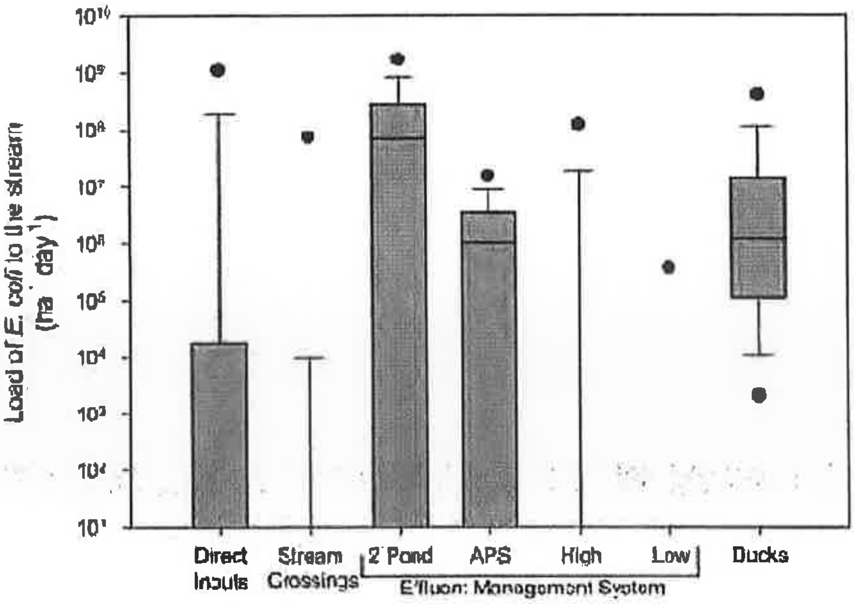

Figure 5: *Box and whisker distributions of the modelled daily E.coli loads from different pastoral farm management practices or from ducks living in the stream.*

[Source: AgResearch, 2010]

In order the avoid the highest risk periods and practices that are detrimental to water quality, a series of proposed mitigation measures have been summarised in Table 9 along with a description of the environmental response.

Table 9: *Summary of water quality issues, mitigation measures and environmental response for the proposed dairy conversion*

Water quality issue	Impact	Mitigation Measures	Response
Nitrogen (in the form of nitrate) concentrations in shallow groundwater in the Waihopai groundwater zone.	The average farm nitrogen loss is modelled as decreasing from 7.5 mg/L under the current land use to 6.7 mg/L under the proposed land use. Nb: the DWSNZ maximum acceptable value is 11.3 mg/L.	- Low rate and deferred FDE irrigation will ensure no ponding, runoff and bypass flow (e.g. through soil macropores) will occur, and leaching is minimised. - The effluent pond will be constructed in accordance with the Code of Practice to ensure no leaks to groundwater - Supplements and fertiliser decisions will be made in accordance with nutrient modelling and soil tests to ensure nutrient losses are minimised - Wintering off will avoid the deposition of urine during winter.	Nitrate may accumulate in the underlying unconfined aquifer relatively quickly (lag time of about 3-5 years[21]) however Overseer modelling indicates concentrations will generally comply with the DWSNZ and therefore Objective 8 in the Regional Water Plan.

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[21] Chanut, P. 2014. Estimating Time Lags for Nitrate Response in Shallow Southland Groundwater. Environment Southland publication number 2014-03, Invercargill.

		- Bore head protection will prevent groundwater contamination around bores and wells.	
Nitrogen concentrations in the Waituna Creek and the un-named tributaries.	As above	As above	Nutrient modelling suggests the majority of nitrogen loss will be through leaching. Overseer modelling suggests nitrogen loss will decrease by 17% under the proposed scenario.
Microbiological contamination in the Waituna Creek and the un-named tributaries.	There are no appropriate tools available to provide a quantitative estimate of microbial losses from the property.	- Exclusion of stock from streams (through fencing) will prevent any discharges directly to water - Buffer zones, including riparian planting, around streams will mitigate contamination from runoff - Low rate and deferred FDE irrigation will minimise the risk of runoff occurring. - Lanes and tracks will be located away from streams to avoid runoff	Based on Figure 3, microbial losses should be low as all high risk activities are to be avoided or mitigated. This research suggests the next highest source of microbial loading will be from ducks, which are part of the natural setting.
Phosphorous and sedimentation contamination in the Waituna Creek and the un-named tributaries.	Phosphorous loss is modelled as increasing from 0.4 kg P/ha/year under the current land use to 0.6 kg P/ha/year under the proposed land use. There are no appropriate tools available to provide a quantitative estimate of sediment losses however the transport mechanisms are very similar to those in phosphorous loss.	- Buffer zones, including riparian planting, around streams will provide some treatment to any contamination from runoff - Exclusion of stock from streams (through fencing) will prevent bank destabilisation and any discharges directly to water - Grass buffer strips will be used to act as an infiltration or deposition zone intercepting particulate material in runoff. - Low rate and deferred FDE irrigation will ensure no ponding, runoff and bypass flow (e.g. discharge through artificial drains) will occur, and leaching is minimised. Visual inspections will also be undertaken. - Supplements and fertiliser decisions will be made in accordance with nutrient modelling and soil tests to ensure nutrient losses are minimised - Lanes and tracks will be located away from streams to avoid runoff	Farm practices will be adopted to ensure water quality contamination from runoff will be avoided. Any contamination which does occur in response to runoff will be mitigated to some degree by fenced and planted riparian zones and grass buffers. These measures particularly target flood and storm flows where the phosphorous and sediment loads are highest. However modelling indicates there is increased potential for greater phosphorus under the proposed activity. The Waituna Creek is P-limited[22] which means increased P loss could result in increased algal growth.
Nitrogen and phosphorous loads to the Waituna Lagoon	Modelled farm nitrogen loss decreases from 35 to 29 kg N/ha/year when	As above	Nutrient modelling suggests nitrogen loss will be reduced by 17% under the proposed activity and phosphorous loss

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[22] Source: Enironment Southland and Te Ao Marama Inc. 2001. *Our Ecosystems: How healthy is the life in our water and our freshwater ecosystems? Part 2 of Southland Water 2010: Report on the State of Southland's Freshwater Environment.* Environment Southland. Invercargill. Publication number 2011/7 ISBN 0-909043-45-0.

	shifting from the existing to proposed land use and phosphorous increases from 0.4 to 0.6 kg P/ha/year.		will increase by 50%. Published reports show current nutrient loads to the Waituna Lagoon are compromising ecological health within the lagoon (particularly in relation to the keystone species *ruppia*). Therefore any reduction in nutrient loads will assist in improving water quality and ecological health in the lagoon and any increase in nutrients is likely to be detrimental, albeit with the modelled changes in nutrient loads associated with this application occurring at undetectable levels.

4.3 Cumulative Effects

Regional scale modelling of nitrogen and phosphorous losses from agricultural land use in the Southland Region by Aqualinc in 2014[23] showed:

- Adoption of mitigation measures on farms could result in reductions in nutrient loads discharged in Southland;
- Within the agricultural sector, nutrient loss from dairy farms make up a disproportionately large proportion of the nutrient load in most Southland catchments compared to the farm area;
- Adoption of mitigation measures on dairy farms alone significantly reduces catchment scale improvements in nutrient losses because sheep and beef farms make up the greatest area of land use[24]. Overall, contributions from both land uses are significant; and,
- Under the status quo of ongoing conversions and increasing production on dairy farms, water quality will not be maintained or improved in the long term even if very stringent mitigation requirements were to be adopted. Setting limits for catchment nutrient loads and then managing discharges to meet these limits appears to be the most appropriate method of ensuring the goal of maintaining and improving water quality in Southland will be achieved.

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[23] Aqualinc, 2014. Assessment of Farm Mitigation Options and Land Use Change on Catchment Nutrient Loads. Prepared for Environment Southland, report number C13055/04.

[24] Adoption of the M1 mitigation package on all farms (i.e. mitigations most easily implemented) reduced agricultural nitrogen loads by 18 – 32% however when only dairy farms adopted M1, nitrogen loads were reduced by only 1 – 6%. Similarly, when all farms adopted M3 (i.e. the most effective but most expensive mitigation measures), nitrogen loads were reduced by 29-37% and phosphorous loads by 40-80% however when only dairy farms adopted M3, nitrogen and phosphorous loads were reduced by 2-18% and 5-32% respectively.

Although this study shows dairying is a significant contributor to nutrient loads in the Southland Region, it does not take into account the receiving environment's assimilative capacity. The sensitivity of the Waituna catchment to nitrogen and phosphorous inputs has been described in Section 3.

In order to provide some context for the average aerial nutrient loading to the Waituna Lagoon, Table 10 provides a summary of phosphorous and nitrogen loads for different time periods. It is noted that in Environment Southland's Waituna Newsletter (Issue 18 – June 2014), DairyNZ have said they are developing a water quality model to estimate total nutrient loads entering the Waituna Lagoon from the catchment[25]. The results of this project are not yet available and as such, have not been presented.

Table 10: *Catchment loads estimates to the Waituna Lagoon*

[Source: Hamilton e *al.*, 2012]

		Phosphorous Load (kg P/ha/year)	***Nitrogen Load (kg N/ha/year)***
Modelled Average Catchment Loss	**Pre-humans**	0.1	0.2
	2001 – 2011 average	0.8	14.4
	2011 land use	**1.1**	**22.2**
Modelled Farm Loss	Current land use	0.4	35
	Proposed land use	**0.6**	**29**

5 Summary

The main receiving environments are un-named tributaries to the Waituna Creek which cross the property and ultimately drain into the Waituna Creek and Waituna Lagoon in turn. There is also a groundwater resource under the property which discharges into the Waituna Creek as well as likely providing some throughflow to groundwater resources in the lower reaches of the catchment. Available monitoring data suggests the main water quality issues with these water bodies are excessive nutrient levels in surface water. The soils and water quality information indicate a relatively complex combination of overland and lateral flow (i.e. soil drainage and discharge from artificial drains) as the primary transport mechanisms for water quality contamination. Nitrate concentrations in surface water may also be affected by groundwater discharge however it is unlikely concentrations will accumulate to unpotable levels.

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[25] Environment Southland, 2014. Waituna Newsletter: Issue 18 – June 2014. Environment Southland, Invercargill. 4p.

Due to the mitigation measures being adopted as part of the proposed dairy conversion, nitrogen losses are expected to decrease by 17% from 35 to 29 kg N/ha/year however phosphorous losses are expected to increase by 50% to 0.6 kg P/ha/year. The modelled losses are within the typical range for dairy farms.

Given the environmental setting and main transport pathways (i.e. overland flow and artificial drainage), the highest risk periods are in association with storm events. Contaminant loss during these periods will be avoided by using low rate, deferred effluent irrigation along with stock exclusion from waterways and the use of buffer zones and riparian planning around streams will reduce nutrient loss. Excessive nutrient loss will be avoided by managing supplements and fertiliser in accordance with a nutrient budget and through the use of a feedpad/herd home which will minimise urine deposits on grazed crops.

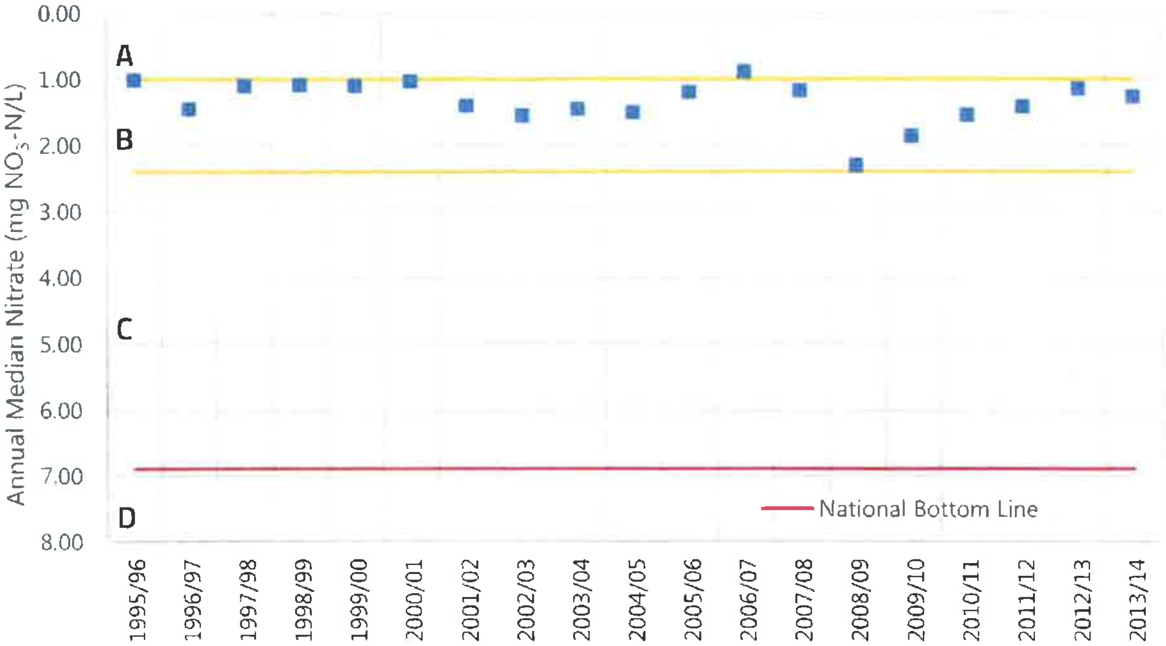
The effects of the proposed activity on the receiving water bodies will be an improvement in nitrogen loss which will help to offset the excessive nitrate levels in the Waituna Creek and Waituna Lagoon. Nitrogen losses to groundwater are anticipated to be well within the DWSNZ maximum acceptable value. Phosphorous losses may increase which could result in increased algal growth in Waituna Creek.

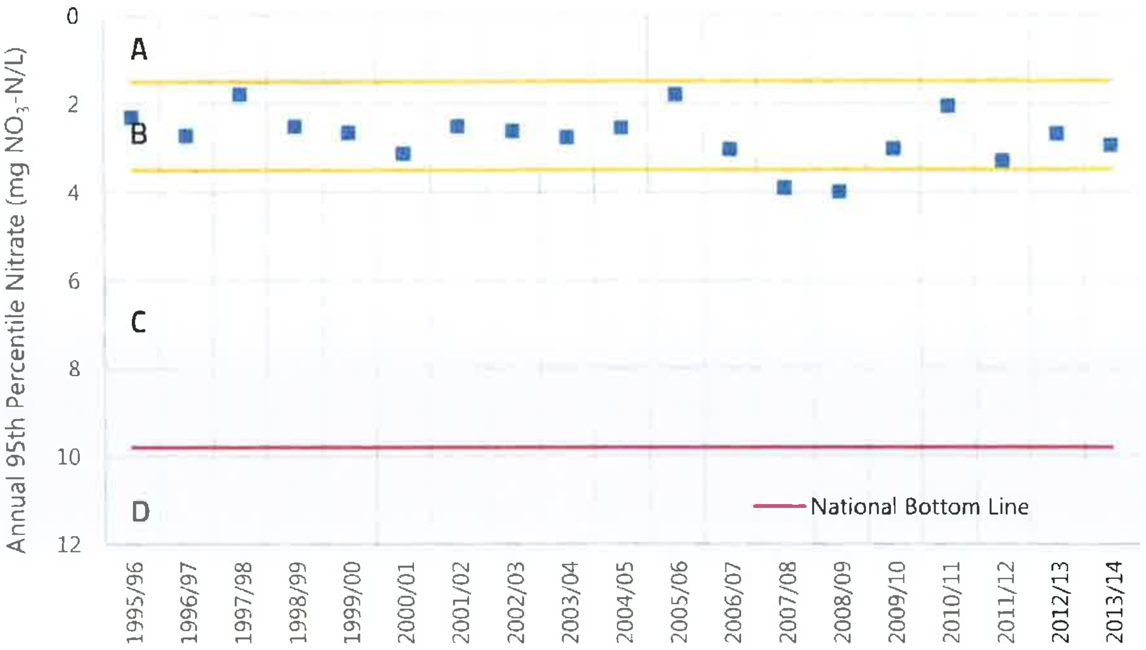
Until such time catchment limits are set for the Southland Region which balance community values for interconnected water bodies, and account for contaminant contributions from all land use types (in accordance with the requirements of the National Policy Statement for Freshwater Management, 2014), it is difficult to assess where the cumulative effect threshold applies in reference to an individual activity. This assessment has therefore been prepared using publically available information assessed against the values and objectives in regional plans.

Attachment A Time series plots of the Waituna Creek at Marshall Road water quality compared against the National Bottom Lines in the National Policy Statement for Freshwater Management 2014.

Nitrate (ecosystem health - toxicity)

Attribute State	Numeric Attribute State		Narrative Attribute State
	Annual Median	**Annual 95th Percentile**	
A	≤1.0	≤1.5	High conservation value system. Unlikely to be effects even on sensitive species
B	>1.0 and ≤2.4	>1.5 and ≤3.5	Some growth effect on up to 5% of species.
C	>2.4 and ≤6.9	>3.5 and ≤9.8	Growth effects on up to 20% of species (mainly sensitive species such as fish). No acute effects.
National Bottom Line	**6.9**	**9.8**	
D	>6.9	>9.8	Impacts on growth of multiple species, and starts approaching acute impact level (i.e. risk of death) for sensitive species at higher concentrations (>20 mg/L)

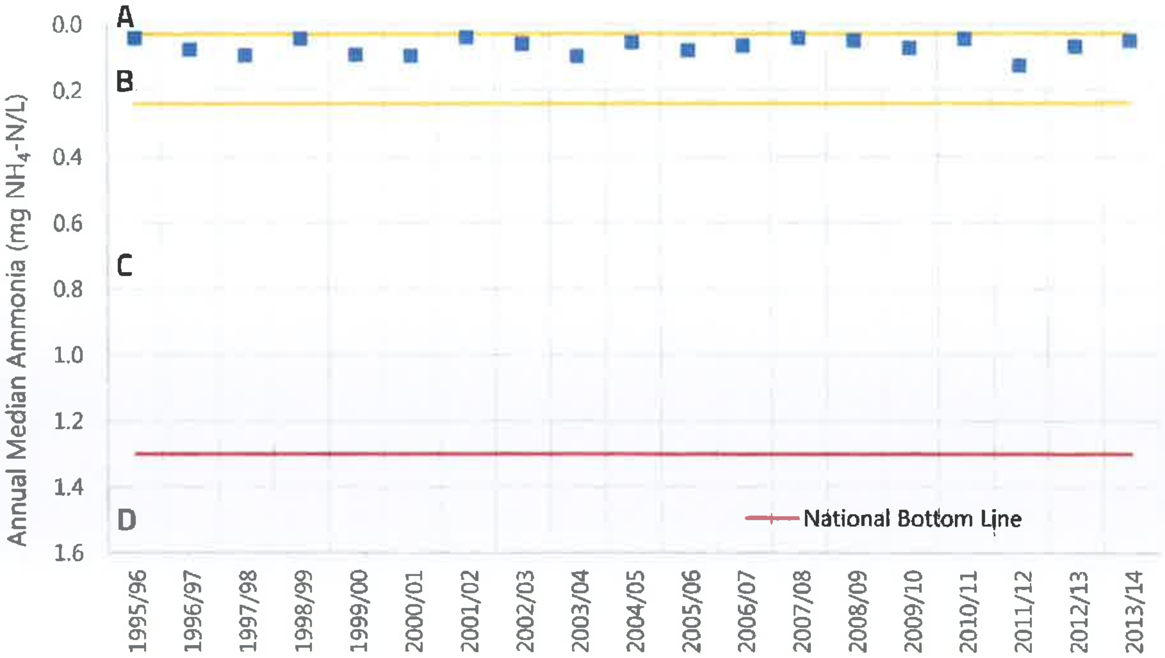




Ammonia (ecosystem health - toxicity)

Attribute State	Numeric Attribute State		Narrative Attribute State
	Annual Median	**Annual Maximum**	
A	≤0.03	≤0.05	99% species protection level: No observed effect on any species tested
B	>0.03 and ≤0.24	>0.05 and ≤0.40	95% species protection level: Starts impacting occasionally on the 5% most sensitive species
C	>0.24 and ≤1.30	>0.40 and ≤2.20	80% species protection level: Starts impacting regularly on the 20% most sensitive species (reduced survival of most sensitive species)
National Bottom Line	**1.30**	**2.20**	
D	>1.30	>2.20	Starts approaching acute impact level (i.e. risk of death) for sensitive species

(Note: compliance with the numeric attribute states should be taken after pH adjustment however in this case, the data has been used as provided by Environment Southland).


Annual Median Ammonia (mg NH4-N/L)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
A
B
C
D
National Bottom Line
1995/96
1996/97
1997/98
1998/99
1999/00
2000/01
2001/02
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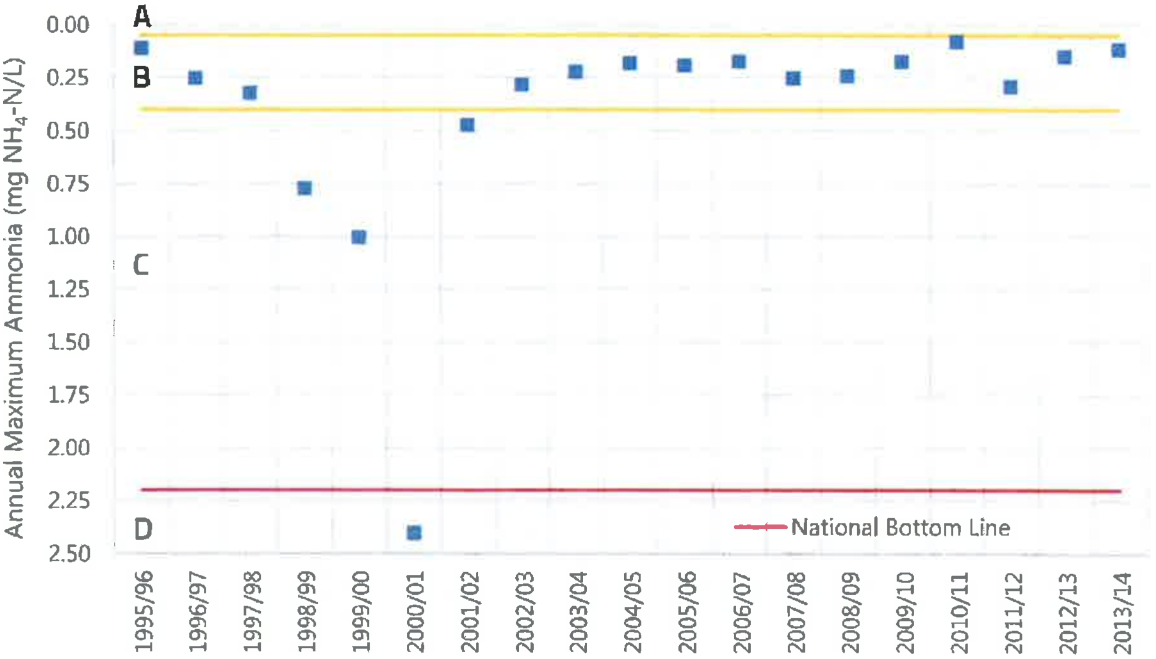
2010/11
2011/12
2012/13
2013/14


Annual Maximum Ammonia (mg NH4-N/L)
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
A
B
C
D
National Bottom Line
1995/96
1996/97
1997/98
1998/99
1999/00
2000/01
2001/02
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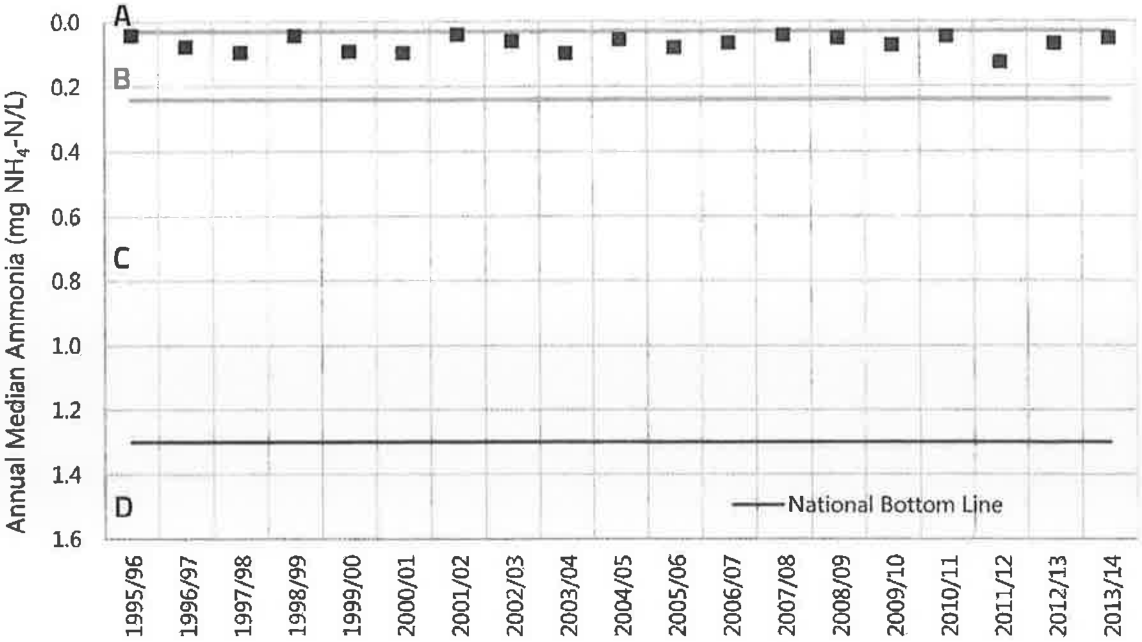
2010/11
2011/12
2012/13
2013/14


Annual Median Ammonia (mg NH₄-N/L)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
A
B
C
D
National Bottom Line
1995/96
1996/97
1997/98
1998/99
1999/00
2000/01
2001/02
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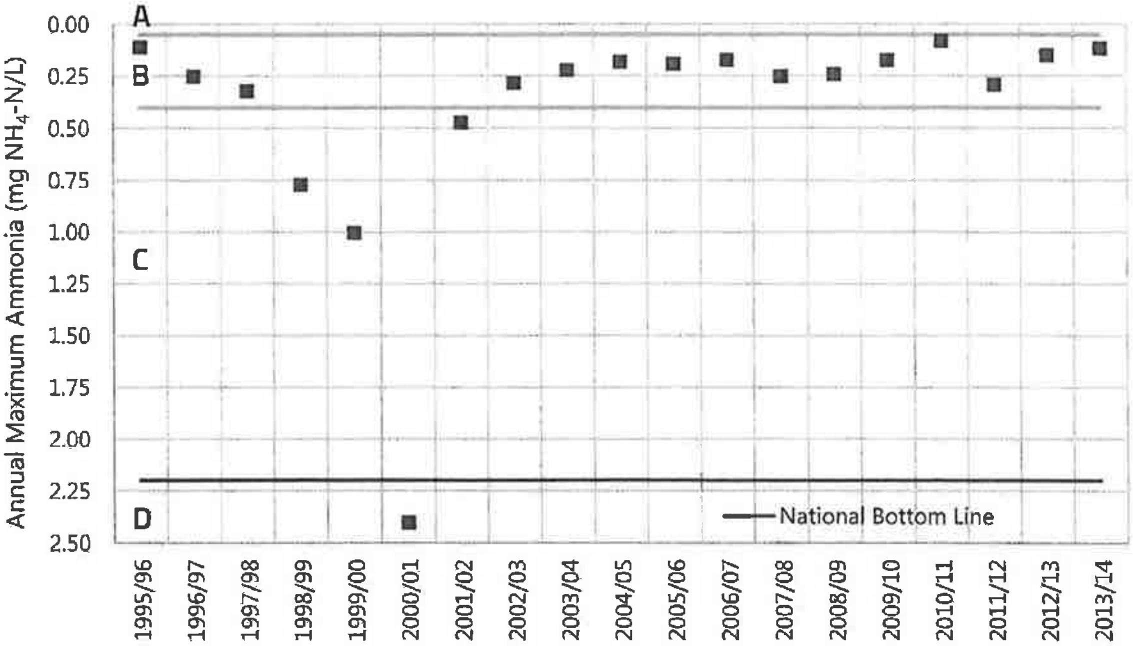
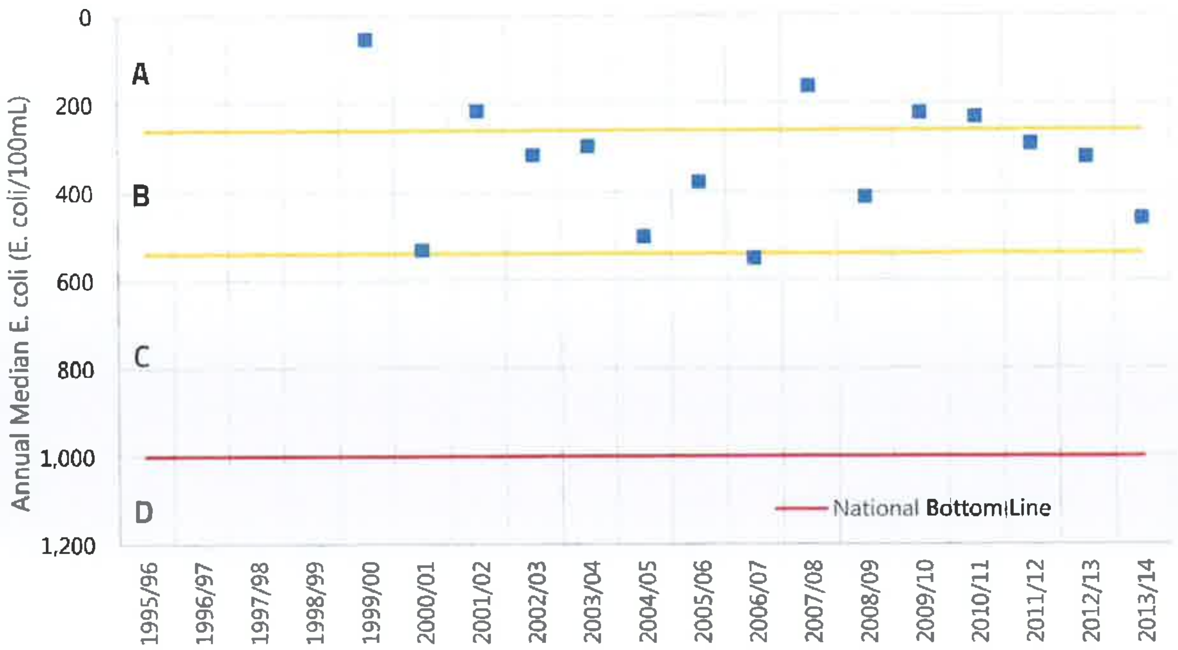
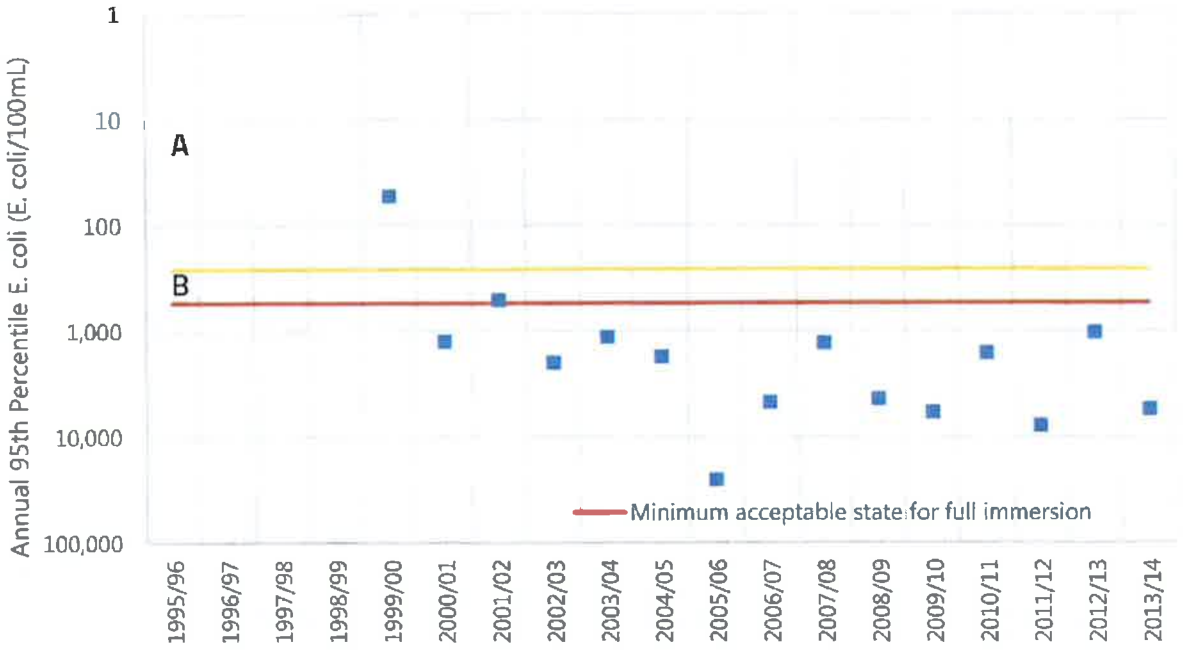
2011/12
2012/13
2013/14


Annual Maximum Ammonia (mg NH₄-N/L)
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
A
B
C
D
National Bottom Line
1995/96
1996/97
1997/98
1998/99
1999/00
2000/01
2001/02
2002/03
2003/04
2004/05
2005/06
2006/07
2007/08
2008/09
2009/10
2010/11
2011/12
2012/13
2013/14

E. coli (human health for recreation)

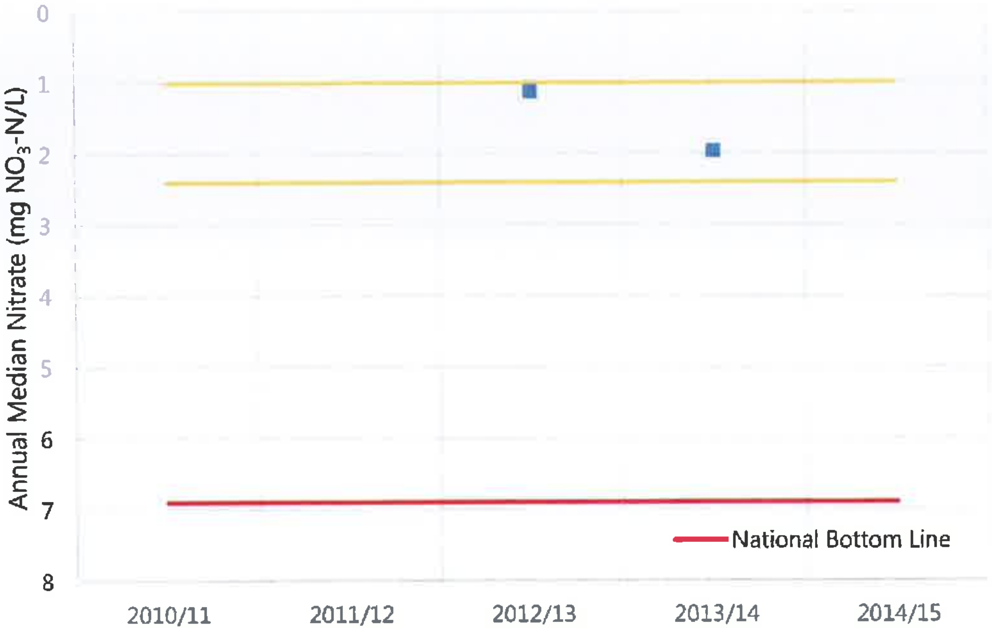
Attribute State	Numeric Attribute State	Sampling Statistic	Narrative Attribute State
A	≤260	Annual median	People are exposed to a very low risk of infection (less than 0.1% risk) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating)
		95th percentile	People are exposed to a low risk of infection (up to 1% risk) when undertaking activities likely to involve full immersion
B	>260 and ≤540	Annual median	People are exposed to a low risk of infection (less than 0.1% risk) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating)
		95th percentile	People are exposed to a moderate risk of infection (less than 5% risk) when undertaking activities likely to involve full immersion. 540/100ml is the **minimum acceptable state** for activities likely to involve full immersion
C	>540 and ≤1000	Annual median	People are exposed to a moderate risk of infection (less than 5% risk) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating). People are exposed to a high risk of infection (greater than 5% risk) from contact with water during activities likely to involve full immersion.
National Bottom Line	**1000**	Annual median	
D	>1000	Annual median	People are exposed to a high risk of infection (greater than 5% risk) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating)

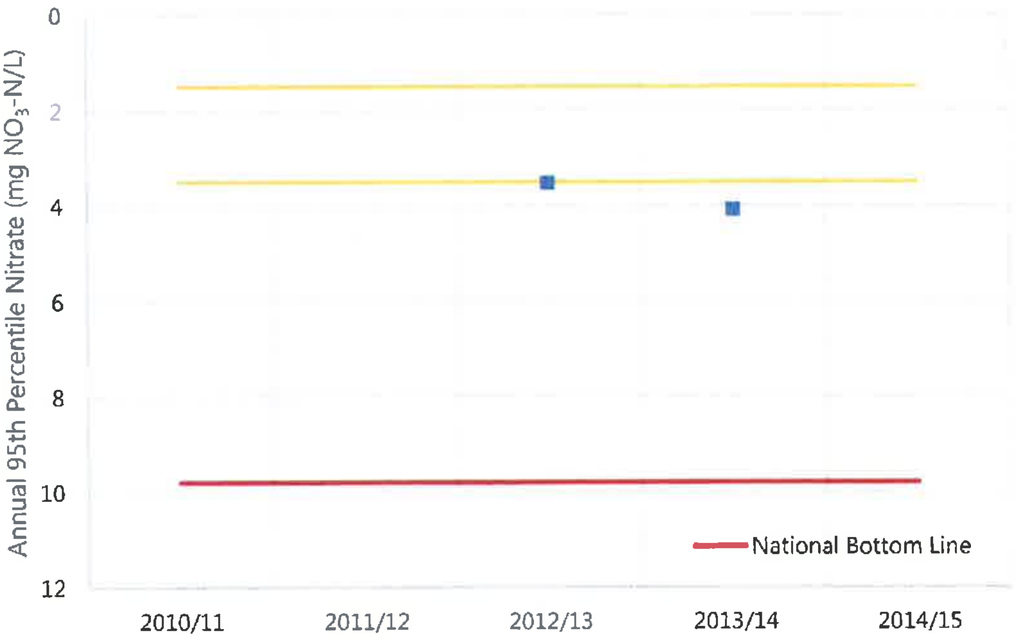

Annual Median E. coli (E. coli/100mL)
0
200
400
600
800
1,000
1,200
A
B
C
D
National Bottom Line
1995/96
1996/97
1997/98
1998/99
1999/00
2000/01
2001/02
2002/03
2003/04
2004/05
2005/06
2006/07
2007/08
2008/09
2009/10
2010/11
2011/12
2012/13
2013/14

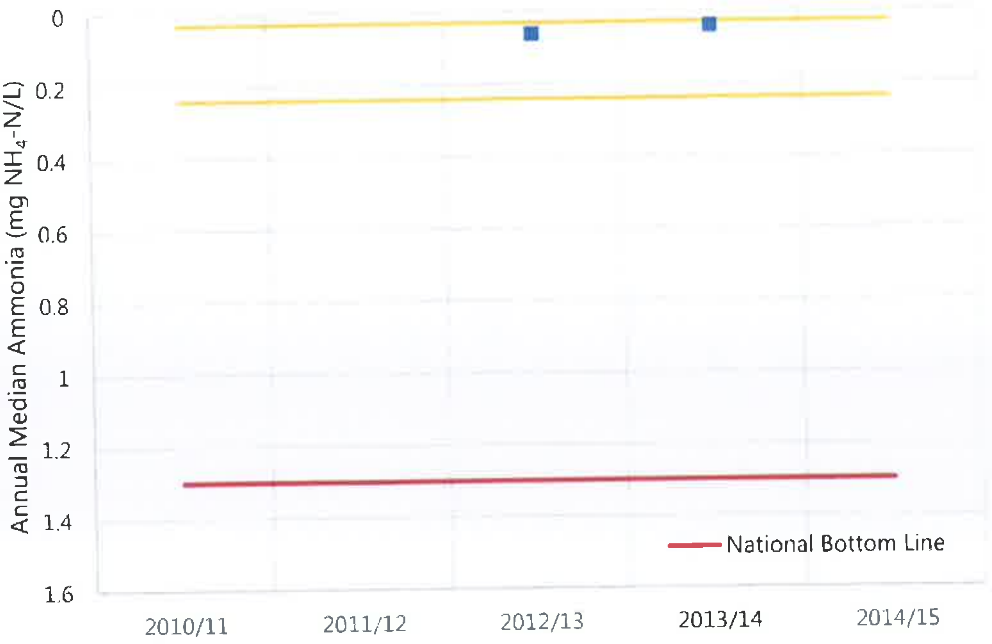

Annual 95th Percentile E. coli (E. coli/100mL)
1
10
100
1,000
10,000
100,000
A
B
Minimum acceptable state for full immersion
1995/96
1996/97
1997/98
1998/99
1999/00
2000/01
2001/02
2002/03
2003/04
2004/05
2005/06
2006/07
2007/08
2008/09
2009/10
2010/11
2011/12
2012/13
2013/14

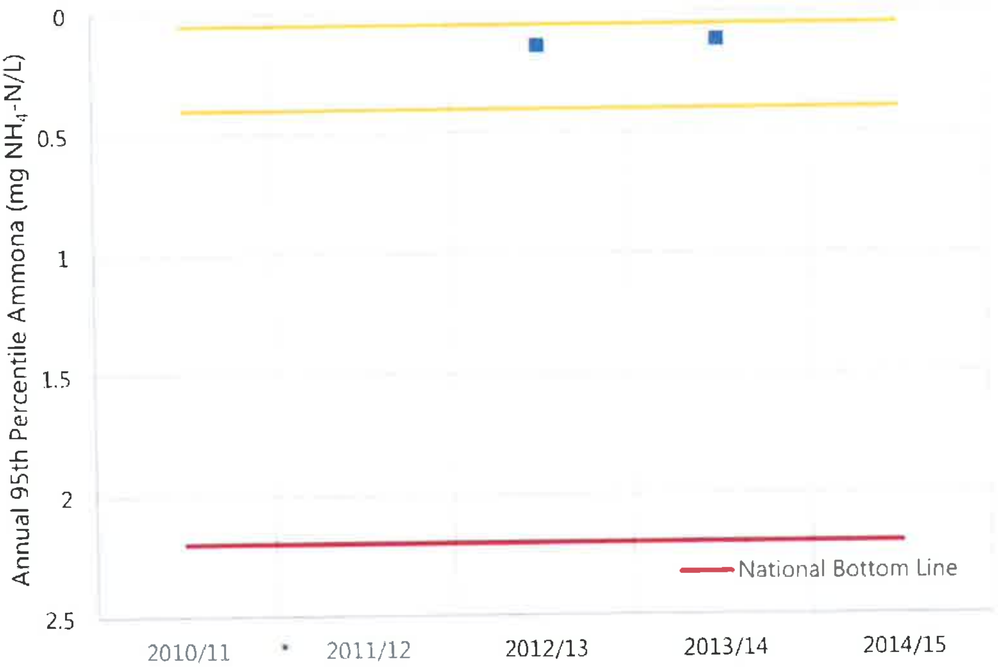
Attachment B Time series plots of the Waituna Creek 1 m upstream Waituna Road water quality compared against the National Bottom Lines in the National Policy Statement for Freshwater Management 2014.

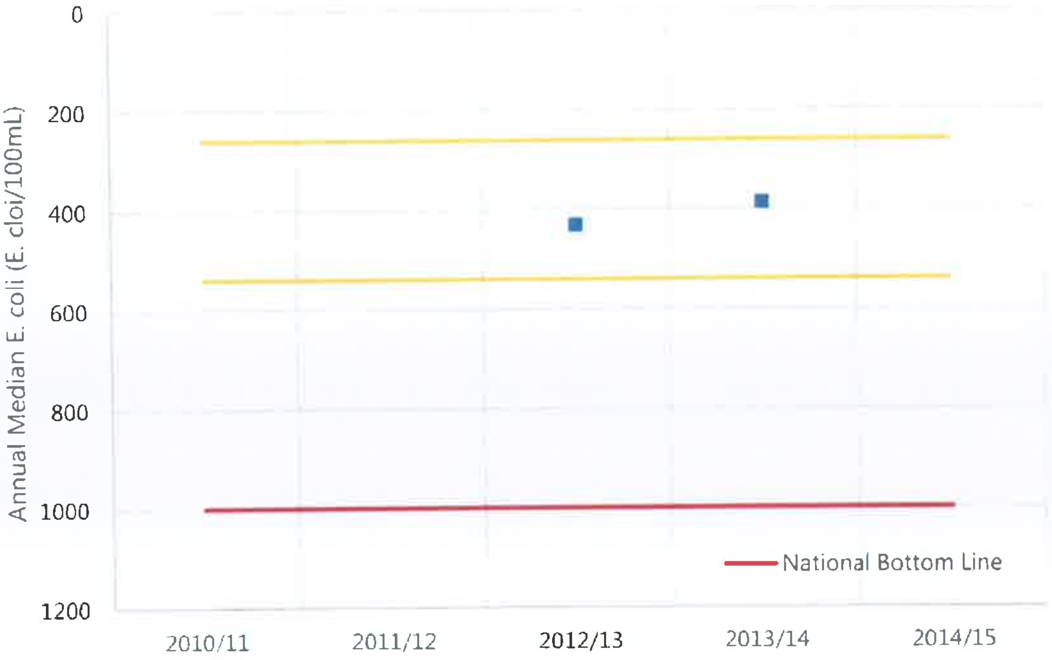
*Note that the 2012/13 record set is incomplete (starts 14 Jan 2013).

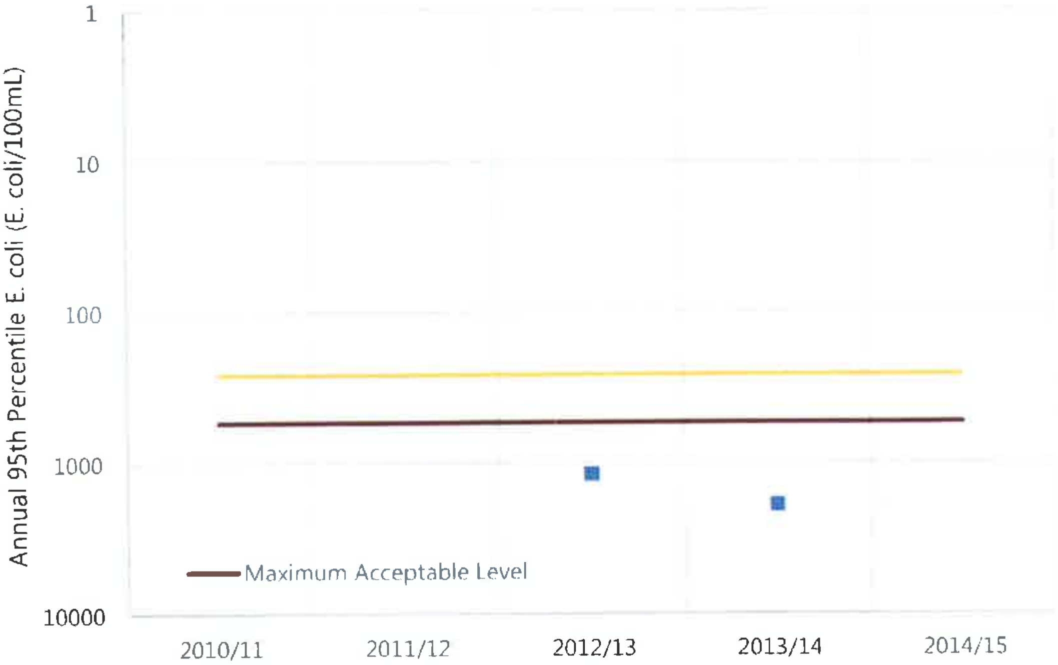





Annual Median Ammonia (mg NH4-N/L)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
National Bottom Line
2010/11
2011/12
2012/13
2013/14
2014/15


Annual 95th Percentile Ammona (mg NH4-N/L)
0
0.5
1
1.5
2
2.5
National Bottom Line
2010/11
2011/12
2012/13
2013/14
2014/15


Annual Median E. coli (E. cloi/100mL)
0
200
400
600
800
1000
1200
National Bottom Line
2010/11
2011/12
2012/13
2013/14
2014/15


Annual 95th Percentile E. coli (E. coli/100mL)
1
10
100
1000
10000
Maximum Acceptable Level
2010/11
2011/12
2012/13
2013/14
2014/15