Bronwyn Auckram

215

From:	Mikayla Scott on behalf of Facility Manager
Sent:	Thursday, 3 January 2019 9:36 a.m.
To:	Resource Consents
Subject:	FW: SILVER FERN FARMS MOSSBURN RESOURCE CONSENT RENEWAL – Reference 95498 (email 1of 2)
Attachments:	Appendix 1 - Silver Fern Farms - Soil Work Initial Land Assessment.pdf; Appendix 2 - Silver Fern Farms - MOS_16-17 Annual Report_16 Nov 2017_FINAL.pdf; Silver Fern Farms Ltd Certificate of Incorporation.pdf; Silver Fern Farms MOS Consent Application Form B_December 2018.pdf; Silver Fern Farms MOS Consent Application Remittance Advice - 17.0818.pdf; Silver Fern Farms MOS Consent Application Form A_December 2018_Signed.pdf; Silver Fern Farms MOS Consent Application Assessment of Environmental Effects_December 2018.pdf

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From: David Orchard [mailto:David.Orchard@silverfernfarms.co.nz]
Sent: Friday, 21 December 2018 3:04 p.m.
To: Facility Manager; Lauren Maciaszek
Cc: Daryn Jemmett
Subject: SILVER FERN FARMS MOSSBURN RESOURCE CONSENT RENEWAL – Reference 95498 (email 1of 2)

Dear Lauren,

RE: SILVER FERN FARMS MOSSBURN RESOURCE CONSENT RENEWAL – Reference 95498

Silver Fern Farms wishes to apply for resource consent renewal of the following consent: **95498**

Please find attached (via 2 emails):

- ✓ Environment Southland – Application Forms A & B for Resource Consent Renewal Silver Fern Farms Mossburn December 2018
- ✓ Assessment of Environmental Effects – Silver Fern Farms Mossburn December 2018
- ✓ Copy of fee deposit - MOS Consent Application Remittance Advice 17.0818
- ✓ Certificate of incorporation
- ✓ Appendix 1 – Soil Work Initial Land Assessment
- ✓ Appendix 2 – Mossburn 2016/2017 Annual Report
- ✓ Appendix 3 – Aqua Firma Initial Hydrology Assessment (email 2)
- ✓ Appendix 4 - Silver Fern Farms Mossburn Integrated Land Management Plan (email 2)
- ✓ Appendix 7 - WWTP Engineers Assessment (email 2)
- ✓ Appendix 8 – Liquid Earth – Mossburn Discharge to Groundwater Effects (email 2)

If you have any questions please do not hesitate to contact Group Environmental Advisor, David Orchard, on 027 548 0643.

Kind regards,

David Orchard

David Orchard
Environmental Advisor

Mob: +64 27 548 0643 **DDI:** +64 3 972 5033 **Tel:** +64 3 379 6900
david.orchard@silverfernfarms.co.nz **www.silverfernfarms.com**
Silver Fern Farms Limited, 34 Branston Street, Hornby, PO Box 283,
Christchurch, 8140, Canterbury, New Zealand

Environment Southland
Private Bag 90116
Invercargill 9840

Silver Fern Farms Venison Limited
283 Princes Street
PO Box 941
Dunedin 9054
Phone No.: +64 3 477 3980
Fax No.: +64 3 474 1087
E-Mail: accounts.payable@silverfernfarms.co.nz

Account No.	102139
Page No	1
Posting Date	17/08/18

Remittance Advice

Document No.	Details	Amount
RESOURCECONSENT/2018	Invoice	1,500.00
Total Amount		**1,500.00**

Credited to Account :

Bank Branch No.	01-0961
Bank Account No.	0018998-000

Application for Resource Consent (PART A)

This application is made under Section 88 of the Resource Management Act 1991

environment SOUTHLAND REGIONAL COUNCIL
Te Taiao Tonga

The purpose of this Part A form and the relevant Part B form(s) is to provide applications with guidance on information that is required under the Resource Management Act 1991. Please note that these forms are to act as a guide only, and Environment Southland reserves the right to request additional information.

To: Environment Southland
Private Bag 90116
Invercargill 9840

Full name, address and contact details of applicant *(in whose name consent is to be issued)*

Name: Silver Fern Farms Limited (Attention Group Environmental

Address: PO BOX 941, Dunedin 9054

david.orchard@silverfernfarms.co.nz

Email: Consent Application Contact: David Orchard, Environmental Advisor

Phone: 03 477 3980 (*Preferred*) 0275480643 (*Additional*) Fax:

Consultant contact details *(if different from above)*

Contact name/agent:

Address:

Email:

Phone: (*Preferred*) (*Additional*) Fax:

Please tick the box for the consent(s) you are applying for and complete the relevant Part B form(s) where available:

Land Use	*Discharge*	*Coastal*
☐ Bore/well	☑ To air	☐ Whitebait stand
☐ New or expanded dairy farming	☐ To water	☐ Structures/occupation of space
☐ Effluent storage	☑ To land	☐ Removal of natural materials
☐ Cultivation	***Water***	☐ Disturb foreshore/seabed
☐ Tree planting	☐ Take and use surface water	☐ Discharge/deposit substances
☐ Gravel extraction	☐ Take and use groundwater	☐ Commercial surface water activity
☐ Feed-pad, wintering pad, calving pad or silage pad	☐ Dam water	☐ Reclaim/drain foreshore/seabed
☐ Riverbed activity	☐ Divert water	☐ Marine farming
☐ Bridges and culverts		☐ Other coastal activities

1 Are there any **current** or **expired** consents relating to this proposal? ☑ Yes ☐ No

If yes, please provide consent number(s) and description:

95498 - To discharge primary treated wastewater to land

2 Are any other consents required from Environment Southland or **other authorities**? ☐ Yes ☑ No

If yes, please state the relevant authority and the type of consent(s) required:

3 For what **purpose** is this consent(s) required: (e.g. discharge of effluent, gravel extraction etc.)

4 **Location** of proposed activity

Address: See AEE section 3.1

Legal Description: See AEE section 2.4

Map Reference (NZTM 2000): ______ E ______ N

5 The name and address of the **owner /occupier**: (if other than the applicant)

Name: ______ Phone: ______

Address: ______

6 **Please attach a map or a coloured aerial photograph, showing at a minimum, the location of the proposed activities.**

7 Assessment of effects on the environment (AEE)

Please complete the applicable Part B form(s) for the proposed activities. For those activities where no Part B form is available, please attach a written statement that assesses the effects that your activities may have on the environment. An assessment of effects **must** include the following information:

- (a) *if it likely that the activity will result in any significant adverse effect on the environment, a description of any possible alternative locations or methods for undertaking the activity;*
- (b) *an assessment of the actual or potential effect on the environment of the activity;*
- (c) *if the activity includes the use of hazardous substances and installations, an assessment of any risks to the environment that are likely to arise from such use;*
- (d) *if the activity includes the discharge of any contaminant, a description of—*
  - (i) *the nature of the discharge and the sensitivity of the receiving environment to adverse effects; and*
  - (ii) *any possible alternative methods of discharge, including discharge into any other receiving environment;*
- (e) *a description of the mitigation measures (safeguards and contingency plans where relevant) to be undertaken to help or prevent or reduce the actual or potential effect;*
- (f) *identification of the persons affected by the activity, any consultation undertaken, and any response to the views of any persons consulted;*
- (g) *if the scale and significance of the activity's effects are such that monitoring is required, a description of how and by whom the effects will be monitored if the activity is approved;*
- (h) *if the activity will, or is likely to, have adverse effects that are more than minor on the exercise of a protected customary right, a description of possible alternative locations or methods for the exercise of the activity (unless written approval for the activity is given by the protected customary rights group).*

You should also include:

- (a) *an assessment of the activity against any relevant provisions of any relevant objectives, policies, or rules;*
- (b) *any information specified to be included in the application in accordance with the relevant regional plan;*
- (c) *for an application to replace an existing consent, an assessment of the value of the investment of the existing consent holder:*

An assessment of effects **must** address the following matters:

- (a) *any effect on those in the neighbourhood and, where relevant, the wider community, including any social, economic, or cultural effects;*
- (b) *any physical effect on the locality, including any landscape and visual effects;*
- (c) *any effect on ecosystems, including effects on plants or animals and any physical disturbance of habitats in the vicinity;*
- (d) *any effect on natural and physical resources having aesthetic, recreational, scientific, historical, spiritual, or cultural value, or other special value, for present or future generations;*
- (e) *any discharge of contaminants into the environment, including any unreasonable emission of noise, and options for the treatment and disposal of contaminants;*
- (f) *any risk to the neighbourhood, the wider community, or the environment through natural hazards or the use of hazardous substances or hazardous installations.*

8 Affected Parties

Please attach written approval from parties who may be affected by your activity. *Written Approval of an Affected Party* forms are available on the Environment Southland website. During the processing of your application, Council may determine that additional approvals are required.

9 Correspondence from Council when using a consultant

It is standard practice that both you and your consultant are copied into all correspondence relating to the consent process. This is so that you know what is going on with your application. Please let us know below if you would like us to only contact your consultant. This means you will only hear from us when your application is/is not accepted, when a decision is made or if we feel that you need to be contacted.

I want all correspondence about my application to go to my consultant only ☐ Yes ☑ No

10 Site visit from the Consents Team

Consents staff are able to meet with you, visit your site and see what you are proposing to do. We find that this is beneficial to everyone involved. The cost of the visit will be included in the total cost of processing your consent. However, we find that applications that have an on-site visit are processed with less congestion and at a similar or lesser overall cost. Please let us know below if you would like us to come and see your site.

I would like a member of the Consents Team to visit my site ☐ Yes ☑ No

11 How much will it cost to process my application?

The cost of a consent depends on the complexity of the activities. Staff time is charged out at a rate of $145/hr and vehicle use for site visits is charged at $0.73/km (inclusive of GST).

The fees shown below under section two are **deposits to be paid at the time of application**. Due to the complexity of these activities, this deposit will not usually cover the full cost of processing the application. **Further costs may be incurred** relating to staff time, disbursements, legal charges, consultation fees, and hearing commissioner fees. Environment Southland's User Charges and Fees document is available at:

www.es.govt.nz/fees-and-charges

When the consent has been processed you will receive an invoice for an additional fee, or for a refund.

The Council's user charges are fixed under Section 36 of the Resource Management Act 1991. Our fee schedule is:

1. Fixed fee:	
Bores and wells	**$290**
Whitebait stand	**$220**
2. Deposit:	
All other non-notified applications including: • Certificates of compliance • Changes to consent conditions (variations) • Change of lapse date	**$1,500**
Applications that require notification or limited notification	**$2,000**

How to pay

Environment Southland accepts payment in the forms of cash, Eftpos, cheque, or electronic transfer. All electronic transfers must include the applicant's name and "consent application" as a reference. Please make electronic payments to: Environment Southland, 01-0961-0018998-00.

User Charges

Please note that additional Annual User Charges will apply to all consents. These are payable in advance on the first day of July each year. Tables 4, 5 and 6 of the Environment Southland User Charges and Fees Schedule outlines the fees associated with Annual Administration Charges and Annual Consent Monitoring and Inspection Charges. Table 7: Annual Research and Monitoring Charges applies only to surface and groundwater takes and comprises the following:

- **Surface water takes (per consent, for volumes up to 50,000 m^3/day):**
  - A charge of **$1.89** per year per cubic metre authorised as a maximum daily take.
  - Minimum of **$138**, maximum of **$7,585**.
- **Surface water takes (per consent, for volumes over 50,000 m^3/day):**
  - **$0.0031** per cubic metre authorised as a maximum daily take.
- **Groundwater takes (per consent):**
  - A charge of **$0.89** per year per cubic metre.
  - Minimum of **$162**, maximum of **$1,782**.

Municipal and stock water discount (of 50%) no longer applies.

12 Checklist: Have you included the following?

- ✓ Payment of the required deposit *(see fee schedule)*
- ✓ Written approval from all potentially affected parties *(forms available from the Environment Southland website)*
- ✓ Site plan/location map/sketch of the proposed activity
- ✓ A copy of the Certificate of Incorporation (*where applicant is a company*)
- ✓ Part B form(s) specific to your activity and/or a separate assessment of environmental effects (AEE)

Note:

(a) If your application does not contain the necessary information and the appropriate fee, Environment Southland must return the application.

Signature of applicant

I hereby certify that to the best of my knowledge and belief, the information given in this application is true and correct.

I undertake to pay all actual and reasonable application processing costs incurred by Environment Southland.

Name (block capitals) Daryn Jemmett, Group Environmental Advisor

Signed [signature] **Date** 21/12/2018

(Signature of applicant or person authorised to sign on behalf of applicant)

NEW ZEALAND

COMPANIES OFFICE

Certificate of Incorporation

SILVER FERN FARMS LIMITED

5474064

NZBN: 9429041428900

This is to certify that HHL GROUP B SUB LIMITED was incorporated under the Companies Act 1993 on the 25th day of September 2014
and changed its name to SILVER FERN FARMS BEEF LIMITED on the 31st day of October 2014
and changed its name to SILVER FERN FARMS LIMITED on the 14th day of December 2016.

REGISTRAR OF COMPANIES NEW ZEALAND

Registrar of Companies
3rd day of March 2017

For further details relating to this company check
http://www.companies.govt.nz/co/5474064
Certificate generated 03 March 2017 09:08 AM NZDT

SCAN TO VIEW
OUR REGISTRATION DETAILS

Application to Discharge to Land (PART B) (non-dairy activity)

This application is made under Section 88 of the Resource Management Act 1991

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

A complete Part A form needs to be provided with this Part B form. The purpose of this Part B form is to provide applicants with guidance on information that is required under the Resource Management Act 1991. These forms are to act as a guide only and Environment Southland reserves the right to request additional information. **Please also refer to Appendix A of the Regional Water Plan for Southland, 2010 and the proposed Southland Water and Land Plan, 2018.**

To: Environment Southland
Private Bag 90116
Invercargill 9840

1 What is this application for?

- [ ] The discharge of contaminants to land where it may enter water
- [x] The discharge of contaminants to land

2 What duration of resource consent is sought? 10 years

3 Please describe the proposed activity:

Irrigation of food processing wastewater to land.
See section section 4 of AEE

4 Please describe the following elements of the proposed discharge to land:

(a) The chemical content (including heavy metals or toxic substances, nitrates, ammonia and dissolved reactive phosphorous)

Wastewater from food processing is largely organic in nature.
See section 4.2 of AEE

(b) Number of discharge points: One irrigation block

(c) Location/area of each discharge point: See section 2.4

(d) Maximum rate/thickness of application: See section 4.2.3

(e) If the proposed discharge is continuous or intermittent: Intermittent

5 What is the proposed frequency and seasonality of discharge (e.g. hours, days, weeks and months that the discharge will occur). Please describe any variations, where appropriate.

See AEE section 4.2

6 Has there been any discharge monitoring carried out in relation to this proposal, or do you have access to any background monitoring? If yes, please describe and attach results.

Yes - see AEE section 4.2 and Appendices

7 What is the depth to groundwater beneath the disposal area? Please also discuss seasonal variations in groundwater depth.

See AEE section 3.2.2 and Appendices

8 Has a subsoil investigation been carried out? ☑ Yes ☐ No

Note: All bore holes and test pits should be drilled in the location of the proposed disposal field and/or reserve area and their location marked on the appended site plan. Generally a minimum of three bore holes or test pits are required for soil category assessment. A separate resource consent may be required for your investigative bore(s).

9 Please provide details of the investigation bore(s)/test pits.

- [ ] Test pit (maximum depth) ________ m No of test pits ________
- [ ] Bore hole (maximum depth) ________ m No of bore holes ________
- [x] Other (specify) See AEE Appendix One and Two
- [ ] N/A

10 Has percolation or soil infiltration testing been carried out and is the test report attached?

- [ ] No
- [x] Yes, please specify method

K value: See AEE Appendix One and Two

11 What is the discharge site soil category (based on the dominant soil type in the first 1 m depth)?

Soil Category	Description	Tick
1	Gravels and sands	✓ See AEE s.3.2
2	Sandy loams	
3	Loams	
4	Clay loams	
5	Light clays	
6	Medium to heavy clays	

Existing Environment

12 **Are any of the following features found within the existing environment of the proposed activity? Describe these features in the space below, along with details of the assessment undertaken to determine the presence of these features.**

	Yes	No
(a) Signs of instream life (e.g. fish, eels, bullies, crayfish, native birds, frogs)?		✓
(b) Areas where food is gathered from watercourses (e.g. watercress, eels, wildfowl)?		✓
(c) Wetlands, wildlife habitats or bird nesting habitats (e.g. swamp areas)?		✓
(d) Other activities occurring in the area (e.g. commercial activity, fishing, swimming, boating)?		✓
(e) Areas of particular aesthetic, cultural or scientific value (e.g. archaeological sites)?		✓
(f) Other waste discharges, any water takes and/or monitoring sites?		✓

See AEE section 3

Please also include a map or site plan (and photographs if necessary) showing the location of roads and property boundaries, water bodies, wetlands and other wildlife habitats, buildings and residential properties, location of discharge points, any registered drinking water takes, and the location of any sensitive sites (e.g. historic places, sites of importance to iwi, public gathering areas etc.) in proximity to the site.

Assessment of Effects

13 Please describe any possible long term or short term effects the discharge may have on the quality of the receiving environment and including effects on water bodies, biota (plant and animal life), soil quality, and odour and dust effects.

See AEE section 6

14 Pursuant to Schedule 4 of the Resource Management Act, 1991, there are a number of matters that must be addressed by an assessment of environmental effects. Please discuss what effects the proposed activity will have on the following:

(a) any effect on those in the neighbourhood and, where relevant, the wider community, including any social, economic, or cultural effects

See AEE Appendix Five

(b) any physical effect on the locality, including any landscape and visual effects

See AEE Appendix Five and Eight

(c) any effect on ecosystems, including effects on plants or animals and any physical disturbance of habitats in the vicinity

See AEE Appendix Five and Eight

(d) any effect on natural and physical resources having aesthetic, recreational, scientific, historical, spiritual, or cultural value, or other special value, for present or future generations

See AEE Appendix Five and Eight

(e) any discharge of contaminants into the environment, including any unreasonable emission of noise, and options for the treatment and disposal of contaminants

See AEE Appendix Five

(f) any risk to the neighbourhood, the wider community, or the environment through natural hazards or the use of hazardous substances or hazardous installations

See AEE Appendix Five

15 Please include a description of the monitoring or mitigation measures (including safeguards and contingency plans where relevant) to be undertaken to help avoid, reduce, remedy or mitigate the actual or potential effects on environmental features and values. For example, if relevant, please include the following:

(a) treatment of the contaminants prior to discharge;

(b) buffer distances from water bodies, sloping land, site boundaries;

(c) details of any storage to be provided to enable deferred irrigation;

(d) a description of the monitoring system to be used for checking and recording the quality and quantity of the discharge. Please include how and when the monitoring will occur, and by whom; and

(e) contingency planning – describe how the equipment controlling the discharge will be operated and maintained to prevent equipment failure, and what measures will be implemented to ensure that the effects of any malfunction are remedied.

See AEE section 5

16 **Please justify the term of consent sought with regard to any effects on the environment.**

See AEE section 2.3

17 **Please include a description of any possible alternative locations or methods for undertaking the activity and why these alternatives have not been selected.**

See AEE section 7

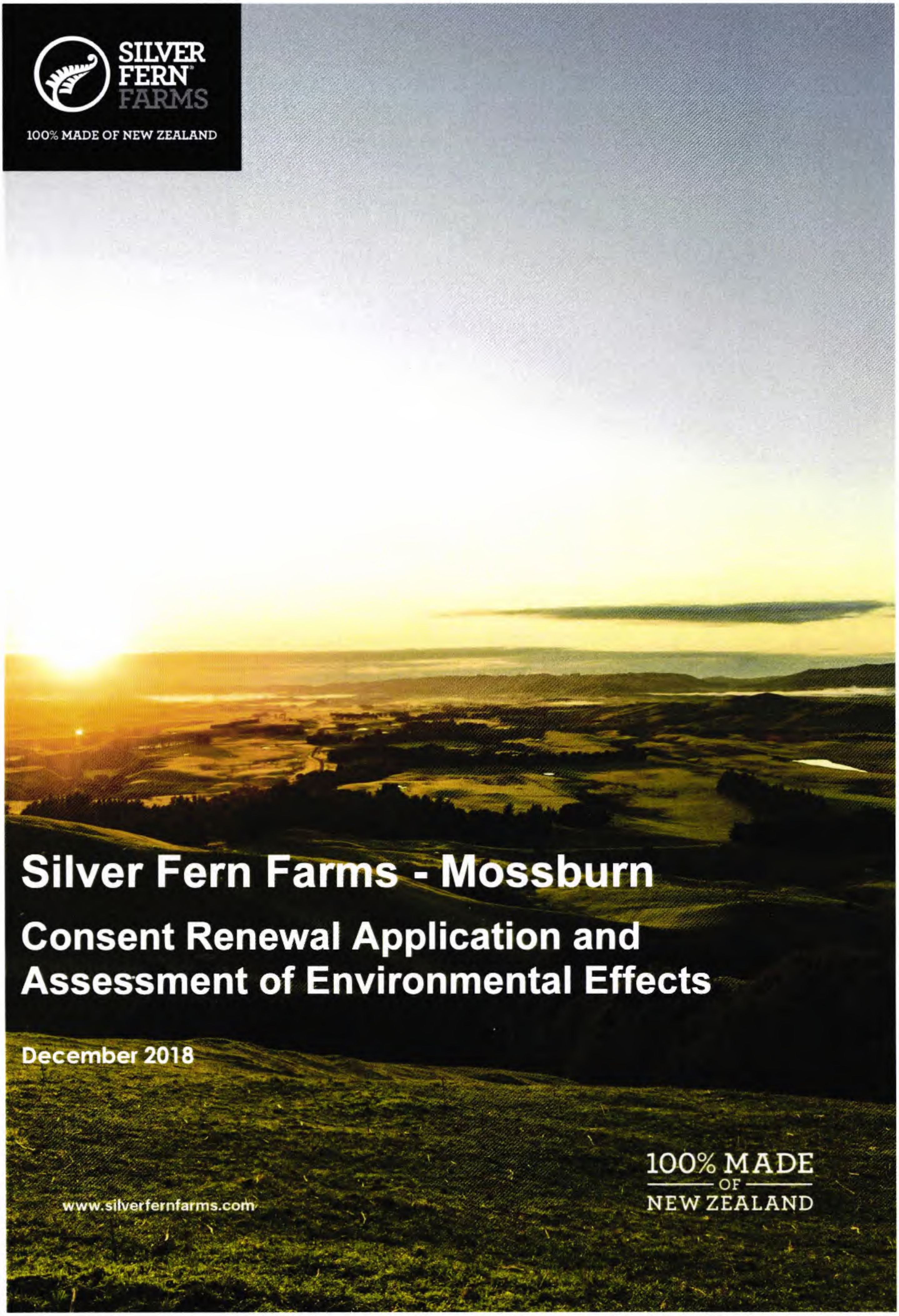
18 **Please include evidence of any consultation undertaken for this application. This may include (but not be limited to) consultation with adjoining landowners, other consent holders in the immediate area, iwi (e.g. Te Rūnanga O Ngāi Tahu, Te Ao Marama Inc), government departments/ministries (e.g. DOC), territorial authorities and recreational associations.**

Please note that in accordance with Schedule 4 of the RMA, you may also be required to provide an assessment of whether or not the proposed activity is contrary to any of the relevant provisions of the following documents.

(a) Regional Policy Statement for Southland, 2017 (and any proposed/subsequent versions)
(b) Regional Water Plan for Southland, 2010 (and any proposed/subsequent versions)
(c) proposed Southland Water and Land Plan, 2018 (and any proposed/subsequent versions)
(c) National Policy Statement for Freshwater Management, 2014
(d) National Environmental Standard for Sources of Human Drinking Water, 2007

Staff are able to advise whether this is required, as it is dependant on the location, scale and complexity of your proposal. We invite you to come in for a pre-application meeting with Environment Southland consents staff to discuss this.

END OF FORM



SILVER FERN FARMS

100% MADE OF NEW ZEALAND

Silver Fern Farms - Mossburn

Consent Renewal Application and Assessment of Environmental Effects

December 2018

www.silverfernfarms.com

100% MADE OF NEW ZEALAND

REPORT TITLE:	**Consent Renewal Application and Assessment of Environmental Effects**
OPERATION:	Silver Fern Farms - Mossburn
VERSION:	**FINAL**
DATE:	December 2018
PREPARED BY:	Silver Fern Farms - Group Environmental

ADDRESS FOR SERVICE:

Silver Fern Farms (Attention: Group Environmental)

PO Box 941

DUNEDIN 9054

Application Primary Contact:

Silver Fern Farms – Group Environmental

Phone:	03 477 3980
Email:	David.Orchard@silverfernfarms.co.nz
Contact Person:	**David Orchard – Environmental Advisor Group Environmental**
DDI:	**03 972 5033**

Site Primary Contact:

Silver Fern Farms

Phone:	03 477 3980
Email:	Karen.McDonald@silverfernfarms.co.nz
Contact Person:	**Karen McDonald – Project manager Operations**
DDI:	**03 470 5258**

CONTENTS

1 INTRODUCTION

1.1 Background

Silver Fern Farms owns a small meat processing operation at Mossburn, Southland (*Silver Fern Farms Mossburn*).

Meat processing activities have been operating on the site under various consents granted by the Southland Regional Council (*Environment Southland*), since 1991. The current resource consents are held on behalf of the operating by Silver Fern Farms Limited

The production site and key service activities are all located on the Holmes Street / Wreys Bush-Mossburn Road site. This includes buildings, car parks, access ways, hardstand areas, water heater (boiler), wastewater irrigation system, and open space areas.

Land support activities occur on company owned land neighbouring the production site, this includes wastewater irrigation and holding of stock as required to support the processing operation and maintain the land-holdings.

The neighbouring wastewater irrigation block is subject of this application, and is bounded by Reid Macauley Road, Bath Street, Surrey Street and neighbouring farmland (a map of the operation is shown in Figure 3.1).

At the time of writing this application, processing at Silver Fern Farms Mossburn has been put on hold. The processing plant and key production activities concluded at the end of the 2015 / 2016 season. Strategic developments across Silver Fern Farms operations has resulted in processing being deferred at Silver Fern Farms Mossburn.

Silver Fern Farms processing strategy includes having plants in the right locations when and if required, and a strong preference for making the most of the capacity of the existing processing sites, enabling more efficient use of existing infrastructure.

2 ACTIVITIES REQUIRING CONSENT RENEWAL

2.1 The Applicant

Silver Fern Farms (*'**Silver Fern Farms**' or the Company*) is New Zealand's largest meat processing company, with operations throughout the country and offices and partners around the world. As a leading food producer, *Silver Fern Farms* takes pride in its commitment to actively caring for the environment and managing environmental matters as an integral part of the business. This is not just the right thing to do, but also essential in meeting the expectations of our suppliers, customers and consumers.

Technically there are a number of subsidiaries under the parent company, each carrying out different functions within delegated authority.

Currently all resource consents are managed under delegated authority by Silver Fern Farms Limited (*the Applicant*).

Silver Fern Farms Limited is the applicant in relation to this application for renewal and will be the consent holder of the updated consent.

2.2 The Application in Brief

When processing occurs at Silver Fern Farms Mossburn, wastewater generated is applied to land neighbouring the processing plant - the land is utilised for wastewater treatment where crops are grown and removed in a cut-and-carry system in order to maintain a net nutrient budget. At other times, the land is lightly harvested and grazed on the boundaries for maintenance of the land-holdings.

The key elements of the Application are based on maintaining the ability to continue the existing consented activities:

- To discharge contaminants onto land;
- To discharge contaminants onto land where they may enter groundwater
- To discharge contaminants to air from the land application of wastewater: and,
- To operate a wastewater treatment operation.

By doing so will:

- ensure the ongoing ability to use travelling irrigators to irrigate wastewater to land as a nutrient source to grow pastoral crops (cut-and-carry) as required; and,
- provide for maintenance of the land-holdings whilst the processing operations are in stasis.

This application is for the replacement of the existing resource consent due to expire in April 2019, and not for new activities. Because of this, information has been generated over the term of the consents that largely obviates the need to try and predict effects as is the case for a consent application for new activities.

Table 1.2 below summarises the current resource consent that requires renewal.

Consent No.	Activity	Expiry Date
95498	To discharge primary treated wastewater from a venison abattoir to land. Lot 1 DP 10874, Lot 2 DP 14189	15 April 2019

Table 1.2: *Existing Resource Consent requiring renewal.*

Silver Fern Farms is seeking replacement of the above resource consent to maintain strategic agility across the company when and if required.

The Application and this supporting Assessment of Environmental Effects (*AEE*) has been prepared to describe the activities and establish that their continuation does not have, or is not likely to have, any adverse effects on the environment. The nature of the activities will not fundamentally change, and none of the effects on the receiving environment are at a level that exceeds those anticipated at the time of the existing consents being granted.

This AEE provides such detail fitting with the scale and significance of the effects that Silver Fern Farms Mossburn operations may have on the receiving environment, while recognising this is an existing activity and the short-term replacement consent being sought. This AEE has been prepared in accordance with the Fourth Schedule of the RMA (see Appendix 5, for a summary matrix).

In order that these activities can occur, if required by strategic developments, while this application is being processed, this application is made in accordance with s.124 RMA.

Whilst Silver Fern Farms lodged an application, and has worked with Council, prior to six months of the expiry of the existing consent, further information required by Council has resulted in this application being re-lodged between the six month and three month period prior to expiry.

Following discussion with Council, Silver Fern Farms had an independent assessment of the land discharge activity carried out. Mr Brydon Hughes (Hydrogeologist) of Liquid Earth Limited ('***Liquid Earth***') was engaged to assess potential effects on groundwater from the proposed operation up to the maximum nutrient application rate and hydraulic loadings being sought, addressing a question raised by Council and supplementing previous assessments by SoilWork Limited ('***SoilWork***').

As a result of this time delay Silver Fern Farms seeks in good faith for Council discretion for continuance whilst the application is processed.

2.3 Term of Consent Being Sought

Table 2.3 below identifies the maximum duration permitted by the RMA (s.123), and the associated term of consent being sought.

Consent Type	Maximum Duration (RMA)	Consent Term Sought
Discharge Permit – Wastewater to land	35	10

Table 2.3: *Term of consent.*

The key elements of this Application is based on continuing existing onsite operations, if required, to provide flexibility and certainty whilst the company continues to undergo strategic realignment.

Silver Fern Farms is applying for a short consent term of ten years.

Whilst a ten-year term generally will not provide economic certainty, this short-term reflects time for strategic considerations. Rather than a term cognisant of the minimal effects on the receiving environment that have been observed during the term of the existing consent, Silver Fern Farms recognise it does not seem appropriate to apply for a longer term if subsequent strategic changes would be required in the short-term.

2.4 Property Legal Descriptions Associated with Activities

The operation can be divided into 3 areas (as shown in Figure 2.4 below):

- Processing plant (purple area) – where buildings and infrastructure are located, including wastewater primary treatment;
- Grazing paddocks (green area) – utilised for grazing, when processing area is available for stockyard overflow if required following breakdown; and,
- Wastewater irrigation block (blue area) – area principally for wastewater irrigation and cut-and-carry when processing, otherwise grazing.

***Figure 2.4:** Indicative operating areas of Silver Fern Farms Mossburn.*

Overall, the Silver Fern Farms Mossburn site encompasses approximately 51 hectares, and is comprised of 8 titles, as shown in Table 2.4 below. The building coverage is a small percentage of the site, approximately 20% of the total land area.

Legal Description	**Area in hectares**
Lot 3 DP 12113 - Cert Title: SL9A/404 – Residential section	0.254 ha
Part Lot 1 DP 9718 & Lot 1 DP 11880 – Cert Title: SL10C/742 – Wastewater treatment plant & tanks, and Grazed paddocks around Plant	**4.1671 ha**
Lot 2 DP 6656– Cert Title: SLA4/464 – Processing Plant	0.0809 ha
Lot 1 DP 6656 – Cert Title: SLB2/403 – Processing Plant	0.0809 ha
Lot 1 DP 6573 – Cert Title: SLB2/170 – Processing Plant	0.1077 ha
Lot 2 DP 6573 – Cert Title: SLB2/1130 -	0.0809 ha
Lot 1 DP 12113 – Cert Title: SL9A/404 - Grazed paddock around Plant (Residential)	0.254 ha
Lot 1 DP 10874 & Lot 2 DP 14189 – Cert Title: SL11B/840 – Wastewater Irrigation Paddock *[Map Ref. 1228989.46 E, 4931065.48 N NZTM]*	**45.9965 ha**

Table 2.4: *Land Information Silver Fern Farms Mossburn*

Of these land-holdings Lot 1 DP 10874 and Lot 2 DP 14189 is utilised for wastewater irrigation, approximately 90% of the site land-holdings. The overall wastewater irrigation block is approximately 46 ha. Of that, around 40 ha is utilised for wastewater irrigation, the remainder consists of buffers and boundaries.

Prior to purchase by Silver Fern Farms for use for wastewater irrigation, the land-holding was used for general farming purposes.

The wastewater primary treatment services and irrigation pumping equipment resides on the processing site, Part Lot 1 DP 9718 & Lot 1 DP, whereas the underground pipeline and irrigator hydrants are across the irrigation block.

3 EXISTING ENVIRONMENT

3.1 General Location

Silver Fern Farms Mossburn operation is located on the southern side of the Mossburn Township, as shown in Figure 3.1 below.

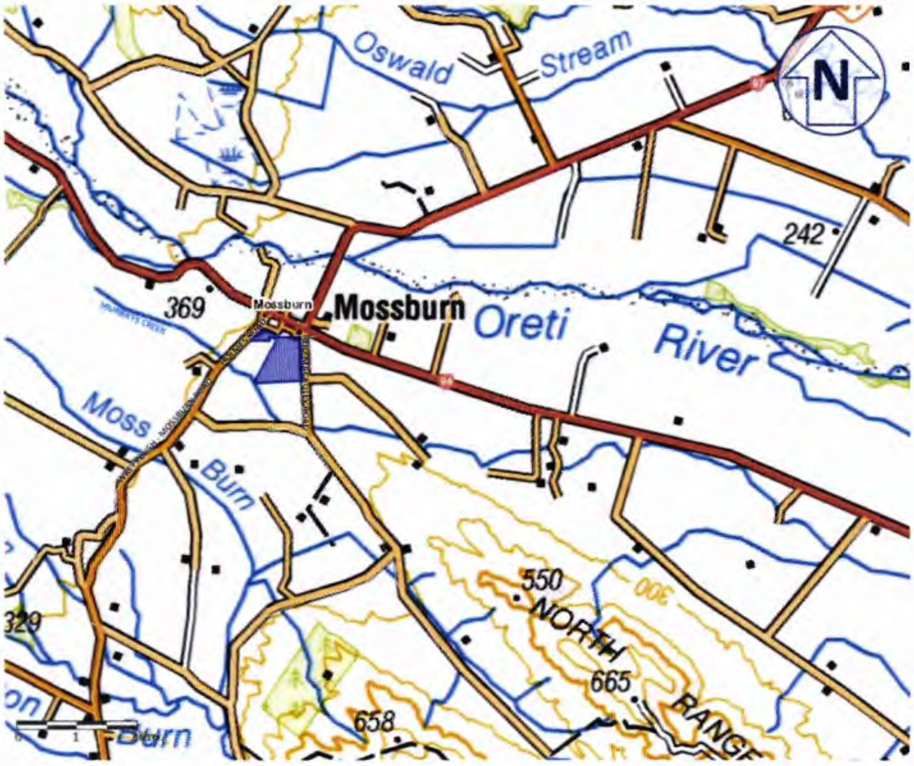


Figure 3.1: *General area where Silver Fern Farms Mossburn located (adapted from Topo maps) [Note: Indicative site location highlighted].*

The site lies in the area between Holmes Street / Wreys Bush-Mossburn Road and Reid Macauley Road, and is surrounded by rural farmland to the south, east and west with the township and residential properties to the north.

The nearest surface water bodies are the Oreti River to the north, and Murray Creek to the south.

There is no reticulated wastewater / trade waste network supplied by the Southland District Council for use by industrial activities at Mossburn. Water to the site is supplied from the Mossburn township water supply, District Council header tanks are located above the town and supplied by gravity to water users following chlorination.

3.2 Zoning

3.2.1 District

The Silver Fern Farms Mossburn processing site is zoned 'Urban', and the wastewater irrigation area is appropriately zoned 'Rural' under the Southland District Plan, as shown in Figure 3.2.1 below.

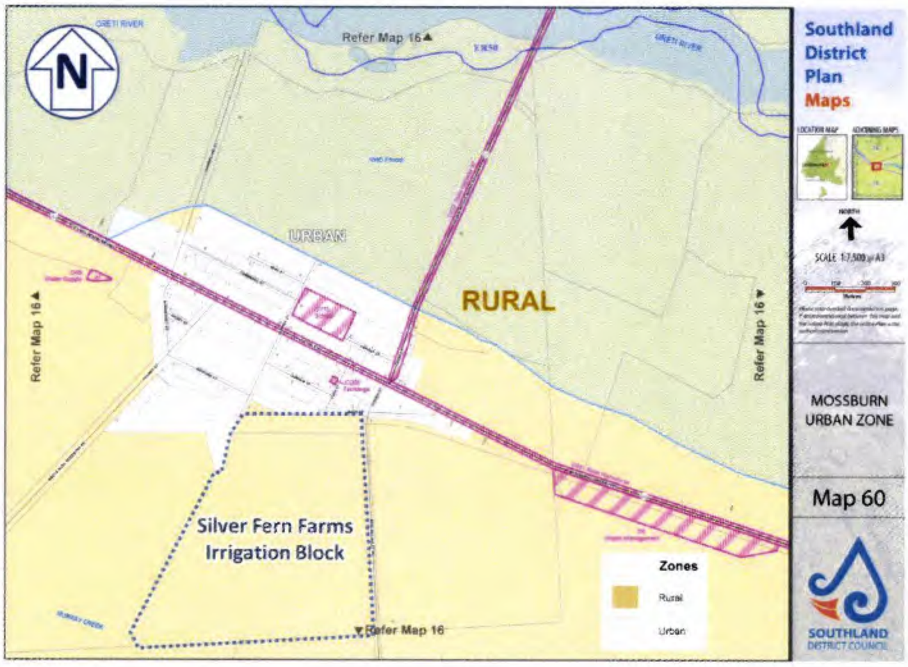


Figure 3.2.1: *Southland District Plan Rural Zoning (adapted from Southland District Plan maps) [Note: Indicative irrigation area outlined].*

The irrigation area is located on gently sloping land just south of Mossburn, and is bounded on three sides by open farmland / rural land. The northern side of the block is bounded by the urban area.

3.3 Hydrology and Soils)

The recent assessment by Liquid Earth outlined the area is geologically and hydrogeologically complex, situated near the boundary of four separate groundwater management zones[1].

The Silver Fern Farms Mossburn wastewater irrigation block, and neighbouring area, is classified as being within the Castlerock groundwater management zone, as shown in Figure 3.2.2(a) below.

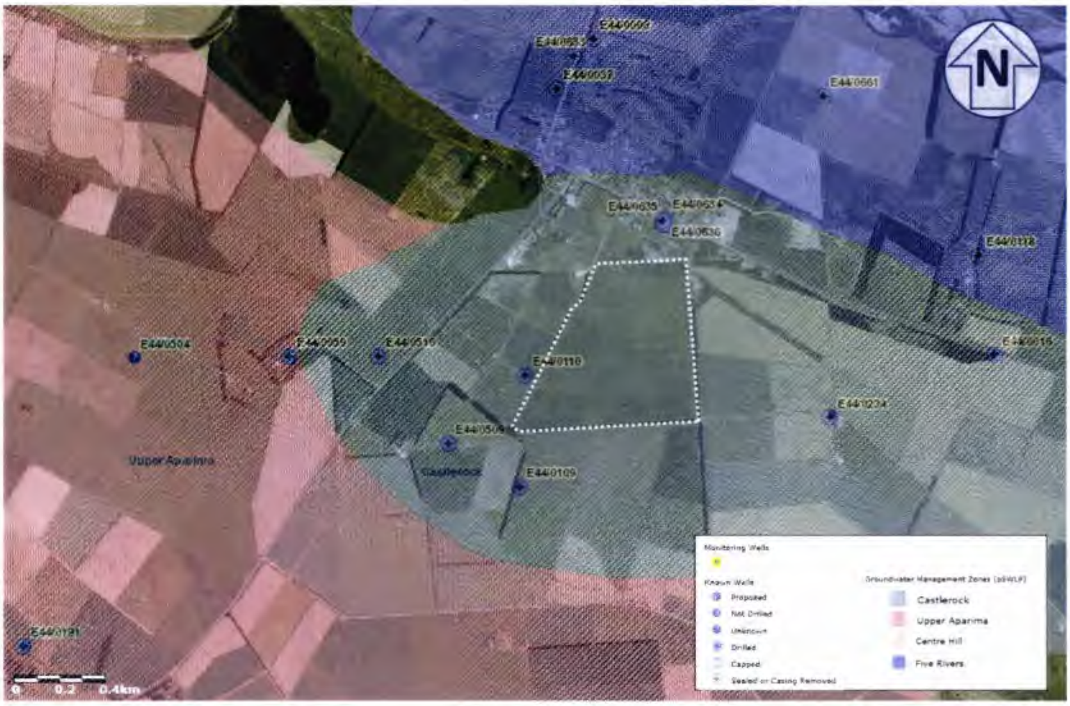


***Figure 3.2.2(a)**: pSWLP Groundwater Management Zones and consents (taken from Environment Southland Beacon GIS) [Note: Indicative irrigation area outlined].*

The likely direction of groundwater is from north-west to south-east following the topography and flow direction of nearby streams towards the Oreti River and Lumsden.

The Castlerock groundwater zone and downgradient Oreti groundwater zone encompasses the alluvial fan from the northern slopes of the North Range. The extent of the alluvial terrace appears to capture the extent of the Oreti River floodplain as well

[1] Liquid Earth (p.1), Appendix 8

as the slightly elevated flat terrace encompassing the Mossburn Township and the site, this is well drained but very stony land, as shown in Figure 3.2.2(b) below.

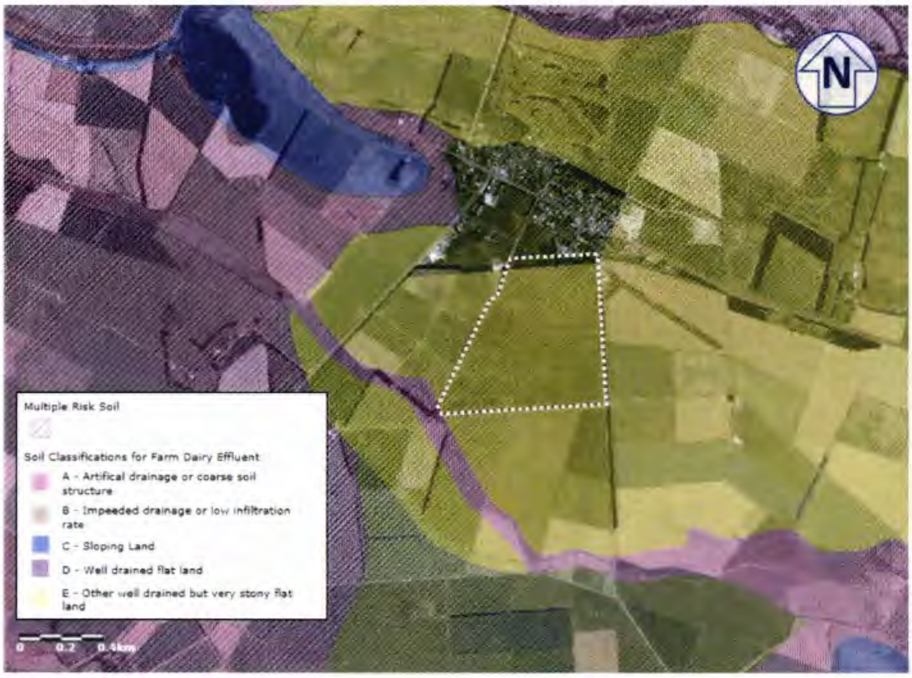


Figure 3.2.2(b): *Soil classification (taken from Environment Southland Beacon GIS) [Note: Indicative irrigation area outlined].*

The Environment Southland Beacon GIS shows there are three groundwater wells within 500 metres of the site, all abstracting from the deep aquifer. One well is located about 320 metres upgradient to the south-west of the site at a depth of 73m, and used for *dairy use*. The other two wells are recorded as *not used*. Wells in a wider area around the site are variously used for irrigation, stock water, domestic supply, water level observation, and monitoring. There is a 34m deep well, potentially downgradient, at just over 600m east of the site, and identified for *industrial* use.

According to Liquid Earth:

- There is a shallow water-bearing layer up to 10 metres deep with a further water-bearing layer occurring around 30 metres below ground. The-water bearing layers are generally separated by a layer of 'claybound gravels' exhibiting some degree of confinement due to low permeability, forming an aquitard over deeper-water-bearing alluvial sediments [2].

- The water table in the vicinity of the irrigation area is relatively shallow (<5 m bgl) with a typical seasonal variation around 1.5 m [3].
- There is limited data available for bores screened in the shallow unconfined aquifer, but based on calculated values it is not unreasonable to assume aquifer transmissivity may be in the order of 500 m^2/day [4].

Environment Southland groundwater specialist indicated that:

> *"bores that we have data for (n=3 bores) are either relatively deep > 30m or of unknown depth"* [5]

[2] Liquid Earth (p.12), Appendix 8

[3] Liquid Earth (p.4), Appendix 8

[4] Liquid Earth (p.5), Appendix 8

[5] Email: via Lauren Maciaszek, 5 Dec 2008

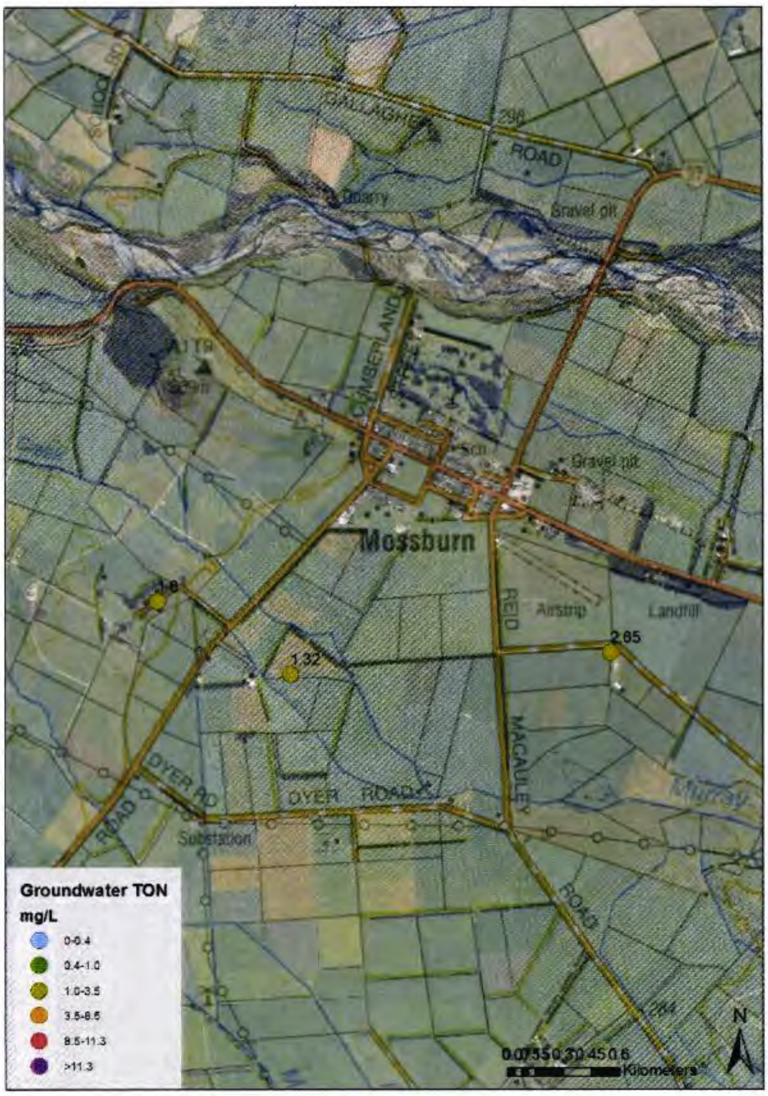


***Figure 3.2.2(b)**: Environment Southland provided bore monitoring information.*

By comparing the bore water quality provided by Environment Southland (shown above in Figure 3.2.2(b)) with those from the Environment Southland Beacon GIS (Figure 3.2.2(a)):

BORE	AQUIFER	TON (mg/l)
E44/0059 (up-gradient)	Deep	1.6
E44/0509 (up-gradient)	Deep	1.32
E44/0234 (down-gradient)	Deep	2.65

***Table 3.2.2**: Neighbouring up-gradient and down-gradient bore monitoring information*

Overall, any nutrient enriched shallow groundwater that may originate from the wastewater irrigation area is likely to remain in, and be diluted by, the shallow aquifer system - due to both dilution and partitioning between aquifers. Given this it is unlikely activities on the Silver Fern Farms Mossburn irrigation area would have resulted in this slightly elevated result in the down-gradient deep aquifer bore, as shown in Table 3.2.2.

3.4 Characteristics of Land

3.4.1 Soils

The Silver Fern Farms Mossburn irrigation block is zoned rural, and is a flat land parcel.

Figure 3.3.1(a), below, adapted from S-Map, shows the distribution of soils across the irrigation block to be uniform Oreti type soils (Morvenf soil type).

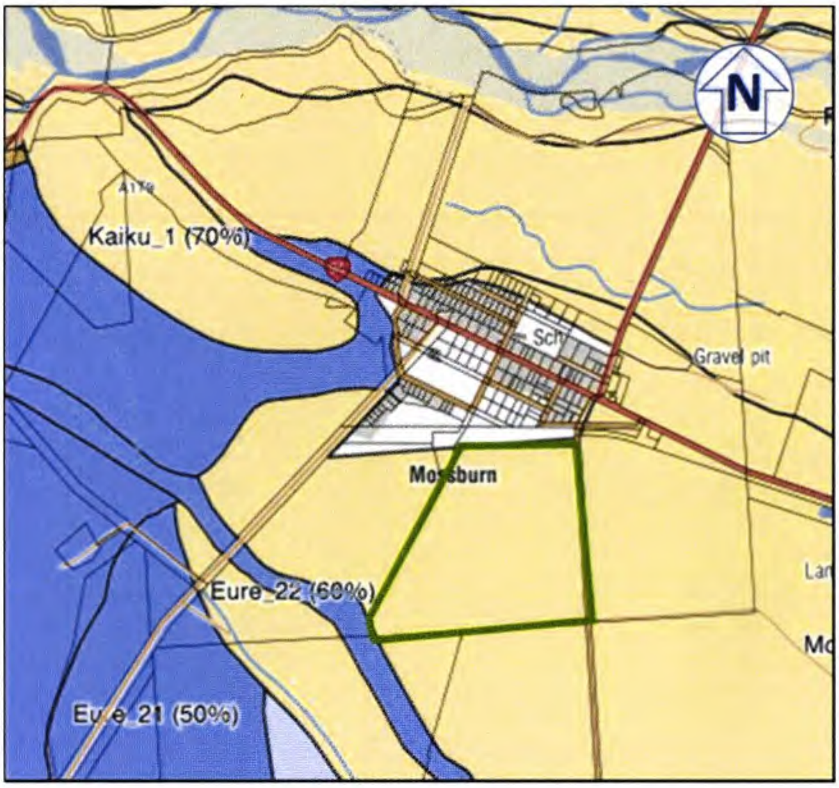


***Figure 3.3.1(a)**: Soil map of Mossburn Area (adapted from S-Map) [Wastewater irrigation block outlined].*

During the previous consent renewal in 1997 (Appendix One and Three), a soil specialist, SoilWork, was engaged to assess the soils of the irrigation block. In that study, the Oreti soil type was described as a free draining soil that is highly suited to wastewater irrigation due to the low potential for ponding or runoff.

Figure 3.3.1(b) from that study[6] outlines the soil horizon, infiltration rate, and hydraulic conductivity at that time; and, Figure 3.3.1(c) describes the observed soil characteristics.

Oreti soil

Horizon	*Depth* (cm)	*Infiltration rate* (mm/hr)	*Hydraulic conductivity* (mm/hr)
A1	0-6	1450	1280
A2	6-19		>1000*
Bw	19-40		190
C	40+		>50*

***Figure 3.3.1(b)**: Oreti soil horizon depth, infiltration rate and hydraulic conductivity (Soil Work technical report 1997).*

Oreti stony fine sandy loam

Horizon	*Depth* (cm)	*Description*
A1	0-6	Dark brown (10YR 3/3) fine sandy loam, very few stones, very friable, moderately to well developed fine nut and crumb structure, many roots, considerable earthworm activity.
A2	6-19	Dark brown (10YR 3/4) stony fine sandy loam, firm, moderately developed fine to medium nut and block structure, many roots, considerable earthworm activity. Compacted at base of horizon.
Bw	19-40	Yellowish brown (10YR 5/6) stony silt loam, weakly developed nut and crumb structure. Many roots. Compact.
C	40+	Gravels and grits cemented in places with iron and manganese.

The Oreti soil is developed from greywacke and volcanic alluvium, and is located on low to intermediate terraces in the Oreti Valley (O'Byrne, 1986). It is strongly enleached. The compacted and cemented zones are the result of clay illuviation, and iron and manganese cementation respectively. Both are features which restrict drainage, but are quite incomplete. Overall, the soil is well to excessively drained.

***Figure 3.3.1(c)**: Oreti soil description (Soil Work technical report 1997).*

Liquid Earth outline these soils are highly permeable and well drained, reinforcing the soil specialist view that infiltration rates of the soil are ideal for wastewater irrigation, or rainwater, without any ponding or runoff.

[6] *Appendix 1: SoilWork report, s.4.1, p.7*

Similar correlation was highlighted in the Liquid Earth report[7] where it was noted from the SoilWork previous findings that wastewater applications resulted in moderate improvements in soil conditions. Liquid Earth also linked increased root and earthwork activities within the irrigated soils resulting in higher infiltration rates than on the nearby control block.

In order to monitor potential effects on soils, soil nutrient levels are analysed annually along with a review of the irrigation activity when processing, this is discussed further in Section 6.

3.4.2 Surface Water

As outlined earlier, there are no surface or near-surface water features across the irrigation block or nearby downgradient. However,

- The Oreti River runs north-west to south-east and is approximately 1,000m north of any wastewater irrigation activity;
- A tributary of the Murray Creek runs almost due south near the upgradient south-west corner of the irrigation block until it is approximately 500m from the irrigation block and then runs almost parallel to the Oreti River; and,
- The likely direction of shallow groundwater is from north-west to south-east running parallel to both the Oreti River and the tributary of Murray Creek.

3.5 Existing Industrial Land Use Patterns

There are no other industrial activities in the immediate area, other than commercial farming activities, and a neighbouring storage yard and a downgradient airstrip utilised by a local rural contractor for carrying out fertiliser top-dressing from.

As outlined earlier, the processing Site and some associated land is zoned urban. Whereas, the neighbouring activities outlined are zoned rural.

[7] Liquid Earth (p.3), Appendix 8

3.6 Existing Rural Use Patterns

The landscape setting of the receiving environment largely surrounding Silver Fern Farms landholdings is predominately rural. Characterised by abundant open space dominated by greenery, normal features associated with a working rural environment are in evidence on the land. These include fencing, shelterbelts, irrigation activities, and farm tracks. Buildings and other physical features, such as roads and transmission lines are also present in the surrounding landscape.

3.7 Existing Urban and Residential Use Patterns

The area to the north of the Site is zoned urban with only a few residential houses near the irrigation block property boundary, located around York Street, as shown in Figure 3.4 below. Silver Fern Farms maintains a wastewater irrigation exclusion (buffer) zone around the irrigation block, including at least 100 m from the nearest residential property boundary, with the residential dwelling setback somewhat further.

***Figure 3.5:** Indicative location of the northerly urban buffer (adapted from Google).*

There are two accommodation businesses in this northerly urban area that have further developed over the term of the existing consents; the 'Mossburn Railway Hotel', and the 'Wheels and Reels Accommodation'.

Potentially sensitive receptors generally include, but are not limited to, hospitals, schools, day-care facilities, elderly housing and convalescent facilities. These are where the occupants are deemed more susceptible to the adverse effects of exposure to pollutants.

The general rule of thumb for determining the significance of potentially sensitive receptors are those within approximately 100 – 400 m of the footprint of the activity. There are no sensitive receptors located within close proximity to Silver Fern Farms Mossburn wastewater irrigation area.

3.8 Climatic Conditions and Air Quality

The closest meteorological station to Mossburn is located approximately 11 kilometres northeast of the township at Five Rivers weather station (ID 40845, location -45.6259, 168.36702)

Wind speed and direction data, as shown in figure 3.6 (a), shows the predominant wind direction across the area is from the west and peaks at around a gentle breeze.

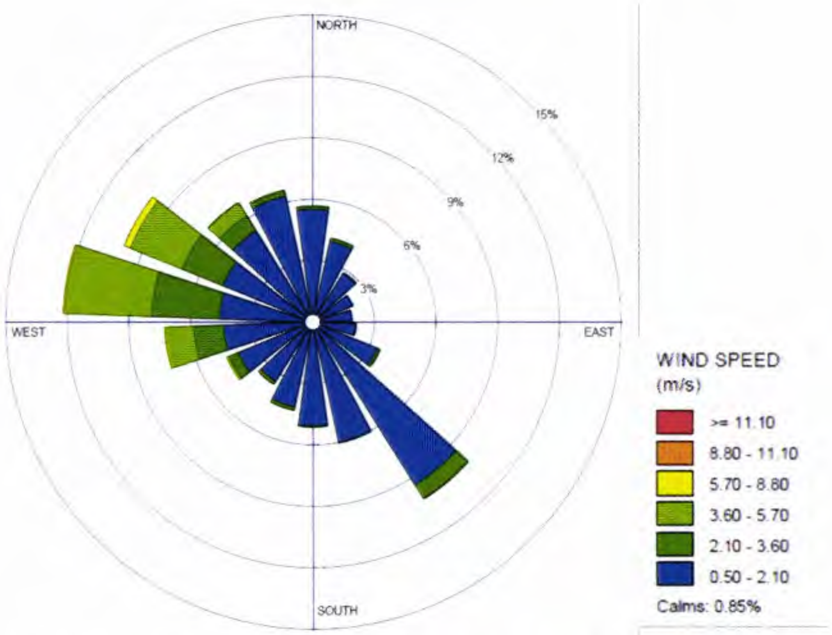


***Figure 3.6(a)**: Wind direction (Dec 2014 – Mar 2018). (Data NIWA Met Station: 40845/ WindRose WRPlot)*

Due to the predominant wind direction any potential discharges to air resulting from wastewater irrigation activities would be largely dispersed away from the Mossburn Township, to the east over rural farmland.

The area surrounding the irrigation block is predominantly utilised for agricultural activities, and as such there will be standard agricultural related air quality in the area. During winter the residential heating is predominantly a mix of wood and coal, with resultant emissions to air similarly being largely dispersed over rural farmland.

3.9 Cultural and Historical Significance

The Mossburn area and surroundings have a history of Serpentine mining and processing. A former Serpentine crushing plant was located on part of the current Silver Fern Farms Mossburn grazing paddock, and was serviced by rail – both the Serpentine plant and rail line have long since disappeared. The only remnant is the Mossburn Railway Hotel, and a piece of foundation concrete for the Serpentine plant conveyor footing.

During previous discussions, recollections of Maori indicate the land use across the district was more for hunting and gathering in transit to Te Anau rather than as any permanent occupancy.

There has been no cultural archaeological evidence found during any of the developments associated with the wastewater irrigation activities, or during site improvements. Whilst there are no further developments planned for the Mossburn wastewater irrigation activity, Silver Fern Farms nevertheless operate to standard New Zealand Historic Places Trust Accidental Discovery Protocols.

3.10 Recreational Values

The land neighbouring the plant is of a rural environment and predominantly utilised for pastoral / grazing activities. The residents of the area do not derive any direct amenity value from the immediate area other than the open landscapes, view of the neighbouring wind-farm, access to the Oreti River, and easy access to Te Anau and Fiordland.

3.11 Operations

Meat processing activities were established on the site in the late 1980's, prior to that the site was established as an eel processing plant around 1962.

The Silver Fern Farms Mossburn operation is set up to principally process venison (deer), but can process bobby calves if this is needed. In order to maintain hygiene and food quality standards, processing operations are required to use considerable amounts of water, producing up to the consented limit of 1,400 m^3 of wastewater each week when processing.

Upon receipt, stock is held within the animal assembly area before being processed, dressed and trimmed in the primary butchery. Carcasses are then transferred to the secondary butchery where they are broken down and packed into cartons awaiting distribution under a chilled environment.

There are no fellmongery, rendering, blood processing, or composting facilities onsite. These by-products are collected and sent offsite to purpose built and appropriately managed third-party facilities.

As noted earlier, Silver Fern Farms Mossburn processing operation was put in stasis at the completion of the 2015 / 2016 processing season for strategic reasons.

When operating, water plays an integral part in the operation across numerous activities:

- Stockyards - as an overhead spray for the animals;
- Management of skins - as an overhead spray to keep the skins cool, and minimising bacterial growth that damages the skin quality, before they are collected and removed for further processing;
- On-site processing - used inside the factory during processing to keep the processing area clean, and at the end of the shift(s) for washdown;
- General site cleanliness – used in the stockyard and stock truck wash areas to keep the areas clean, minimising the potential for odours being generated;
- Refrigeration process - utilised by the refrigeration cooling tower to quench heat generation in the refrigeration network; and,

- Office and the amenities block, which includes the site laundry - the latter facility processes all the uniforms and all the laundry needed for the staff onsite and is discharged via the septic system rather than the wastewater irrigation area.

Wastewater is generally derived from the processing of animals and keeping yard areas clean.

There is no septic or domestic discharges to the wastewater irrigation area, this is managed by its own treatment network, and disposal field.

The irrigation of wastewater to land via travelling spray irrigation is described in Section Four below.

4 DESCRIPTION OF ACTIVITIES FOR CONSENT RENEWAL

At present, Silver Fern Farms Mossburn is consented to discharge primary treated wastewater to land on the wastewater irrigation block to the east of the plant, as shown in Figure 2.3 and detailed in Table 2.3.

4.1 Wastewater Network and Treatment

Water plays an integral part in the processing of primary products into consumer items. All wastewater generated is largely organic in nature and contains very little material that is not fully degradable by biological means; generally consisting of settleable and suspended solids derived from processing wash-down water, stockyard washings, and fat / protein from meat tissue.

There are two main sources of wastewater associated with the processing plant. These are generally known as:

- Green stream – wastewater from animal assembly, truck-wash, gut wash and internal products (paunch).
- Red stream – wastewater from blood bearing departments including primary butchery, secondary butchery and internal products.

Figure 3.1(a) below shows a simplified schematic of the wastewater network.

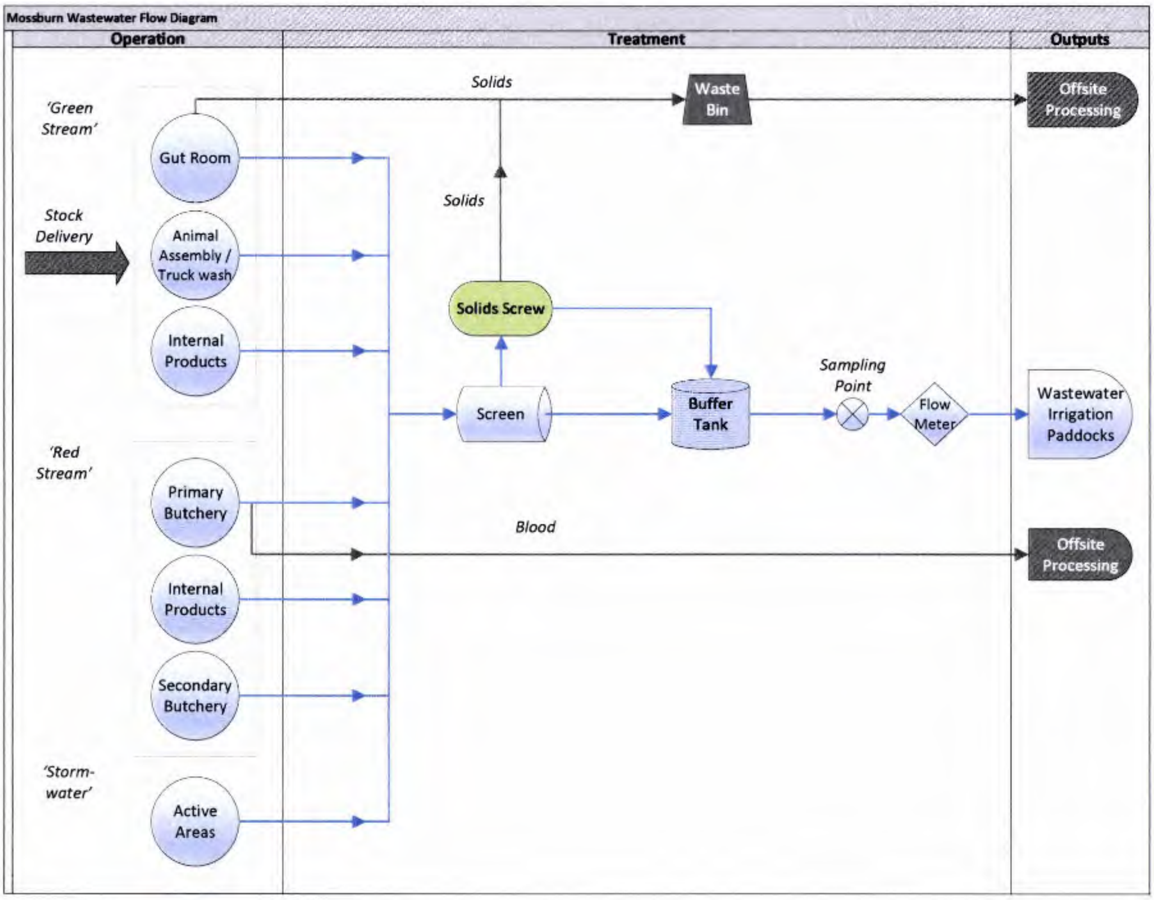


***Figure 3.1(a)**: Wastewater treatment system.*

All wastewater streams are combined before undergoing primary treatment. Combined wastewater is mechanically screened (0.5mm screen) to recover coarse particles or 'solids'. Screened solids are conveyed from the screening area to a 'waste' bin via a screw, approximately 250 kg/day of screened solids are collected. Note, paunch is recovered separately prior to screening. Recovered solids are transported off site to a third party for further processing.

Following the removal of gross solids, the screened wastewater is directed into buffer tanks, where it is combined with:

- wastewater that is separated during the dewatering (via screw press) of the screened solids collected; and,
- potentially contaminated stormwater from active areas when processing.

The buffer tanks provide 4 x 22,000 litre capacity (88,000 litres), along with the screen sump volume (49,000 litres). At peak operations this equates to approximately 75% of a day's volume of wastewater being held. All wastewater is discharged to land via irrigation as soon as possible to avoid the potential for odours.

The processing period generally occurs around November to June, with the peak coming in around the start of the season, in summer.

Between the time the plant was established in the late 1980's and until 1996 when the irrigation activity was established, process wastewater was legally discharged through three large soakage pits in farmland north of the plant, approximately where the serpentine plant once stood.

4.1.1 Nature of Wastewater discharge

As outlined earlier wastewater generated from processing is largely organic in nature and contains very little material that is not fully degradable by biological means.

As the wastewater is generated from food processing operations, trace amounts of substances used for cleaning may be present in the wastewater. Cleaning substances are an essential tool necessary to maintain food hygiene standards, these have low residual effects on equipment, a requirement that is closely regulated by the Ministry for Primary Industries (MPI). Given the active ingredient of these cleaning substances disassociate in organic matter, there is unlikely to be any residual impacts when the wastewater, rich in organic material, is discharged to land.

The water quality of the wastewater has been regularly monitored for key parameters as part of the compliance monitoring. However, limited analysis has been undertaken for parameters other than those required by consent conditions. This notwithstanding, data from the last consent replacement application in 1997 would be comparable (Figure 4.1.1(a) below) – the consistency of animal type being processed (Venison) means the results would be comparable for typical composition:

:

pH	7.9
BOD	520 g/m^3

Suspended Solids	250 g/m^3
Nitrogen (TKN)	160 g/m^3
Ammonia Nitrogen	25 g/m^3
Total Phosphorus	6.7 g/m^3
Potassium	5 g/m^3
Calcium	13 g/m^3
Magnesium	5 g/m^3
Sodium	9.5 g/m^3
Copper	0.07 g/m^3
Cobalt	<0.05 g/m^3
Selenium	<0.005 g/m^3

Table 4.1.1(a): *Typical composition of wastewater composition (1997 AEE)*

As shown above, a major proportion of the nitrogen in the wastewater is in an immobile organic protein form, about 86% TKN, and only about 14% in an ammoniacal form. This means only a small percentage of the nitrogen load will be in the mobile phase at any given time, the slow transformation of immobile organic protein nitrogen by mineralisation and nitrification to mobile nitrate reduces the potential for nutrient losses, and provides greater opportunity for plant uptake.

The sodium level is relatively low leading to a low SAR value which poses no salinity or soil structure problems from the land irrigation of the wastewater.

Copper, cobalt and selenium levels are negligible, however overtime a lack of these trace minerals may lead to deficiencies of these elements on this property if not corrected by the application of trace minerals from time to time.

Wastewater sampling and analyses is conducted twice per season for conductivity, biological oxygen demand (BOD), total Kjeldahl nitrogen, phosphorus and faecal coliforms. Figure 4.1.1(b) below is a summary of wastewater constituents from the past 12 years.

Season	Conductivity (mS/m)	BOD (g/m3)	Total Kjeldahl Nitrogen TKN (g/m3)	Total Phosphorus TP (g/m3)	Faecal Coliforms FC (cfu/100 ml)
2015-16	62	405	107	3.7	1.90E+06
2014-15	95	495	156	8.7	3.60E+06
2013-14	91	350	140	6.7	1.20E+05
2012-13	71	465	135	6.3	1.20E+05
2011-12	89	662	211	6.7	6.50E+05
2010-11	78	590	182	9.1	2.00E+06
2009-10	95	630	190	7.8	4.00E+05
2008-09	87	430	188	6.4	3.40E+07
2007-08	95	525	180	6.5	7.00E+06
2006-07	66	463	152	6.6	4.10E+06
2005-06	54	540	137	5.7	1.70E+06
2004-05	98	661	186	5.8	2.00E+06
Average	**82**	**518**	**164**	**6.7**	**4.80E+06**

Table 4.1.1(b): *Average seasonal wastewater analysis*

As is expected there is some seasonal variation, this is largely contingent on the condition of the farming season and stock availability. Weather during the season may influence the quality of feed matter available, and the resultant health and number of stock being presented.

Other minerals present in the wastewater stream are monitored via soil sampling and chemical analysis of these results are shown and illustrated in section 4.2.7.

4.2 Wastewater Irrigation

4.2.1 Description of Activity

Silver Fern Farms utilise land-based treatment of wastewater across a number of its sites, where the wastewater from processing activities is irrigated onto pasture. The general premise is that the nutrient rich wastewater acts as a fertiliser and soil improver.

At the Silver Fern Farms Mossburn site, this occurs via a low pressure rotating boom travelling irrigator (Briggs Model 25E, as shown below in Figure 4.2.1, specifications outlined in s.4.2.3).

The retro-action of the wastewater discharging through nozzles causes the boom to rotate providing a relatively even spread of wastewater; the rotation of the boom provides the motive force that propels the irrigator via a wire cable winch – the cable is fixed to a post and pre-laid down the irrigation run, the winch winds in the cable pulling the irrigator forward.

The speed of the cable winch, and the speed of the irrigator, can be varied across six speeds if required – changing the speed of the irrigator changes the application rate, i.e., a faster speed results in a lower application rate. Given the topography and pipeline drag due to pasture growth, it is difficult to maintain the highest speed (Gear Setting 6). Therefore, a mid-range speed is preferentially utilised (Gear Setting 4 and 5).

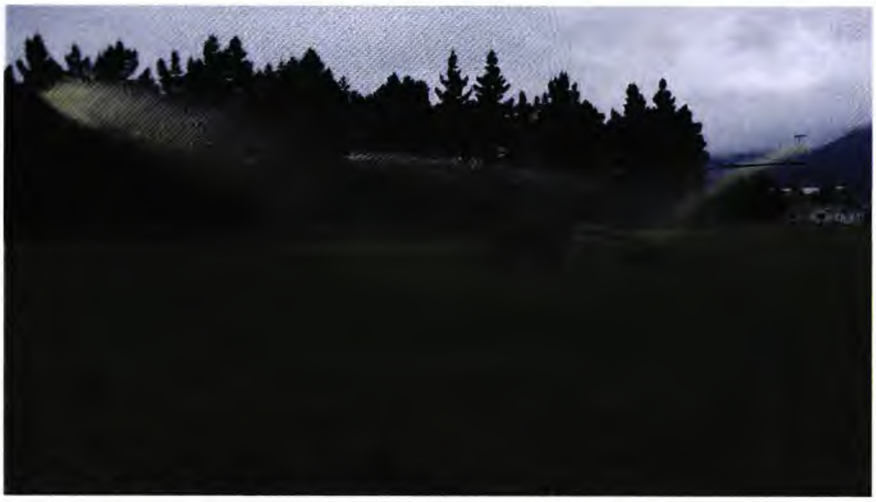


Figure 4.2.1: *Rotating boom travelling irrigator in action*

There is limited wastewater storage capacity onsite as standard practice is to discharge wastewater on the same day as it is produced. This is due to the potential of odourous discharges when irrigating stored (non-fresh) wastewater. The predominate organic form of nitrogen in the wastewater also reduces the potential for nutrient losses, and therefore also reduces the need to store wastewater prior to irrigation.

When managed correctly, soil helps to 'treat' the wastewater in a sustainable manner while also providing a valuable source of nutrients to grow crops. The crops, primarily of high nitrogen demand, take up the nutrients provided, are harvested and removed (along with the nitrogen they have taken up) from the site as frequently as possible (cut-and-carry). No grazing of the wastewater irrigation blocks occurs during processing.

When processing is not occurring, the land and the crop is managed by a mixture of harvesting and grazing as required for maintenance.

4.2.2 Application Area

The overall wastewater irrigation block is approximately 46 ha. Of that, 40 ha is utilised for wastewater irrigation. The balance of the block is comprised of the wastewater exclusion (buffer) areas, including 100 m from the nearest northern boundary with the Urban Zone (Residential Boundary), and 10 m from the property boundary.

The irrigation block is divided into 20 runs as shown in figure 3.2.2 below. There are no surface watercourses, water abstraction or collection points on the irrigation block.

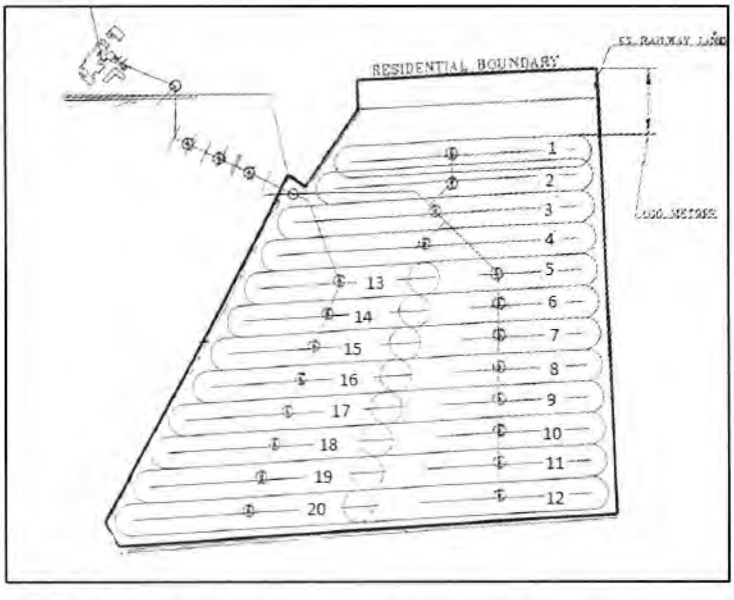


Figure 4.2.2: *Indicative location of wastewater irrigation runs*

4.2.3 Irrigation Operation and Management

Wastewater is pumped through an underground mainline before it is discharged to land using the rotating boom travelling irrigator.

As outlined earlier the rotating boom travelling irrigator is a Briggs Model 25E, supplied by Rainer Irrigation Limited with design specifications of:

- Boom length = 30 metres
- Wetted width = 55 metres
- Flow range = 22 to 55 m^3/hour – At Silver Fern Farms Mossburn this is operated at 20 m^3/hour.
- Six variable travel speeds - At Silver Fern Farms Mossburn this is generally operated between Gear Setting 4 and Gear Setting 5.

Detailed information of the wastewater irrigation system and irrigator specifications are detailed in Table 4.2.3 below, and graph of actual wastewater application return periods are shown in Figure 4.2.3(a) and Figure 4.2.3(b).

Flow Rate (m^3/hour)	Gear Setting	Ground Speed (m/hour)	Run time for 400 m (hours)	Application Rate
20 m^3/hr	3	17	23	21
	4	23	17	16
	5	31	13	12
	6	39	10	9.1

***Table 4.2.3:** Wastewater Irrigation System Parameters Silver Fern Farms Mossburn (adapted for lower flow rate from Rainer Irrigation performance chart for Briggs Model 25)*

As is standard for travelling irrigators, performance fluctuations may be encountered due to external variables, e.g., wind / grass length and pipeline drag / weather.

The irrigation block is divided into 20 runs that have a minimum return period of 7 days and an average return period of greater than 30 days, as shown below (Figure 4.2.3(a) and Figure 4.2.3(b)).

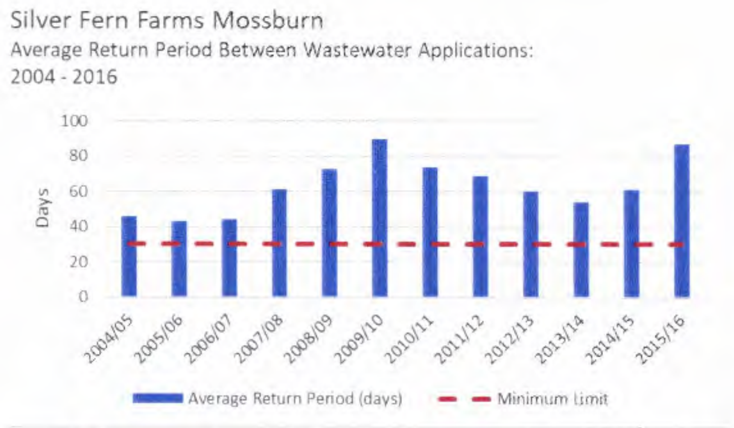


***Figure 4.2.3(a):** Silver Fern Farms Mossburn average return periods 2004 - 2016*

Over the past 12 seasons, the average return period was 63.5 days, well over the consented minimum average limit of 30 days.

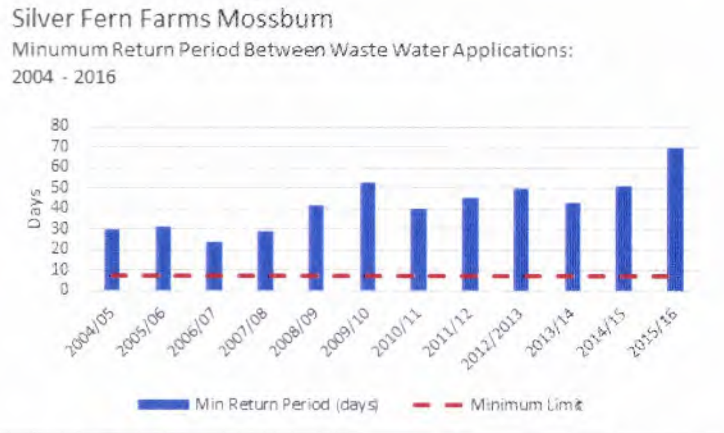


***Figure 4.2.3(b):** Silver Fern Farms Mossburn minimum return period 2004 - 2016*

Over the past 12 seasons, the shortest return period was 24 days, well over the consented minimum period of 7 days.

4.2.4 Discharge Volumes

The volume of wastewater varies from season to season. This is largely contingent on the condition of the farming season and stock availability.

Prior to the operation being placed in stasis, and with diminishing stock numbers, the site when processing were producing approximately 25,000 m^3 of wastewater per season. The entirety of which is discharged to land at an average of 534 m^3 per week. Figure 3.2.4 below shows the weekly discharge volumes of the 2014/2015 and 2015/2016 seasons.

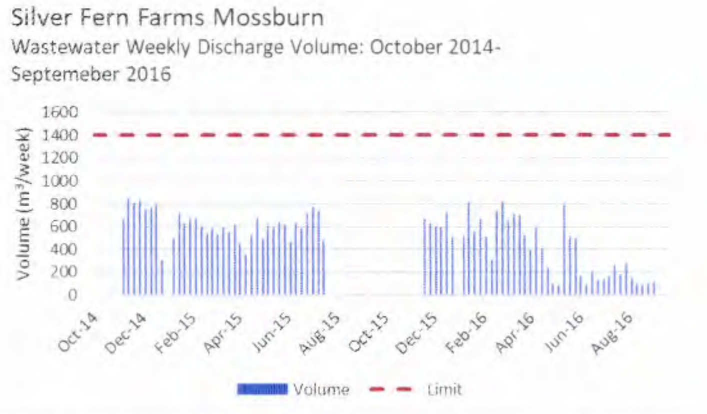


***Figure 4.2.4**: Weekly wastewater discharge volume to land 2014 - 2016*

As shown above all discharges were well managed below the consented limit of 1,400m^3 per week during this period.

4.2.5 Application Rate

The application of wastewater is managed by controlling the traveling irrigator flow rate and speed (parameters shown in table 3.2.3). Figures listed in the SoilWork annual reports indicate that this management has resulted in an average hydraulic loading of 15.7 mm over the past 12 processing seasons.

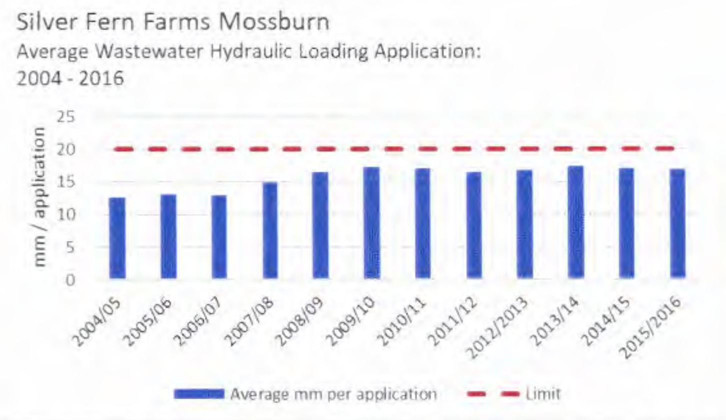


***Figure 4.2.5**: Weekly average wastewater hydraulic loading application 2004 - 2016*

As shown above average hydraulic loadings were managed below the consented limit of 20mm per week during this period.

The Liquid Earth report [8] outlined that the slow transformation of organic nitrogen to nitrate reduces the potential for large losses of nitrate in response to periods of high rainfall, and thereby minimises any concern over an application rate of 20mm. However, to minimise the risk Liquid earth suggested amending the return period to reflect actual operations, this is further discussed in Section 6.

4.2.6 Nitrogen Loading

The key contaminants of relevance to this renewal for the land-based treatment of wastewater are nutrients, principally nitrogen. Applied nitrogen is managed through a cut-and-carry system. Nitrogen applied through the irrigation of wastewater is taken up by the plants and removed through the harvesting of crops and taken offsite for feed.

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[8] Liquid Earth (p.16), Appendix 8

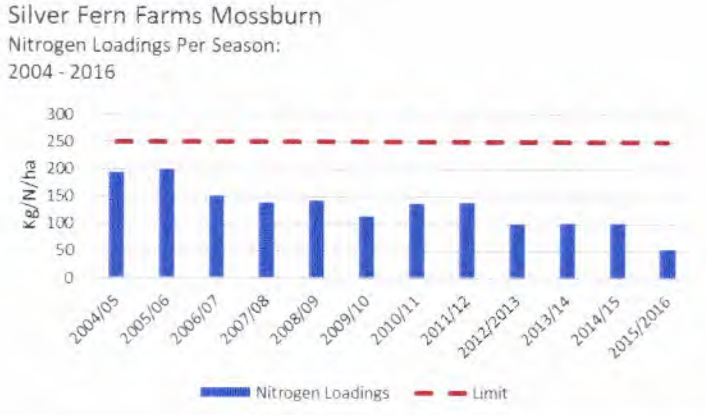
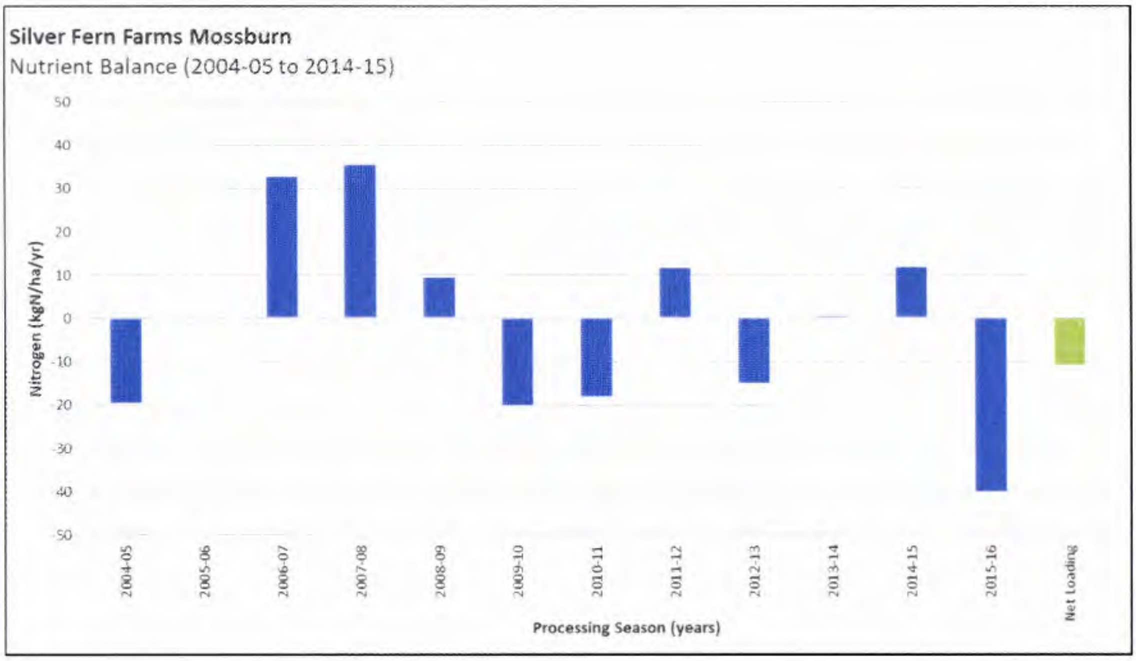


***Figure 4.2.6(a)**: Nitrogen loadings per season 2004 - 2016*

Figures listed in the SoilWork annual reports indicate that Total Nitrogen loading over the past 12 seasons have been managed well below the maximum limit of 250 kg/N/ha per year. The highest loading over that period was 199 kg/N/ha per year and the average loading was 131 kg/N/ha per year. This indicates that there is a low potential for nitrogen leakage from this activity.

Silver Fern Farms seeks to continue with the current maximum nitrogen loading limit as it will provide a degree of flexibility when processing volumes are high. It is not expected that the site will operate to the fullest of the limit all of the time, as evidenced by the past 12 seasons, but having the flexibility available to accommodate natural variations dependant on stock quality and quantity. As outlined in the Liquid Earth report the wastewater is largely in an organic form and not readily leachable. Significant volumes of dry matter, and plant available nitrogen are removed each year from the cut-and-carry system.

Silver Fern Farms is of the view that nitrogen loading should be considered in terms of "net loading" and viewed in conjunction with the cut-and-carry removal of nutrients from the wastewater irrigation blocks. When considering the net nitrogen loading over the past 12 seasons, the net nitrogen loading varies between -28 kg/N/ha per year (nutrient deficit), and 41 kg/N/ha per year (nutrient surplus) with an overall moderate nutrient deficit of -10.8 kg/N/ha per year as sown in figure 3.2.6(b) below. These results provides further evidence of the low potential for nitrogen leakage occurring from the wastewater irrigation activity.



This is further discussed in the Liquid Earth report where it is stated the figures show an average of 100 kgN removed each year under the cut and carry system [9].

4.2.7 Soil Quality

Other soil quality parameters are sampled and analysed annually when irrigating wastewater to assess the performance of the irrigation system. Sampled soil parameters include:

- pH
- exchangeable calcium
- exchangeable magnesium
- exchangeable potassium
- exchangeable sodium
- phosphorus
- total organic carbon

As outlined earlier this assessment is conducted by an external soil specialist, SoilWork,who produces annual reports for Environment Southland detailing trends of the results, assessment of environmental effects and provides recommendations (if required).Samples are collected from the irrigation block and results compared

[9] Liquid Earth (p.9), Appendix 8

against samples collected from a dryland control block.. Below is an excerpt of results from the 2016/17 report:

SITE	Sampling date	pH	Ca [1]	K [1]	Mg [1]	Na [1]	Olsen P (μg ml^{-1})	Organic carbon (%)	Total N (%)	ESP (%)
Irrigated	Sep 2001	5.7	6	10	17	5	17	10.5	0.80	0.7
	Oct 2002	5.6	9	5	10	4	10	7.0	0.59	0.5
	May 2003	5.7	9	9	18	5	17	9.6	0.77	0.6
	May 2004	5.8	11	12	15	5	19	9.0	0.72	0.6
	May 2005	6.1	13	7	12	6	17	8.5	0.68	0.8
	May 2006	5.9	9	7	14	6	14	9.4	0.71	0.8
	May 2007	5.9	11	5	14	5	16	9.3	0.70	0.6
	May 2008	5.9	11	13	16	8	20	9.1	0.76	0.8
	May 2009	6.2	14	9	14	7	15	9.4	0.77	1.0
	May 2010	6.1	14	7	13	8	11	9.0	0.72	0.9
	May 2011	5.8	11	4	11	5	12	7.8	0.68	0.5
	May 2012	5.7	9	4	11	6	10	7.2	0.67	0.7
	May 2013	5.9	9	5	10	7	11	8.1	0.65	0.8
	May 2014	6.1	12	5	11	5	10	9.1	0.71	0.6
	May 2015	6.1	12	5	13	6	13	8.8	0.71	0.6
	May 2016	6.3	15	5	14	6	12	9.3	0.75	0.7
	May 2017	**6.1**	**11**	**3**	**12**	**4**	**8**	**8.7**	**0.71**	**0.5**
Dryland control	Sep 2001	5.7	5	6	13	5	18	8.5	0.63	0.8
	Oct 2002	5.4	7	6	13	4	15	7.1	0.57	0.5
	May 2003	5.7	6	6	11	5	12	8.1	0.59	0.7
	May 2004	5.7	9	10	15	4	18	8.3	0.62	0.5
	May 2005	5.7	9	6	12	5	15	8.0	0.64	0.6
	May 2006	5.9	9	6	14	7	13	7.8	0.66	0.7
	May 2007	5.9	10	6	12	7	13	8.0	0.67	0.9
	May 2008	6.1	17	12	17	5	23	7.7	0.66	0.5
	May 2009	6.4	16	10	18	5	14	8.3	0.72	0.6
	May 2010	6.2	15	6	15	5	12	8.2	0.67	0.6
	May 2011	5.8	10	3	9	5	12	7.7	0.57	0.6
	May 2012	5.8	9	4	8	4	8	6.9	0.59	0.6
	May 2013	5.9	8	3	9	5	12	8.1	0.65	0.7
	May 2014	6.4	13	4	9	3	10	7.9	0.58	0.4
	May 2015	6.2	9	3	10	4	10	6.7	0.47	0.5
	May 2016	6.0	12	4	11	5	12	8.4	0.63	0.6
	May 2017	**6.1**	**11**	**3**	**11**	**5**	**9**	**8.4**	**0.62**	**0.7**

[1] Equivalent MAF Quick Test Units

As can be seen there is no significant differences in soil chemical properties between the control and wastewater irrigation areas

In the previous two assessment reports (2015/16 & 2016/17), monitoring has indicated that wastewater had no significant adverse effects on soil chemistry and physical properties. Instead, wastewater applications resulted in moderate improvements in soil conditions. Additionally, all values of soil ESP (Exchangeable Sodium Percentage), soil pH, and concentrations of the various nutrients and organic carbons indicated the soils are suitable for continued wastewater irrigation.

5 MITIGATION MEASURES AND MONITORING

5.1 Wastewater irrigation to land

Wastewater irrigation is managed to mitigate any potential effects. The table below summarises potential effects, controls and associated outcomes.

Potential Effect	Control	Outcome
Odour from Wastewater Irrigation	Buffer zones	Buffer zones have been established between the irrigation areas and surrounding features, namely neighbouring urban properties and the irrigation block property boundary.
	Complaints management	If complaints are made directly to Silver Fern Farms Mossburn, these are logged and the complaint is investigated and controls put in place.
	Minimal holding time	Holding time of wastewater is kept to a minimum to prevent wastewater creating off odours. Wastewater is typically discharged as soon as practicable.
	Solids removal during wastewater treatment	Removal of solids from the wastewater stream before irrigation reduces the possibility of material being discharged to land that may go odourous. Removing solids also reduces the likelihood of blockages, or material settling out in pipelines and going anaerobic.
	Flushing Pipelines	Wastewater irrigation pipelines are routinely flushed with freshwater to prevent wastewater becoming stagnant in lines and creating off odours when discharged.
Discharge to Surface Water or Groundwater	Wastewater Irrigation Management: • No direct discharge • Application Rate • Discharge Volume • Return Periods • No surface water bodies	Wastewater irrigation management practices control the rate, volume and frequency in which wastewater is discharged to land by spray irrigation. By maintaining these practices the potential for leakage to groundwater or ponding and runoff is controlled.
Discharge to surface water from ponding and runoff	No surface water features on the wastewater irrigation blocks	As there are no surface water features on the wastewater irrigation blocks there is no immediate risk of discharges to surface waters.
	Soil Type	As stated previously the soil type of the wastewater irrigation block is well suited to discharges to land reducing the potential for ponding or runoff from a well-managed application rate.
Nutrient Leaching	Monitoring: • Application Rate • Nutrient Loading • Discharge Volumes	When processing activities are operational for a particular season, routine soil monitoring is conducted. This is analysed for a number of parameters to assess the performance of the existing controls, and identify potential emerging trends before any negative effects may occur.
	Cut-and-Carry – Uptake and removal of wastewater nutrients	Applied nutrients, particularly nitrogen, is managed through a cut-and-carry system. Nitrogen applied through the irrigation of wastewater is taken up by the plants and removed through the harvesting of crops and taken offsite for feed. This practice reduces the potential for nutrient leaching from the wastewater irrigation block.

***Table 5.1:** Wastewater treatment operation mitigation measures*

Silver Fern Farms Mossburn intends to continue the management and monitoring controls set out above and in the previous section.

5.2 Effectiveness of existing mitigation measures

As outlined various mitigation and monitoring measures are currently in place to control / minimise the potential for effects to the environment from the wastewater irrigation activities at Silver Fern Farms Mossburn. The existing resource consent conditions incorporate the various mitigation measures and monitoring requirements.

There is nothing to indicate from monitoring, or complaints logs, held by Silver Fern Farms Mossburn that either the mitigation measures, or the diligence of site management and operations, are not sufficient, appropriately applied when required, and effective to an acceptable level.

The effects of wastewater irrigation on groundwater quality is controlled by the onsite irrigation management. The projected effects are expected to be similar to those observed under the current wastewater irrigation to date.

Given this, Silver Fern Farms believe the conditions in the existing resource consent provide adequate mitigation measures and controls and do not require alteration except to provide for reduced management during shut down periods, and non-irrigation of wastewater.

The Liquid Earth report on the potential groundwater effects largely concurs with the assessment of minor effects, this is further discussed in the following section.

6 ACTUAL AND POTENTIAL EFFECTS ON THE SUROUNDING ENVIRONMENT

The potential effects from activities resulting from the land-based treatment / irrigation of wastewater could be considered to be:

- Potential effects on soil quality;
- Potential for effects on groundwater quality;
- Potential for effects on surface water quality;
- Potential effects on air quality (odour);
- Potential for effects on neighbours; and,
- Potential social and economic effects.

6.1 Potential Effects on Soil Quality

The application of food processing wastewater to land generally raises concerns regarding where levels of nutrients and trace minerals in soils irrigated with wastewater may rise or change in ratio over a period of time, in turn affecting the desired balance, or resulting in a higher than desired level of one particular component within the soils. In order to monitor the potential effects of wastewater on soils within the disposal blocks, soil nutrient levels are routinely analysed.

Similar concerns also arise where excess soil moisture could lead to: ponding; runoff; contamination of groundwater; soil structure damage; reduced pasture growth; and, anaerobic soil conditions and odours. In order to mitigate these effects, irrigation is managed to reduce the potential for ponding and / or runoff.

Annual assessment of the wastewater irrigation block is conducted by an independent soil specialist, SoilWork. The assessment monitors a range of soil and irrigation parameters to assess the impacts of the wastewater irrigation on the environment.

Their latest assessment from October 2017 (appendix two) concluded:

- No significant adverse effects on the soil chemical and physical properties measured
- Moderate improvements in soil condition as a result of wastewater irrigation
- Increased earthworm and root activity

- Higher average organic carbon concentrations
- Improved and more stable soil structure
- Higher average infiltration rate
- Increased average hydraulic conductivity

The observable and measured effects on soil quality and structure from the wastewater irrigation activity are therefore considered to be positive, i.e., improving the overall fertility of the soil (soil structure and condition) through improving the organic content of the soil. The overall result indicates that the soil is both well suited to and benefits from the application of wastewater.

This notwithstanding, SoilWork in 2016 recommended that a lack of phosphorus in the wastewater was causing an imbalance in soil phosphorus and required correction through the application of a phosphate fertiliser, the Council concurred with this assessment. As a result, Silver Fern Farms applied phosphate to the land.

Whilst wastewater irrigation occurs there is no requirement to apply any nitrogen based fertiliser as other farms in the district are required to do.

6.2 Potential for Effects on Groundwater Quality

The application of wastewater to land generally heightens concerns regarding levels of nutrients and trace minerals leaking through the soil profile into the underlying groundwater profile - the main nutrient species of concern are nitrates.

As shown in section 3.2.6, the highest annual nitrogen loading of 199 kg/N/ha per year, and average nitrogen loadings of 131 kg/N/ha per year, are managed well below the consented limit of 250 kg/N/ha per year. Nitrogen is additionally managed through the cut-and-carry operation whereby nitrogen irrigated to land is principally taken up by the crops grown.

The land treatment system, cut-and-carry, mitigates the potential for effects to occur when wastewater irrigation is occurring. Considering the wastewater application rate, plant growth and resultant nutrient uptake, along with the removal of nutrients through cut-and-carry, volatilisation, assimilated with soil microbes, etc., means the potential effects to groundwater are shown to be less than minor.

Following discussion with Environment Southland, Silver Fern Farms engaged Liquid Earth to further assess the potential for effects on groundwater, report Appendix 8. In summary, Liquid Earth found:

- Mass balance calculations indicate discharge of wastewater up to a maximum proposed nitrogen loading of 250 kg N/ha are unlikely to result in elevated nitrate concentrations in groundwater down-gradient.
- Irrigation of wastewater up to the proposed maximum nitrogen loading is unlikely to result in more than minor effects associated with Phosphorus, Sodium, trace metal and microbial components of the wastewater.
- The predominantly organic form of nitrogen in the wastewater reduces the potential sensitivity of nutrient losses due to weather related events – only a minor proportion of the nitrogen load occurs in the soluble nitrate form.

  However, Liquid Earth recommended that the minimum irrigation period be amended to reflect the actual operational return period of around 30 days to limit the maximum nitrogen load during periods when the potential for nutrient losses are elevated. Silver Fern Farms agree with this recommendation, in as much as for periods when soil moisture levels may be elevated by rain events. At other times a lower operational return period may be required to avoid plant stress due to insufficient soil moisture levels.

6.3 Potential for Effects on Surface Water Quality

As there are no surface water features on the wastewater irrigation blocks there is no immediate risk of discharges to surface waters.

In addition, as outlined earlier there is minimal risk of creating excess soil moisture and surface water runoff by irrigation.

Potential for groundwater to reach surface water, such as estuaries at the end of the catchment, are not likely to be effected as down-gradient groundwater reaching these waters will have concentrations that are unlikely to result in more than minor effects. Liquid Earth outlined that any down-gradient water would be significantly diluted by the larger water surplus in the area. Given the Oreti Estuary is some 95 km down-gradient there will likely be negligible effects, if any, and highly unlikely to be discernible.

Overall, effects on surface water quality are not expected.

6.4 Potential Effects on Air Quality (Odour)

The application of wastewater to land has the potential to generate aerosols as well as droplets from sprinklers.

However, whilst Silver Fern Farms have a company-wide policy requiring a complaints register, taking appropriate actions where required, and to escalate any issues raised by the community.

As at writing of this application, no third party complaints have been recorded by Silver Fern Farms Mossburn over the term of the existing consent. This is supported by no history of complaints received by Environment Southland against the site over the term of the existing consent.

To maintain this level of service when operating, Silver Fern Farms Mossburn will continue to:

- Maintain appropriate buffer distances to ensure no issues beyond the boundary;
- Ensure operating wastewater irrigation equipment continue to work effectively and efficiently; and,
- Carry out intermittent flushing of irrigation system with freshwater to reduce the potential for wastewater going anaerobic in the pipeline prior to irrigation.

Silver Fern Farms considers that the scale, nature and location of wastewater irrigation activities, in conjunction with the mitigation and monitoring controls, result in the overall effects from odour to be less than minor.

6.5 Potential for Effects on Neighbours

Immediate neighbours of the irrigation area include residential properties to the north and rural farmland to the east, west and south. As the potential effects to the environment are considered to be less than minor, Silver Fern Farms does not envisage any parties will be affected by a continuation of existing consented activities.

It is considered the management of discharges to land, including potential for odours, have shown to be sufficiently effective to avoid or mitigate discharges to an acceptable extent. This is evidenced by no odour complaints being received by Environment Southland or Silver Fern Farms as a result of this activity.

Given this, Silver Fern Farms considers the effect on neighbours will continue to be less than minor.

6.6 Potential Social and Economic Effects

Silver Fern Farms has invested significantly in physical resources such as land, buildings, and structures - with an insured value of around $9.2M.

The renewal of resource consent will enable the continued use, and development, of those physical resources enabling any potential opportunity of the operation into the future.

The cut-and-carry harvesting of crops from the wastewater irrigation block is sold standing and distributed offsite. When processing, besides wages / contractor payments etc. the harvesting of the crops supports local primary producers by providing ready access to reliable feedstock. Similarly when not processing, the harvesting of the irrigable areas and maintenance grazing of the other land-holdings provides extra income to the local community.

Overall, Silver Fern Farms considers the positive social and economic contribution of renewing the resource consent will outweigh the less than minor effects on the receiving environment of continuing operations.

7 CONSULTATION

The consent renewal application sought is to renew existing resource consent for existing operations. This limits some of the options that might be available, or expected, from an applicant proposing to construct a new facility.

Whilst effects on the receiving environment are shown to be no more than minor, it is questionable whether a consideration of alternatives is appropriate. However, this notwithstanding Silver Fern Farms have considered aspects of this below.

Similarly, as this is an application for the renewal of existing resource consent a number of groups and individuals have been consulted over the term of the existing consent, including our staff that generally reside and contribute to the community in and around our operations.

7.1 Consultation

Consultation is an ongoing and integral part of all Silver Fern Farms operations.

In compiling this AEE, it was seen as the activity has been a consented activity for some time, then the renewal of those consents for an operation that is no greater in scale and nature would have no more effects than the existing baseline. As a result there would be no change to those effects considered and granted by the existing consents, and for which potentially affected parties gave written approval for during the various resource consent application and variations for the Silver Fern Farms Mossburn site over the years (1997, 1999 and 2006).

During the last consent variation process in 2006, twelve submissions were received from the public. All twelve submissions supported the application. A similar amount of responses and support were received in 1997 and 1999. There have not been any submission opposing the operation in any of the previous consent applications and variations.

A number of those submitters who provided written approval as a potentially affected party owned properties bounding the Silver Fern Farms Mossburn wastewater irrigation block, as shown in Figure 7.1 below (the list of potentially affected parties at that time is provided in Appendix 6).

Figure 7.1: *Previous written approval of bounding properties.*

Of the other parties consulted during the previous consent variation process in 2006 were: Fish & Game; Department of Conservation; and, the local Community Group. There were no issues identified by any of the parties.

As part of preparing this consent renewal application, Silver Fern Farms has also sought advice from Environment Southland, and this advice has been taken into account in this document.

8 CONSIDERATION OF ALTERNATIVES

8.1 Location of Operation

As outlined earlier, Silver Fern Farms processing strategy includes having plants in the right locations, and a strong preference for making the most of the capacity of the existing processing sites, enabling more efficient use of existing infrastructure.

The Silver Fern Farms Mossburn operation is located in a District zone that best suits the activities being carried out. Any other location would need to be able to provide the same potential benefits.

Whilst at the time of writing this consent renewal AEE the Silver Fern Farms Mossburn operation is in stasis. In order to maintain strategic agility across the company when and if required little would be served in relocation to another site.

8.2 Wastewater Treatment

There would appear to be no practical alternative to the current irrigation land-based wastewater treatment system, via cut-and-carry, as there is no nearby municipal water treatment option, or other appropriate discharge location.

Further treatment to remove nutrients from the wastewater may be possible, but would be costly to develop and operate, and would also likely limit the amount of harvested crop from the cut-and-carry operation.

This option would result in a significant cost of construction, increased running costs through increased power use. The environmental benefits of this option would be negligible as the current operation is already providing treatment with minor environmental effects, and any improved treatment would not yield significantly improved environmental outcomes.

Any solids removed from the wastewater stream through any improved treatment plant would require disposal, and given the remote location this would likely to be via the nearest landfill / farm pit. Further treatment would still require a discharge route for the treated wastewater, and this would likely remain via discharge to land in the absence of any alternative discharge routes.

As the land is highly suitable for wastewater irrigation, and the land treats the wastewater with less than minor environmental effects, Silver Fern Farms considers the additional costs associated with further treatment not practicable at this time.

8.3 Alternative Land Discharge Location

If an alternative land discharge area could be found it would provide no further benefit than the existing area.

Any alternative area would require a greater level of infrastructure to transport the wastewater to the area. This poses the risk of greater volumes of wastewater being at risk of going anaerobic inside the piping, and resulting in odours.

Given the land-form of the area, and resultant groundwater flow path, it is unlikely effects would be any different than those of the current operation.

8.4 Alternative Irrigation Activity

Given the level of organic material contained within the wastewater creates issues with other irrigation systems, it generally follows the consideration of alternatives like centre-pivot only occurs for high-volume operations.

Silver Fern Farms Mossburn in meat processing terms is a relatively low volume operation.

The mechanisms required to avoid blockages are only feasible under economy of scale factors. The cost of implementation would require changing all sunken infrastructure, and as a result require significant funds. Centre-pivot irrigation for wastewater applications require considerable more sunken infrastructure, a lesson Silver Fern Farms learned at our much larger Pareora operation. A change to centre-pivot irrigation would likely make the operation questionable.

In low pressure irrigation systems, the organic material has the potential to accumulate and block irrigation droppers. The open nozzle of a travelling irrigator generally helps avoid blockages from occurring.

9 STATUTORY AND PLANNING MATTERS

For the purposes of assessment of the proposed activities, regard needs to be given to the following:

- Resource Management Act
- National Environmental Standard for Sources of Human Drinking Water
- National Environmental Standard for Freshwater Management
- Regional Water Plan Southland
- Regional Effluent Land Application Plan for Southland (although relevant conditions in this plan
- Proposed Southland Water and Land Plan
- Iwi Management Plan – Te Tangi a Tauira

Please note, although conditions in the Regional Effluent Land Application Plan for Southland have been superseded, consideration has been given for this plan for completeness of this application.

Each of these is addressed separately below.

9.1 Resource Management Act

Of particular relevance to the resource consent renewal is:

Part 2 – Purpose and principals

- Section 5, the purpose of the RMA, is to promote the sustainable management of natural and physical resources and refers to:

  '... *safeguarding the life-supporting capacity of air, water, soil and ecosystems.*'

  Consistent with this aspect of Section 5, the activities described in this renewal do not adversely affect the life-supporting capacity of air, water, soil and ecosystems.

Part 3 – Duties and restrictions under this act

- Section 15(1)(c) and (d), discharge contaminants into environment, states that:

  'No person may discharge any contaminant from any industrial or trade premises into air or onto or into land unless the discharge is expressly allowed by a national environmental standard or other regulations, a rule in a regional plan as well as a rule in a proposed regional plan for the same region (if there is one), or a resource consent.'

  Silver Fern Farms Mossburn is currently consented to discharge contaminants to land and air. This permit was issued by Environment Southland and due to expire in April 2019 - this application seeks to renew this consent.

Part 6 – Resource Consents

- Section 88 of the RMA sets out the information that must accompany a resource consent application. This application for consent renewal has been provided in accordance with the provisions set out in Schedule 4 of the RMA. (see Appendix 5)

- Section 104 (2A) of the RMA requires that when considering an application, the consent authority must have regard to the value of the investment of the existing consent holder. Silver Fern Farms has considerable capital sunk into the Mossburn operations. If the operation resource consent were not renewed, the sunk capital items would largely not be recoverable.

- Section 124 of the RMA allows a consent holder to continue to exercise their existing consent while a new consent is being determined. Since Silver Fern Farms have applied for new consents within 6 months of their expiry, section 124 applies to this consent renewal application.

The purpose of the Resource Management Act is:

To promote the sustainable management of natural and physical resources

- There are no adverse effects of the activity on the environment.
- As shown in the remainder of this section, the activity is consistent with the relevant statutory planning documents and regulations.
- The renewal of this resource consent achieves the purpose of the Act by continuing a sustainable activity that has less than minor effects on the environment.

Silver Fern Farms therefore considers that renewing the resource consent is consistent with the RMA.

9.2 NES for Sources of Human Drinking Water

NES for Sources of Human Drinking Water Regulations deal with resource consents for water or discharge permits upstream of drinking water abstraction points. These sections apply to activities that have the potential to affect registered drinking water supplies.

The Southland District Council's Mossburn Township bores are over 600 metres from the Silver Fern Farms Mossburn wastewater irrigation block in an up-gradient direction (north nor-west). It is highly unlikely that the discharge of wastewater is likely to increase any of the determinants at the abstraction points nor increase the concentration of any aesthetic determinants above guideline values.

As shown in Section 3.2.2 of this report there were no identifiable groundwater bores downgradient being used for drinking water purposes.

9.3 National Policy Statement for Freshwater Management

The National Policy Statement for Freshwater Management is being implemented through the Southland Water and Land plan. The current consents comply with the relevant standards / conditions / terms of the rules of the water and land plan. As such, Silver Fern Farms activities are managed in accordance and consistent with the policies.

9.4 Regional Water Plan for Southland

The Regional Effluent Land Application Plan contains four relevant objectives to this application (Obj.2, 3, 8 & 9 A-C).

- ***Objective 2 – Maintain Water Quality***

  The management of wastewater application and the cut-and-carry nature of the operation assist to limit nutrient loading to land, such that water quality is unaffected.

- ***Objective 3 – Surface Water Bodies Other Than In Natural State***

  The alternative to land discharge by spray irrigation is discharge to a nearby surface water, or via a soakage pit to ground as previously carried out prior to land irrigation.

  The application of wastewater to land via spray irrigation will not affect surface water bodies

- ***Objective 8 – Drinking Water Standard***

  As illustrated in the Liquid Earth report (pg12), the potential down gradient concentration of nitrogen will be well below drinking water standards for New Zealand. Liquid Earth also reports that phosphorus, microbial and trace metal contaminants are unlikely to result in more than minor effects on the quality of receiving waters.

- ***Objective 9A – Maintain Soil Quality***

  The management of wastewater application and the cut-and-carry nature of the operation assist to limit nutrient loading so that activities are consistent with land use capability. The application of wastewater increases the organic content of the soil, which enhances the biological properties enhancing the soil.

- ***Objective 9B – Human Health*** *and* ***Objective 9C – Habitats and Ecosystems and Other Values***

  Discharges of wastewater are managed so as to minimise the potential for odour to occur beyond the boundary. At the time of this renewal, Silver Fern Farms

Mossburn has not received any environmental complaints over the term of the existing consent. Additionally, Environment Southland has also not received any complaints over the duration of the consent. This indicates that there is no sign of adverse effects on human health, animal health or amenity value from discharge activities when they occur.

The Regional Water Plan contains four policies relevant to the Silver Fern Farms Mossburn application, including:

- ***Policy 25*** *– Adverse effects arising from point source and non-point source discharges.*
- ***Policy 31A*** *– Matching discharge onto or into land to match risk.*
- ***Policy 31C*** *– Manage discharges of contaminants onto or into land*
- ***Policy 31D*** *– Beneficial use.*

The operations at Silver Fern Farms Mossburn has clearly shown over the term of the existing consent to comply with resource consent requirements. As evidenced by no formal complaints lodged and ongoing compliance of soil management parameters. There have been no monitored adverse effects. The activity continues to suit the capability of the land.

Irrigation to land continues utilise the beneficial reuse of wastewater to enhance plant growth and remove nutrients.

Silver Fern Farms considers that the risk, scale, nature and location of the wastewater irrigation, along with mitigation and monitoring measures, continues to meet these policy outcomes.

For the purpose of this renewal, Silver Fern Farms has considered the Regional Water Plan rules, specifically:

- **Rule 16D** - D*ischarge of contaminants originating from industrial or trade premises is a discretionary activity.*

As Silver Fern Farms Mossburn is an industrial premises the wastewater irrigation activity is at a **discretionary** level.

9.5 Regional Effluent Land Application Plan for Southland

The Regional Effluent Land Application Plan contains four relevant objectives to this application (Obj.4.1.1 / Obj.4.1.2 / Obj 4.1.3 / Obj.4.1.4).

- ***Objective 4.1.1***

  To ensure that the life supporting capacity of the soil ecosystem is safeguarded from the adverse effects of discharges of effluent and sludge onto or into land.

  The management of wastewater application and the cut-and-carry nature of the operation assist to limit nutrient loading so that activities are consistent with land use capability. The application of wastewater increases the organic content of the soil, which enhances the biological properties enhancing the soil.

- ***Objective 4.1.2***

  To ensure that water quality and the life supporting capacity of the water ecosystem is safeguarded from the adverse effects of discharges of effluent and sludge onto or into land which may enter water.

  The management of wastewater application and the cut-and-carry nature of the operation assist to limit nutrient loading to land, such that water quality is unaffected.

  The alternative to land discharge by spray irrigation is discharge to a nearby surface water, or via a soakage pit to ground as previously carried out prior to land irrigation.

  The application of wastewater to land via spray irrigation reduces the risk of nutrients entering any water ecosystem.

- ***Objective 4.1.3*** *and* ***Objective 4.1.4***

  To ensure that effluent and sludge discharges onto or into land do not adversely affect human and animal health.

  To ensure that amenity values are not adversely affected by discharges of effluent and sludge onto or into land.

  Discharges of wastewater are managed so as to minimise the potential for odour to occur beyond the boundary. At the time of this renewal, Silver Fern Farms Mossburn has not received any environmental complaints over the term of the existing consent. Additionally, Environment Southland has also not received any complaints over the duration of the consent. This indicates that there is no sign of adverse effects on human health, animal health or amenity value from discharge activities when they occur.

The Regional Effluent Land Application Plan contains ten policies relating to these objectives. Six of these policies have relevance to the Silver Fern Farms Mossburn application, including:

- **Policy 4.2.1** – *Protect the sustainability of the soil ecosystem from adverse effects of effluent and sludge discharges onto or into land.*
- **Policy 4.2.2** – *Utilise land treatment of effluent and sludge where this can be undertaken in a sustainable manner and without significant adverse effects.*
- **Policy 4.2.3** – *Avoid where practicable, remedy or mitigate adverse effects on water quality, water ecosystems and water potability from effluent and sludge discharges onto or into land.*
- **Policy 4.2.9** – *Avoid where practicable, remedy or mitigate any adverse effects on amenity values from discharges of effluent and sludge systems onto or into land.*
- **Policy 4.2.10** – *Monitor, as appropriate, discharges of effluent and sludge onto or into land and, where practicable, the effects.*

The operations at Silver Fern Farms Mossburn has clearly shown over the term of the existing consent to comply with resource consent requirements. As evidenced by no formal complaints lodged and ongoing compliance of soil management parameters.

Silver Fern Farms considers that the scale, nature and location of the wastewater irrigation, along with mitigation and monitoring measures, continues to meet these policy outcomes.

For the purpose of this renewal, Silver Fern Farms has considered the Regional Effluent Land Application Plan rules, specifically:

- **Rule 5.5.1** - *The discharge onto or into land of effluent from industrial and trade processes, other than agricultural effluent, is a discretionary activity.*

  As Silver Fern Farms Mossburn is an industrial trade process and the wastewater generated meets the definition of "Industrial Effluent" the current wastewater irrigation activity remains at a **discretionary** level.

9.6 Proposed Southland Water and Land

The proposed Southland Water and Land Plan contains six relevant objectives to this application (Obj.1, 2, 13, 13A, 13B, and 18).

- ***Objective 1***

  Land and water and associated ecosystems are sustainably managed as integrated natural resources, recognising the connectivity between surface water and groundwater, and between freshwater, land and the coast.

  The management of wastewater application and the cut-and-carry nature of the operation assist to limit nutrient loading to land such that water quality is unaffected. The alternative to land discharge is discharge to a nearby surface water. The application of wastewater to land reduces the risk of nutrients entering any water ecosystem.

- ***Objective 2 & 13***

Water and land is recognised as an enabler of primary production and the economic, social and cultural wellbeing of the region.

Enable the use and development of land and soils to support the economic, social, and cultural wellbeing of the region.

The ability to discharge wastewater to land enables Silver Fern Farms to provide support services for our primary production suppliers and to enable a large number of people to provide for their social and economic wellbeing. The discharge of wastewater uses land and soil resources to provide a vital activity for the viable operation of the food processing facility.

- ***Objective 13A & 13B***

The quantity, quality and structure of soil resources are not irreversibly degraded through land use activities or discharges to land

The discharges of contaminants to land or water that have significant or cumulative adverse effects on human health are avoided.

Ongoing monitoring has shown there are no adverse effects from this activity. Monitoring also indicates that no accumulative effects or irreversible degradation is occurring as a result of this activity.

- ***Objective 18***

All activities operate in accordance with "good management practice" or better to optimise efficient resource use, safeguard the life supporting capacity of the region's land and soils, and maintain or improve the quality and quantity of the region's water resources.

The management of wastewater application and the cut-and-carry operation requires good management practices to optimise nutrient uptake. Monitoring results supports the current management practices and effective use of resources by showing that soils have improved alongside the irrigation activity

The proposed Southland Water and Land Plan contains five policies that have particular relevance to the Silver Fern Farms Mossburn application, including:

- ***Policy 2*** *– Water and land is recognised as an enabler of primary production and the economic, social and cultural wellbeing of the region*
- ***Policy 10*** *– In the Oxidising physiographic zone, avoid, remedy, or mitigate adverse effects on water quality from contaminants.*
- ***Policy 10*** *– Recognise that the use and development of Southland's land and water resources, including for primary production, enables people and communities to provide for their social, economic and cultural wellbeing*
- ***Policy 14*** *– Prefer discharges of contaminants to land over discharges of contaminants to water, unless adverse effects associated with a discharge to land are greater than a discharge to water. Particular regard shall be given to any adverse effects on cultural values associated with a discharge to water*
- ***Policy 16A*** *– Minimise the adverse environmental effects (including on the quality of water in lakes, rivers, artificial watercourses, modified watercourses, wetlands, tidal estuaries, salt marshes and groundwater) by requiring the adoption of the best practicable option to manage the treatment and discharge of contaminants derived from industrial and trade processes*

The discharge of food processing wastewater to land is aligned with these policies as it is the preferred option compared to discharges to water. The activity also enables Silver Fern Farms to provide support services for our primary production suppliers, and to enable a large number of people to provide for their social and economic wellbeing. The discharge of wastewater uses land and soil resources as the best practicable option to treat wastewater constituents, and is aligned with preferences within *Ngāi Tahu ki Murihiku Natural Resource and Environmental Iwi Management Plan 2008.*

For the purpose of this renewal, Silver Fern Farms has considered the proposed Southland Water and Land Plan rules, specifically:

- **Rule 15** - *(a) The discharge of stormwater onto or into land in circumstances where contaminants may enter water, or into a lake, river, artificial watercourse,* *modified watercourse or wetland, is a permitted activity provided the following conditions are met:*

> *(ii) the discharge does not originate from industrial or trade premises where hazardous substances are stored or used unless:*
>
> > *(1) hazardous substances cannot enter the stormwater system;*

During shutdown periods when no operations are occurring and hazardous substances have been removed from site, stormwater discharges will be at a **permitted** level, as no hazardous substances can enter the stormwater system.

When in operation any stormwater that enters active areas will flow into the wastewater system and be discharged to land as a **discretionary** activity in accordance with Rule 34. In the event of a spill during operation, the site has the ability to stop discharges and hold any potentially "contaminated" wastewater. Discharge from the holding sump is only carried out by pump as required, this can be turned off during any incident.

If any potentially contaminated stormwater eventuates, this can then be sucker trucked out of holding sump and buffer tanks and transported to an appropriate trade waste facility.

- **Rule 34** - *Other than as provided for by Rule 32C, the discharge of wastewater, sludge or effluent from industrial and trade processes, other than agricultural effluent, onto or into land in circumstances where contaminants may enter water is a discretionary activity.*

  As Silver Fern Farms Mossburn is an industrial trade process, the current wastewater irrigation activity remains at a **discretionary** level. The activity is not provided by rule 32C as it is not a new facility.

  Following advice from a consultant acting for Environment Southland as part of this consent renewal process, Silver Fern Farms had a structural integrity survey carried out of the wastewater system by a certified Chartered Professional Engineer. The assessment report, provided in Appendix 7, outlines the wastewater system is satisfactory for continued use.

9.7 Ngāi Tahu ki Murihiku Natural Resource and Environmental Iwi Management Plan 2008 – Te Tangi a Tauira

The Iwi Management Plan is being implemented through the Proposed Southland Water and Land plan. The current consents comply with the relevant standards / conditions / terms of the rules of the water and land plan. As such, Silver Fern Farms activities are managed in accordance and consistent with the policies.

Of particular relevance from the Iwi Management Plan, the activity of wastewater irrigation to land is consistent with Section 3.5.2, Policy 6 wastewater disposal - "generally, all discharge must first be to land".

9.8 Statutory Summary

After reviewing the applicable statutory requirements, Silver Fern Farms considers the activities requiring replacement of resource consent at the Silver fern Farms Mossburn site is at a **discretionary level.**

This is based on the current Regional Effluent Land Application Plan for Southland, and the Proposed Southland Water and Land Plan. As such, a resource consent continues to be required.

The current onsite controls and monitoring in conjunction with current resource consent conditions have effectively managed onsite activities to the degree that potential effects on the receiving environment over the past twenty years, term of the existing consent, has clearly shown them to be less than minor.

Silver Fern Farms therefore considers that renewal of resource consents is appropriate and consistent with the RMA and relevant Regional plans.

10 CONCLUDING REMARKS

Silver Fern Farms accepts that it has an obligation to manage resources sustainably, and to balance environmental effects and economic benefits. As part of its corporate culture, sustainability and environmental policies, Silver Fern Farms states that the company's goal is to minimise any adverse effects on the environment through our processing activities. The company also subscribes to the principle of continuous improvement and regularly evaluates operations to enhance each sites environmental performance.

Silver Fern Farms considers it has demonstrated managing an industrial operation whilst balancing the potential effects on the wider community, specifically:

- Continually avoiding, remedying or mitigating any actual or potential adverse effects to an extent that collectively they are less than minor.
- Over the term of the existing consent has consistently had no complaints.

Given that on site operations over the term of the existing resource consents (past 20 years):

- Have resulted in less than minor effects on the environment.
- Operate within compliance limits of resource consent requirements.
- Operate within an appropriately zoned location for the activities being carried out.

There would appear no impediments in granting a renewal of the resource consents being sought.

Silver Fern Farms considers that the scale, nature, location, and management of the operation consistently results in the overall effects on the receiving environment being less than minor.

Granting the consent renewal would not result in a fundamentally different activity or one having materially different environmental effects, or would expand or extend the existing activity. In light of this, Silver Fern Farms considers the consent renewal could proceed on a non-notified basis, and trust the Council concur with this assessment.

11 ENVIRONMENTAL OUTCOMES – PROPOSED CONSENT CONDITIONS

The existing resource consent conditions in Consent No. 95498 are considered largely appropriate for continued operation. Silver Fern Farms do not wish to fundamentally alter / change any of the conditions of the consent from the existing version. The only minor proposed changes are to reflect decreased requirements during periods of shutdown.

The following shows Silver Fern Farms proposed revised changes to the relevant consent conditions. However, Silver Fern Farms are cogniscent that the Council may suggest something similar deemed appropriate. Deletions are shown in **bold ~~strikeout~~ text** and any new, additional or amended conditions are identified by ***italicised bold underlined text***. Any descriptive information is given in ***[bold italicised square brackets]***.

11.1 Proposed Consent Conditions

Discharge Permit

Pursuant to Section 105(1) of the Resource Management Act 1991, a resource consent is hereby granted by the Southland Regional Council (the "Council") to **~~Silver Fern Farms Management Limited~~** ***Silver Fern Farms Limited*** (the "consent holder") of P O Box 941, Dunedin 9054 from **~~15 April 1999~~** ***Oct 2018***

[as outlined Silver Fern Farms have amalgamated subsidiaries back into the parent company]

Details of Permit

Purpose for which permit is granted:		To discharge primary treated wastewater from a **~~venison abattoir~~** ***food processing facility*** to land ***[Silver Fern Farms considers 'abattoir' is old terminology and doesn't reflect a modern food processing operation]***
Location	- site locality	Wreys Bush-Mossburn Road, Mossburn
	- map reference	E44:384-932
	- receiving environment	Land
	- catchment	Oreti
Legal description of land at the site:		Lot 1 DP 10874, Lot 2 DP 14189

Schedule of Conditions

1. The consent expires on 15 April 2029.

2.

a) The consent authorises the discharge of up to 1400 m^3/week of wastewater from a ~~**venison abattoir**~~ ***food processing facility*** on to land generally described as Lot 1 DP 10874 and Lot 2 DP 14189, Taringatura Survey District.
[Silver Fern Farms considers 'abattoir' is old terminology and doesn't reflect a modern food processing operation]

b) The land disposal system shall be operated generally in accordance with the consent application and the Farm Management Plan appended to it. Any change to the plant operation or the disposal system that may have an adverse affect on the environment must be approved in writing by the Council's Director of Environmental Management. *NB: This approval may require an application to amend the consent or apply for an additional resource consent.*

3. The ~~**venison abattoir**~~ ***food processing facility*** wastewater shall be sprayed onto land. This consent does not authorise the disposal of wastewater to any surface watercourse, either directly or indirectly, or disposal of wastewater directly in to the ground via artificial, free-draining areas.
[Silver Fern Farms considers 'abattoir' is old terminology and doesn't reflect a modern food processing operation]

4. The return period between the completion of one irrigation cycle and the start of the next shall be an average of no less than 30 days, and at no time, less than ~~**seven**~~ ***15*** days. For the purposes of this condition, the average shall be calculated on an annual basis from 1 September to 31 August each year.
[Silver Fern Farms agrees with Liquid Earth to amend the return period to reflect actual activities, however also are cogniscent of the need to ensure plants retain enough water in summer period to maintain growth and the uptake of nutrients.]

5. The hydraulic loading rate of wastewater applied to the irrigation area shall not exceed 20 mm per application.

6. The nitrogen loading rate for wastewater***, or any fertiliser nutrient application,*** shall not exceed 250 kg/ha/year, averaged over the area utilised for irrigation in any one year. The year over which the loading rate shall be measured is as described in condition 4.
[Silver Fern Farms considers for the avoidance of doubt that any application of fertiliser should be included in the overall annual nitrogen loading limit.]

7. There shall be no surface run-off, significant ponding, or contamination of surface water, resulting from the application of wastewater to the land, nor shall the disposal system be operated in such a way that offensive smell or any other nuisance is created at the boundary of the property. For the purpose of this consent, significant ponding is deemed to occur if wastewater ~~**remains**~~ ***results in contiguous puddling of water*** on an area of more than 50 m^2 ***for*** ~~**24**~~ ***four*** hours after being irrigated.

8. In accordance with its duty under Section 17 of the Act, the consent holder shall avoid, remedy or mitigate any adverse effects on the environment arising from the disposal of its effluent on to land. In particular, the consent holder shall observe the following buffer zones, into which no irrigated effluent may be discharged:

   a) 20 metres from any surface watercourse;
   b) 10 metres from any property boundary;

c) 100 metres from any residential dwelling, excluding those owned by the consent holder;
d) 100 metres from any domestic or stock water abstraction point or building which has a roof catchment used for potable supply.

9. The consent holder shall:

   a) ***when operating*** appoint a person to be responsible for the day-to-day operation of the disposal system and to act as a contact for Council staff when carrying out routine inspections and/or responding to problems; and

   b) each day record ***when operating***, in writing, all activities associated with the wastewater disposal system including, but not limited to the following:

      (i) irrigation blocks sprayed and the return period between successive irrigation events for each block;

      (ii) hours of operation on each irrigation block;

      (iii) volume discharged to each irrigation block (this parameter shall be measured to the satisfaction of the Council's Compliance Manager);

      (iv) volume discharged per day; and

      (v) complaints received and action taken.

   The records shall be available for inspection by Council staff upon request.

   [Amended to reflect the site is currently in stasis, and any records need only be maintained when operational.]

10. The consent holder shall carry out the following monitoring:

take a 24 hour flow proportional sample of the wastewater and analyse for the following:

- electrical conductivity
- carbonaceous biological oxygen demand
- total nitrogen
- total phosphorus
- faecal coliforms

(a) the sampling shall be carried out at ~~**quarterly intervals for the first two years of this consent, and thereafter at**~~ six monthly intervals (one each in the periods January to March and June to August) ***when the processing facility is in operation***. The results of monitoring shall be forwarded to the Council within 10 working days of being available to the consent holder.

(b) when the processing facility is not in operation the council is to be informed and with agreement with the council no sampling is required.

[Amended to reflect the site is currently in stasis, and any records need only be maintained when operational.]

11. (a) For the purpose of this consent, the analyses and preservation of all aqueous samples shall be carried out in accordance with the latest edition of APHA "Standard Methods for the Analysis of Water and Wastewater" or by methods approved by the Council's Director of Planning and Resource Management.

(b) The monitoring and analyses specified in condition 4 are to be carried out by a laboratory with IANZ registration or equivalent, or as agreed to in writing by the Council's Director of Environmental Management.

12. Once annually, ***when the facility is operating,*** the consent holder shall take two Oreti soil samples. One sample from the area that receives wastewater, and the other from an area that does not receive wastewater. Each sample shall be analysed for the following:

- pH
- exchangeable calcium
- exchangeable magnesium
- exchangeable potassium
- exchangeable sodium
- phosphorus (Olsen P)
- total organic carbon
- total nitrogen

In addition, the infiltration rate and hydraulic conductivity shall be measured at each soil sampling site.

> ***[Amended to reflect the site is currently in stasis, and any records need only be maintained when operational.]***

13. By 31 October each year ***when operating*** the consent holder will supply to Council an annual report for the year ended 31 August, that assesses the performance of the irrigation system. This report will be prepared by a suitably qualified person and will include but not be limited to:

- an assessment of the status of the irrigation area;
- trends in analytical results;
- effects on the environment;
- recommendations for improvements in the system;
- summary information on return periods and the applications of effluent on each block;
- results of soil testing in accordance with condition 12;
- water budget, detailing water inputs, rainfall, irrigation volume and daily estimates of water losses (drainage, evapotranspiration) and daily estimates of soil water content for irrigated and non-irrigated areas.

13A. By 31 October each year when the site is non-operational the consent holder will supply to Council a letter outlining that fact for the year ended 31 August.

[Included to reflect the site is currently in stasis, and there are no activity / effects to report against.]

14. The consent holder shall pay to the Council the following user charges which are fixed under Section 36 of the Act:

    (a) an administration charge; and

    (b) a compliance monitoring charge.

    User charges are payable on receipt of invoice each year.

15. The Southland Regional Council may, in accordance with the conditions of this consent, and in accordance with Sections 128 and 129 of the Act, serve notice at two yearly intervals, within one month of the anniversary date of the commencement of this consent, of its intention to review conditions of this consent for the purposes of:

    (i) dealing with any adverse effects on the environment which may arise from the exercise of this consent; or

    (ii) complying with the requirements of a regional plan.

16. The consent holder may, in accordance with Section 127 of the Act, apply to the Council at two yearly intervals, within one month of the anniversary date of commencement of this consent, for a review of the consent conditions for the purpose of a change or cancellation of any condition of this consent.

APENDIX ONE - Soil Work Initial Land Assessment

App 1

SoilWork Ltd
Environmental & Agricultural
Soil Consultants

Primary Producers Co-operative Society Ltd
Christchurch
New Zealand

PROPOSED LAND TREATMENT OF DEER ABATTOIR WASTEWATER AT MOSSBURN:

Technical report on soils and related factors, and recommendations for irrigation parameters.

April 1996

P.B. Greenwood

SoilWork Ltd Report SW-R-0069

5 Kitchener Street, P.O. Box 5908, Dunedin, New Zealand Phone (03) 477 1060 Fax (03) 477 1018

CONTENTS

SUMMARY

A study was undertaken to evaluate the soil and related aspects of a proposed land treatment system for deer abattoir effluent at a Mossburn sheep and deer farm in Southland. The main objectives of the work were to develop parameters for the irrigation of wastewater and provide an assessment of the likely effects of that irrigation. This report, to the Primary Producers Co-operative Society Ltd, presents the results of that work which was based mostly on a site survey, field and laboratory assessments and measurements, and modelling.

The soil processes and information considered are: soil types and their distributions; infiltration rate; retention of wastewater in the soil; drainage of excess water from the soil; and a nitrogen balance. Suitable irrigation areas are determined from a soil survey and associated measurements, and the irrigation parameters are based on considerations of hydraulic and nitrogen loadings together with irrigation return intervals. Recommendations for monitoring the effects of wastewater irrigation are given.

The major findings and recommendations are as follows:

1. The Mossburn property comprises three soils: Oreti fine sandy loam, Honeywood stony silt loam, and Dipton silt loam. The Oreti soil has a low water retention capacity because it is shallow and stony, and is well drained. In contrast, the Dipton soil is poorly drained because it contains a compacted and cemented stony subsoil horizon. However it has a high water retention capacity. The Honeywood soil is intermediate.

   The total amount of water that can be retained by the Oreti, Honeywood and Dipton soils at field capacity are 61mm, 93 mm, and 191 mm respectively.

2. Most of the deer block on the farm comprises Oreti soil with some areas of Honeywood and Dipton soils. Soil water storage capacity is generally low, and much of that area is well drained. The sheep block consists mostly of Honeywood and Dipton soils with varying soil water storage capacities. In general most of that area is imperfectly to poorly drained.

3. Infiltration rates of the three soils are high, and quite satisfactory for rapid infiltration of wastewater without ponding. Rates decline markedly immediately following an application of wastewater, but then progressively recover to pre-irrigation values. For the Oreti soil such recovery occurs within approximately 17 days, whereas for the finer textured Dipton soil it occurs by 25 days after irrigation.

   It is recommended that an average irrigation return period of 30 days is used. This period is conservative, but will allow for less favourable soil conditions for wastewater degradation which may occur.

4. Estimations of daily soil water conditions and drainage using a soil water balance model show that soil water contents in the March to October period are generally high, and mostly near field capacity. During the November to February period, soil water content is lower, with permanent wilting point being occasionally reached in the Oreti soil. The number of days above field capacity in an average year is estimated to be between approximately 20 and 160 days for the different soils. Annual drainage is estimated to be approximately 140-260 mm in such a year. In wet years, annual drainage increases to approximately 500-570 mm.

5. Based on initial modelling of the effects of irrigation of the three soil types with 185 m^3 of wastewater on each abattoir processing day, it is recommended that a combination of Oreti, Honeywood, and Dipton soils be used for wastewater treatment on this farm. Ten paddocks (four within the deer block and the remainder on the sheep area) are recommended and comprise, in total, 15.5 ha of Oreti soil, 13.3 ha of Honeywood soil, and 11.8 ha of Dipton soil.

   This combination of soils provides the greatest opportunity to maximise plant uptake of the nutrients contained in wastewater whilst minimising the potential both for leaching and ponding. It also allows for flexibility in farm and irrigation management during periods of very wet or dry conditions.

   In order to achieve this flexibility, irrigation return intervals of less than 30 days must be accommodated. This is not considered to pose any problems, and soil water conditions and drainage over the entire irrigation area are unlikely to be significantly influenced on an annual basis. For a limited number of occasions each year (to approximately 30% of the total) it is considered that irrigations may be conducted using short return intervals.

6. The following irrigation parameters are recommended, and result in an annual average application of approximately 124 mm of wastewater to the irrigated area at an average nitrogen loading of 137 kg N/ha/yr:

Number of irrigation blocks (daily irrigation areas)	22
Average annual wastewater irrigation area	36.1 ha
Average area of each irrigation block	1.64 ha
Average number of wastewater applications to each block annually	11
Quantity of wastewater applied to each block per irrigation	11.3 mm

7. Modelling of the effects of the recommended wastewater regime estimates that irrigation increases annual drainage from the irrigation area by approximately 90-120 mm, and increases the number of days when soil water content exceeds field capacity by approximately 20-45 days. It is considered that, for this farm, such effects are not significant in terms of the incidence of ponding, ease of farm management, and susceptibility to soil compaction.

8. Using estimates of nitrogen balances, it is estimated that leaching of nitrogen increases from approximately 25 kg N/ha/yr to approximately 30-60 kg N/ha/yr with wastewater irrigation. The high proportion (78%) of wastewater nitrogen in an organic form is an important feature of the nitrogen balance and significantly reduces the opportunity for leaching. The estimated magnitude of leaching under the proposed wastewater irrigation area is less than estimated leaching losses for many Southland dairy farms.

1. INTRODUCTION

1.1 Purpose of this report

This report has been prepared for Primary Producers Co-operative Society Ltd to provide technical information on soil factors relevant to the proposal for land treatment of deer abattoir wastewater at a site near Mossburn in Southland. It is based mostly on a site survey, field and laboratory assessments and measurements, and modelling.

1.2 Factors considered

The following soil processes and information are considered in this report:

- soil types and their distributions (from a site survey and soil descriptions);
- infiltration rate, and its recovery after wastewater application (from an infiltration rate study);
- retention of wastewater in the soil (from assessments of soil water holding capacity and estimations of water balances);
- drainage of excess water from the soil (from measurements of hydraulic conductivity and estimations of water balances);
- nitrogen balance (from farm and soil data and published information).

These factors, together with general climate, site, and farm management information, are used to evaluate the effects of wastewater irrigation at this site, and to determine the most appropriate irrigation area and irrigation management parameters to be used. Suitable areas are determined from the soil survey and associated measurements, and the irrigation parameters are based on considerations of hydraulic and nitrogen loadings together with irrigation return intervals. Recommendations for monitoring the effects of wastewater irrigation are given.

2. SITE

The site of the proposed wastewater irrigation system is an existing sheep and deer farm adjoining the PPCS deer abattoir at Mossburn. It is centred on grid reference NZMS 260 E44:925-380 (Lat 45.675, Long 168.208). The deer block is approximately 30 ha in area. It is set stocked from fawning until weaning (mid to late November until mid January) and rotationally grazed with approximately 300 hinds for the remainder of the year. The sheep block comprises approximately 90 ha which is set stocked from early September until weaning (mid December). It is rotationally grazed at other times. During winter, it is strip-grazed once only with approximately 1300 ewes per ha.

Pastures on the property are healthy and vigorous, and capable of optimum productivity at the current level of soil fertility in this environment. Based on the current farm stocking rate of approximately 13.5 SU/ha, it is estimated that annual pasture production is approximately 9,500 kg DM/ha.

Adjoining properties comprise other deer and sheep farms.

3. CLIMATE

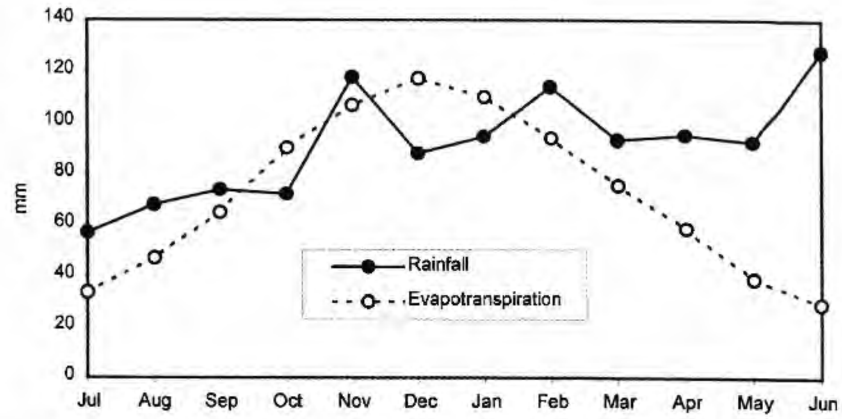
For this assessment, rainfall and evapotranspiration are considered because that data is important for the determination of a soil water balance and hydraulic loading (Section 5.2).

For rainfall, reliable daily records are available for three local sites (Centre Hill, West Dome, and Dunrobin), but only for limited periods (not later than 1963). For the purpose of this investigation, daily data for the period 1952-1960 was used from the West Dome station. This station was used because it is within 7 km of the irrigation site, and is at a similar altitude (approximately 280 m asl).

For evapotranspiration, meteorological stations at Gore and Winton are the closest installations which provide sufficient daily data (wind run, wet and dry bulb temperatures, radiation). Mean monthly values for evapotranspiration are very similar for the two stations, therefore data from Gore was used because this station has the most complete data set. Average daily values of evapotranspiration were calculated using daily records of the required parameters for the 1989-95 period. The Penman equation (Penman, 1963) was used because it has been successfully used by the author in other water balance work in Southland, Otago, and Canterbury, and is widely used internationally.

Daily values of both rainfall and evapotranspiration are used for the water balance described later in Section 5.2. As a general indication of the climate at the wastewater irrigation site, monthly means of rainfall and evapotranspiration are shown in Figure 1.

Figure 1
Mean monthly rainfall and evapotranspiration



The data in Figure 1 shows that rainfall exceeds evapotranspiration in all months except October, December, and January. Drainage of excess water through the soil profile is not taken into account in this data, however, therefore it underestimates the potential water deficit at this site. A detailed analysis of the soil water balance is provided in Section 5.2.4.

4. SOILS

The Mossburn property comprises three main soils which have been examined, described, and mapped. They are:

- Oreti stony fine sandy loam (yellow-brown shallow and stony soil);
- Honeywood stony silt loam (yellow-grey earth);
- Dipton silt loam (moderately gleyed yellow-grey earth).

These three soils have been described in general terms by O'Byrne (1986).

4.1 Soil descriptions

Descriptions of profiles of the three soils at the Mossburn property are given below.

Oreti stony fine sandy loam

Horizon	*Depth (cm)*	*Description*
A1	0-6	Dark brown (10YR 3/3) fine sandy loam, very few stones, very friable, moderately to well developed fine nut and crumb structure, many roots, considerable earthworm activity.
A2	6-19	Dark brown (10YR 3/4) stony fine sandy loam, firm, moderately developed fine to medium nut and block structure, many roots, considerable earthworm activity. Compacted at base of horizon.
Bw	19-40	Yellowish brown (10YR 5/6) stony silt loam, weakly developed nut and crumb structure. Many roots. Compact.
C	40+	Gravels and grits cemented in places with iron and manganese.

The Oreti soil is developed from greywacke and volcanic alluvium, and is located on low to intermediate terraces in the Oreti Valley (O'Byrne, 1986). It is strongly enleached. The compacted and cemented zones are the result of clay illuviation, and iron and manganese cementation respectively. Both are features which restrict drainage, but are quite incomplete. Overall, the soil is well to excessively drained.

Honeywood stony silt loam

Horizon	*Depth (cm)*	*Description*
A1	0-9	Brown (10YR 4/4) silt loam, very few stones, friable, moderately developed fine nut and crumb structure, few iron mottles (5YR 4/8). Many roots, considerable earthworm activity.
A2	9-18	Brown (10YR 4/4) stony silt loam, firm, moderately developed block structure, few iron mottles (5YR 4/8). Many roots, considerable earthworm activity.
Bw	18-30	Dull yellowish brown (10YR 5/3) gravely fine sandy loam, weakly developed fine crumb, 10-20% reddish brown (5YR 4/8) iron mottles. Many roots.
Bs	30-80	Compact gravels and grits cemented in places with iron to form thin (<1 cm) pans.
C	80+	Gravel and sand.

This soil is a yellow-grey earth, developed from greywacke and volcanic alluvium with a shallow loess cover (O'Byrne, 1986). It is derived from the Dipton set. It is found associated with Dipton soils on the intermediate terraces in the Oreti Valley.

Compaction and cementation of gravels and grits is marked, and results in restricted drainage. Overall, this soil is imperfectly drained.

Dipton silt loam

Horizon	*Depth (cm)*	*Description*
A	0-18	Greyish yellow brown (10YR 5/2) silt loam, very friable, moderately to strongly developed fine nut and crumb structure. Many roots, considerable earthworm activity.
AB	18-27	Worm-mixed horizon.
Bg	27-38	Light grey (2.5Y 7/1) heavy silt loam, firm, weakly developed fine to medium blocky structure. Many medium, distinct bright brown (7.5YR 5/8) mottles. Many roots.
Bs	38-68	Bright reddish brown (5YR 5/8) stony gravels and grits with heavy silt, compact, moderately cemented with abundant strongly cemented iron and manganese nodules.
C	68+	Light yellow (2.5Y 7/3) gravels and grits in a silty clay matrix.

The Dipton soil is a gleyed yellow-grey earth developed from greywacke and volcanic alluvium with a shallow loess cover (O'Byrne, 1986). It is found associated with Oreti and Honeywood soils on the intermediate terraces in the Oreti Valley.

The gravel pans (Bs horizon) significantly restrict downward transmission of water through this soil, resulting in gleying and mottling of the overlying horizon. This soil is imperfectly to poorly drained.

In the Dipton soil, parts of the A horizon were compacted. The degrees of compactness were indicative of damage which often occurs in poorly drained soils with animal treading during moist conditions. In this case, the gravel pans evident below 30 cm depth result in slow drainage resulting, in turn, in susceptibility to compaction by treading. Areas of these soils on this farm are generally tile drained to improve drainage.

The degree of compactness within the 0-30 cm depth can be managed by close management of grazing during moist conditions to avoid intensive treading. Stock may be grazed preferentially on Oreti soils at such times.

4.2 Soil physical properties

The two main soil physical properties which influence soil suitability for land treatment of wastewater are water transmission (infiltration rate and hydraulic conductivity) and water storage. Assessments of these properties, together with a general assessment of aggregate stabilities were made for each of the three soil types.

4.2.1 Infiltration rate and hydraulic conductivity

Infiltration rate was measured *in situ* using the twin ring method (Scotter, *et al.*, 1982). Five replicate measurements were made for each soil. Additionally, an infiltration rate study was conducted to determine the effect of wastewater applications. The results of the latter are reported in Section 5.1.

Saturated and unsaturated (at 0.1 kPa matric potential) hydraulic conductivities were measured for selected horizons of each soil in order to provide data for the water balance model used in Section 5.2 to estimate soil water contents and drainage. The results of the saturated conductivity measurements are reported here to provide information on the drainage characteristics of each soil. For stony horizons, the twin ring method was used *in situ*, while for stone-free depths, undisturbed soil cores (100 mm diameter, 55 mm depth) were collected, and laboratory measurements of hydraulic conductivity were made. The latter were made using an automated permeameter system. There were five replicates of each hydraulic conductivity measurement.

Mean values of infiltration rate and saturated hydraulic conductivity are given below. Estimates (*) are given where measurements were not made.

Oreti soil

Horizon	*Depth* (cm)	*Infiltration rate* (mm/hr)	*Hydraulic conductivity* (mm/hr)
A1	0-6	1450	1280
A2	6-19		>1000*
Bw	19-40		190
C	40+		>50*

Honeywood soil

Horizon	*Depth* (cm)	*Infiltration rate* (mm/hr)	*Hydraulic conductivity* (mm/hr)
A1	0-9	720	950
A2	9-18		415
Bw	18-30		118
Bs	30-80		<5*

Dipton soil

Horizon	*Depth* (cm)	*Infiltration rate* (mm/hr)	*Hydraulic conductivity* (mm/hr)
A	0-18	360	150 (upper half of horizon)
			23 (lower half of horizon)
AB	18-27		130
Bg	27-38		120
Bs	38-68		<5*

This data shows that infiltration rates are rapid for all soils, but the Honeywood and Dipton soils contain horizons which restrict drainage. In the Honeywood soil, that restriction occurs at approximately 30 cm depth, while in the Dipton soil it is evident at 10-18 cm and 38 cm depths. For the latter soil, the moderate to low value of conductivity in the lower half of the A horizon is the result of soil compaction resulting from stock treading. With careful stock management during wet conditions, this will improve naturally with root and earthworm activity.

The infiltration rates are high because soil within the 0-5 cm depth is well structured with no evidence of compaction. The relatively lower rate for the Dipton soil reflects the finer texture of the surface horizon. Current infiltration rates pose no problems in relation to wastewater irrigation. They are satisfactory for rapid infiltration of wastewater into the soil.

The low values of hydraulic conductivity in the subsoil of the Honeywood and Dipton soils, however, are of more significance because they are natural soil features resulting from clay, iron, and manganese illuviation. As a result, both soils are imperfectly to poorly drained. When soil water storage capacity for approximately the 0-30 cm (Honeywood) and 0-38 cm (Dipton) depths of soil are exceeded, further applications of water at even low rates of application will result in soil water contents exceeding field capacity. The soils are then susceptible to damage by compaction. Further applications of water then result in waterlogging and eventually ponding. Although the Dipton and Honeywood soils are tile drained to reduce the incidence of such effects, the application of excessive quantities of water to these soils should be avoided wherever possible.

4.2.2 Soil water storage capacity

Soil water storage capacities were assessed by determining the main textural class of each soil horizon and, where necessary, measuring the stone content. This information was used to estimate water holding capacity for the appropriate soil depths.

Estimated values of soil water retention for each of the soils are given in Table 1. For each soil type, the total depths of soil used to estimate storage capacities were determined by the depths to horizons which can either retain very little water or are a significant restriction to drainage and root penetration. For the Oreti, Honeywood, and Dipton soils, those depths are 40 cm, 30 cm, and 45 cm respectively.

Table 1
Soil water retention capacities for the three soils at the proposed wastewater irrigation site.

Soil	Amount of water (mm) retained by the soil at: Permanent wilting point	Field capacity	Saturation
Oreti	24	61	85
Honeywood	40	93	125
Dipton	85	191	241

Table 1 shows that there are large differences in water holding capacities between the three soil types. Those differences reflect contrasts in soil textures and stone contents. For instance, the 0-45 cm depth of the Dipton soil is stone-free whilst the 19-40 cm depth of the Oreti soil comprises, on average, 73% stones.

With increasing water storage capacity, the ability of a particular soil to retain wastewater within the most biologically active depth of soil increases. Drainage characteristics must also be taken into consideration, however, if the quantities of wastewater to be applied exceed soil water storage capacity. The effects of both factors are addressed, in relation to the three soil types, in Section 5.2 which provides estimates of soil water contents and drainage for this Mossburn farm.

4.3 Soil chemical properties

Because of a higher stone content, the Oreti soil is more highly enleached. This is reflected in its yellow-brown classification, compared to a yellow-grey classification for the other two soils.

A chemical analysis of soil sampled from the deer block in November 1994 yielded the following results: pH 5.8, Ca 8, P 32, K 4, SO_4 13, Mg 30. The analysis was conducted by AgResearch (Soil Fertility Service) and results are given in standard quick test units. They indicate that the soil chemical fertility of the deer block is reasonably maintained. It is considered that the sheep block is similarly maintained. Typical annual fertiliser applications consist of 250 kg/ha superphosphate with occasional substitution of 375 kg/ha potassic superphosphate. Occasional dressings of selenium and copper are also made.

4.4 Other soil features

During site visits, considerable earthworm activity was apparent, and there was no evidence of near-surface accumulation of organic matter in the form of undecomposed pasture root or leaf material. This indicates a reasonably high degree of biological activity. Such activity is important for biological degradation of the abattoir wastewater on and within the soil.

The water stabilities of soil aggregates from the A horizons of the soils were estimated, and are considered to be medium to high. They are therefore currently of no concern in relation to wastewater applications.

4.5 Soil mapping

The locations of the three soil types described in Section 4.1 were determined with a soil survey of the Mossburn farm. The distribution of each soil was determined by locating soil boundaries. Within each area of a particular soil, an approximate uniformity of that soil was also assessed. For this, drainage status and soil water storage capacity were estimated because these are the two most important soil features determining the relative suitabilities of the soils for wastewater applications.

The distribution of the three soil types, soil drainage status, and general soil water retention capacities are shown for this farm in Figures 2-4.

For soil drainage, three drainage status classes are shown. The Oreti soil is classified as well drained, while typical Honeywood and Dipton soils are given imperfect to poor drainage classifications. An area of Honeywood soil which contains a near-complete layer of iron cementation is shown as very poorly drained.

Four soil water retention classifications are used. The very low retention capacity corresponds to the shallow and stony Oreti soil, while the highest water retention areas correspond with deep Dipton soils where the 0-80 cm soil depth is stone-free. The medium and low soil water storage capacity classifications are intermediate classes. These were mapped on the basis of soil type, depth to stones, and approximate stone content. Soil water storage capacities corresponding to the very low, low, medium, and high storage classifications are 37, 53, 106, and 118 mm respectively.

Most of the deer block is comprised of Oreti soil with some areas of Honeywood and Dipton soils. Soil water storage capacity is generally low, and much of that area is well drained. The sheep block consists mostly of Honeywood and Dipton soils with varying soil water storage capacities. In general most of that area is imperfectly to poorly drained. The locations of proposed wastewater irrigation areas in relation to soil types are described in Section 6.2.

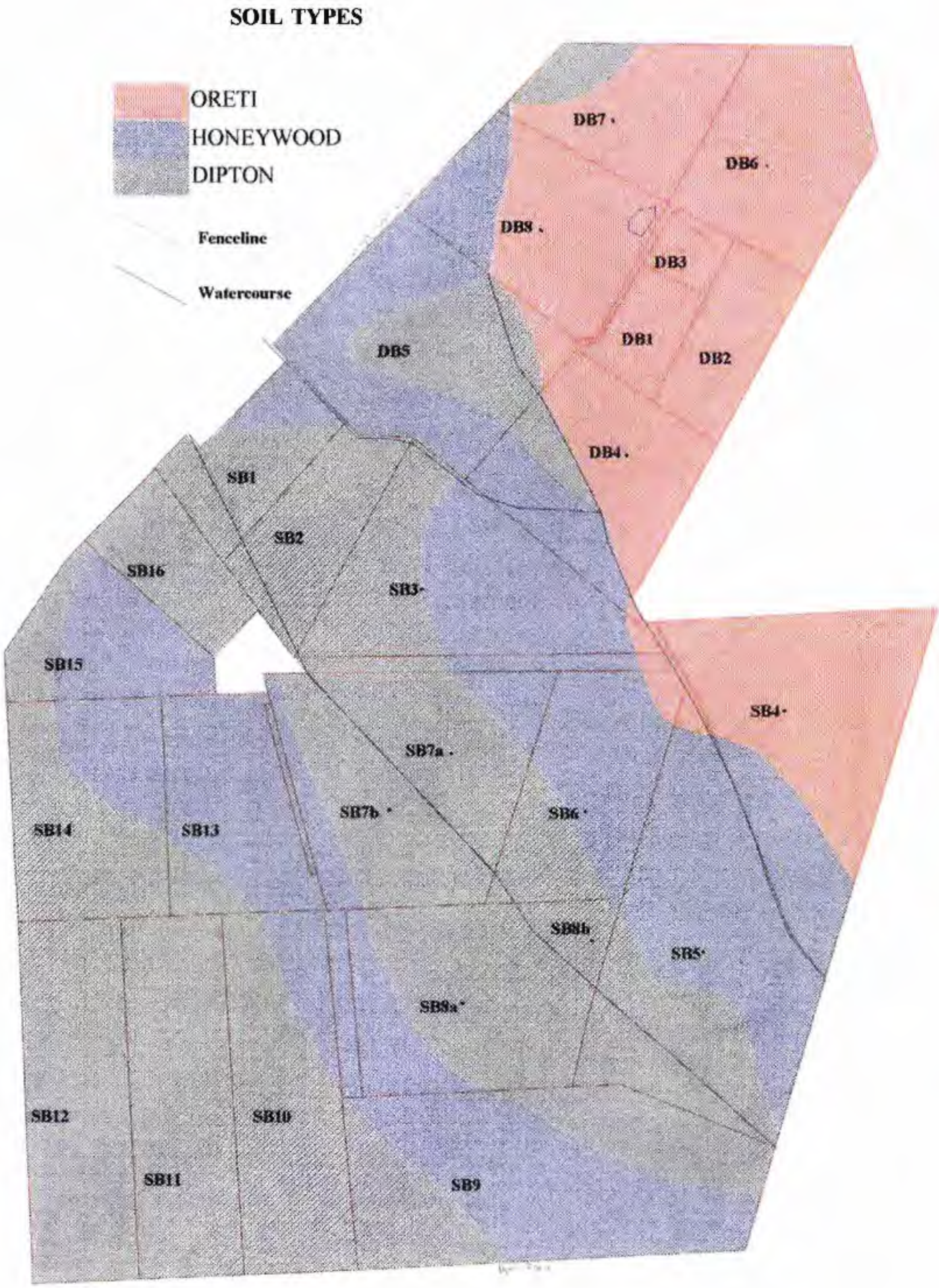


Figure 2: Soil map of the Mossburn farm.

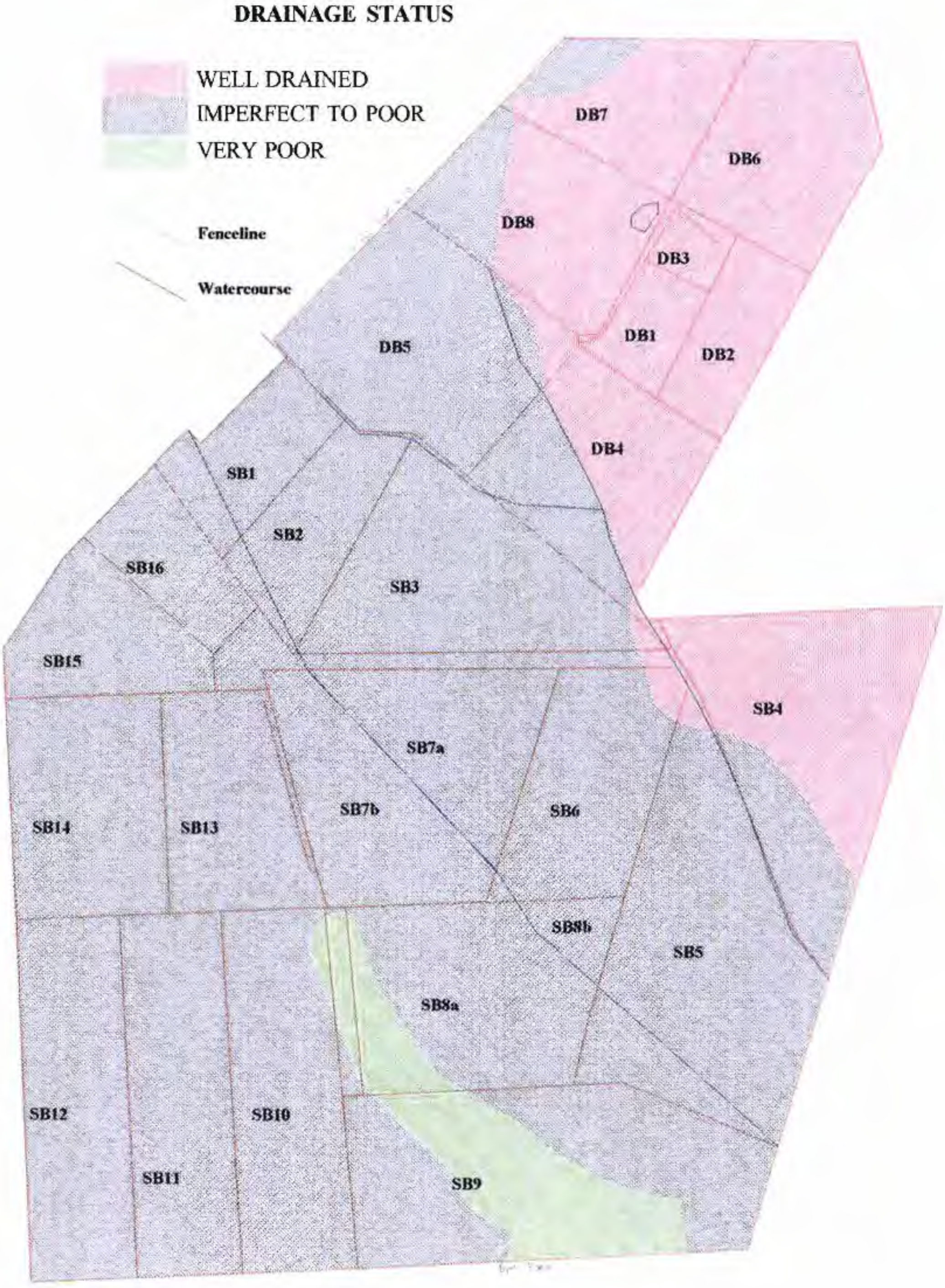


Figure 3: Soil drainage classes of land on the Mossburn farm.

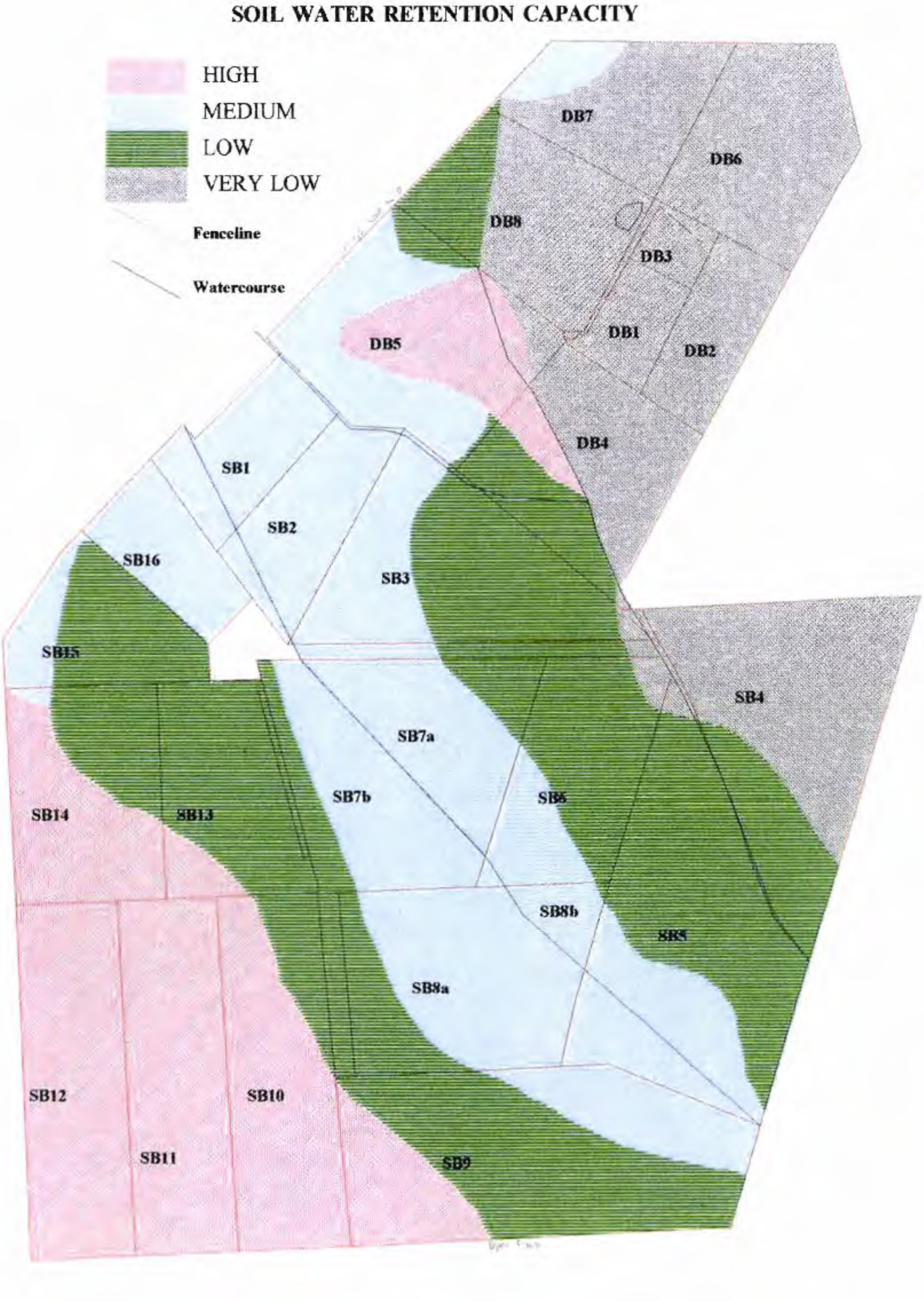


Figure 4: Soil water retention classes of land on the Mossburn farm.

5. WASTEWATER IRRIGATION - SOIL FACTORS

To determine suitable irrigation depths and frequencies, and the most appropriate area of the farm for wastewater applications, the following factors have been considered in this section:

- soil type;
- effects of wastewater on infiltration rate;
- hydraulic loading.

5.1 Infiltration rate

A study was conducted on the Mossburn property to determine the effects of wastewater applications to the Dipton and Oreti soils on soil infiltration rates. The recovery of infiltration rate after an application of wastewater was also assessed to determine optimum application return interval.

5.1.1 Method

Twenty four replicate *in situ* infiltration measurements were made on several occasions in each of two paddocks. One paddock (Paddock SB4, Figure 2) was considered to be representative of the Oreti soil present on this farm, while the other (Paddock SB7) was representative of the Dipton soil. The twin ring infiltration method (Scotter *et al.*, 1982) was employed using automated field permeameters.

Abattoir wastewater was applied to twelve of each of the twenty four sites in each paddock on 23 July 1996. It was supplied by abattoir staff, and considered by them to be a representative sample of wastewater filtered with a 0.5 mm mesh screen. A total of 15 mm of wastewater was applied to each of the appropriate sites at a rate of approximately 8 mm/hr.

Infiltration measurements were made 3 hours after wastewater application, followed by further measurements after 1, 2, 6, 17, 25, and 35 days. At each measurement, soil temperature was recorded at 5 cm soil depth.

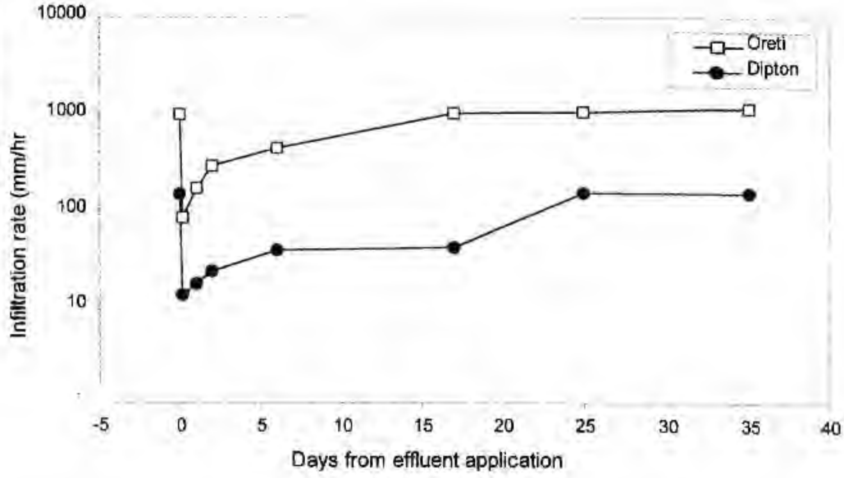
5.1.2 Results

The results of the infiltration study are shown in Figure 5.

The results show a marked decline in infiltration rate immediately after the application of wastewater. This occurs because of some blockage of soil macropores with solid wastewater material.

Although a reduction in infiltration rate occurred in both soils, the effect is of more significance for the Dipton soil where rates are naturally lower because this soil contains a higher proportion of silt and clay and fewer large macropores. For this soil, infiltration rate soon after the wastewater application was approximately 13 mm/hr. Generally, however, the infiltration rates measured are high enough for adequate entry of water into the soil during irrigation and most rain events.

Figure 5
Geometric means of infiltration rates for the Oreti and Dipton soils before and after a 15 mm wastewater application.



Recovery of infiltration rate was apparent soon after the application of wastewater. For the Dipton soil, recovery then proceeded until approximately 25 days after application. At the end of that period, infiltration rate (approximately 150 mm/hr) was approximately equivalent to that immediately before the wastewater application. In the Oreti soil, recovery occurred more rapidly and was largely complete by 17 days after wastewater was applied. The final infiltration rate was approximately 1500 mm/hr.

During the infiltration rate study, soil temperatures varied between 4.0 and 7.2 °C. It is likely, therefore, that infiltration rate recovery following wastewater irrigation will be more rapid during warmer months. The results of this study are likely to be indicative of the coldest periods of the year for wastewater irrigation, and of the lowest rates of recovery. It should be noted, however, that the study was conducted in an area with no history of wastewater applications, and that, after wastewater has been irrigated for some time, infiltration rates may be somewhat reduced. General soil biological activity, however, is likely to be stimulated with additions of organic material, therefore the net effect of long term applications of wastewater may indeed be positive.

Overall, it is considered that the results of this study provide a conservative representation of wastewater degradation within the soils at this site. It is recommended that an irrigation return period of 30 days is used. This period is conservative, but will allow for less favourable soil conditions for wastewater degradation which may occur. Such conditions may arise if the soil is compacted during grazing in wet conditions, or if an irrigation fault causes overloading of the soil with wastewater.

5.2 Soil water balance

A soil water balance model developed earlier by SoilWork Ltd was used to estimate the effects of wastewater irrigation on soil water status and drainage.

5.2.1 General description

In general terms, the model estimates the balance of water inputs (rainfall, wastewater applications), surface ponding, storage within the soil, and water losses (evapotranspiration, downward transmission through the soil). With input of rainfall and potential evapotranspiration data, it estimates actual evapotranspiration using the current soil water content as a basis for adjustments to the potential rate. Actual evapotranspiration and rainfall are then used to estimate a new soil water content after submodels for drainage and ponding are initiated.

The model requires the following data:

- daily rainfall;
- daily values of wind run, maximum and minimum temperatures, wet and dry bulb temperatures, mean temperature, radiation;
- volumetric soil water contents at matric potentials of 0, 5, 10, 1500 kPa;
- hydraulic conductivity at matric potentials of 0, 0.1, 1.0 kPa.

Values for these parameters were taken from the various assessments reported in earlier sections, and from the authors experience with similar soils. Daily values of rainfall for an average and a wet year amongst the 1952-1960 period (Section 3) were used for the modelling. The annual rainfall for the average year was 973 mm, close to the 1951-1980 long term mean of 1012 mm at West Dome (New Zealand Meteorological Service). The annual rainfall for the wet year used was 1349 mm. This represented the wettest year at West Dome between 1952 and 1960 for which reliable daily records were available. For evapotranspiration, mean daily values of the appropriate parameters for the 1989-95 period measured at Gore (Section 2) were used.

5.2.2 Soils

Modelling was conducted for the Oreti, Honeywood, and Dipton soils. The deepest phase of the Dipton soil was not used for modelling because, on this farm, this soil is used primarily for cultivation of fodder crops and for hay and silage production. Areas under such management are considered to be unsuitable for regular applications of wastewater.

5.2.3 Irrigation parameters

The irrigation parameters shown in Table 2 were used for the initial modelling of the effects of wastewater irrigations. They are based on a 30 day return period recommended in Section 5.1.2, wastewater volumes of 185 m^3/dy on each processing day (five days per week, with no processing during September), suitable areas of land available on the farm for irrigation, and a nitrogen loading of 170 kg N/ha/yr.

Table 2
Irrigation parameters used to model the effects of wastewater irrigations.

Number of irrigation blocks (daily irrigation areas) required	22
Number of wastewater applications to each block annually	11
Required size (ha) of each irrigation block to achieve required N loading	1.3

5.2.4 Results for a non-irrigated scenario

Summaries of model output data for the average and wet years are given in Tables 3 and 4 respectively. Estimated daily values of soil water content are presented for each of the three soils without wastewater applications in Figures 6-8.

Table 3
Data summary for the non-irrigated scenario for an average year.

	Oreti soil	Honeywood soil	Dipton soil
Annual rainfall (mm)	973	973	973
Annual actual evapotranspiration (mm)	740	790	835
Wastewater applied annually (mm)	0	0	0
Annual drainage (mm)	255	189	137
Average number of days when soil water content exceeds field capacity	21	139	158
Average number of days when ponding occurs	0	0	0

Table 4
Data summary for the non-irrigated scenario for a wet year.

	Oreti soil	Honeywood soil	Dipton soil
Annual rainfall (mm)	1349	1349	1349
Annual actual evapotranspiration (mm)	798	838	850
Wastewater applied annually (mm)	0	0	0
Annual drainage (mm)	568	517	499
Average number of days when soil water content exceeds field capacity	57	209	249
Average number of days when ponding occurs	3	7	3

Figure 6
Estimated soil water contents for the non-irrigated Oreti soil in an average year.

The upper and lower horizontal lines represent soil water contents at field capacity and permanent wilting point respectively.

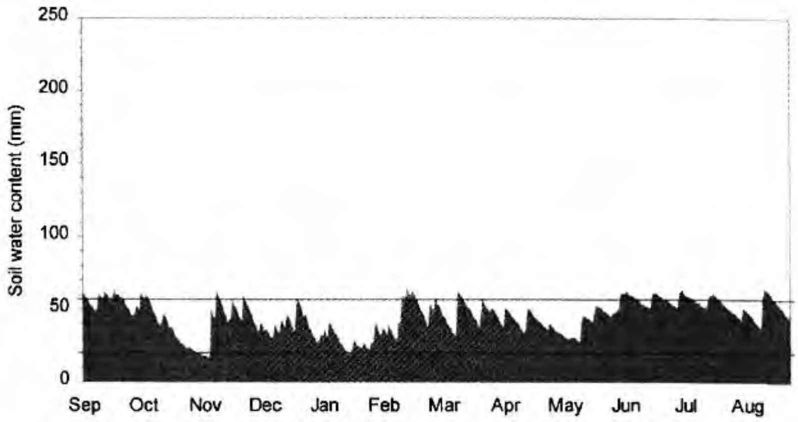


Figure 7
Estimated soil water contents for the non-irrigated Honeywood soil in an average year.

The upper and lower horizontal lines represent soil water contents at field capacity and permanent wilting point respectively.

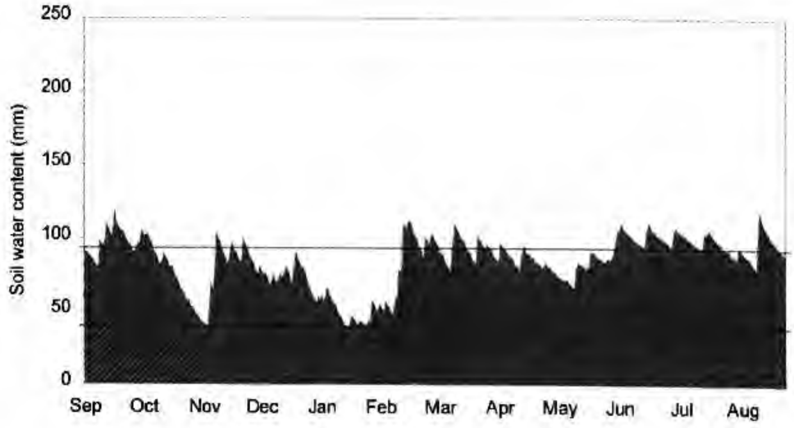
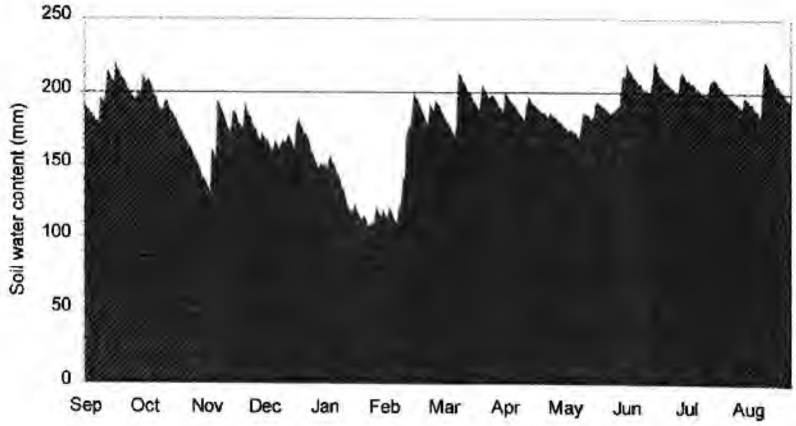


Figure 8
Estimated soil water contents for the non-irrigated Dipton soil in an average year.

The upper and lower horizontal lines represent soil water contents at field capacity and permanent wilting point respectively.



Results from the non-irrigated simulations indicate that soil water contents in the March to October period are generally high, and mostly near field capacity. For the Oreti, Honeywood, and Dipton soils, the number of days above field capacity in an average year are estimated to be 21, 139 and 158 respectively. These differences between soils reflect differences in drainage where the Dipton soil is the most slowly draining soil and therefore is wetter than field capacity for longer periods. Conversely, because this soil retains more water, the annual quantity of drainage is less than for the Oreti and Honeywood soils (Table 3).

Table 4 shows the marked effect of a wet season. Annual drainage increases significantly to approximately 500-570 mm, while the number of days when soil water content exceeds field capacity also increases. Surface ponding is estimated to occur on a number of occasions during the year. In such a year, high soil water contents for significant periods of time can result in farm management difficulties, and an increased incidence of soil compaction. These problems are reduced on this Mossburn farm by tile drainage systems which are installed in the more poorly drained Honeywood and Dipton soils.

During the November to February period, soil water content is lower, with permanent wilting point being occasionally reached in the Oreti soil. Pasture production is likely to be reduced on this soil because of water stress during January and February. Such an effect is less likely in the Honeywood and Dipton soils, especially the latter, because they retain more plant available water during dry periods.

5.2.5 Results for the wastewater irrigation scenario

Results of wastewater simulations using the parameters described in Section 5.2.3 are shown in Tables 5 and 6 and in Figures 9-11.

Table 5
Data summary for the wastewater irrigation scenario for an average year.

	Oreti soil	Honeywood soil	Dipton soil
Annual rainfall (mm)	973	973	973
Annual actual evapotranspiration (mm)	781	828	850
Wastewater applied annually (mm)	152	152	152
Annual drainage (mm)	359	299	269
Average number of days when soil water content exceeds field capacity	34	204	257
Average number of days when ponding occurs	0	1	0

Table 6
Data summary for the wastewater irrigation scenario for a wet year.

	Oreti soil	Honeywood soil	Dipton soil
Annual rainfall (mm)	1349	1349	1349
Annual actual evapotranspiration (mm)	810	841	850
Wastewater applied annually (mm)	152	152	152
Annual drainage (mm)	704	661	644
Average number of days when soil water content exceeds field capacity	70	244	284
Average number of days when ponding occurs	3	9	4

Figure 9
Estimated soil water contents for the irrigated Oreti soil in an average year.

The upper and lower horizontal lines represent soil water contents at field capacity and permanent wilting point respectively.

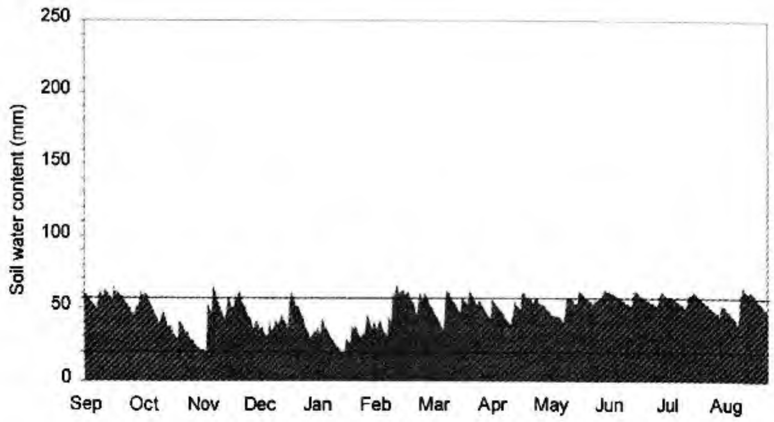


Figure 10
Estimated soil water contents for the irrigated Honeywood soil in an average year.

The upper and lower horizontal lines represent soil water contents at field capacity and permanent wilting point respectively.

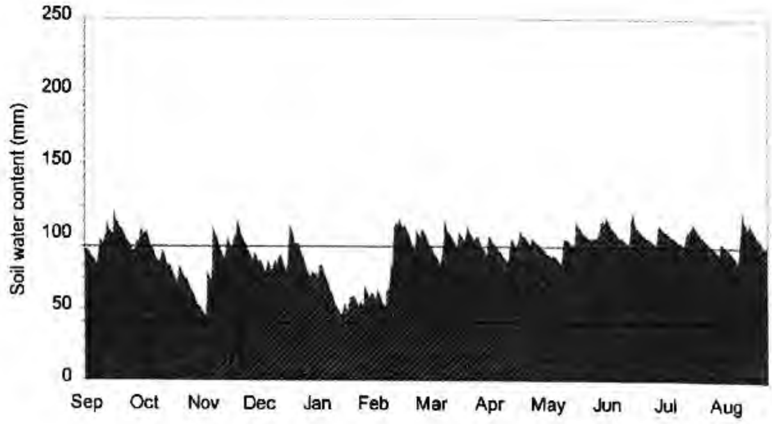
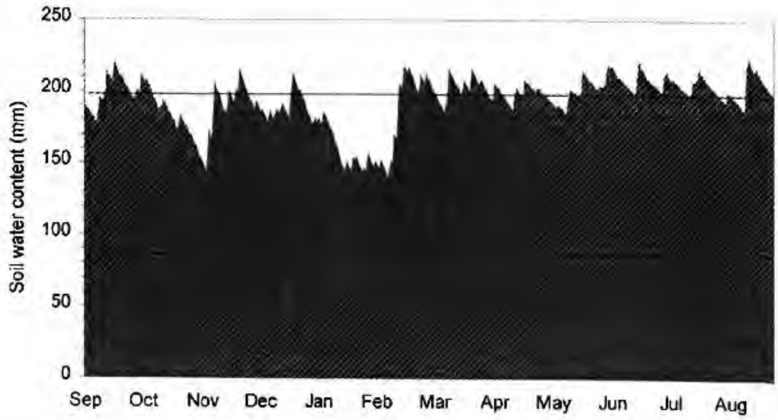


Figure 11
Estimated soil water contents for the irrigated Dipton soil in an average year.

The upper and lower horizontal lines represent soil water contents at field capacity and permanent wilting point respectively.



Simulations of wastewater irrigation show that irrigation increases the number of days above field capacity and the annual quantity of drainage, with differences dependent on soil type.

Because the Oreti soil is well drained compared with the Honeywood and Dipton soils, increases in the number of days above field capacity are greatest for the latter two soils. In an average year, it is estimated that the number of days increases by approximately 13 days for the Oreti soil but by approximately 100 days in the Dipton soil.

Compared with the average annual rainfall of approximately 1000 mm, the quantity of wastewater applied annually (152 mm) is small. It is estimated that it results in increases in drainage of approximately 100-130 mm annually in an average year and 135-145 mm in a wet year.

6. WASTEWATER IRRIGATION - RECOMMENDATIONS

6.1 Soil types

Based on the water balances shown in Section 5.2.5, it is recommended that areas of all three soils (Oreti, Honeywood, and Dipton) are used for wastewater irrigation on this farm.

With the most rapid drainage, but lowest water retention capacity, the Oreti soil allows the greatest annual drainage of water but is not as wet as the Dipton for most of the year. The Honeywood soil is intermediate between both the Oreti and Dipton soils in relation to these features. Because both soil features are important determinants of leaching losses of solutes, and of the incidence of waterlogging, ponding, and soil compaction, a combination of soils will provide the greatest opportunity to maximise plant uptake of the nutrients contained in wastewater whilst minimising the potential both for leaching and ponding.

A combination of soils also allows for flexibility in farm and irrigation management during periods of very wet or dry conditions. When conditions are very wet and soil water content in poorly drained soils scheduled for irrigation may be near saturation, wastewater can be applied to Oreti soils instead, in order to avoid ponding. While this may result in increased annual drainage, that increase would be minor.

Alternatively, when soil water content is low due to very dry conditions, irrigation of Dipton and Honeywood soils would result in greater immobilisation and plant uptake of the wastewater and its products than would irrigation of Oreti soils. Consequently annual drainage would be reduced.

In order to achieve this flexibility, irrigation return intervals of less than 30 days must be accommodated. Because the return intervals recommended in Section 5.1.2 are conservative, especially for the Oreti soil, and the quantity of wastewater applied at each irrigation is small, this is not considered to pose any problems. Soil water conditions and drainage over the entire irrigation area are unlikely to be significantly influenced on an annual basis. It is therefore considered that, for a number of occasions (to approximately 30%) each year, irrigations may be conducted using short return intervals.

6.2 Areas for irrigation

It is recommended that the following paddocks (refer to Figure 2) be used for irrigation:

Paddock	***Stock type***	***Area (ha)***
DB4	Deer	2.0
DB6	Deer	3.7
DB7	Deer	2.8
DB8	Deer	4.1
SB3	Sheep	5.4
SB4	Sheep	5.2
SB5	Sheep	5.6
SB6	Sheep	4.3
SB7a	Sheep	3.1
SB8a	Sheep	4.6
Total area		***40.8 ha***

Areas of the three soil types are shown in Table 7.

Table 7
Areas of the three soil types represented in each of the irrigated paddocks.

Paddock number	Oreti soil	Honeywood soil	Dipton soil
DB4	2.0	0	0
DB6	3.7	0	0
DB7	2.5	0	0.3
DB8	3.2	0.9	0
SB3	0	3.2	2.1
SB4	4.1	1.1	0
SB5	0	4.3	1.2
SB6	0	3.1	1.2
SB7a	0	0.7	2.4
SB8a	0	0	4.6
Total	15.5	13.3	11.8

Overall, the percentages of the proposed irrigation area occupied by Oreti, Honeywood, and Dipton soils are approximately 38%, 33%, and 29% respectively.

6.3 Irrigation parameters

Based on a recommended average return interval of 30 days, an abattoir wastewater volume of 185 m^3 on each processing day (5 days per week, no processing in September), and the areas detailed in the previous section, the irrigation parameters shown in Table 8 are recommended.

Table 8
Recommended irrigation parameters.

Number of irrigation blocks (daily irrigation areas)	22
Average annual wastewater irrigation area	36.1 ha
Average area of each irrigation block	1.64 ha
Average number of wastewater applications to each block annually	11
Quantity of wastewater applied to each block per irrigation	11.3 mm
Average annual quantity of wastewater applied to each block	124.3 mm
Average annual nitrogen loading	137 kg N/ha/yr

The total area receiving wastewater in a given season (36.1 ha) is less than the total area available for irrigation (40.8 ha) as described in Section 6.2. This occurs because the landowner reserves the right to cultivate one of the irrigable paddocks in the sheep block each year for crop. Consequently, an area corresponding to the average area of the irrigated paddocks within the sheep block (4.7 ha) is subtracted from the total irrigable area to provide an average annual irrigation area of 36.1 ha.

7. EFFECTS OF WASTEWATER IRRIGATION USING RECOMMENDED PARAMETERS

7.1 Hydraulic loading

The estimated effects of wastewater irrigation (using the recommended soil areas and irrigation parameters) on soil water contents and drainage are shown in Table 9.

Table 9
Effects of wastewater irrigation on soil water conditions and drainage.

	Non-irrigated		Irrigated with wastewater	
	Average year	Wet year	Average year	Wet year
Annual rainfall (mm)	973	1349	973	1349
Annual actual evapotranspiration (mm)	778	823	808	829
Wastewater applied annually (mm)	0	0	124	124
Annual drainage (mm)	207	535	296	650
Average number of days when soil water content exceeds field capacity	92	152	136	175
Average number of days when ponding occurs	0	5	0	5

The water balance model estimates that wastewater irrigation results in increases in drainage of approximately 90-120 mm annually and increases in the number of days when soil water content exceeds field capacity of approximately 20-45. It is considered that, for this farm, such effects are not significant in terms of the incidence of ponding, ease of farm management, and susceptibility to soil compaction.

The increases in drainage shown in Table 9 will result in some increase in nitrate leaching. To assess the magnitude of that effect, source concentrations and forms of nitrogen must be considered. These are estimated in the following section with nitrogen balances.

7.2 Nitrogen loading

Estimated nitrogen balances for non-irrigated land and land irrigated with wastewater on the Mossburn farm are provided in Figures 12 and 13.

The various estimations comprising the budgets are derived from farm information (Mr J. Douglas), wastewater analyses (Mr G. Keeley, PPCS), and partitioning estimates previously published (Haynes and Williams, 1993; Williams, 1993).

Figure 12
Estimated nitrogen balance for non-irrigated land.

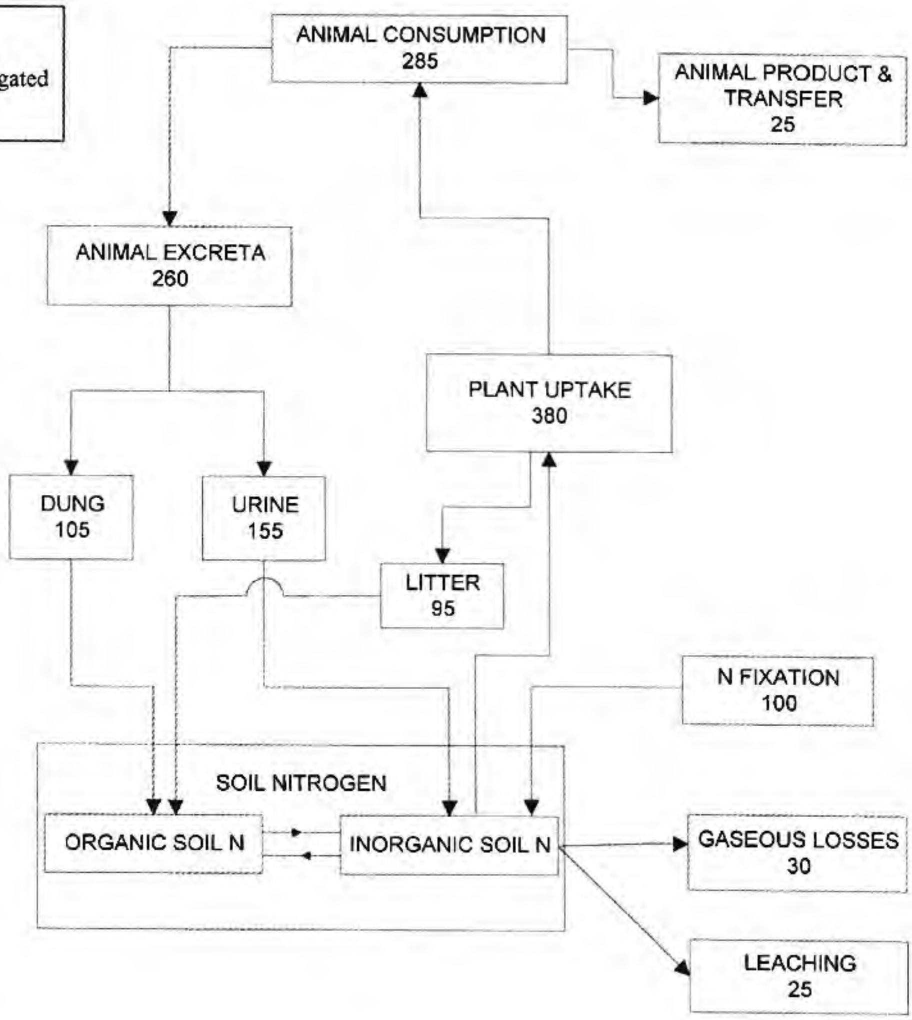
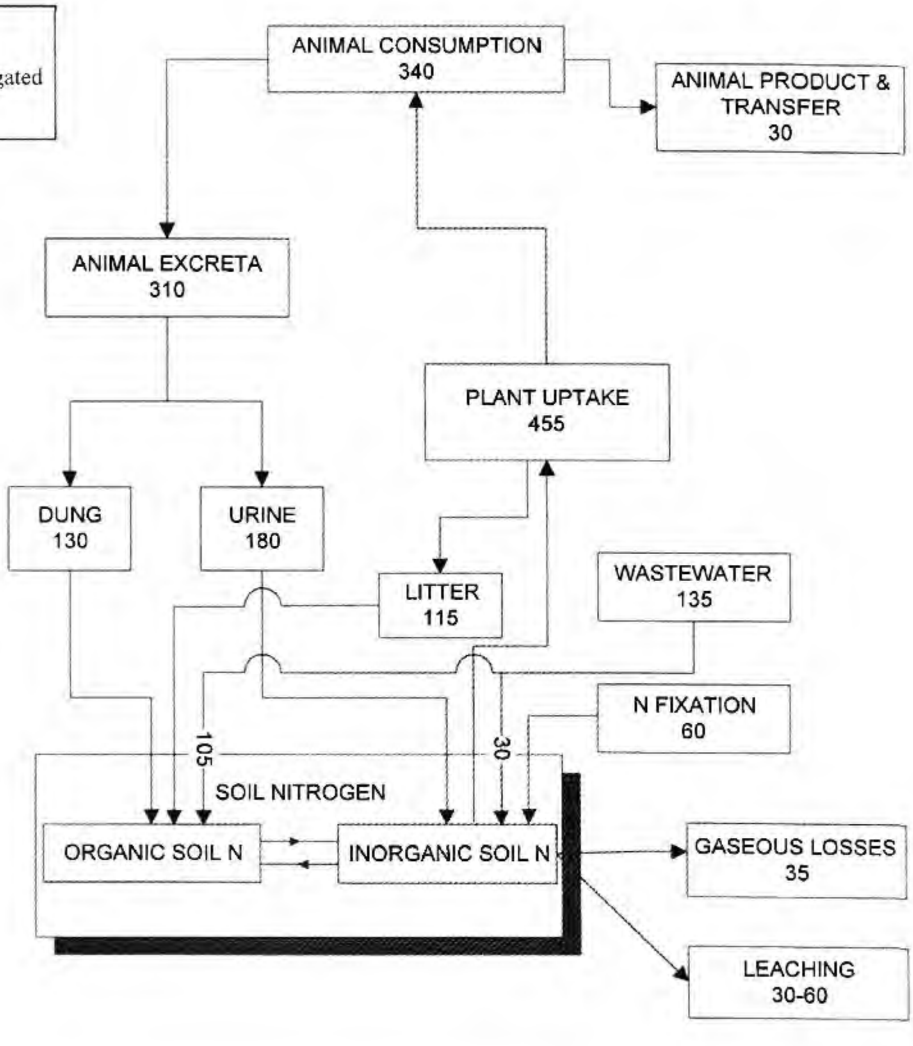


Figure 13
Estimated nitrogen balance for land irrigated with wastewater.



Of particular significance in Figure 13 are the forms of nitrogen contained in the wastewater which is applied to land. Approximately 78% of the total Kjedahl extractable nitrogen (110 g/m^3) is organic (Mr G. Keeley, PPCS). This portion, comprising fats and protein, is not readily leachable. Mineralisation and nitrification of the organic N is first required within the soil to provide a source of NO_3-N which is available for plant uptake and susceptible to leaching. The remaining 22% of the nitrogen in wastewater comprises NH_3-N. This form of nitrogen is readily available for further nitrification to NO_3-N, and can then be absorbed by plant roots and lost by leaching.

Overall, it is estimated that wastewater irrigation increases nitrate losses by leaching from approximately 25 kg N/ha/yr to approximately 30-60 kg N/ha/yr. The latter is less than leaching losses of approximately 80-90 kg N/ha/yr previously estimated for Southland dairy farms (Williams, 1993).

7.3 Other soil effects and pasture production

The supply of plant nutrients with wastewater, particularly N, P and K, will reduce the requirement for fertilisers on the irrigated land. Monitoring of soil nutrient levels is recommended (Section 8). Particular attention should be paid to pH, P, and K to prevent nutritional imbalances if levels become too high. Imbalances can result in Mg and trace element deficiencies for stock.

Because the wastewater contains only a small proportion of sodium (approximately 9.5 g/m^3), structural stabilities of the soils on this Mossburn farm are not expected to significantly deteriorate. The likely effects of sodium are best assessed using sodium absorption ratio which should be below 10-15 to prevent problems of soil structural breakdown. Using wastewater concentrations of sodium, magnesium, and calcium provided in section 2(f) of the AEE, sodium absorption ratio is calculated to be less than 1.0.

Application of wastewater will result in significant increases in pasture production as a result of nitrogen responses. These will be most marked in the spring and autumn, and of considerable value in early parts of both seasons; in early spring for lambing, and in late autumn for winter feed conservation. Pasture responses greater than 80% have been recorded in New Zealand with abattoir wastewater (Russell and Cooper, 1987). It is estimated that wastewater applications will result in an annual increase in dry matter production on this Mossburn farm of approximately 20% (L.C. Smith, Agresearch, Woodlands, *pers. comm.*).

8. RECOMMENDATIONS FOR MONITORING THE EFFECTS OF WASTEWATER IRRIGATION

The following sections present recommendations for monitoring the effects of wastewater irrigation on soil processes and conditions.

8.1 Soil physical and chemical

Each year for the purpose of monitoring the effects of wastewater irrigation, the consent holder shall carry out sampling of the Dipton and Oreti soils at a minimum of five replicate sites for each soil, one of which will be a non-irrigated control, and analyse for the following:

- infiltration rate
- hydraulic conductivity

- pH
- exchangeable calcium
- exchangeable magnesium
- exchangeable potassium
- exchangeable sodium
- phosphorus (Olsen P)
- total organic carbon
- total nitrogen

8.2 Water balance

To monitor the effects of wastewater irrigation on soil water conditions and drainage, the consent holder will maintain a water budget for the farm detailing water inputs (rainfall and wastewater irrigation volumes), daily estimates of water losses (drainage and evapotranspiration), and daily estimates of soil water contents for each irrigation block, and non-irrigated areas (for the Oreti and Dipton soils).

The consent holder will supply to the Council an annual report of this water budget prepared by a suitably qualified person.

9. REFERENCES

Haynes, R.J.; Williams, P.H. (1993). Nutrient cycling and soil fertility in the grazed pasture ecosystem. *Advances in Agronomy 49:* 119-199.

O'Byrne, T.N. (1986). *Soils of part Wallace County, South Island, New Zealand.* New Zealand Soil Bureau Soil Survey Report 91. 120 pp.

Penman, H.L. (1963). *Vegetation and hydrology.* Commonwealth Agricultural Bureau Technical Communication 53.

Russell, J.M.; Cooper, R.N. (1987). Irrigation of pasture with meat-processing plant effluent. *Proceedings of the 42nd Industrial Waste Conference, 1987:* 491-497.

Scotter, D.R., et al. (1982). Measuring saurated hydraulic conductivity and sorptivity using twin rings. *Australian Journal of Soil Research 20:* 295-304.

Williams, P.H. (1993). *Assessment of the impact of dairy farming on the environment using contaminant budgets.* In: Southland Dairy Farming Expansion, Environmental Impact Assessment. Report prepared for Southland Regional Council by Robertson Ryder & Associates, Dunedin: 19-57.

APENDIX TWO – Silver Fern Farms Mossburn Annual Report 2016 / 2017

App2.

SOILWORK LTD

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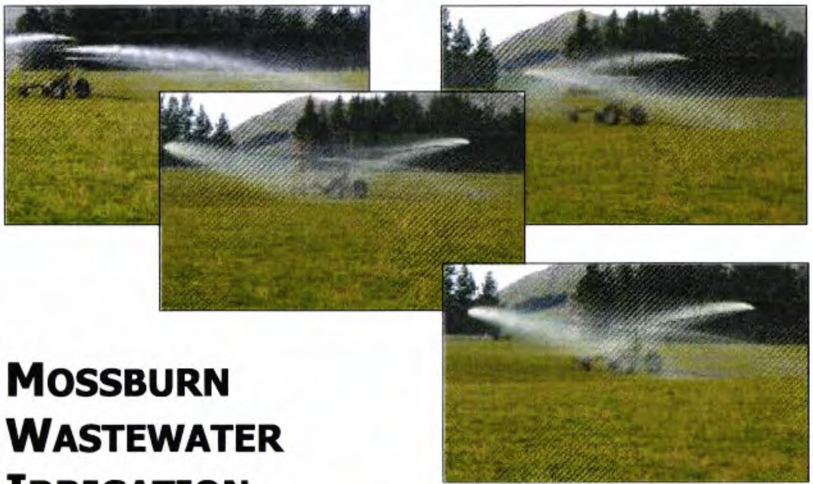
SILVER FERN FARMS LTD



MOSSBURN WASTEWATER IRRIGATION

SOIL MONITORING 2016-2017

Prepared for

Silver Fern Farms Ltd

By Dr P. B. Greenwood

October 2017

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1 INTRODUCTION

Under Southland Regional Council Consent No. 95498, wastewater from Silver Fern Farms Ltd Mossburn venison processing plant was irrigated onto approximately 34 ha of land adjoining the plant until the end of the 2015-2016 season. Following closure of the plant, no further wastewater applications were made during the current reporting period (1 September 2016-31 August 2017).

This report summarises results of a soil assessment that was conducted in May 2017, approximately one year after the final venison kill. The relevant consent condition is given below:

CONDITION 12

"Once annually, the consent holder shall take two Oreti soil samples. One sample from the area that receives wastewater, and the other from an area that does not receive wastewater. Each sample shall be analysed for the following:

- *pH*
- *exchangeable calcium*
- *exchangeable magnesium*
- *exchangeable potassium*
- *exchangeable sodium*
- *phosphorus (Olsen P)*
- *total organic carbon*
- *total nitrogen*

In addition, the infiltration rate and hydraulic conductivity shall be measured at each soil sampling site."

2 SOIL MONITORING

2.1 METHODOLGY

Six replicate measurements of infiltration rate and three samplings for hydraulic conductivity measurements were made at each of two monitoring sites (one irrigated and one non-irrigated) on the Oreti soil.

Infiltration rate was measured in situ using the twin ring method. Automatic recordings of water column height in mariotte devices were made with transducers, and a processor coupled to the transducers simultaneously calculated infiltration rate results.

Hydraulic conductivity was measured for the 0-5, 5-10, and 10-15 cm soil depths at each sampling location. Measurements were made using constant head permeameters connected to a logging and calculation device. Saturated hydraulic conductivities were measured for each soil core.

For the soil chemical sampling, 0-7.5 cm soil cores were sampled at regular distances along diagonal transects across each sampling area. Approximately 40 soil cores were collected from each site. After mixing, a subsample of sufficient size was withdrawn and used for analyses. Soil chemical determinations were made by RJ Hill Laboratories Ltd.

2.2 RESULTS

SOIL CHEMICAL PROPERTIES

Results of soil chemical tests are given in Table 2.1 with some earlier results for comparison. For the irrigated comparison, results prior to May 2006 are from two irrigated sites that were averaged for comparison with the one irrigated site that has been monitored since May 2006.

Table 2.1:
Results of soil chemical analyses.

SITE	Sampling date	pH	Ca (1)	K (1)	Mg (1)	Na (1)	Olsen P ($\mu g\ ml^{-1}$)	Organic carbon (%)	Total N (%)	ESP (%)
Irrigated	Sep 2001	5.7	6	10	17	5	17	10.5	0.80	0.7
	Oct 2002	5.6	9	5	10	4	10	7.0	0.59	0.5
	May 2003	5.7	9	9	18	5	17	9.6	0.77	0.6
	May 2004	5.8	11	12	15	5	19	9.0	0.72	0.6
	May 2005	6.1	13	7	12	6	17	8.5	0.68	0.8
	May 2006	5.9	9	7	14	6	14	9.4	0.71	0.8
	May 2007	5.9	11	5	14	5	16	9.3	0.70	0.6
	May 2008	5.9	11	13	16	8	20	9.1	0.76	0.8
	May 2009	6.2	14	9	14	7	15	9.4	0.77	1.0
	May 2010	6.1	14	7	13	8	11	9.0	0.72	0.9
	May 2011	5.8	11	4	11	5	12	7.8	0.68	0.5
	May 2012	5.7	9	4	11	6	10	7.2	0.67	0.7
	May 2013	5.9	9	5	10	7	11	8.1	0.65	0.8
	May 2014	6.1	12	5	11	5	10	9.1	0.71	0.6
	May 2015	6.1	12	5	13	6	13	8.8	0.71	0.6
	May 2016	6.3	15	5	14	6	12	9.3	0.75	0.7
	May 2017	**6.1**	**11**	**3**	**12**	**4**	**8**	**8.7**	**0.71**	**0.5**
Dryland control	Sep 2001	5.7	5	6	13	5	18	8.5	0.63	0.8
	Oct 2002	5.4	7	6	13	4	15	7.1	0.57	0.5
	May 2003	5.7	6	6	11	5	12	8.1	0.59	0.7
	May 2004	5.7	9	10	15	4	18	8.3	0.62	0.5
	May 2005	5.7	9	6	12	5	15	8.0	0.64	0.6
	May 2006	5.9	9	6	14	7	13	7.8	0.66	0.7
	May 2007	5.9	10	6	12	7	13	8.0	0.67	0.9
	May 2008	6.1	17	12	17	5	23	7.7	0.66	0.5
	May 2009	6.4	16	10	18	5	14	8.3	0.72	0.6
	May 2010	6.2	15	6	15	5	12	8.2	0.67	0.6
	May 2011	5.8	10	3	9	5	12	7.7	0.57	0.6
	May 2012	5.8	9	4	8	4	8	6.9	0.59	0.6
	May 2013	5.9	8	3	9	5	12	8.1	0.65	0.7
	May 2014	6.4	13	4	9	3	10	7.9	0.58	0.4
	May 2015	6.2	9	3	10	4	10	6.7	0.47	0.5
	May 2016	6.0	12	4	11	5	12	8.4	0.63	0.6
	May 2017	**6.1**	**11**	**3**	**11**	**5**	**9**	**8.4**	**0.62**	**0.7**

(1) Equivalent MAF Quick Test Units

The May 2017 data in Table 2.1 shows that approximately one year after the final wastewater irrigation on this site values of soil pH, and concentrations of all base cations, Olsen P, and organic carbon, were much the same for both the irrigated and control areas. With low concentrations of soil sodium, both values of soil exchangeable sodium percentage were very low and easily satisfactory for the maintenance of good soil structure.

Total soil nitrogen is the only parameter that shows a clear difference between control and wastewater sites, with the concentration within irrigated areas (0.71%) being greater than for the control site (0.62%). Both of those are within a high range, however they are the same as corresponding averages for the previous sixteen annual assessments, and values of C:N ratios calculated using this data are similar for both areas (irrigated, 12%; control, 14%), and are within a medium range. Those ratios indicate a normal rate of organic matter turnover.

Because this was expected to be the final soil chemical assessment here, values of anaerobically mineralisable nitrogen (also referred to as available nitrogen) were also assessed. This parameter is a measure of the amount of nitrogen that can be readily mineralised from soil organic matter, and resultant values of available nitrogen were 72 kg/ha for the control area and 103 kg/ha for the irrigated sampling areas. While the value was highest for irrigated areas, both are within a low range and indicate a low potential nitrogen supply to growing pasture plants, and thus also a low current potential for nitrogen leaching.

Overall, as in other seasons when wastewater was applied, there were no significant differences in soil chemical properties between the control and wastewater areas in May 2017. Values of soil ESP, soil pH, and concentrations of calcium, magnesium, and organic carbon were satisfactory, however because of 'cut and carry' herbage removals from the site, concentrations of soil Olsen P and potassium were deficient for pasture production and amounts of available nitrogen were within a low range. For future optimum pasture production, fertilisation with phosphorus, potassium, and some nitrogen is required.

SOIL PHYSICAL PROPERTIES

Geometric means of infiltration rates for the monitoring sites are given in Table 2.2.

Again, the May 2017 data continues to show that infiltration rates at both the control and wastewater sites remain high and easily adequate for full infiltration of any wastewater and rainwater without ponding or runoff occurring.

For both areas, the most recent infiltration rates were lower than long-term averages of 382 mm/hr for the wastewater sites and 261 mm/hr for the control site, but these differences are of little relevance because all the rates have remained high since recording began in 2001.

As reported previously, soil organic carbon concentrations, and both root and earthworm activities, are good at this site, while soil compacting processes have been limited to the traffic associated with just 2-4 pasture harvests each season. Consequently, increases in soil compactness to the extent necessary to significantly reduce infiltration rate have not occurred. Instead, increased root and earthworm activities under wastewater irrigation here have resulted in higher infiltration rates than for the non-irrigated control. For all wastewater irrigation seasons, and including the current reporting season after the cessation of irrigation, average values of infiltration rate for the wastewater and control sites are 377 mm/hr and 258 mm/hr respectively.

Table 2.2:
Geometric means of infiltration rates.

SITE	Sampling date	Infiltration rate (mm/hr)
IRRIGATED	Sep 2001	2,322
	Oct 2002	122
	May 2003	414
	May 2004	510
	May 2005	612
	May 2006	328
	May 2007	540
	May 2008	350
	May 2009	309
	May 2010	540
	May 2011	284
	May 2012	287
	May 2013	313
	May 2014	432
	May 2015	378
	May 2016	309
	May 2017	**302**
DRYLAND CONTROL	Sep 2001	2,551
	Oct 2002	468
	May 2003	378
	May 2004	504
	May 2005	244
	May 2006	169
	May 2007	310
	May 2008	205
	May 2009	179
	May 2010	166
	May 2011	165
	May 2012	144
	May 2013	144
	May 2014	320
	May 2015	281
	May 2016	237
	May 2017	**220**

Geometric means of saturated hydraulic conductivities in May 2017 are given, along with results from earlier measurements, in Figure 2.1.

In May 2017, soil within both the wastewater irrigation area and the non-irrigated control area remained well-structured and friable, with good root and earthworm activities. However, because the latter have been enhanced by previous wastewater irrigations, soil within the wastewater zone has a more stable structure and thus a somewhat higher permeability. As a result, hydraulic conductivity for the 0-15 cm soil depth there was again higher than at the control site. The average 0-15 cm depth values in May 2017 were 1.1×10^{-4} m/s for the wastewater sites and 4.7×10^{-5} m/s in the control area. Those values are broadly similar to corresponding long-term means of 9×10^{-5} m/s and 3×10^{-5} m/s.

Current values of hydraulic conductivity, as with all previous values in seasons when wastewater was applied, are satisfactory and reflect good soil structure and high permeability. They remain easily sufficient for adequate soil aeration and for good internal transmission of excess water through the soil without waterlogging or ponding occurring.

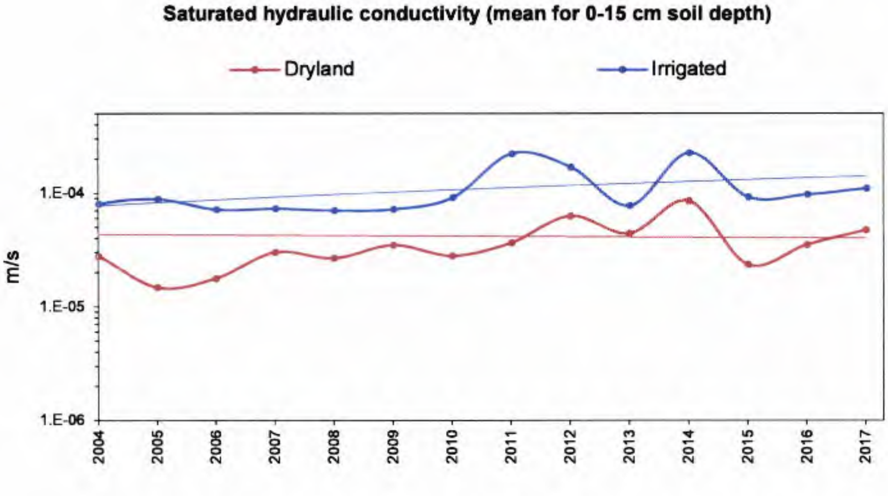


Figure 2.1:
Geometric means of hydraulic conductivities with trendlines.

3 SUMMARY AND RECOMMENDATIONS

During earlier periods of irrigation at this site, wastewater had no significant adverse effects on the soil chemical and physical properties measured. Instead, it resulted in greater earthworm and root activities, and consequently in higher average organic carbon concentrations (8.7% versus 7.9%), improved and more stable soil structure, higher average infiltration rate (377 mm/hr versus 258 mm/hr), and increased average hydraulic conductivity (8.8×10^{-5} m/s versus 3.5×10^{-5} m/s). Overall, therefore, wastewater applications resulted in moderate improvements in soil conditions.

Except for deficiencies in potassium and Olsen P, current values of soil parameters measured under this consent are satisfactory, and unless wastewater irrigation is resumed, it is recommended that no further soil monitoring is necessary.

APENDIX THREE - Aqua Firma Initial Hydrology Assessment

App 5

PPCS Mossburn Venison Abattoir;
Assessment of Effects on the Environment;

Technical Report on Surface Water Hydrology, Surface Water Quality Effects, Hydrogeology and Groundwater Quality Effects.

1. Introduction.

Primary Producers Cooperative Society Ltd (PPCS) have applied for a resource consent to cover the operation of a proposed expansion of their current land irrigation operation associated with the Mossburn venison abattoir in north-west Southland. This technical report integrates the following:

- the initial *pro forma* Assessment of Effects covering surface water and groundwater impacts on the environment,
- responses to a request for additional information, and
- two supplementary reports concerning surface water flow / quality characterisation, and hydrogeology.

This technical report is intended to be an appendix of the principal Assessment of Effects on the Environment and complementary to other appended technical reports on subjects such as soil science.

2. Characterisation of Physical Resources.

2.1. Geology.

2.1.1. Geological Basement

The basement rock type ultimately underlying the entire effluent application area is undifferentiated hardened siltstone and sandstone of Triassic (220 million years before present) age. The rock can be colloquially described as 'greywacke'.

The basement rock crops out in the flanks of the Mossburn Hill. A quarry about 1 kilometre north-west of Mossburn on the Lumsden - Te Anau highway shows good exposures of jointed lithified siltstone ('greywacke'). The inferred surface expression of the basement has been mapped by Wood (1966) and encompasses all of Mossburn Hill and its flanks.

2.1.2. Quaternary deposits

Sedimentary deposits of the last 2 million years before present are dominated by glacial outwash deposits left by the penultimate (120,000 years before present) and last (16,000 years before present) glacial periods. The site lies upon a terrace formed by glacial outwash left at the close of the last glacial period. It is generally composed of sandy gravel layers formed in a braided river environment analogous to the present-day Oreti River. Exposures of the upper terrace gravel deposits can be found in the gravel pit adjacent to the town landfill. However, the uppermost 8 metres of the alluvium encountered in drilling investigations has a highly mixed lithology comprising silt, clays, clayey boulder lags and occasional layers of sandy gravel or sand.

Water bores drilled in the Mossburn township indicate that there is at least 14 metres' thickness in these outwash gravels under Mossburn township. This thickness will decrease with proximity to the margins of Mossburn Hill. Soils, especially those in the deer block, generally form directly over the gravel deposits without significant mantling by loess.

2.2. *Hydrogeology.*

2.2.1. Water Bores

Prior to the Mossburn township being supplied by Wallace County Council with a reticulated supply, several households and businesses sank bores for water. Bore logs available for the 1950's and 1960's include several bores in the Mossburn area.

The deepest recorded bore sunk in Mossburn on the upper terrace had a depth of about 14 metres. It had a standing water level of 4.2 metres below ground and a specific capacity of 220 gallons per hour per foot drawdown (7.36 m^3/d/m in metric units). The bore drew on sandy gravels. Another bore on Wreys Bush Road to the south-west of the effluent application areas encountered topsoil and clay for the uppermost 6 metres and sandy gravel to 10 metres' depth thereafter. Drillers anecdotes suggest that there are extensive areas of quite 'tight' alluvium unsuitable for water bore or well development along Wreys Bush Road.

Test drilling on the Oreti River flood plain to north-east of Mossburn township in September 1980 revealed that specific capacity in a transect of 8 drill holes along Golf Links Road decreased with distance away from the Oreti River, from 1,025 m^3/d/m at 480 metres distance, to 86 m^3/d/m at 715 metres distance at the foot of the terrace riser. Specific capacity measured in the upper terrace 14 metre water bore (mentioned above) is an order of magnitude lower than the lowest Oreti River flood-plain specific yields. This pattern is consistent with that observed throughout Eastern Southland (Rekker, 1994; and Rekker, 1995)

Few water bores still exist in the district since the reticulation of supply from the District Council well on the Oreti flood-plain. Inquiries with locals and the District Council village man (Bill Pearson) failed to locate any existing bores or wells. However, on further examination one disused water bore was found on land comprising the site of the former NZ Electricity Department line camp. Education Board files record the presence of a water bore serving the Mossburn Primary School prior to reticulation. It is not believed to be operative.

2.2.2. Estimates of Parameters

While the range of specific capacity measured in old bores in the Mossburn area are useful in comparing bore yields and relative transmissivity, they are not a valid data-set from which to estimate aquifer permeability.

Previous aquifer tests have derived a range of permeabilities for Southland Quaternary gravels. In general, aquifer tests of rank 1 terraces such as the upper terrace at Mossburn indicate horizontal permeabilities (K) in the range of 80 - 200 metres per day.

The aquifer parameter of storage is not easily determinable from pumping tests. The range of specific storage (S_y) is generally accepted to be 0.1 to 0.25 (dimensionless). Effective porosity which partly controls groundwater flow velocity falls in the range of 0.1 to 0.2 (10 to 20%) for the types of deposits found at the effluent application areas.

Table 2 Ranges of hydrogeologic parameters for the Mossburn area.

Parameter	**Value**
Horizontal coefficient of permeability (m/d)	80 - 200
Specific storage (m/m)	0.1 - 0.25
Effective porosity (m/m)	0.1 - 0.2 (10 - 20%)

2.2.3. Groundwater Flow Pattern

Replenishment of these aquifers is generally by soil drainage of excess precipitation. Rarely, streams and creeks will provide replenishment of the aquifer.

The overlying soil acts as a reservoir and attenuator of precipitation falling in the area. During periods of precipitation when the field capacity of the soil is exceeded excess water will also drain through the subsoil into the moist gravels above the water table. Excess soil water may also runoff the soil because of infiltration overload. Artificial drains are often very effective in capturing soil drainage and conducting the water away to water courses before water logging or infiltration to groundwater. Excess soil water which is beyond the reach of drains percolate slowly through the moist gravels and coalesce with groundwater at the water table.

Groundwater appears to be perched on clay layers and clayey boulder lags at various levels or the sub-soil profile under the proposed effluent application site (see Drilling Investigations). Such a setting sometimes involves perched groundwater ultimately percolating to a 'regional' water table. Alternatively, the perched groundwater may flow laterally into semi-confined saturated layers, or leave the ground at drains or water courses.

Once below the perched or 'regional' water table, groundwater movement tends to become lateral, in the direction of predominant groundwater flow in the case of the 'regional' water table. The discharge sites of alluvial groundwater systems are usually streams, ponds, wetlands and rivers upon or incised into the alluvial deposits.

Murray Creek may be the principal receptor of groundwater in the effluent application area. Alternatively, the 'regional' unconfined aquifer may flow north-east towards the

Oreti River or seepage creeks that drain the foot of the terrace riser between the Oreti River flood-plain and upper terrace.

2.3. Surface Water Hydrology & Water Quality.

Figure 2.1 shows the location of various water courses in the effluent application areas. The areas lie wholly within the Murray Creek catchment which rises on Mossburn Hill west of Wreys Bush Road and flows through the Douglas farm and out to the Oreti River.

A number of farm ditches are also maintained through the farm property. Tile drains flow into these ditches and Murray Creek. The pattern of farm drainage is also shown on figure 2.1. Several areas of moist pasture are found on the property. Generally these patches are drained by tile drains.

2.3.1. Murray Creek

Murray Creek at the Douglas property is a small, channelised creek on the border-line between perennial and ephemeral. Its bed is a mixture of cobbles and clay with silty banks. Its mean discharge is estimated to be 5 litres per second. It gains significant recruitment of flow from drains and farm ditches in the Douglas property.

A recent survey of Murray Creek about 5 kilometres downstream has been undertaken in Southland Regional Council resource investigations (Ryder, 1995). This reach of Murray Creek earns a macroinvertabrate community index (MCI) score ranging between 100 and 81, indicating an enriched / modified macrofaunal association. The dissolved inorganic nitrogen concentration (see section 2.4 for water quality characterisation), as nitrate, nitrite and ammoniacal nitrogen, exceeds the 0.10 to 0.04 g/m^3 guideline for the nuisance algal growth guidelines by an order of magnitude. Comparison of February 1995 low flow water quality within the Oreti catchment, with respect to the magnitude of nitrate concentration, found only Waikiwi Stream near Invercargill (Ryder, *ibid*) to be of higher concentration. The existing creek water chemistry would appear to reflect a moderately to highly impacted water body.

2.3.2. Oreti River

The Oreti River lies about 2 kilometres to the north of the effluent application areas. In 1994 the river had a mean flow of 11.8 m^3/s at the upstream Three Kings recording station and the lowest daily flow in 1994 was 2.9 m^3/s (*pers. comm.*, Chris Jenkins).

Water quality is 'good to very good' (Ryder, 1995). Total phosphorus and nitrogen in the river is 2 and 150 mg/m^3 (ppb), respectively (Ryder, *ibid*). Faecal contamination at 110 faecal coliforms MPN per 100 ml during February 1995 low flow conditions is below the bathing guideline (Ryder, *ibid*).

Figure 2.1 Arrangement of surface water features and farm drainage.

2.4. *Field Studies of Surface Water Quality.*

2.4.1. Method.

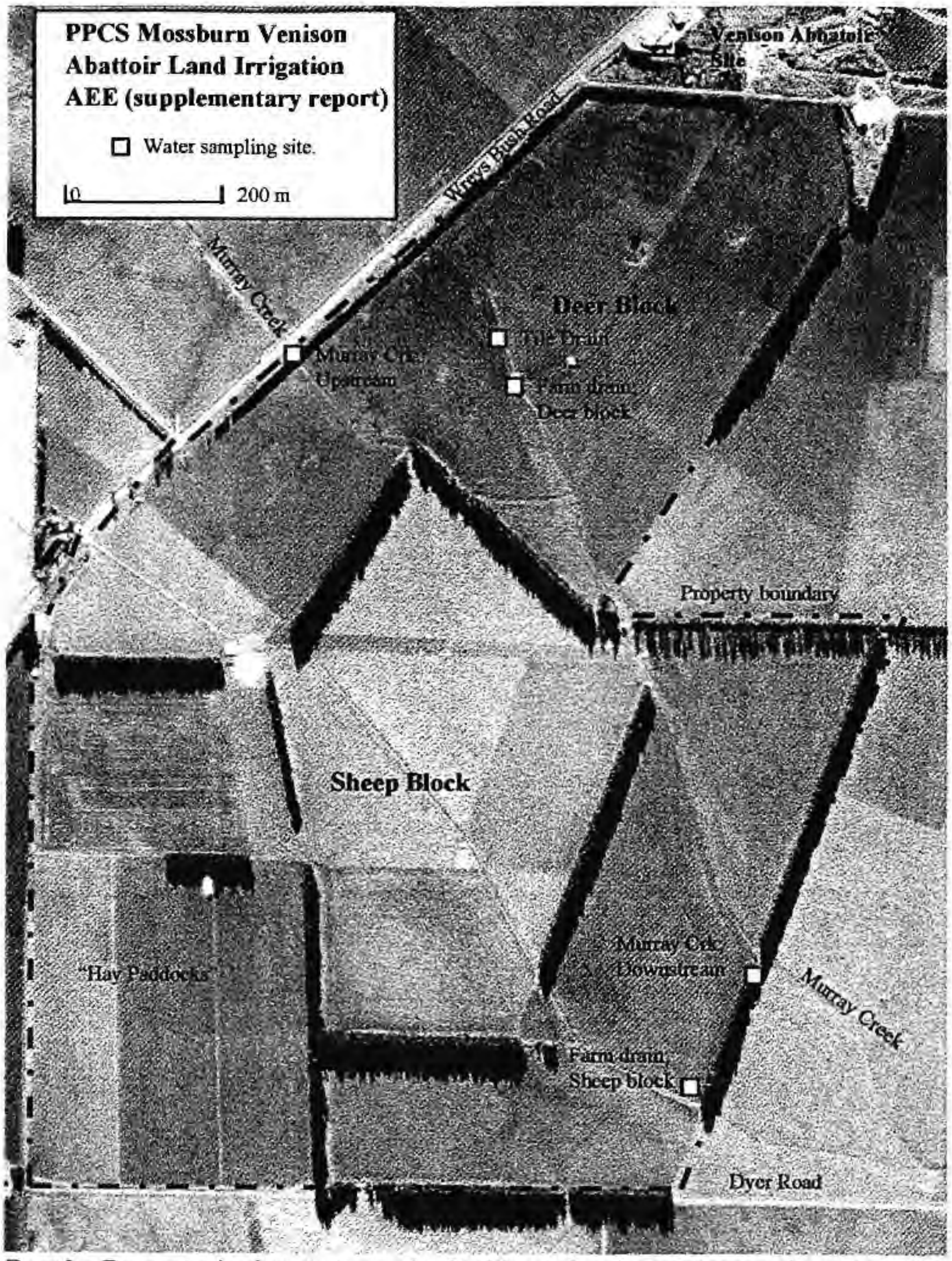
Five separate samples of surface water and soil water were taken on 7 August 1996. Grab samples were taken in mid-stream using a specialised sampling arm. Some of the samples were fixed with preservatives, and all were chilled in bins to about 4°C for delivery to the analytical laboratory on the same day. The weather was cloudy and rain had fallen heavily in the previous two days.

2.4.2. Sample Sites.

Murray Creek is the principal water body in the farm area. A set of samples each were taken at the upstream (north-western) boundary and on the downstream (south-eastern) boundary where the creek leaves the farm property. Additional farm drains in the deer and sheep blocks respectively were sampled. In order to obtain a sample of soil drainage a sample was taken from a flowing tile drain discharge. Each of the sample sites is shown in the aerial photograph of the farm.

2.4.3. Analytical Results.

Units in g/m^3	Murray Crk; Upstream	Murray Crk; Downstream	Farm Drain; Sheep Block	Farm Drain; Deer Block	Tile Drain; Deer Block	Mass in Murray Creek D/S (kg/d)
pH	6.99	7.17	6.34	6.2	5.48	
Elect. Cond. (μS/cm)	85.8	93.4	91.3	124.9	141.4	
Mg	2.1	2.3	1.7	2.8	1.9	15.9 kgMg/d
Na	4.6	4.5	3.6	2.8	3.3	31.1 kgNa/d
K	1.06	1.08	1.2	4.4	0.44	7.5 kgK/d
Ca	7.4	7.8	8	13	18.3	53.9 kgCa/d
Cl	4.4	4.6	4.5	4.1	5.1	31.7 kgCl/d
NO_3-N	1.69	2.1	2.1	4.9	6	14.5 $kgNO_3$-N/d
NO_2-N	0.008	0.009	0.004	0.006	<0.002	0.06 $kgNO_2$-N
SO4	2.3	3.4	6.5	9.1	11	23.5 $kgSO_4$/d
NH_4-N	0.05	0.03	0.02	0.03	0.02	0.2 $kgNH_4$-N/d
Susp. Solids	3	15	<2	7	<2	102.7 kgSS/d
BOD_5	<2	<2	<2	<2	<2	-
Diss. Oxygen	12.87	13.2	13.31	11.48	10.22	-
Total P	<0.02	0.02	<0.02	<0.02	<0.02	0.13 kgP/d
Diss. React. P	<0.01	<0.01	<0.01	<0.01	0.05	-
HCO_3	25	24	23	25	15.6	-
Total Coliforms	71	77	54	56	14	-
E. Coli /ml	1	nil	nil	nil	nil	-
Flow Rate	52 l/s	80 l/s	24 l/s	10 l/s	0.5 l/s	



Douglas Property Aerial-photograph Positions of surface water sampling sites shown.

2.4.4. Interpretation of Results.

The non-microbiological parameter results in the table above breach neither the drinking water standards for potable water nor the guideline values for stock water (ANZECC, 1992).

The tile drain discharge of 0.5 litres per second contained the highest concentrations of contaminants potentially derived from agricultural activities, such as nitrate and dissolved reactive phosphorus. The concentrations measured in the tile drain give some indication of soil drainage concentrations during high soil-water content periods (such as following heavy winter rain). The nitrate result of 6 gNO_3-N/m^3 in soil drainage is approximately consistent with the estimate of about 20 $kgNO_3$-N/ha/yr.

2.5. *Surface Water Gauging.*

Several flow gaugings were made of the water bodies flowing through the farm.

2.5.1. Methodology.

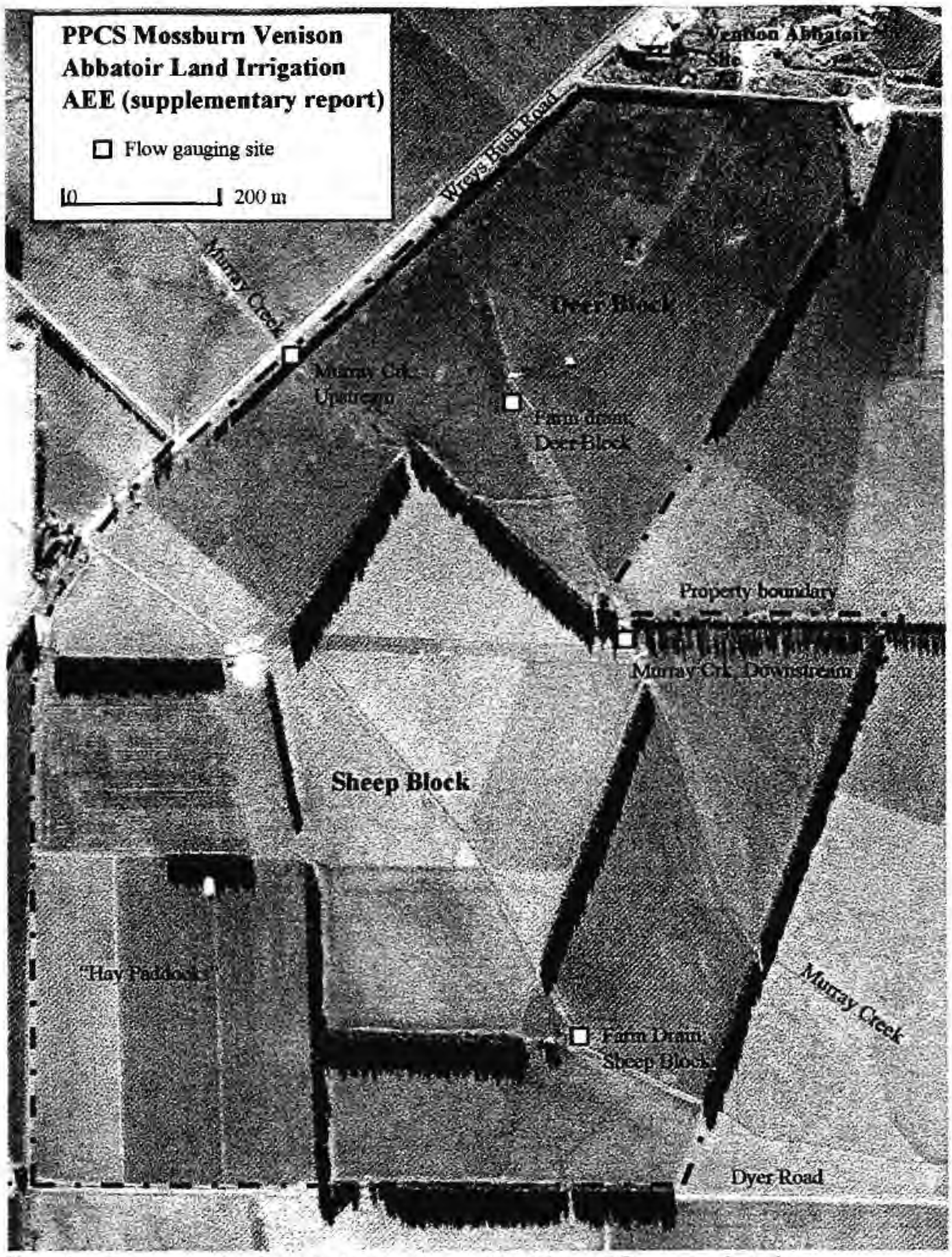
All gaugings were carried out on 6 August 1996. A counting flow velocity meter employing a Baby-OTT propeller was used to carry out creek transect and culvert gauging of creek and farm drain discharge. Culverts were used in preference to creek transects due to the uniform geometry and absence of aquatic plants.

The tile drain discharge was simply gauged using a calibrated 3 litre jug and timing the quantity filled inside a number of seconds. This gauging was made on 7 August, at the time of sampling.

2.5.2. Flow Rates.

	Murray Crk; Upstream	Murray Crk; Downstream	Farm Drain; Sheep Block	Farm Drain; Deer Block	Tile Drain; Deer Block
Flow Rate	52 l/s	80 l/s	24 l/s	10 l/s	0.5 l/s

The crossing of a Murray Creek by Reid Macauley Road about 1 kilometre downstream of the Douglas property boundary was also gauged and was estimated to be flowing at a rate of 97 litres per second.



Douglas Property Aerial-photograph Position of flow gauging sites.

The pattern of creek flow increment shows a steady increase with distance downstream. Runoff coefficients have not been derived for these flow rates due the one-off nature of the data and the uncertainty as to flow divides. The existing farm sub-surface drainage appears to dominate the generation of creek flow and this is consistent with the observation of little overland flow runoff potential suggested in soil - water modelling (Greenwood, 1996).

2.6. Tile Drain Short-Circuit Trials.

Some uncertainty remained as to whether a potential existed for irrigation effluent to short-circuit *via* the tile drain network into surface water. Two trials were designed to test the degree and minimum length of soil - water retention directly above these field drains. The assumption is made that a minimum retention time of 1 day is sufficient to protect surface water quality from gross quality impacts such as BOD and suspended solids.

2.6.1. Methodology.

Two tile drains, one each in the deer and sheep blocks, were selected for the trials. The deer block drains are excavated to a depth of about 53 centimetres in poorer draining soils. The sheep block drains are also excavated to a similar depth in slightly more freely draining soils.

The path of the drain excavation was identified using a hand-held cone penetrometer probe. A 25 centimetre diameter containment ring was installed over the alignment of the drain at 6 to 10 metres laterally from the discharge. The soil was wetted by the addition of 3 litres of creek water to the sheep block ring and 2 litres to the deer block ring. Once these quantities had infiltrated about 1 litre of rhodamine tracer dye was applied within the ring.

2.6.2. Resulting Observations.

The tile drain discharge was periodically checked through the course of the 6th and 7th of August. No sign of dye was noted at the discharge or in surface water over the 24 hour period following dye application.

3. Drilling Investigations.

Drilling investigations were undertaken on the site on 17 December. Figure 3.1 shows the position of the two drill holes. The objectives of drilling were:

- to characterise in more detail the geology and hydrogeology of the alluvium beneath the effluent application site,
- to test the feasibility of installing permanent sampling bores on the site,
- to characterise groundwater quality if sampling bore installation is successful.

3.1. Drilling Methodology

A combination rotary - cable tool drilling rig employing temporary, threaded 4 inch casing was used in both drill holes. The drilling method used a drag bit and hollow drilling rods inside 4 inch steel casing. Water from Murray Creek was introduced into the drill hole through the rods and past the drill bit, and rose back to the surface through the temporary casing bringing drilled material to the surface in washings..

Both drill holes were pursued to a depth of 9 metres below ground.

3.2. Lithological Observations & Sample Bore Construction

The drilling method used made it difficult to fully describe the washed materials, but the general picture is that of considerable variability, clay-rich fine gravels and possibly perched shallow water tables. The geological materials found in drilling were unexpectedly variable and of lower permeability than anticipated. The appendix contains the bore logs drawn up from observations of material washed to the surface.

Due to the variability two sampling ports were placed in the ground at shallow and deep positions relative to each other, in order that water depth variations be accessible for comparison. The main 50 mm sampling tube was placed in the deep positions of 5.1 and 5.5 metres in DH1 and DH2, respectively. A second 20 mm sampling tube was placed at a shallower depth at the appropriate level to access a potentially perched water table in each drill hole. Slotted PVC waste pipe of D class was used in making up the sampling bores. A length of 1 metre of slotting at the bottom of each sampling bore. The annular space around each PVC bore was filled with Walton Park sand, back-fill, or bentonite pellets in accordance with standard sampling bore construction practice.

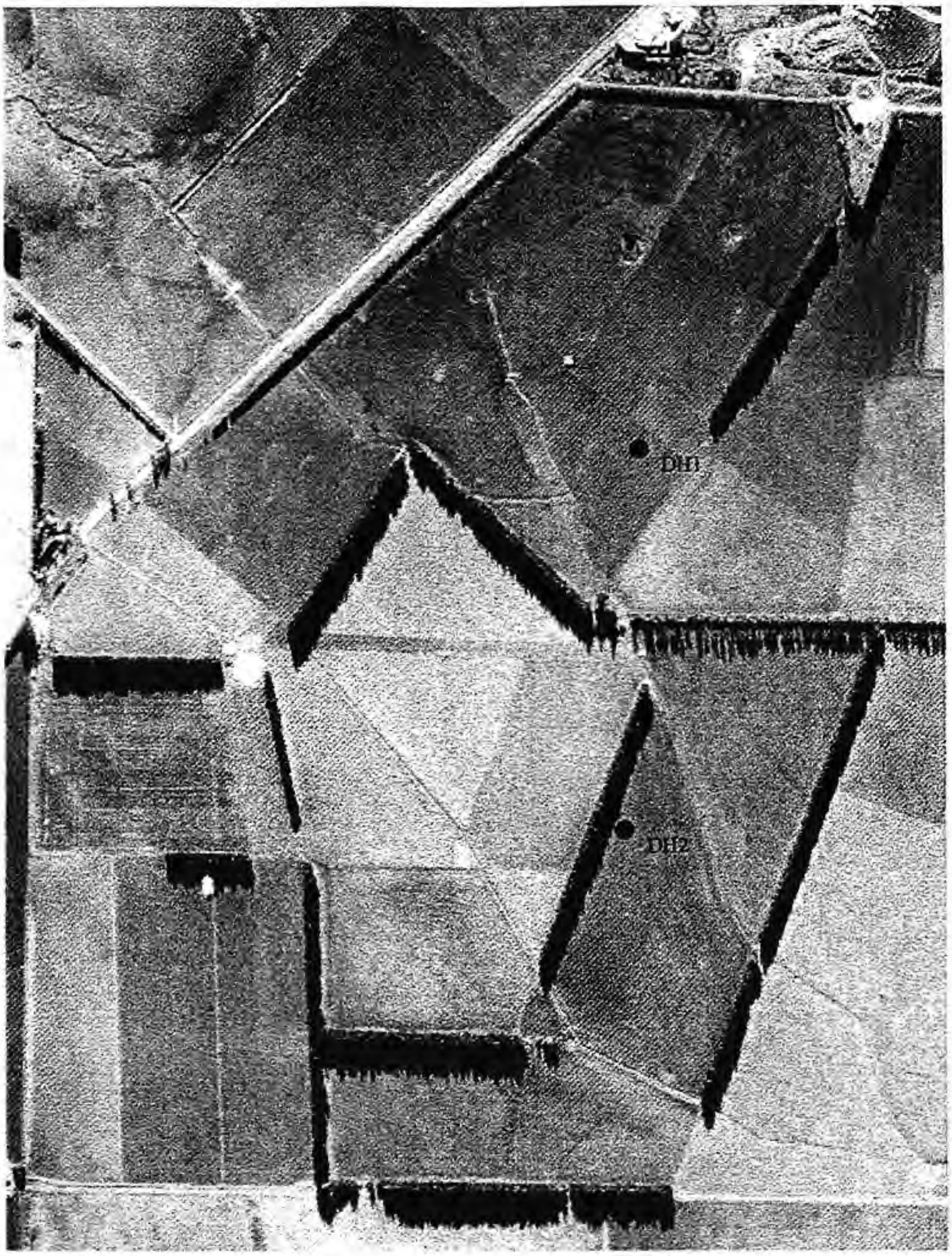


Figure 3.1 Position of drill holes.

3.3. Water Level and Sampling Observations

A (perched) water table was found at 1.1 metres below ground level in DH1 within the deer block as measured immediately following drilling and installation in the shallower sampling bore. Sampling was attempted from both drill hole's main 50 mm sampling bore resulting in a single turbid sample of groundwater being taken from the deer block (DH1) monitoring bore for nitrate, nitrite, ammonia, pH and conductivity analysis. The groundwater may be affected by added drilling water.

A follow-up sampling visit to both sample sites was made on 22 January 1997. Both of the main sampling bores were filled only with moist clay. The DH1 shallow sampler held water, but efforts to draw a representative sample were fruitless. The drilling contractors were instructed to inspect both sampling bore sites and take remedial action. This was done in February 1997. A further visit to ascertain whether sampling was feasible was made on 6 March 1997. Once again water was absent from the main 50 mm sampling bores and they were clogged with moist clay. No samples of groundwater could be drawn

It is inferred that at both levels selected to place the screens the sediments did, in fact, bear water at the time of drilling. That is to say, they intercepted perched water tables. However, the effects of drilling disturbance has been to cause a localised drainage of perched groundwater leading to the sampling bore being unable to collect groundwater.

4. Water Utilisation in the Area and Sensitivity of the Potential Receiving Environment.

4.1. Water Use in the Mossburn Area

As far as could be ascertained, almost all water use in and around Mossburn utilises the town supply obtained from the District Council well located on Golf Links Road. The supply is reticulated through the town and to a number of neighbouring farm properties so that little dependence is made on water bores or surface water. The rural area ringed by Wreys Bush Road, Reid Macauley Road, Dyers Road and State Highway 94, within which the effluent site lies, is reticulated from the Mossburn township water supply. Given the presence of this reliable, inexpensive, treated and pressurised water supply, it is hardly surprising not to find utilisation of groundwater in the present day.

Some passive use of Murray Creek for stock water is made on the Douglas farm. Several stock water supplies about 5 kilometres east from Mossburn utilise wind-driven water bores. A spring, above the effluent application site elevation, on Mossburn Hill is used for domestic water supply. In view of the low likelihood of groundwater utilisation in the broader area, the sensitivity of the potential groundwater receiving environment is low.

5. FARM SURVEYING.

5.1. Methodology.

The only map available at 1:6,250 scale, reduced from an original 1:2,000 scale, was a hand drawing traced from an aerial photograph dating from May 1986. Sufficient inaccuracy existed in the existing farm map to require surveying and a new farm map be produced. Also required was mapping of land surface and water features to identify overland flow runoff and ponding potential.

Global Positioning System technology was employed to carry out the surveying. Two Trimble 4000 units were used in Real Time Kinematic mode. One unit served as the base station, the other as a roving unit. Post-processing of the units' digital records included correction to existing benchmarks in Mossburn, Lumsden and Athol. The resulting map coordinate fixes and elevations are considered to be accurate to within 1 metre in the horizontal plane, and 2 centimetres in the vertical plane.

The paddocks proximal to the venison abattoir were considered to have the most undulation and most likely to be included in the land irrigation system. Hence the deer block and closer parts of the sheep block were included in the survey. The invert level in Murray Creek and the deer block drain were also included as points. The number of points almost exceeded 300, making the average density of surveying about 5.6 points per hectare. GPS surveying of boundary points was undertaken wherever possible to relate the scanned aerial-photograph and allow its scaling to full size.

Once the outline of the deer block and proximal sheep blocks was defined. the scanned airphotograph image was overlain and scaled to fit. Hence a composite drawing of the farm from surveying and the airphotograph was synthesised. Subsequently, farm paddock areas have been planimetered directly from the drawing. Figure 5.1 shows the numbered paddocks and their approximate areas in hectares.

The resulting 3-dimensional points were referenced to NZMG map grid system and mean sea level (Bluff datum) for map coordinates and elevation respectively. These were put into the computer graphical packages; AutoCAD® and Surfer®. For contouring of the land surface, the kriging interpolation method was used. Figure 5.2 shows contours drawn across the surveyed farm area by the method described.

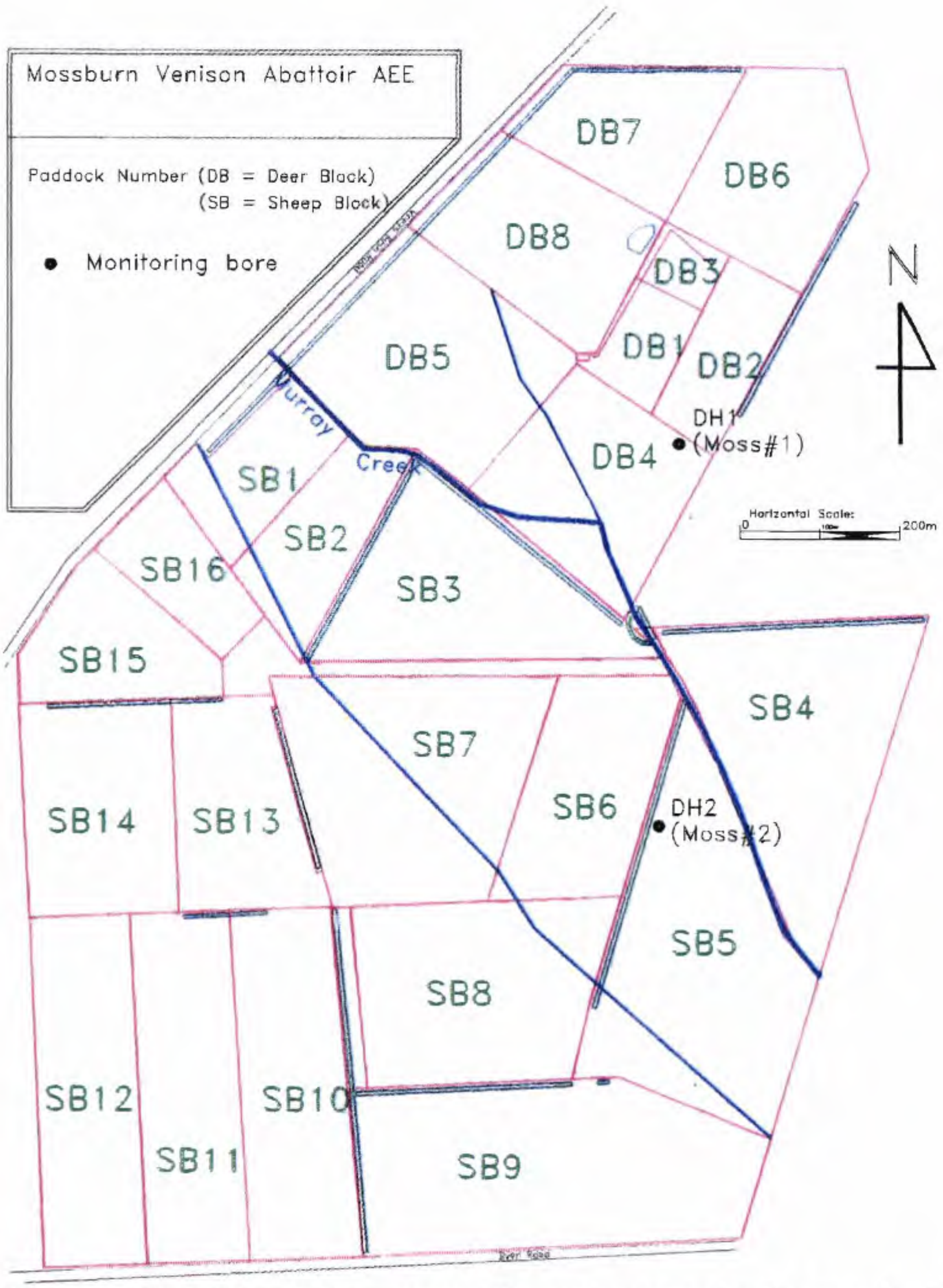


Figure 5.1 Map of Douglas farm property. The map is a composite of a scanned aerial photograph and the GPS survey data. The position of drill holes is shown.

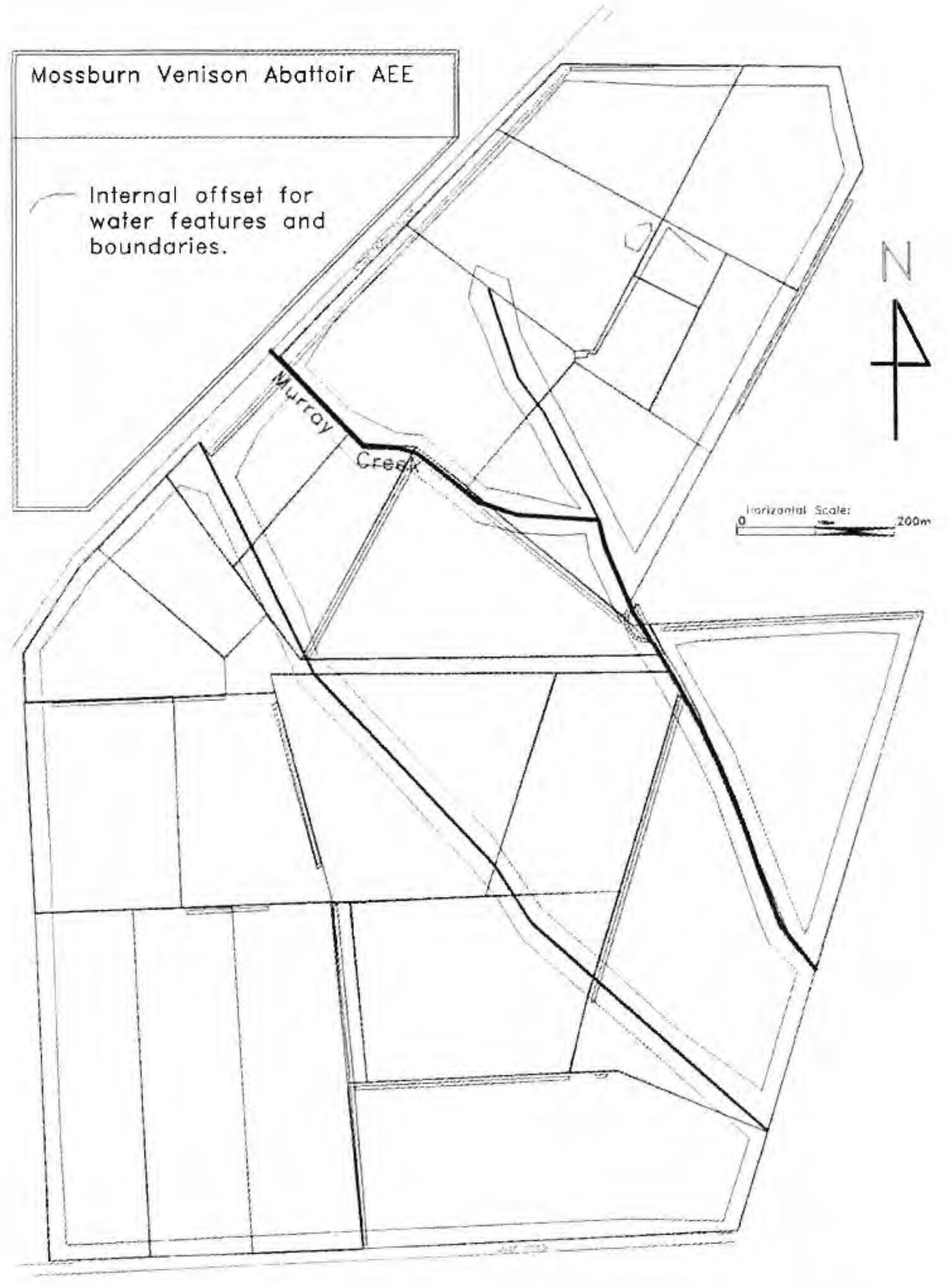


Figure 4.3 20 metre Buffer / Offset boundaries from water features and property boundaries.

Figure 5.2 Contoured ground elevation in Deer Block and proximal sheep paddocks. Elevation is referenced to mean sea level. Main metre contours are marked.

5.2. *Observations on Topography.*

From figure 5.2 it can be seen that Murray Creek and the deer block are the major depressions in the farm land surface. A further depression can be discerned in the north of the deer block, chiefly in paddocks DB6 and DB2.

The hollow and ephemeral pond in paddock DB8 shows up in the topographic survey as an isolated depression. Only very subdued topography was found in the sheep block paddocks of SB1, SB2, SB3, SB7, SB16 and SB15. A general 1% (1 in 100) gradient towards the south east is discernible from the topographic survey.

The topographic relief indicated in the topography survey does not adversely affect the suitability of the Douglas farm property site for land irrigation purposes. Slopes less than 2% have a significantly diminished capacity to support overland flow of rain runoff (Ontario Farm Environmental Coalition, 1993). Providing 20 metre buffer distances are observed to water courses, there is little likelihood of effluent running off into surface water under normal climatic conditions.

6. Buffer Distances.

The Proposed Regional Plan for Effluent Land Application (Southland Regional Council, 1996) contains buffer distance criteria for permitted activities. Even though the current application is for a discretionary activity under the heading of Industrial and Trade Process Effluent Discharges of the Proposed Plan, the guidelines set as to buffer distances for permitted activities are used here to mitigate potential adverse water quality effects.

The Douglas farm property map is re-drawn with 20 metre buffer distances set off from each water feature and external farm boundary. The map with offsets and new internal irrigation-available areas is shown below in figure 4.3. A new break-down of irrigation-available areas of the total farm area of 120.73 ha is given below:

Deer Block	22.37 ha
Sheep block (central)	19.70 ha
Sheep block (east)	5.22 ha
Sheep block (south)	49.39 ha
Total irrigation-available	96.68 ha

A further 1.54 ha will be lost from availability around the sheep yard buildings and lane within the sheep block. Another 0.2 ha may be lost from the tally due to the depression in paddock DB8 for which offsets may need to be observed. Alternatively, the depression may require landscaping. The question of re-landscaping is being examined.

7. Water Quality Monitoring.

Waters in the effluent irrigation site have some potential for being affected by effluent irrigation activity. In terms of the Resource Management Act 1991 and the Fourth Schedule to the Act, monitoring may be required if the effect of the activity is of a scale and significance to warrant it. A programme of monitoring water quality is suggested in sections 7.1 and 7.2, below.

7.1. Surface Water Quality.

The monitoring of surface waters within the site are Murray Creek and several tributary farm drains is suggested for an initial period of 2 years.

	Analyses	**Sampling Frequency**	**Comments**
Murray Creek Upstream at Wreys bush Rd crossing, GR 2137930mE, 5492920mN NZMG	$N0_3$-N, NH_4-N, TP, DRP, Faecal coliforms, pH, Electrical conductivity	Quarterly, for 2 years, then bi-annually	Upstream, ambient stream quality will be determined by this site
Murray Creek Downstream at Douglas property boundary, GR 2138610mE, 5492130mN NZMG	$N0_3$-N, NH_4-N, TP, DRP, Faecal coliforms, pH, Electrical conductivity	Quarterly, for 2 years, then bi-annually	Downstream affected stream quality will be determined by this site
Sheep Block farm drain at downstream property boundary, GR 2138550mE, 5491930mN NZMG	$N0_3$-N, NH_4-N, TP, DRP, Faecal coliforms, pH, Electrical conductivity	Quarterly, for 2 years, then bi-annually	Downstream water quality of this tributary to Murray Creek
Deer Block tile drain discharge, GR 2137660mE, 5493360mN NZMG	$N0_3$-N, NH_4-N, TP, DRP, Faecal coliforms, pH, Electrical conductivity	Quarterly, for 2 years, then bi-annually	Water quality of soil drainage will be monitored.

7.2. *Groundwater Quality*

If a serviceable sampling bore can be installed, quarterly sampling of tile drain water quality and flow rate should be undertaken in at least one sampling bore on the effluent application site. The results of quarterly tile drain water quality monitoring will be sufficient to demonstrate the effect of effluent irrigation on soil drainage quality and consequently on groundwater recharge.

	Analyses	Sampling Frequency	Comments
Tile Drain Discharge	NO_3-N, NH_4-N, TP, DRP, Faecal coliforms, pH, Electrical conductivity and flow rate	Quarterly, for 2 years, then bi-annually	Potentially impacted soil drainage water quality will be determined and impacts on groundwater

8. References Cited.

ANZECC (Australian & New Zealand Environment & Conservation Council), 1992. National Water Quality Management Strategy: Australian guidelines for fresh and marine water. 210p.

Balks, N.R. 1995. Some effects of land treatment / disposal of New Zealand meat processing plant effluent on soil properties. Partial requirement for the degree of Doctor of Philosophy, University of Waikato.

Greenwood, P.B. 1996. A preliminary assessment of the suitability of soils, and system design parameters, for land application of deer abattoir effluent at Mossburn. Prepared for Primary Producers Co-operative Society Ltd by SoilWork Ltd, Dunedin.

Ontario Farm Environmental Coalition, 1993. Ontario Environmental Farm Plan. Ontario Federation of Agriculture, Toronto, Canada.

Rekker, J.H. 1994. Southland Regional Groundwater Resource; Scoping Study. Southland Regional Council, Invercargill.

Rekker, J.H. 1995. Mossburn Water Supply Well. Southland District Council, prepared by AquaFirma Ltd, Dunedin.

Robertson Ryder & Associates. 1993. Southland Dairy Farming Expansion. Environmental Impact Assessment. Southland Regional Council, prepared by Robertson Ryder & Associates, Dunedin.

Robertson, B.M. 1992. Oreti - New River Estuary Review of Existing Water Quality. Southland Regional Council, prepared by Barry Robertson & Associates, Dunedin.

Ryder, G. 1995. Oreti Catchment Aquatic Biota/Chemistry Assessment 1995. Southland Regional Council, prepared by Robertson Ryder Ltd, Dunedin.

Wood, B.L. 1966. Geological Map of New Zealand, Sheet 24 Invercargill, Scale of 1:250,00. Dept. of Scientific & Industrial Research, Geological Survey. Wellington, New Zealand.

APENDIX FOUR - Silver Fern Farms Mossburn Integrated Land Management Plan

App 4

Environmental Management

EN

Integrated Land Management Plan

Environmental systems and procedures for Silver Fern Farms Mossburn land based activities

SILVER FERN™ FARMS

Printed copies are uncontrolled

Date Printed: 20 August 2018

Revision History

Date	Details	Amended by
1997	Farm Management Plan created	
August 2018	Update to Integrated Land Management Plan. Revisions include format, continual improvement, and content update as required.	Group Environmental

Terms Used

Buffer	A defined area from an activity being undertaken and a fixed point between which the activity is restricted.
Cut-and-carry	The term used to describe the resultant harvesting and removal of grass from a paddock following irrigation.
IANZ	International Accreditation New Zealand.
PLC	'Programmable logic controller' – runs the automation programmes interfacing with infrastructure and receives / messages automated alarms.
Primary Screening	The physical separation of material from the incoming waste stream, particularly solids by physical screening.
SCADA	'Supervisory Control and Data Acquisition' – Computer programme which is the interface between staff and the automation systems. Is controlled by the PLC's.
Soil Testing	A laboratory analysis of soil cores to evaluate the fertility status of the soil, providing a basis for fertiliser recommendations.
Wastewater	Liquid streams generated from meat processing operations and general wash-down water.

TABLE OF CONTENTS

1 Background

1.1 Environmental Management Plans

Silver Fern Farms next generation Environmental Management Plans are living documents that will be continuously improved upon. These consist of a roadmap to a larger set of documents, company-wide and plant specific, covering what is required to appropriately manage the relevant environmental aspects across Silver Fern Farms operations.

Each section of the Management Plan sets out the context to the subject matter, and a reference to the elements that make up the day-to-day systems and controls that guide what we do.

1.2 Integrated Land Management Plan

The aim of this Integrated Land Management Plan ('Management Plan') is to provide guidance to the systems and controls for the effective management of land-based wastewater irrigation, activities at Silver Fern Farms Mossburn operation.

Ensure alignment with other Silver Fern Farms Mossburn management plans, and other relevant company requirements, along with compliance with applicable legal requirements.

The systems and procedures referenced within ensure that land-based wastewater irrigation is undertaken in accordance with company's environmental objectives, and regulatory approvals (e.g., resource consents).

1.3 Objectives

In implementing this management plan, the primary objective is to achieve effective land treatment of all processing wastewater whilst meeting the following:

- maintaining high soil chemical, physical, and biological soil quality;
- avoiding surface ponding and runoff of wastewater,
- maximising degradation of wastewater on and within the soil;
- minimising leakage of wastewater constituents and products through the soil to the groundwater;
- maintain high nutrient take off through cut and carry operations
- appropriate management of the land when the processing facility is not in operation

2 Introduction

2.1 Physical address

Wreys Bush-Mossburn Road, Mossburn

2.2 Land Holdings

The Silver Fern Farms Mossburn land holdings comprise a total of 51 hectares.

2.3 Ownership and Tenure

The collective area of the Silver Fern Farms, Mossburn land holdings are shown in Figure 2.3 below.

Figure 2.3: *Indicative land area.*

2.4 References

The relevant resource consent for this land-based activity is summarised in Table 2.4:

Consent No.	Activity
95498	To discharge primary treated wastewater from a venison abattoir to land. Lot 1 DP 10874, Lot 2 DP 14189

Table 2.4: *Relevant resource consent*

2.5 Company Contact

Contact details for company representatives who act as contacts for the site are;

Silver Fern Farms Head Office 03 477 3980

2.6 Site Responsibilities

A summary of current site responsibilities is provided in Table 3.3 below.

Regional Manager	• Overall Responsibility
Environmental Land Manager (Group Environmental)	• Provides guidance and direction to Mossburn Farm Manager. • Assists to develop land management budgets, develop and maintain land management systems and procedures. • Oversee land agreement
Farm Manager (currently held by land agreement holder)	• Responsible for the day-to-day operation and management of the land-based wastewater disposal. • Provides the necessary resources to achieve operational objectives. • Selection, approval and engagement of required support contractors. • Responsible for carrying out tasks in managing the operations of the land-based wastewater disposal. • Responsible for alerting management to all environmental incidents or hazards which may result in an environmental incident, regardless of the nature or scale
Contractors	• Active involvement. • Responsible for carrying out tasks in accordance with their contractual requirement. • Responsible for alerting management to all environmental incidents or hazards which may result in an environmental incident, regardless of the nature or scale.

Table 3.3: *Summary of site responsibilities*

3 Health, Safety, Environmental and Training

Health, safety and environmental management is a cornerstone of all Silver Fern Farms operations, with an emphasis on zero harm to people or the environment.

Training awareness is conducted to all employees and contractors as part of induction and onsite awareness sessions.

Training systems are such to ensure that any person(s) performing a task is competent in the activity and aware of hazards, risks, controls and expected behaviours in relation to their workplace activities.

❖ Systems and Controls

Aspects are managed through a series of company policies and procedures; on-site manuals, supporting programmes and task instructions:

Element	Programme Type
ORA Health and Safety Policy	Company Policy
Environmental Policy	Company Policy
Induction	Company Standard
Training Coordinators Manual	Company Guidance
Mossburn Health and Safety Manual	Site System
Site Specific Aspects, e.g., o Site induction o Contractor induction o Isolation tagging o Hot work permit o Confined spaces o Working at heights o Project management	Various*

*

4 Wastewater Treatment System

When processing wastewater is sourced from across Silver Fern Farms Mossburn operations (primary butchery, secondary butchery, animal assembly, and areas of potentially contaminated storm water). Control of 'wet' activities within operational areas has direct influence on volumes and loadings of the wastewater discharged from those areas, this is largely influenced by food safety requirements.

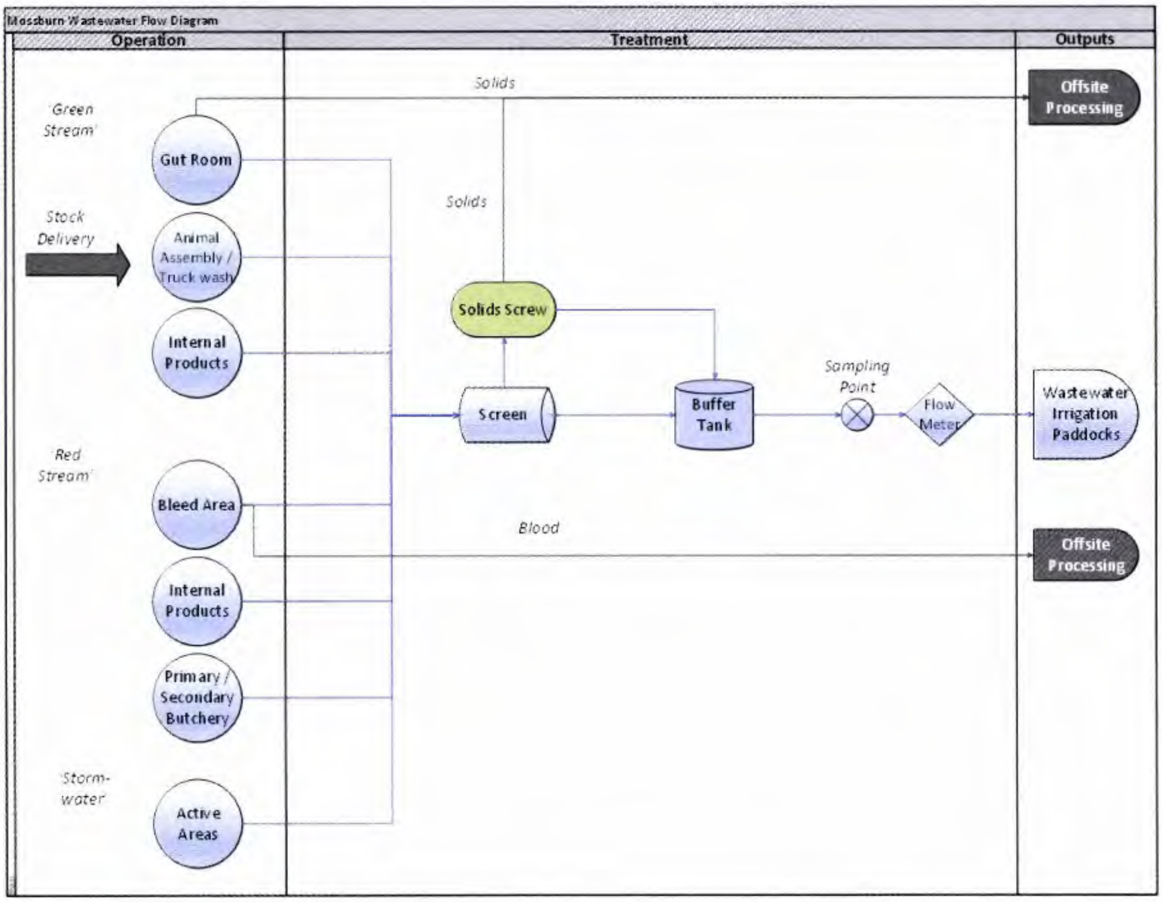


Figure 3.1(a): Wastewater treatment system.

All wastewater streams are combined before undergoing primary treatment. Combined wastewater is mechanically screened to recover coarse particles or 'solids'. Screened solids are conveyed from the screening area to a waste bin via a screw. Recovered solids are transported off site to a third party for further processing.

Following the removal of gross solids, the screened wastewater is directed into a buffer tank where it is combined with: wastewater that is separated during the dewatering (via screw press) of the screened solids collected; and, potentially contaminated stormwater from active areas when processing. All wastewater is discharged to land via irrigation.

4.1 Management of Wastewater Volume and Loading

There are a number of activities carried out across operational areas to manage the flow of wastewater and the overall contaminant loadings where possible.

Note, stock throughput has a direct bearing on the wastewater volume and loading at any particular time of the year. In addition, food safety cleaning requirements may also have a strong influence over wastewater volumes, e.g., if there is a global food safety issue MPI will automatically defer to increased cleaning requirements to protect NZ supply to those global markets.

- **Systems and Controls**

Wastewater volumes and contaminant loadings are managed by:

Element	Programme Type
Cleaning – between breaks and shifts	Task Instruction
Containment Procedures	Task Instruction
Automatic chemical dosing systems (where possible)	System Design
Water flow restriction valves on sterilisers within the primary and secondary butchery	System Design
Discharge to land	System Design

4.2 General Operation and Maintenance

4.2.1 Wastewater Treatment Plant

Operational and maintenance procedures are in place for individual components of the wastewater treatment plant for when the processing facility is in operation.

All plant and equipment is operated, maintained, inspected and tested using systems and procedures that manage risk.

Procedures control the operation and maintenance of plant and equipment that have a potential to impact performance. This plant and equipment is maintained, inspected and tested on a regular basis to ensure fit for purpose.

❖ **Systems and Controls**

General operation of the wastewater plant is managed by:

Element	Programme Type
Routine inspection and maintenance of equipment as required	Performance Standard Preventative Maintenance Scheduling
Annual inspection and maintenance	Preventative Maintenance Scheduling
PLC Alert if 'Fault' condition	Alert - SCADA & Cell
Automated spray cleaning – removes fouling on screens	System Design
Visual inspection – checking screen wear and tear	Preventative Maintenance Scheduling
Stormwater only manual control	System Design

4.2.2 Pipework and Valves

Regular routine maintenance of the pipelines and valves at the stages of wastewater treatment is essential to provide reliable operation.

❖ **Systems and Controls**

To ensure pipelines and valves remain operational, the following is also undertaken:

Element	Programme Type
Regular inspection of exposed pipes, fittings and valves	Preventative Maintenance Scheduling
Replacing pipes, fittings and valves as needed	Preventative Maintenance Scheduling
Painting pipework's with corrosion protection paint	Preventative Maintenance Scheduling
Use of non-return valves	Performance Standard
PLC alert if valves are in a 'Fault' condition	Alert - SCADA & Cell
Corrective actions for pipeline failures	Task Instruction
Pipeline flushing	Task Instruction

4.2.3 Pumps

The wastewater discharge system has one pump that can be operated automatically or manually.

❖ **Systems and Controls**

Pumps within the wastewater treatment plant are managed by:

Element	Programme Type

Daily visual inspection to monitor pumps operation	Preventative Maintenance Scheduling
Annual pump overhaul	Preventative Maintenance Scheduling
PLC alert if a pump is in a 'Fault' condition	Alert - SCADA & Cell
Stormwater only manual control	System Design

4.2.4 Pumping Operation

Under normal flow conditions, wastewater and stormwater is pumped from the buffer tank to the land irrigation network.

- **Systems and Controls**

Discharges to the land irrigation network are also managed by:

Element	Programme Type
Understanding the wastewater pump system	Task Instruction
PLC – alert if there is a pump failure, 'Fault' condition	Alert - SCADA & Cell

4.2.5 Flow Meter

The flow meter provides both instantaneous and totalised flows discharged volumes and is linked back to the sites PLC control and SCADA system, or manually read.

- **Systems and Controls**

The discharge flow meter is also managed by:

Element	Programme Type
Discharge volumes	PLC Monitoring
Regular inspection of exposed pipes, fittings and valves	Preventative Maintenance Scheduling
Five yearly flow meter verification – undertaken by a suitably qualified technician	Preventative Maintenance Scheduling
Understanding the fault light indicators on the wastewater pump system	Task Instruction
Reading the wastewater meter (automated)	SCADA system
Reading the wastewater meter (manual)	Task Instruction

4.2.6 Discharge Scheduling

Discharges to the land-based irrigation areas are determined by set return period irrigation scheduling based on the previous application depth. Due to the free draining nature of the majority of the underlying soils, land-based irrigation activities across the Silver Fern Farms Mossburn irrigation areas are largely moisture constrained rather than nutrient constrained.

Application rates are controlled by speed settings (cam) on each travelling irrigator.

Detailed records of wastewater discharged to each irrigation run are maintained.

- **Systems and Controls**

Discharges to the land-based irrigation areas are managed by:

Element	Programme Type
Automated scheduling system	System design
Setting up an irrigator	Task Instruction
Ten commandments of Wastewater Management	Task Instruction
Reading the wastewater meter	Task Instruction

5 Irrigation Network

5.1 Objectives

- *To operate the irrigation system so that application rates optimise nutrient uptake by plants, and manage risks associated with wastewater applications to ensure resource compliance.*
- *To avoid spray drift and odours beyond the boundary of the property.*
- *To manage application rates to achieve less than minor ponding .*
- *To maintain or improve the physical and biological condition of the soils*
- *To maintain the pastures in a productive state*
- *To minimise movement of sediment, phosphorus and other contaminants to waterbodies.*
- *To adopt the principles of sustainability for land and agricultural related waste by reducing waste, recovering and recycling materials, and reusing any waste stream before considering any residual management.*

5.2 Irrigation

This section outlines the systems and procedures in place for irrigation scheduling and the management of the land-based irrigation network for when the processing facility is in operation.

Snow and frozen ground

The irrigation system incorporates a back-up irrigator for frost protection and, for limited snowfall events, so irrigation can continued. During the winter months, all irrigation runs are available. In the event of extreme conditions persisting, irrigation will likely cease due to the processing plant temporarily closing.

❖ Systems and Controls

Irrigation and land based activities are managed by overarching systems and controls:

Element	Programme Type
Operational controls –Land Based Activities	Overarching document
Scheduling of irrigation runs	System design
Ten commandments of Wastewater Management	Task Instruction
Visual inspections throughout day	Preventative Maintenance

5.3 Travelling Irrigators

Whilst every component is designed for peak reliability, performance and efficiency, the irrigator and associated equipment are nevertheless regularly inspected for wear & tear, and overall ongoing integrity.

Applications to land are managed through a series of on-site procedures, manuals and task instructions that outline corrective actions for pipeline failures, opening and closing pipeline valves, flushing of wastewater main lines, and the operation and maintenance of irrigator.

Parameter	Approximate outcome
Application rate	10 – 15 mm/hr
Spray Diameter	45 m
Volume Flow rate	20 m3/hr
Traveling Irrigator Speed	30 m/hr
Application Depth	12 mm
Irrigation Runs	20

Table 5.3: *Travelling Irrigator parameters*

❖ Systems and Controls

The systems and controls in place to maintain irrigation infrastructure are:

Element	Programme Type
Routine inspection and maintenance of equipment	Performance Standard Preventative Maintenance Scheduling
Annual inspection and maintenance	Preventative Maintenance Scheduling
Quarterly inspection and maintenance	Preventative Maintenance Scheduling
Setting out an irrigator	Task Instruction
Packing up a travelling irrigator	Task Instruction
Laying out a hose for travelling irrigator	Task Instruction
Winding up a hose for travelling irrigator	Task Instruction
Turning on hydrants	Task Instruction

5.4 Irrigation Area

The overall wastewater irrigation block is approximately 46 ha. Of that, 40 ha is utilised for wastewater irrigation. The balance of the block is comprised of the wastewater exclusion (buffer) areas, including 100 m from the nearest northern boundary with the Urban Zone (Residential Boundary), and 10 m from the irrigation block property boundary.

Wastewater is pumped through an underground mainline before it is discharged to land using a travelling rotating irrigator. The irrigation block is divided into 20 runs that have a minimum return period of 7 days and an average return period of greater than 30 days. There are no surface watercourses, water abstraction or collection points on the irrigation block.

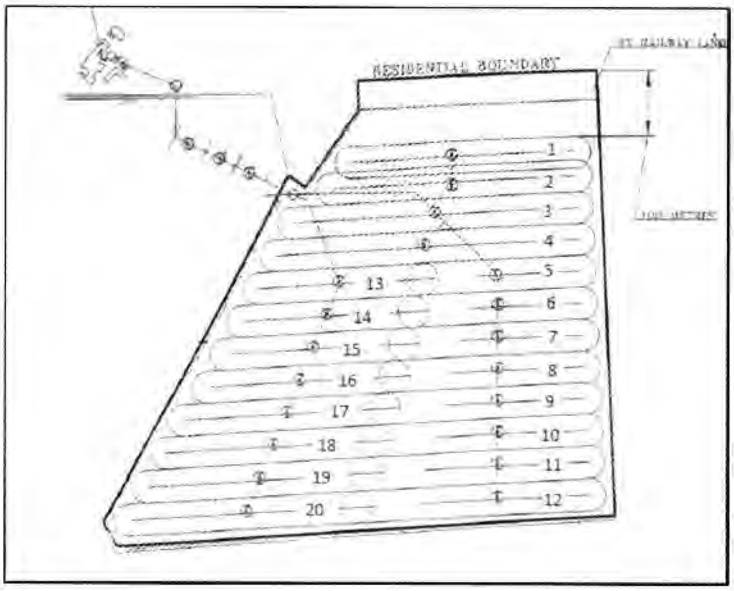


***Table 6.4:** Irrigation method per Block*

All land-based maintenance / development activities are planned for on a seasonal basis and managed through the annual budget process.

Vegetation harvesting, land development and management is carried out through contractual arrangements. Most of the vegetation grown is sold 'standing' through the Agricultural contractor

❖ Systems and Controls

The systems and controls in place to maintain the irrigation areas are:

Element	Programme Type
Annual Soil Testing	Contractual

Return Periods	Preventative Scheduling
Annual Budget	Group Standard
Weekly inspection of land holdings	Preventative Maintenance
Annual plant density counts	Preventative maintenance
Minimum cultivation	Preventative measure
Accredited Agricultural Contractors	Contractual

5.5 Spray drift and Odour Management

5.5.1 Spray drift and Odour Objective

To avoid spray drift and odours beyond the boundary of the property.

The travelling irrigator has large diameter nozzles to produce large droplets. These nozzles and irrigation conducted at low pressure prevents significant aerosoling.

Set buffer distances are maintained around the irrigation Blocks are maintained to provide a barrier to neighbouring properties. In the event of an excessive or off-odour noted by those working onsite or from an external complaint, actions taken include a boundary survey to identify the source and take corrective action if required.

- **Systems and Controls**

The systems and controls in place to avoid or remedy odours and spray drift are:

Element	Programme Type
Pipeline flushing	Task Instruction
Irrigator scheduling	Preventative measure
Borders and buffers	Preventative measure
Incident reporting	Flash Report
Environmental complaint	Environmental Complaint Report Form

5.6 Ponding and run-off Management

5.6.1 Ponding and run-off objective

To manage wastewater application rates to achieve less than minor ponding (less than 2 hours for any ponding).

Soil types of the irrigation block is such that ponding and run off is not expected even in adverse weather conditions.

❖ **Systems and Controls**

The systems and controls in place to avoid run-off and significant ponding are:

Element	Programme Type
Irrigator placement	Preventative measure
Visual inspection	Preventative measure
Corrective actions for ponding	Task Instruction
Borders and buffers	Preventative measure
Walking the line	Task Instruction

5.7 Nutrient Management

5.7.1 Nutrient Objectives –

- *To maximise plant uptake of wastewater nutrients.*
- *To manage to annual gross nitrogen wastewater loadings to 250kgN/ha.*
- *Minimising leaching of wastewater constituents and products through the soil to the groundwater;*

Processing wastewater contains a valuable source of nutrient for the pastures, that when harvested provide a source of revenue for the land holdings.

❖ **Systems and Controls**

The systems and controls in place to manage nutrient objectives are:

Element	Programme Type
Annual Nutrient Mass Balance calculation	Supporting programme
Irrigator scheduling	Preventative measure
Time flow proportional sample of wastewater	Task Instruction
Soil Sampling	Task Instruction

6 Land Management

6.1 Soils and Pasture Management

6.1.1 Soils and Pasture Objectives –

- *To maintain or improve the physical and biological condition of the soils*
- *To maintain the pastures in a productive state*
- *To minimise movement of sediment, phosphorus and other contaminants to waterbodies.*
- *Maintaining high soil chemical, physical, and biological soil quality*

Pastures receiving processing wastewater are sown with a mix of tetraploids and diploid grasses, selected on yield, sugar content, pest and drought tolerance and ability to uptake nitrogen.

Routine soil analysis is undertaken to monitor soil nutrients. In the event that analysis indicates an imbalance in soil nutrients, appropriate supplementary fertilisers may be applied.

Chemical use is minimised to avoid any effects on bacteria and soil micro-organisms, and earthworms.

❖ **Systems and Controls**

The systems and controls in place to maintain soil and pasture health are:

Element	Programme Type
Pasture mixes	Accredited Agricultural Agronomist
Harvesting	Task Instruction
Annual Soil Monitoring	Contractual

6.2 Waste Management

Silver Fern Farms, Mossburn, is committed to actively caring for the environment as an integral part of its business and environmental policy.

❖ **Systems and Controls**

The systems and controls in place to achieve the objective are:

Element	Programme Type
Waste reduction, recovery, reuse, recycling before residual management.	Company Guideline

7 Environmental Monitoring & Measurement

Assurance of activities is achieved by monitoring, auditing and reviewing performance and systems to identify trends, measure progress, assess compliance and drive continual improvement.

Monitoring forms an integral part of this management plan to ensure performance indicators are being met, and to identify where additional measures may be required. Each of the applicable resource consents include specific monitoring requirements to measure the performance of the management activities and a programme for implementation.

Key monitoring activities are summarised below.

7.1 Monitoring

The level of environmental monitoring is conducted in conjunction with consent requirements.

Environmental samples are collected by appropriately trained / suitability experienced personnel and are analysed by a laboratories IANZ accredited.

Table 7.1 below summarises the compliance monitoring undertaken to monitor the effects of land-based discharge of wastewater.

Activity	Frequency
Discharge volume (when operating)	Daily
Wastewater 24 hour flow proportional sample (when operating)	6 Monthly
Soil analysis	Annually

Table 7.1: *Monitoring summary (refer to appropriate resource consent for detail)*

To manage and maintain all data requirements from environmental monitoring, the systematic capture of data is held within the Silver Fern Farms' secure intranet data warehouse. The control of access to this data storage is managed in order to avoid inadvertent data loss or changes.

❖ **Systems and Controls**

Routine monitoring is managed by:

Element	Programme Type
Soil Sampling	Task Instruction

Wastewater Discharges	Data Warehouse
Soil Analysis	External Contractor

8 Incidents, Emergencies, and Response Measures

Environmental incidents and emergencies are reported, corrective action undertaken, investigated and analysed. Procedures and resources are in place to effectively respond to any such events.

The manager responsible for the work area where an incident occurs is responsible for ensuring the appropriate steps are undertaken. Incident details, corrective actions taken and learnings are shared across the company.

In the event of impending adverse weather or other conditions, appropriate precautionary measures may be undertaken to safeguard personnel, property, and/or the environment.

Depending on the consequence of the incident, the relevant internal and external parties are notified in accordance with established timeframes and/or legislative requirements.

8.1 Significant Event

In a significant emergency event, the appropriately trained on-site, and/or off-site, Emergency Response Team(s) may be mobilised to manage the situation.

❖ **Systems and Controls**

In a serious event the following procedures shall be implemented:

Element	Programme Type
Containment Procedures	Task Instruction
Crisis Management Plan Mossburn	Site Management Plan
Emergency Procedures	Site Manual

8.2 Environmental Incident

In the event of an incident, certain steps are required to be followed. These include:

- Conducting an incident investigation.
- Generating a "Flash report" within 24 hours of the incident occurring.
- Notifying affected parties, both internal and external, of the incident and corrective / preventative actions taken.

Any incidents or near misses, irrespective of whether damage to property or equipment resulted, are reported through 'Flash' reporting and investigated with recommendations made where required on how to prevent a recurrence or deal with any deficiencies in the appropriate systems and controls.

- **Systems and Controls**

Environmental incidents are managed by:

Element	Programme Type
Containment Procedures	Task instruction
Flash Report	Group Standard
Incident Investigation	Task Instruction
Corrective Actions Investigation	Task Instruction

8.3 Enquiry / Complaints Handling

Enquiries and complaints may occur via a number of different mechanisms whether coming from internal or external sources.

All environmental related enquiries and complaints are received, handled, responded to and recorded following a systematic process in accordance with incident management standards and guidelines.

To handle complaints, the responsible personnel shall determine the appropriate corrective and preventative actions to ensure the actions are implemented effectively to rectify the problem.

- **Systems and Controls**

In the event that a complaint is received, complaints are managed by:

Element	Programme Type
Resource Consent Complaints	Task Instruction
Recording Complaints	Group Standard
Mossburn Complaint Register	Group Standard

9 Environmental Reporting and Review

Environmental performance reporting is carried out to both internal and external parties on a regular basis. Regulatory annual reporting is provided to Environment Southland for all relevant activities across the Site.

When processing, an interpretive annual report is provided to Environment Southland by 31st October each year. The report summarises the Sites environmental performance for the seasonal reporting period 1 September – 31 August, including:

- An assessment of the status of the irrigation area
- Trends in analytical results
- Effects on the environment
- Recommendations for potential improvements
- Summary information on return periods and the applications of wastewater
- Results of soil testing
- Water and nutrient budgets

9.1 Environmental Performance

When processing, environmental performance reporting is carried out in accordance with the required timeframes as required internally and externally.

❖ **Systems and Controls**

Reporting requirements are managed by:

Element	Programme Type
Monthly Environmental Report	Internal and External Reporting
Annual Environmental Performance Report	External / Internal Reporting

9.2 Performance Assessment

Routine environmental performance reviews, formal and informal, are conducted by both Silver Fern Farms personnel and external parties, including regulatory agencies. The findings of these reviews are recorded and actions and/or recommendations addressed and tracked as required.

❖ **Systems and Controls**

Environmental performance reviews are managed by:

Element	Programme Type
Environmental Advice Note	Group Environmental Review
Contracted Review (as required)	Contractual

9.3 Environmental System Assessment

Silver Fern Farms takes the opportunity during the annual reporting process to review the suitability and effectiveness of the Integrated Land Management Plan, in addition to the Environmental Management Systems for the Site.

This Management Plan may also be reviewed at any time depending upon triggering events (carried out as appropriate and based on the magnitude of the trigger):

- Inclusion of lessons identified through incident investigation.
- Inclusion of audit outcome or finding.
- Change in nature of activity and associated risks.
- Change in regulatory or Company requirements.

Consistent with the principles of continuous improvement, the Silver Fern Farms Mossburn controls and other related documents will be periodically updated.

If amendments to the Management Plan are made, the updated plan will be submitted to Council shortly thereafter as is standard practice.

APENDIX FIVE – Resource Management Act Schedule 4 Matrix

Clause	Section	Description	Section Reference
2	(1)(a)	Description of activity	Section 4 (specifically section 4.2.1)
	(1)(b)	Description of the site	Section 3
	(1)(c)	Full name and address of each owner occupier of the site	1.1, 2.1, 2.4
	(1)(d)	Description of other activities that relate to the application	4.1
	(1)(e)	Description of any other resource consents required for the proposal	NA
	(1)(f)	Assessment of activity against Part 2 of the RMA	8.1
	(1)(g) and sub clauses: (2)(a) (2)(b) (2)(c)	Assessment of activity against relevant provisions in documents referred in section 104(1)(b) (Regional Plans, NES, etc) including: • Relevant objectives, policies and rules • Relevant requirements, conditions or permissions in any rule • Any other relevant requirements	Section 8
	(3)(a)	Information required by clause 6	See clause 6 of this matrix
	(3)(b)	Address maters specified in clause 7	See clause 7 of this matrix
	(3)(c)	Include details that correspond with the scale and significance of the effects of the activity	Whole of document
3	(a)	Permitted activity	8.5
	(b)	Existing consent	2.2 & 8.1
	(c)	Customary Marine Title	NA
4		Subdivision Consent	NA
5		Reclamation Consent	NA
6	(1)(a)	Description of any possible alternative locations	Section 7 (Note: no significant adverse effects)
	(1)(b)	Assessment of any actual or potential effects on the environment	Section 6
	(1)(c)	Hazardous installations	NA
	(1)(d)(i)	The nature of the discharge, sensitivity of the environment	3.3, 4.2, Section 5, Appendix One, Two and Three
	(1)(d)(ii)	Possible alternative methods	Section 7
	(1)(e)	Description of mitigation measures	Section 5
	(1)(f)	Identification of affected parties	6.5, 6.6, 7.1 & appendix Six
	(1)(g)	Description of monitoring	4.2.3, 4.2.6,4.2.7, Section 5 & Appendix Two
	(1)(h)	Effects on customary rights	NA (none affected)
	2	Include provisions of any policy or plan	Section 8
	3		7.1 & appendix Six
7	(1)	Assessment of effects	Section 3 & Section 6
	(2)	Provisions of policy statement or plan	Section 8

APENDIX SIX – List of Potentially Affected Parties 2006

LIST OF POTENTIALLY AFFECTED PARTIES		
1	Grant Reid	Bedford St., Mossburn.
2	Dave George Rutland	28 Bath St., P O Box 41 Mossburn,
3	Mrs G A Anderson	8 Sussex St., Mossburn
4	Lindsay Hugh & Josephine Margaret Muir	177 Dyer Road., Mossburn
5	Robert William Cleland of Airspread South Ltd	17 Cornwall St., & 7 Cumberland St., Mossburn
6	Mr Frank Humpheries	York St., Mossburn
7	Mr & Mrs Owen Duthie	3 Durban St., Mossburn
8	Mr Thomas Law (Mossburn Hotel)	York St Mossburn
9	Northern Southland Transport Holdings	Cnr Stanley & Camp Street, Queenstown
10	Mr M Rodway Fish & Game Southland	P O Box 59 Lumsden Phone 248 7636
11	Department of Conservation, Southland	P O Box 743 Invercargill
12	Mr Jim Guyton for Community Development Association.	
13	Mr John Douglas	R D 2 Te Anau

APENDIX SEVEN – Professional Chartered Engineer Assessment of Wastewater Treatment System

REF 0273-REP-001

Silver Fern Farms
PO Box 283
Christchurch

26 September 2018

Attention: David Orchard

Dear Sir

Mossburn Processing Plant – Assessment of WWTP

Purpose Of Assessment:

The purpose of this assessment was to determine the adequacy of the structural integrity of the waste water treatment system, to assess the potential for failure of the system.

Description of Plant:

The Waste Water Treatment Plant at the Mossburn Processing Plant consists of

A) A Primary Treatment System which collects processed waste water from the processing plant and treats this water to be of a quality which is of a composition as required to permit distribution to the Secondary Distribution System.
B) A Secondary Distribution System which delivers this treated water to an irrigation system for direct application to the surrounding land.

The Primary Treatment System is as portrayed on the original 1996 drawings from Kingston Morrison and numbered 8439 sheets 01 to 05 (as appended) except that the 600m³ holding pond has been replaced with the use of 4 only 22,000 litre plastic water storage tanks. These have been erected on a bunded area measuring 8.75 x 8.75m to the East of the screening and effluent pump chamber. Drainage of this bunded area is direct back into the screening and effluent pump chamber via a permanently open drain.

The feed system from the main processing plant to the Primary Treatment Plant is by gravity

The system was originally designed for a processing capacity of 200 m³/day.

The system was originally installed in 1996 with a specified design life of 50 years. The tanks were installed in 1997.

Current Usage of Plant:

The main processing plant on site was temporarily closed 2 years ago and is currently not operational. As a result the existing waste water treatment system is currently only processing stormwater and from minor amenity usage on the site.

Extent of Assessment:

This assessment only included the Primary Treatment System, and up to the outlet / supply pipe to the secondary distribution system.

This assessment did not include the Secondary Distribution System.

Internal camera inspections of all pipework was not undertaken.

Method of Assesssment:

The assessment of the waste water treatment plant involved:

1. On site inspection of the plant
2. Consultation with operational personnel
3. Search of Southland District Council Files
4. Records from Environment Southland

The visual assessment of the processing plant paid particular attention to:

a. The general integrity and condition of the concrete.
b. Any cracking of the concrete within the screening and effluent pump chamber.
c. Any subsidence or cracking of the concrete paving surrounding the screening and effluent pump chamber.
d. Assessment of all visually accessible drains, sumps and pipework.
e. Assessment for leaks from or evident deterioration of all pipework.
f. Assessment of the overall general condition of all equipment

Observations From Assessment:

Due to the non-processing of the main plant, the contra-shear screen and solids screw conveyor have been temporarily removed from the screening and effluent pump chamber.

From my observation I confirm all items in the Waste Water Treatment System as assessed are in good condition.

The screening and effluent pump chamber is in sound condition with no evidence of any deterioration, cracking or movement in the concrete chamber.

All pipe penetrations through the chamber walls appear adequately sealed.

All accessible piping joints and valves were in overall good condition.

Adequate seismic restraint of the tanks is provided.

There is minor cracking to the floor of the tank bund.

There is minor bulging to the tanks in the lower wall area. This is partly due to the approx. 100 - 125mm deep concrete poured internally in the base of the tank to provide hold down under wind conditions, and possibly partly due to the age of these tanks.

The plastic holding tanks are as originally installed and so approximately 22 years old. There is no identification on the tanks, but generally tanks of this era and material would only have a specified design life of approx. 15 years due to the composition and age deterioration of the plastic.

Consequence of a System Component Failure:

The greatest consequence of failure would occur from ground contamination due to:

a) A failure of the screening and effluent pump chamber.

b) A failure of an underground pipework

Any failure of the holding tanks would be contained within the chamber except for potential minor weeping through the floor of the tank bund.

Conclusion:

In my opinion the Waste Water Treatment Plant at the Mossburn Venison Processing Plant is satisfactory for continued service with only a very low risk of a failure occurring, and with consideration to the age of the plant.

This condition will be a reflection of the original plant having a design life of 50 years and only being installed approx. 22 years ago.

As with any processing plant, as the age of the plant increases so does the risk of a failure occurring, and it is important to provide a more regular assessment of the condition of the system to predict eminent failure, and also maintaining an appropriate maintenance programme.

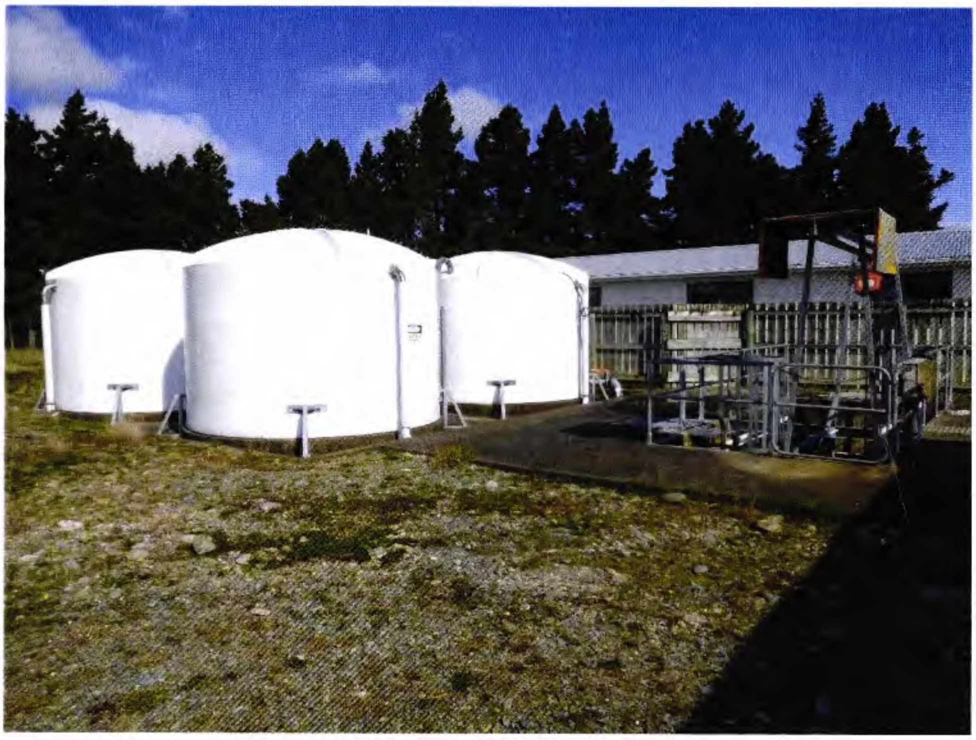
Particular attention should be paid to the holding tanks which will have exceeded their original design life. A regular girth measurement of the tank should be taken at approx. 300mm above the base of the tank and when this measurement exceeds 2.5% of the original tank girth, these tanks should be considered for replacement.

Prepared by

km-mechanical

Kevin Mair

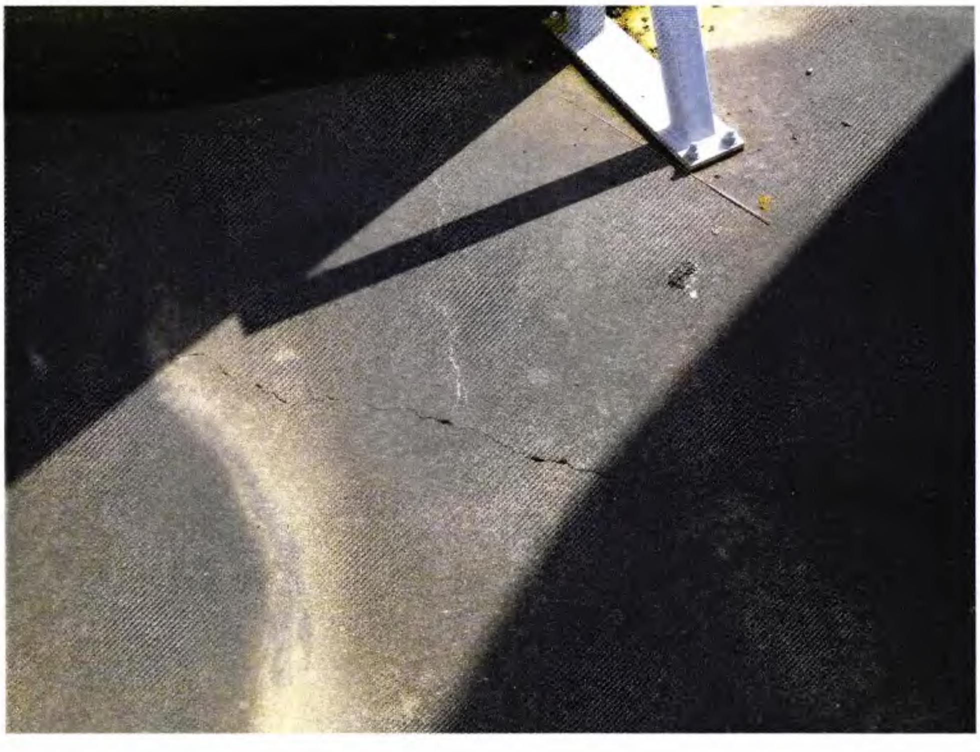
CMEngNZ CPEng - Registration No 243859



Overall View of Primary Treatment Plant

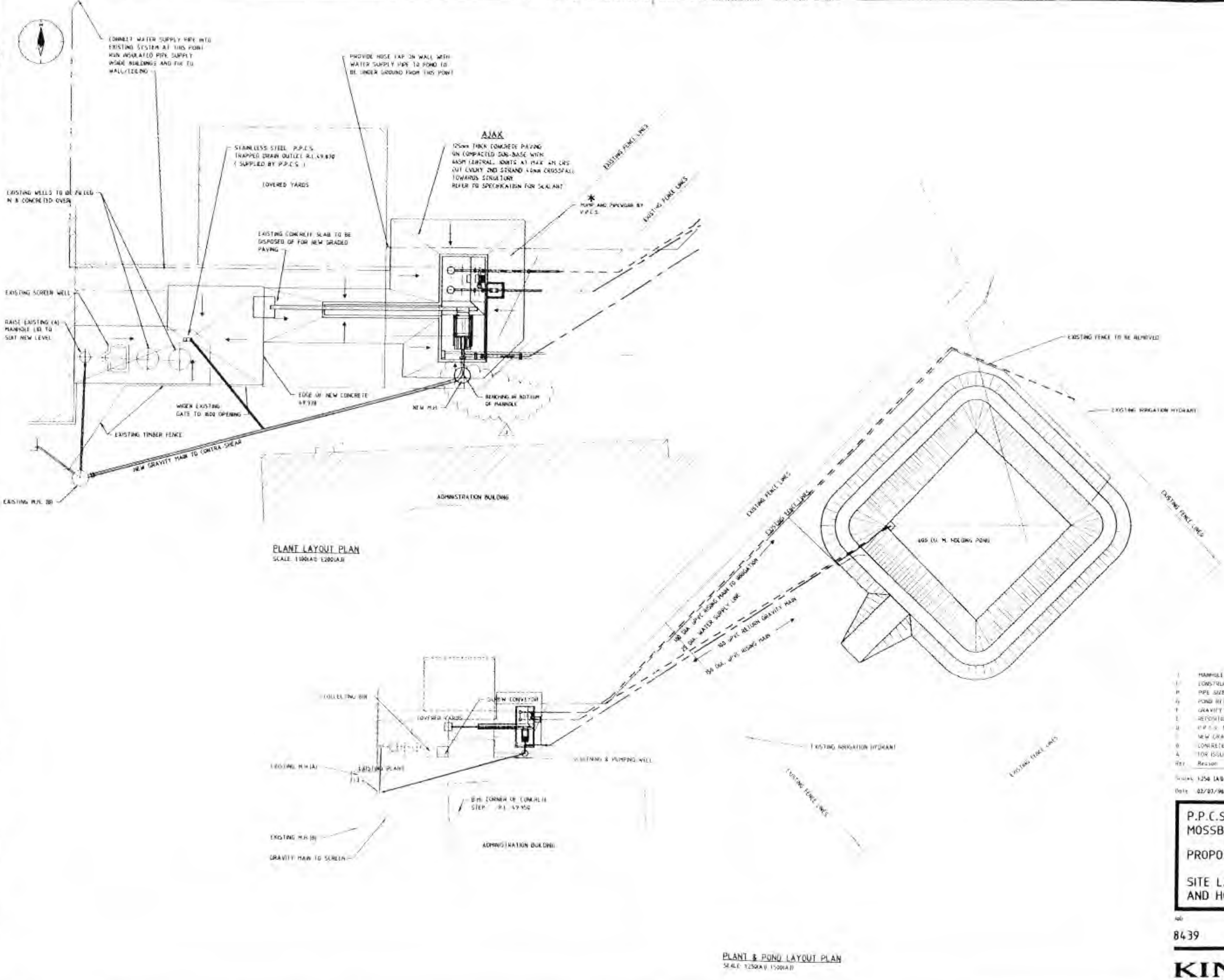
Overall View of Primary Treatment Plant

Cracking to Bund Floor



Minor Bulging of Lower Side Wall

Verify all dimensions prior to construction. Do not scale



PLANT LAYOUT PLAN

PLANT & POND LAYOUT PLAN

Rev	Reason	By	Chk	Appr	Date
J	MANHOLE MOVED	RGY	MS		16.1.97
I	CONSTRUCTION ISSUE	RGY	MK		18.12.96
H	PIPE SIZES & LAYOUT ALTS	WWS			03/12/96
G	POND RETURN PALT	RTS			12/11/96
F	GRAVITY MAIN TO SCREEN	RTS	RTS	MWF	6/11/96
E	REPOSITION OF PLANT	RTS	RTS	MWF	30/10/96
D	P.P.C.S. TRAP OUTLET	RTS	RTS	MWF	06/09/96
C	NEW GRAVITY MAIN	RTS	RTS	MWF	4/09/96
B	CONCRETE PAVING AREA	RTS	RTS	MWF	22/07/96
A	FOR ISSUE TO CLIENT	RTS	RTS	MWF	16/07/96

Scales 1:250 (A3) 1:500 (A3) Drawn RTS Designed RTS
Date 02/07/96 (17:24 14/01/97) CAD Ref 8439501 Checked MWF

P.P.C.S.
MOSSBURN PLANT

PROPOSED EFFLUENT PLANT

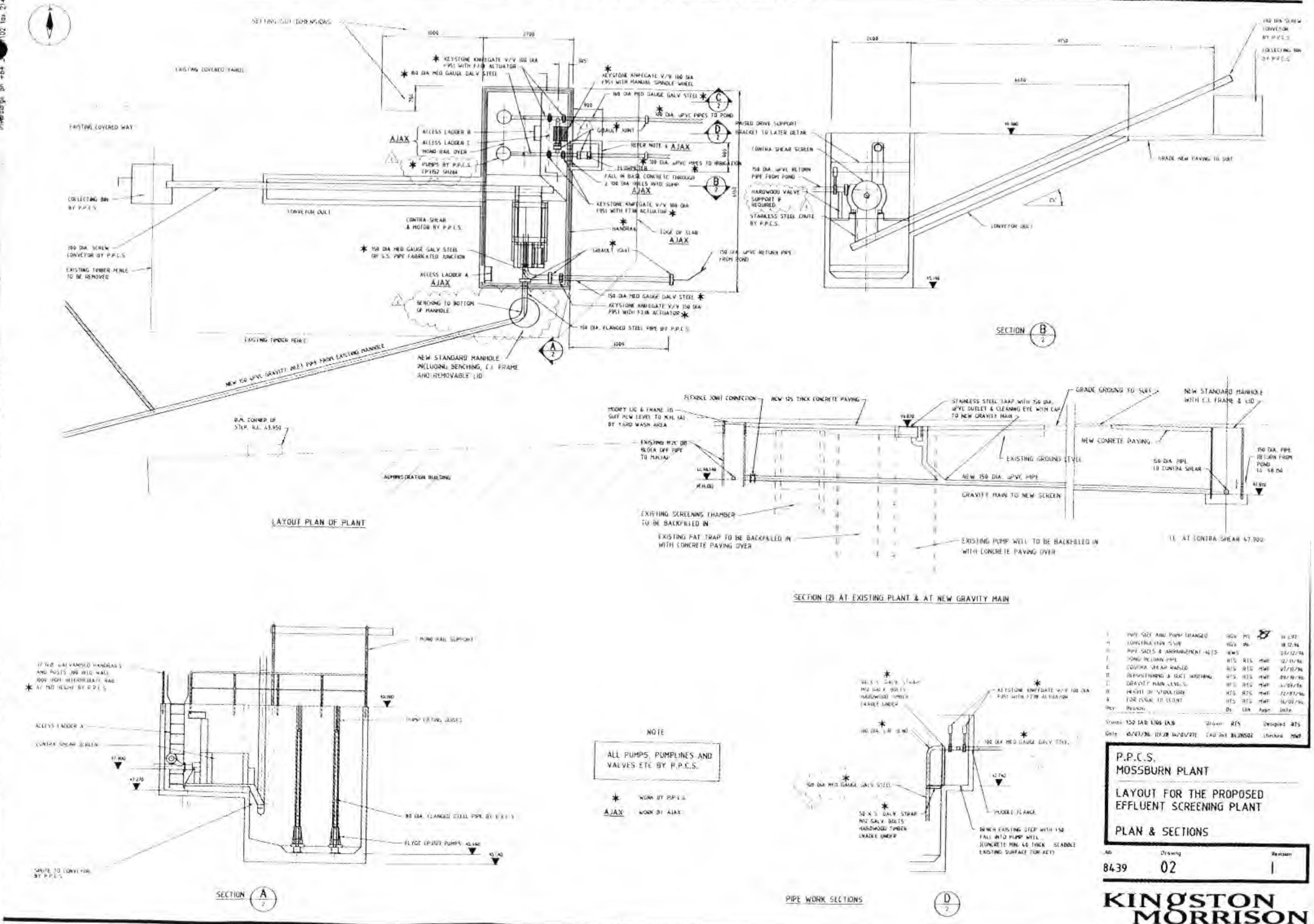
SITE LAYOUT OF SCREENING PLANT AND HOLDING POND

Job	Drawing	Revision
8439	01	J

KINGSTON MORRISON
Architects Engineers Planners Scientists

Kingston Morrison Limited New Zealand

Verify all dimensions prior to construction : Do not scale



Rev	Revision	Dr	Chk	Appr	Date
I	PIPE SIZE AND PUMP CHANGED	RGV	MS		1/.1.97
H	CONSTRUCTION ISSUE	RGV	MS		18.12.96
G	PIPE SIZES & ARRANGEMENT ALTS	WWS			03/12/96
F	POND RETURN PIPE	RTS	RTS	MWF	12/11/96
E	CONTRA SHEAR RAISED	RTS	RTS	MWF	07/11/96
D	REPOSITIONING & DUCT WIDENING	RTS	RTS	MWF	09/10/96
C	GRAVITY MAIN LEVELS	RTS	RTS	MWF	/09/96
B	HEIGHT OF STRUCTURE	RTS	RTS	MWF	22/07/96
A	FOR ISSUE TO CLIENT	RTS	RTS	MWF	16/07/96

Scales 1:50 (A1) 1:100 (A3) Drawn RTS Designed RTS
Date 16/07/96 Checked MWF

P.P.C.S.
MOSSBURN PLANT

LAYOUT FOR THE PROPOSED EFFLUENT SCREENING PLANT

PLAN & SECTIONS

Job	Drawing	Revision
8439	02	I

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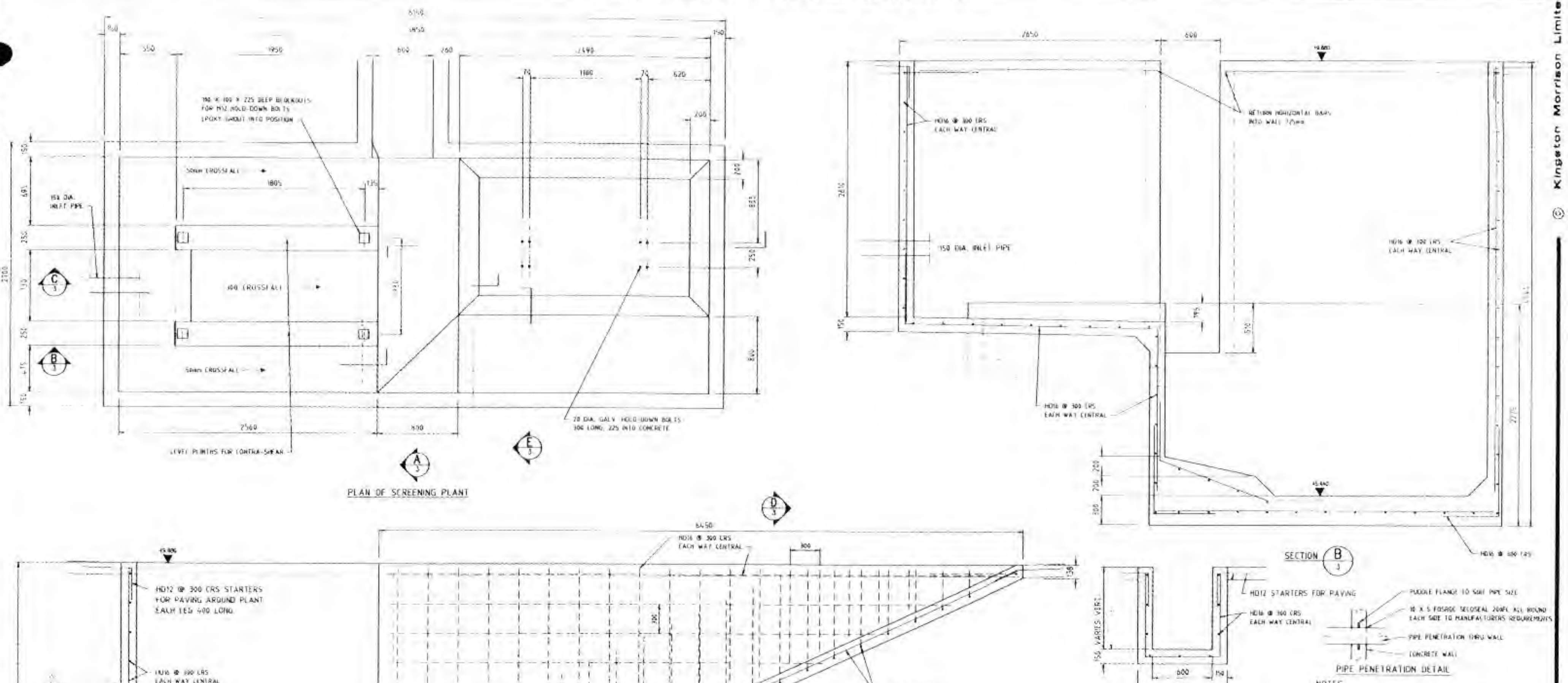
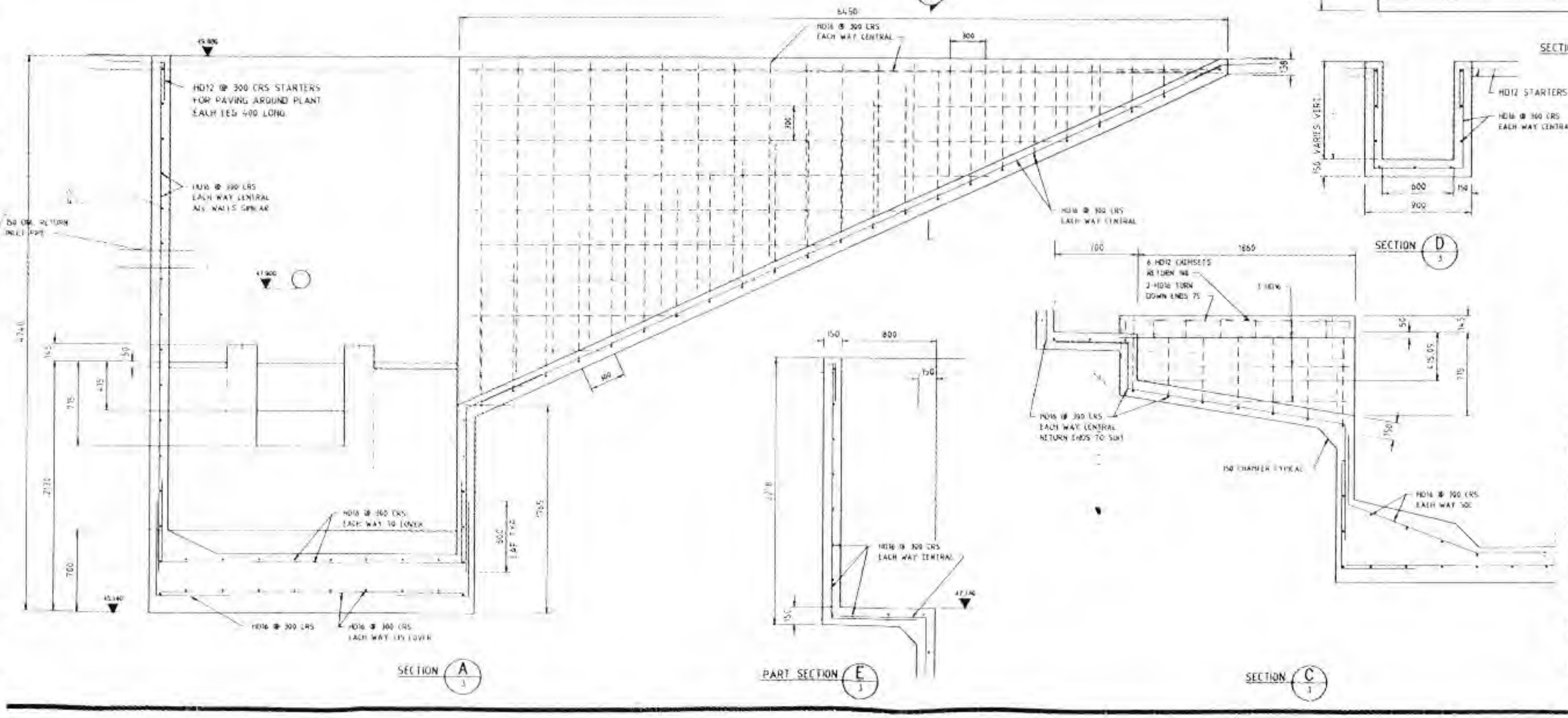
Kingston Morrison Limited New Zealand





NOTES

- DURING CONSTRUCTION & PRIOR TO BACKFILLING OUTSIDE GROUND LEVEL SHALL NOT BE MORE THAN 1500 HIGHER THAN INSIDE WATER LEVEL
- CONCRETE TO BE 25MPa AT 28 DAYS
- REINFORCING STEEL TO GRADE 430 MESH TO NZS 3422
- REINFORCING STEEL LAPS SHALL BE 40 DIAMETER MIN.
- COVER TO STEEL AS SHOWN

Rev.	Revision	By	Chk	Appr	Date
G	POND RETURN PIPE	RTS			12/11/96
F	CONTRA-SHEAR RAISED	RTS	RTS	MWF	07/11/96
E	WIDENING OF CONVEYOR DUCT	RTS	RTS	MWF	09/10/96
D	CONVEYOR DUCT DIMENSIONS	RTS	RTS	MWF	6/09/96
C	REDRAWN FOR REINFORCING STEEL	RTS	RTS	MWF	4/09/96
B	HEIGHT OF STRUCTURE	RTS	RTS	MWF	12/07/96
A	FOR ISSUE TO CLIENT	RTS	RTS	MWF	16/07/96

Scales 1:20 (A1) 1:40 (A3)   Drawn RTS   Designed JGB

Date 04/06/96 (20:09 12/11/96)   CAD Ref 8439R503   Checked MWF

P.P.C.S.
MOSSBURN PLANT

EFFLUENT SCREENING PLANT

REINFORCED CONCRETE DETAILS
PLAN & SECTIONS

Job	Drawing	Revision
8439	03	G

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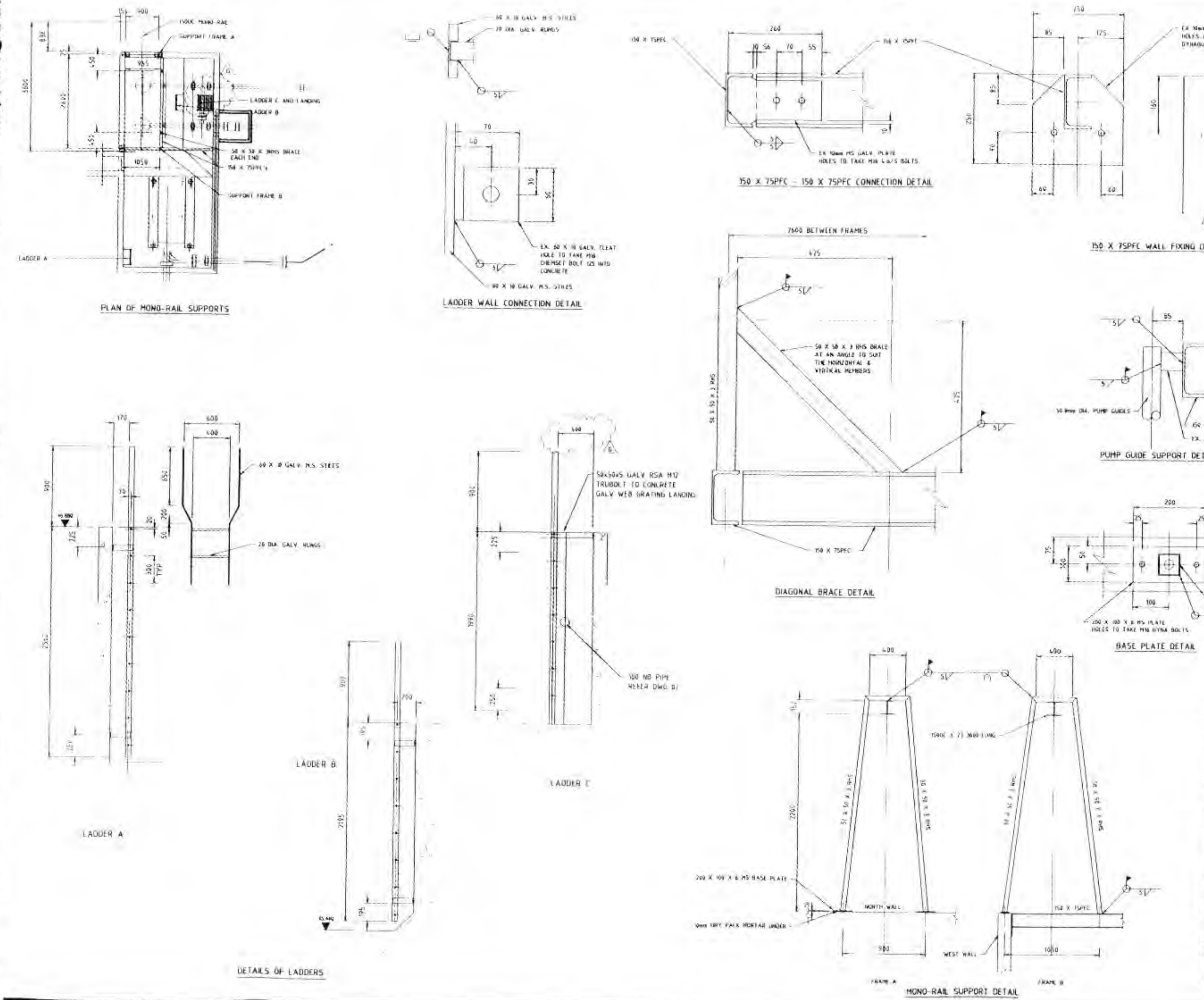

NOTES

- ALL BOLTS, NUTS & WASHERS TO BE GALVANISED
- ALL STRUCTURAL STEEL TO BE HOT DIP GALVANISED

Rev	Reason	By	Chk	Appr.	Date
G	LADDER MOVED	RGV	MS		14/1/97
F	LADDER C AND LAYOUT	MWS			13/12/96
E	POND RETURN PIPE	RTS			12/11/96
D	RETURN FROM POND	RTS	RTS	MWF	7/11/96
C	LADDER A	RTS	RTS	MWF	06/09/96
B	HEIGHT OF LADDERS	RTS	RTS	MWF	22/07/96
A	FOR ISSUE TO CLIENT	RTS	RTS	MWF	16/07/96

Scales 1:5,20 (A0) 1:10,40 (A3) Drawn RTS Designed JGR

Date 19/08/96 (18:24 14/01/97) CAD Ref 8439S04 Checked MWF

P.P.C.S.
MOSSBURN PLANT

EFFLUENT SCREENING PLANT

STRUCTURAL STEEL DETAILS

Job	Drawing	Revision
8439	04	G

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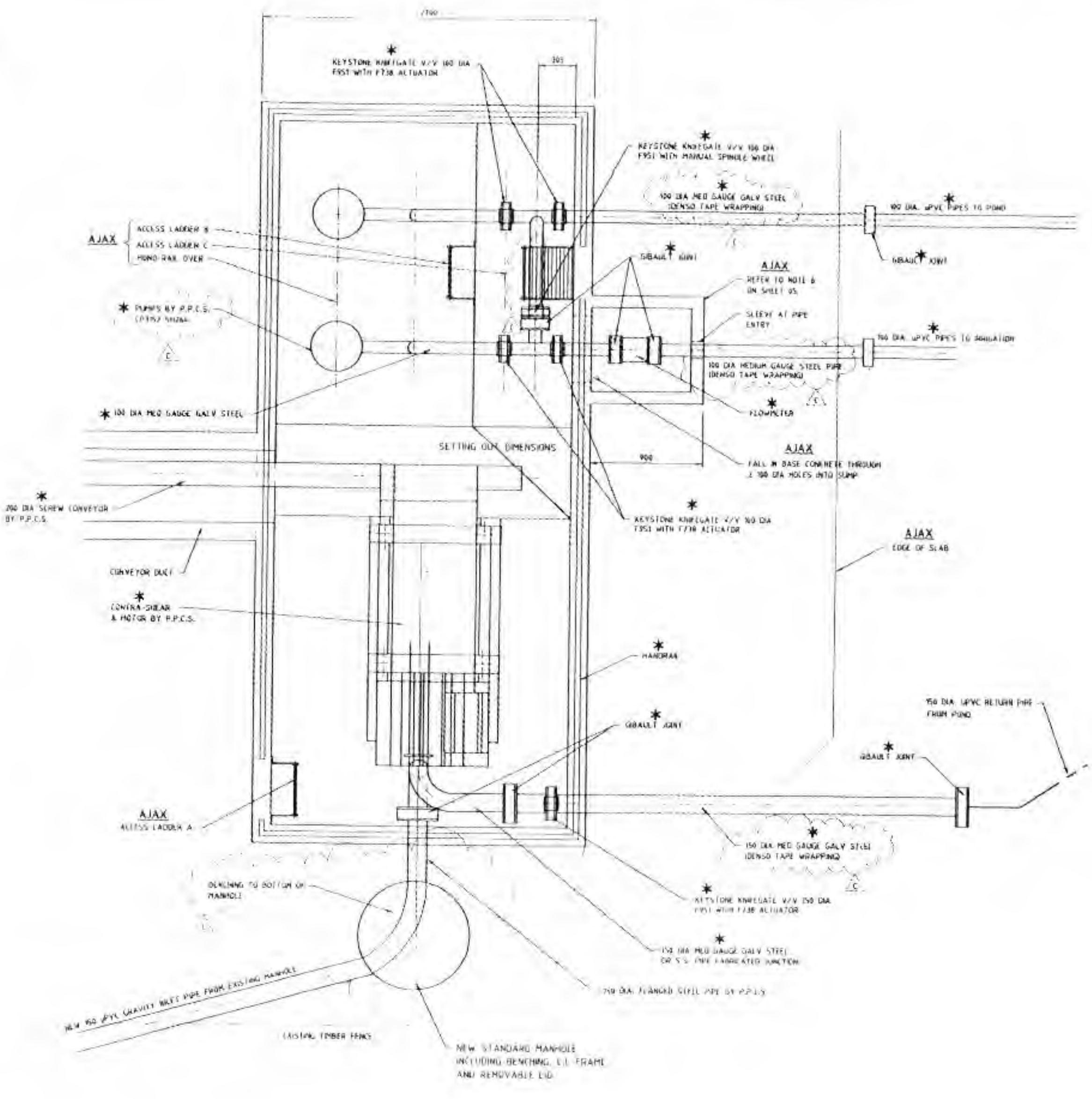
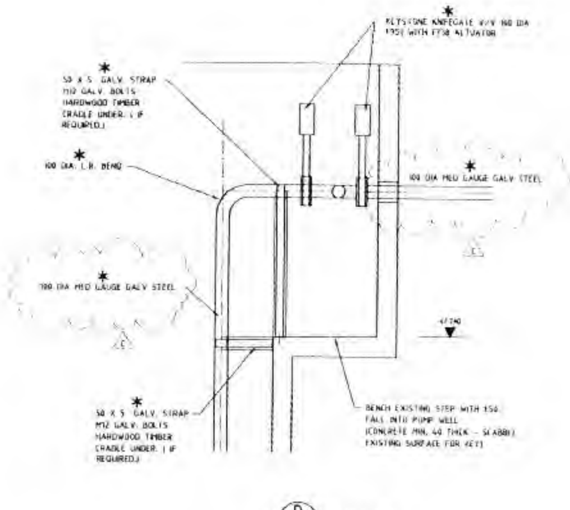


LAYOUT PLAN OF PLANT   SCALE 1 TO 20

PLAN FROM DWG 02 AT LARGER SCALE



D / 2   SCALE 1 TO 20

DETAIL FROM DWG 02 AT LARGER SCALE

* WORK BY P.P.C.S.

AJAX WORK BY AJAX

NOTES

- * 1 ALL FLANGES 'E' TYPE
- * 2 ALL FITTINGS WELDABLE FLANGES AND TEES UNLESS GIBAULT/FLANGE WHERE SHOWN
- * 3 UTILIZE THE EXISTING HIGH LEVEL PIPE HOLES FOR THE OUTFLOW PIPES TO THE POND AND IRRIGATION
- * 4 FLOW METER TO UNDISTRUBED FLOW 5 DIA UPSTREAM AND 3 DIA DOWNSTREAM
- * 5 WRAP STEEL PIPE BURIED IN GROUND WITH 2 LAYERS OF DENSO TAPE
- AJAX 6 100 THICK WALLS AND 150 THICK FLOOR WITH D10-250 EW C (OR 665 MESH) EPOXY GROUT D10 STARTERS 250LG 100 INTO EXISTING PUMP SUMP WALLS 20 FALL TO DRAIN THROUGH HOLES. ALUMINIUM CHEQUER PLATE COVER

Rev	Reason	By	Chk	Appr	Date
C	CONSTRUCTION ISSUE	RGV			16.1.97
B	CONSTRUCTION ISSUE	RGV			19.12.96
A	FOR ISSUE TO CLIENT	WWS			03/12/96

Scales 1:20 (A1) 1:40 (A3)   Drawn WWS   Designed

Date 03/12/96 (17:57 14/01/97)   CAD Ref 8439WS05   Checked

P.P.C.S.
MOSSBURN PLANT

LAYOUT FOR THE PROPOSED
EFFLUENT SCREENING PLANT

VALVE DETAILS

Job	Drawing	Revision
8439	05	C

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APENDIX Eight – Liquid Earth Groundwater Effects from Wastewater Irrigation

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Project Ref: SFF05

13 December 2018

Silver Fern Farms - Irrigation of Meat Processing Wastewater at the Mossburn Plant

Silver Fern Farms Ltd hold an existing consent (AUTH-95498) authorising discharge of wastewater generated in their Mossburn processing plant to land. This consent was granted in April 2009 and expires on the 15th April 2019 and authorises the discharge of up to 1,400 m^3/week of wastewater via spray irrigation. Silver Fern Farms Ltd recently an application with Environment Southland to replace the existing consent to enable future wastewater disposal from the Mossburn plant.

In October 2018 Environment Southland returned the application as being incomplete under Section 88(3A) of the Resource Management Act. In order to accept the application Council indicated a range of additional information was required to satisfy requirements of the 4th schedule of the Resource Management Act.

This report provides an assessment of effects of the proposed discharge activity on groundwater quality. The assessment utilises historical data on irrigation practice, wastewater composition, nutrient loading and hydraulic loading provided in Annual Monitoring and Performance Reports prepared by SoilWork Limited to provide an assessment of potential effects on groundwater resulting from proposed operation of the wastewater discharge up to the maximum nutrient application rate and hydraulic loadings sought in the application.

1. Environmental Setting

As shown on Figure 1 below, the Silver Fern Farms irrigation block is located immediately south of the Mossburn township near the western extent of the Oreti Basin. This area is geologically and hydrogeologically complex being situated near the boundary of four separate groundwater management zones defined by Environment Southland, the extent of which reflect current and historical drainage patterns of the Oreti River.

1.1 Soils

As described in the AEE, the irrigation block is located within an area of relatively uniform Oreti Soils. Oreti soils (Cemented Firm Brown) are described as having a silt loam to sandy loam topsoil texture with abundant gravel in the subsoil (>70 %) which frequently contains a cemented pan which restricts plant rooting depth. These soils are characterised as highly permeable and well drained (sometimes excessively) due to the high subsoil gravel content, with a plant readily available water (PRAW) capacity typically in the range of 25 to 50 millimetres. Oreti soils typically have a low to very low base saturation and a moderate to low cation exchange capacity. Topoclimate South (2002)[1] classify Oreti soils as having a very severe nutrient leaching vulnerability which reflects the good profile drainage, low total available water and rapid permeability.

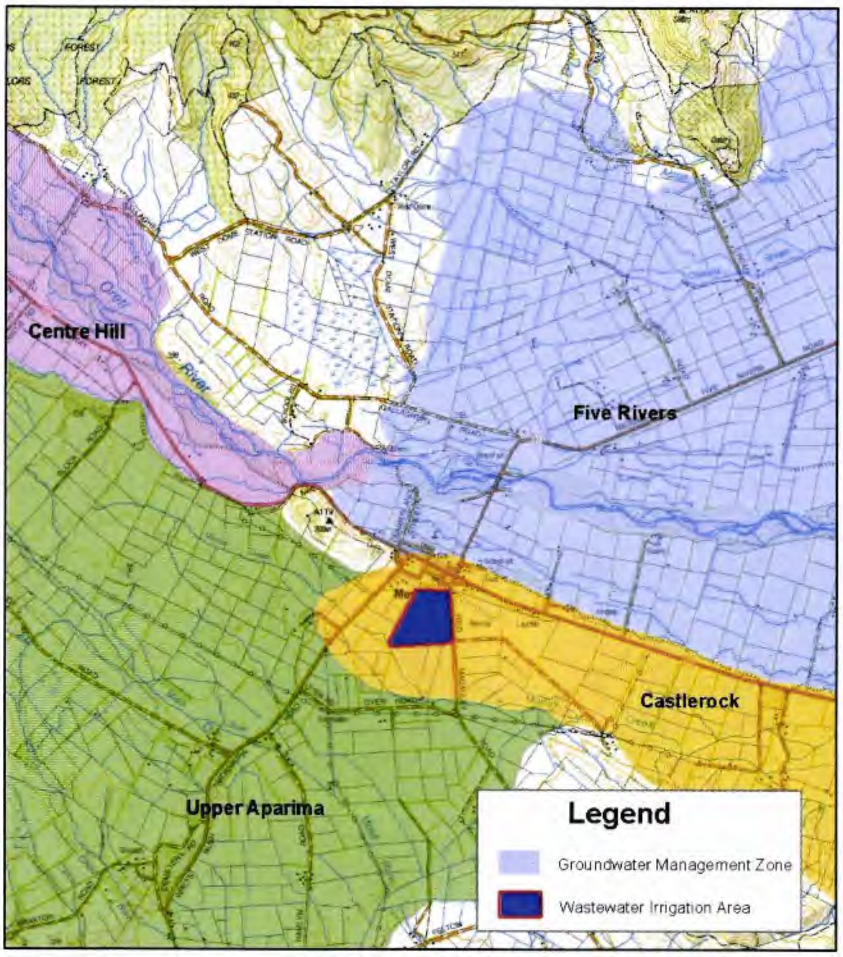

Figure 1. *Location of the Silver Fern Farms Mossburn wastewater irrigation area*

As described in SoilWork (2016) historical wastewater irrigation at the Mossburn site did not result in any significant effects on soil pH or on soil concentrations of calcium, potassium, magnesium, sodium or available phosphorus. Similarly, no irrigation-related effects on exchangeable sodium percentage were identified compared to control sites.

[1] Topoclimate South, 2002; *Topoclimate Southland Soil Technical Data Sheet No 14. Oreti*

The most recent assessment of soil physical properties (SoilWork 2017)[2] indicates the soils overlying the irrigation area are highly permeable with a long-term average infiltration rate of 382 mm/hr, which is slightly higher than the 261 mm/hr recorded on the nearby control site. The higher infiltration rates on the irrigation are attributed to increased root and earthwork activities within the irrigated soils. The report notes:

> *During earlier periods of irrigation at this site, wastewater had no significant adverse effects on soil chemical or physical properties measured. Instead it resulted in greater earthworm and root activities, and consequently in higher average organic carbon concentrations (8.7% versus 7.9%), improved and more stable soil structure, higher average infiltration rate (377 mm/hr versus 258 mm/he), and increased average hydraulic conductivity (8.8 x 10^{-5} m/s versus 3.5 x 10^{-5} m/s). Overall, therefore, wastewater applications resulted in moderate improvements in soil conditions.*

1.2 Geology

The Silver Fern Farms irrigation site is located close to the western extent of the Castlerock Terrace. This terrace comprises Q2 alluvium deposited during the late Quaternary when the Oreti River followed a course along the southern margin of the Oreti Basin, flowing south of the basement high exposed at Rocky Point immediately west of the Mossburn township. As noted by Turnbull and Allibone (2003)[3], previous channels of the Oreti River flowed south down the current alignment of the Aparima River during the mid-Quaternary before being diverted to the current easterly alignment possibly due to contemporaneous uplift along the Hillfoot Fault (which trends north-west to south-east along the base of the North Range). As a consequence, the geometry and nature of deposition of Quaternary alluvial materials is not as clearly defined in this area as it in other parts of the Oreti catchment.

The steeply dipping northern limb of the Southland Syncline forms the southern boundary of the Oreti basin. Preferential erosion of the alternating mudstone and sandstone units have resulted in the formation of prominent strike ridges which can be traced from Kaka Point on the Catlins Coast along the Hokonui Hills as far west as Mossburn. The Silver Fern Farms site occupies an area between Rocky Point and the western end of the north range where the basement materials of one of the more prominent strike ridges have been eroded and replaced with younger Tertiary and Quaternary sediments.

1.3 Hydrogeology

A majority of bores in the vicinity of the irrigation area are completed in Quaternary alluvium at depths less than 40 metres. Although details vary between individual logs, bore log and construction details

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[2] SoilWork, 2017; *Silver Fern Farms Ltd, Mossburn Plant. Wastewater Irrigation Annual Monitoring and Performance Report*, October 2017.

[3] Turnbull, I.M., Allibone, A.H (compilers) 2003: Geology of the Murihiku area. Institute of Geological & Nuclear Sciences 1:250 000 geological map 20. 1 sheet and 74 p. Lower Hutt, New Zealand. Institute of Geological & Nuclear Sciences Limited.

appear to show a shallow water-bearing layer hosted in recent (Q2) alluvium up to 10 metres deep, with a further water-bearing layer occurring around 30 metres below ground. The water-bearing layers are generally separated by a sequence recorded as comprising 'claybound gravels'. This is similar to the general hydrostratigraphic sequence observed across the wider Oreti Basin, with a relatively thin unconfined aquifer (10 to 15 metres deep) overlying a deeper water-bearing layer, which typically exhibits some degree of confinement due to the low permeability of the intervening claybound gravels (SKM, 2005)[4].

No specific geological or hydrogeological information is available for the land disposal area. However, E44/0509 located approximately 300 metres to the south-west shows a shallow water bearing gravel layer extending to 12 metres below ground. This layer is underlain by claybound gravels to a depth of 36 metres where a further sequence of water-bearing alluvium is recorded to a depth of 43 metres. The alluvial sediments overly a thick sequence of marine sediments (comprising silt with shells) of the Tertiary (Oligocene to Miocene) East Southland Group. Similar sediments have been encountered at depths of 40 to 60 metres below ground elsewhere along the base of the North Range.

The unconfined aquifer hosted in the upper alluvial gravel sequence is interpreted to be recharged by infiltration of local rainfall. As shown in Figure 2 below, water levels recorded in a shallow bore (E44/0016) at the former Mossburn landfill site (approximately 1,300 metres east of the irrigation area) exhibit a relatively regular pattern of seasonal variation with levels peaking in mid to late-winter and reaching a minimum in early autumn, consistent with recharge being primarily derived from land surface recharge. The data indicate the water table in the vicinity of the irrigation area is relatively shallow (<5 m bgl) with a typical seasonal variation is around 1.5 metres[5]. Temporal variation in groundwater levels recorded in E44/0016 indicate that flow losses observed from the Oreti River downstream of Rocky Point are unlikely to make any significant contribution to the water balance of the unconfined aquifer in the vicinity of the disposal area.

[4] SKM, 2005; Hydrogeology of the Oreti Basin. Report prepared for Environment Southland, July 2005.

[5] It is noted that drilling investigations reported by AquaFirma (1997) indicate two shallow piezometers installed on the original land disposal area (on the property immediate west of the current irrigation area) intercepted a shallow perched water table (static water level 1.1 m bgl) when drilled in December 1996. However, in January 1997 no samples could be collected from the piezometers suggesting the initial 'perched' water table observed following piezometer installation may have in fact represented water introduced during drilling which had ponded on a shallow, low permeability layer within the alluvial deposits.

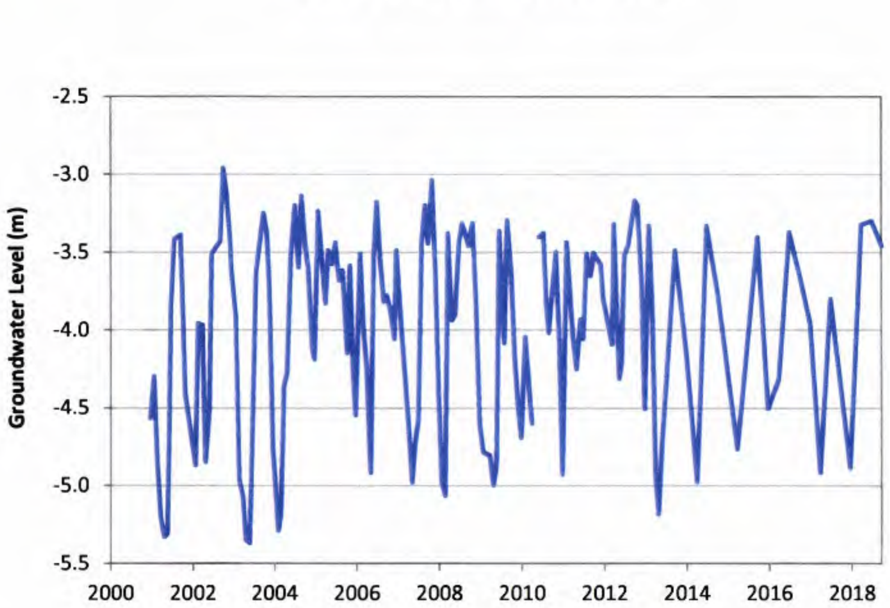

Figure 2. *Groundwater levels recorded in E44/0016, 2000 to 2018*

Chaut (2014) estimated mean annual land surface recharge in the vicinity of the irrigation area at 389 mm/year. This figure is consistent with the 370 mm annual average water surplus for the dryland control calculated by SoilWork (2016)[6] for 2004-05 to 2015-16 irrigation seasons at the Silver Fern Farms site.

Figure 3 below shows a map of piezometric contours in unconfined aquifers in the Oreti basin defined by SKM (2005). The figure indicates groundwater in the vicinity of the irrigation area is likely to flow in an easterly direction following the general topographic gradient to the Castlerock Terrace, with an approximate hydraulic gradient of 0.005.

[6] SoilWork, 2016; *Silver Fern Farms Ltd, Mossburn Plant. Wastewater Irrigation Annual Monitoring and Performance Report 2015-16*, October 2016.

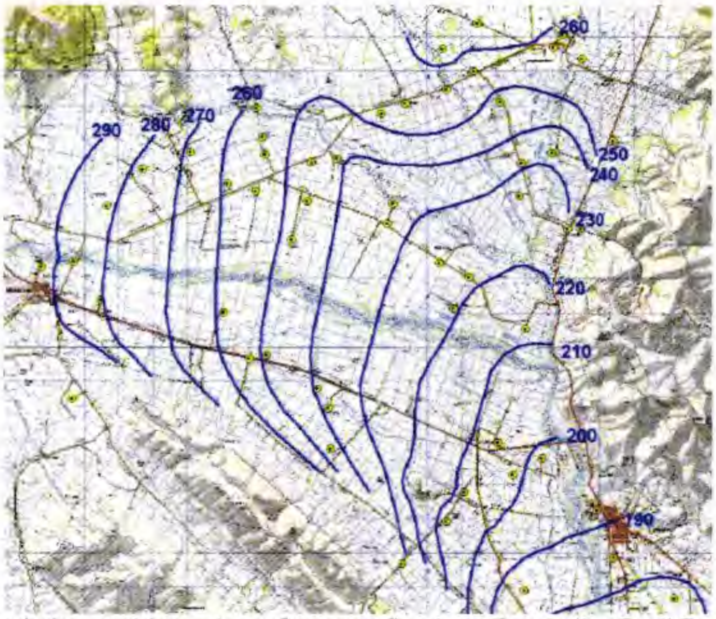

Figure 3. *Estimated piezometric contours for unconfined aquifers in the Oreti Basin (SKM, 2005)*

While a significant amount of aquifer test information is available to enable characterisation of the hydraulic properties of deeper water-bearing layers in the Oreti Basin, limited data is available for bores screened in the shallow unconfined aquifer. Based on calculated values for similar alluvial deposits elsewhere in the Southland Region, it is not unreasonable to assume aquifer transmissivity may be of the order of 500 m^2/day in sandy alluvium[7]. The few specific capacity data for shallow bores in the Mossburn area indicate higher yields but this likely reflects their location close to, or within, younger Q1 alluvial deposits associated with the Oreti River.

Application of Darcy's Law, assuming an aquifer transmissivity of 500 m^2/day and a hydraulic gradient of 0.005, indicates groundwater throughflow in the unconfined aquifer underlying the irrigation area (which extends approximately 750 metres perpendicular to the interpreted groundwater flow direction) of the order of 1,900 m^3/day.

2. Wastewater Discharge

2.1 Wastewater Composition

Wastewater generated from meat processing is largely organic in nature and contains very little material that is not fully degradable by biological means; generally consisting of settleable and suspended solids derived from blood, paunch content liquids, stockyard washings and fat / protein from meat tissue.

[7] A hydraulic conductivity value of 100 m/day was assumed in AquaFirma (1977) for alluvium underlying the irrigation area. This equates to a transmissivity of 500 m2/day assuming a 5 metre saturated thickness.

Condition 10 of the existing Silver Fern Farms discharge consent requires a 24-hour flow proportional sample of wastewater to be analysed twice a year. SoilWork (2016) provides a summary of annual average wastewater analyses results from sampling undertaken between the 2004-05 and 2015-16 seasons. The data indicate appreciable variations in wastewater composition between individual samples most likely reflecting differences in the number and type of stock being processed.

For the purposes of this assessment median values for individual parameters have been adopted as broadly representative of the likely composition of any future discharge from the processing facility. These figures indicate a mean TKN concentration of approximately 160 g/m^3, a total phosphorus concentration of 6.6 g/m^3 and a Faecal Coliform loading of 2.0 x 10^6 cfu/100mL.

Table 1. *Measured wastewater composition at the Mossburn Plant*

Season	**Conductivity (mS/m)**	**BOD (g/m^3)**	**Total Kjeldahl Nitrogen (TKN) (g/m^3)**	**Total Phosphorus (g/m^3)**	**Faecal Coliforms (cfu/100 mL)**
2015-16	62	405	107	3.7	1.9 x 10^6
2014-15	95	495	156	8.7	3.6 x 10^6
2013-14	91	350	140	6.7	1.2 x 10^5
2012-13	71	465	135	6.3	1.5 x 10^5
2011-12	89	662	211	6.7	6.5 x 10^5
2010-11	78	590	182	9.1	2.0 x 10^6
2009-10	95	630	190	7.8	4.0 x 10^5
2008-09	87	430	188	6.4	3.4 x 10^7
2007-08	95	525	180	6.5	7.0 x 10^6
2006-07	66	463	152	<6.6	4.1 x 10^6
2005-06	54	540	137	5.7	1.7 x 10^6
2004-05	98	661	186	5.8	2.0 x 10^6
Median	**88**	**510**	**168**	**6.6**	**2.0 x 10^6**

Limited analysis has been undertaken of wastewater from the Mossburn plant for parameters others than those required by consent conditions. Table 2 summarises the typical composition of Mossburn wastewater from samples undertaken to support the original 1997 consent application, along with representative data from the former Islington Plant which operated a similar processing facility. The data show similar pH, BOD and TKN concentrations to those measured in Mossburn wastewater, and indicate low concentrations of trace metals (including Copper, Cobalt, Selenium, Cadmium, Chromium, Nickel, Zinc and Mercury) consistent with the primarily organic nature of the wastewater.

***Table 2.** Representative composition of meat processing wastewater*

Parameter	Units	1997 AEE	Islington Wastewater
pH	g/m³	7.9	7.5
BOD	g/m³	520	540
Suspended Solids	g/m³	250	237
Nitrogen (TKN)	g/m³	110	
Ammonia Nitrogen	g/m³	25	
Total Phosphorus	g/m³	2	
Potassium	g/m³	5	
Calcium	g/m³	13	
Magnesium	g/m³	5	
Sodium	g/m³	9.5	
Copper	g/m³	0.07	0.017
Cobalt	g/m³	<0.05	
Selenium	g/m³	<0.005	
Cadmium	g/m³		<0.001
Chromium	g/m³		0.004
Nickel	g/m³		0.004
Zinc	g/m³		0.399
Mercury	g/m³		<0.001

2.2 Maximum Nutrient and Hydraulic Loadings

The SoilWork Annual Performance and Monitoring Reports for the 2004-05 to 2015-16 seasons list the annual nitrogen loading for individual irrigation blocks. The data show nitrate loadings vary from year to year depending on wastewater concentrations and the number of irrigation returns. Typical loading rates vary between 80 to 140 kg N/ha, with maximum application rates of up to 185 kg N/ha on individual irrigation blocks in some years.

The current application seeks to retain the maximum nitrogen application rate of 250 kg/ha/year specified in Condition 6 of the current consent (AUTH-95498). Assuming a representative wastewater nitrogen concentration of 170 g/m³, application of wastewater up to the maximum nitrate loading of 250 kg N/ha would require 1,470 m³ of wastewater to be applied to each hectare of the irrigation area (equivalent to an application depth of 147 mm/year).

The application further proposes retention of the current maximum wastewater application rate of 20 mm per application. Application of wastewater up to the maximum nitrogen loading rate would therefore require approximately 7.4 applications per year. Assuming a 300 day processing season, this would equate to an average return period of approximately 40 days.

For comparison, as summarised in Table 3 below, data reported in SoilWork (2016) indicate the irrigation system has historically operated with a typical application depth of between 14 to 19 mm across 4 to 8 irrigations per year, resulting in a mean annual application depth of between 50 to 100 mm, with an average return period of between 40 to 60 days.

Table 3. *Summary of historical irrigation practice*

Year	Number of irrigations	Application depth per irrigation (mm)		Seasonal application depth (mm)		Return period (days)	
		Mean	Maximum	Mean	Maximum	Mean	Minimum
2015-16	3.0	16.9	18.4	50.7	55.2	87	70
2014-15	3.9	17.0	18.9	66.3	73.7	61	41
2013-14	4.3	17.4	19.7	74.8	84.7	54	43
2012-13	4.0	16.7	18.8	66.8	75.2	60	50
2011-12	4.0	16.4	19.1	65.6	76.4	69	45
2010-11	4.7	17.0	19.6	79.9	92.1	74	40
2009-10	3.4	17.2	20.5	58.5	69.7	90	53
2008-09	5.0	16.5	19.9	82.5	99.5	73	42
2007-08	6.0	14.8	18.6	88.8	111.6	61	29
2006-07	7.0	12.9	17.4	90.3	121.8	44	24
2005-06	8.0	13.1	17.0	104.8	136.0	43	31
2004-05	8.0	12.6	16.3	100.8	130.4	46	30

3. Potential effects on groundwater quality

3.1 Annual Nitrate Loading

The Silver Fern Farms Mossburn wastewater irrigation area comprises a total land area of approximately 40 ha, of which approximately 34 ha is within the effective irrigation area (SoilWork, 2016). The irrigation area is divided into 20 separate irrigation blocks (runs) of between 1.2 ha and 2.0 ha in size which are irrigated using a rotary boom irrigator. The irrigated area comprises grass-based pasture from which significant volumes of dry matter are removed each year using a cut and carry system.

As outlined in Table 4 below, SoilWork Annual Monitoring and Performance reports provide an estimate of the mass of nitrogen removed from the irrigation area based on the weight of dry matter removed and the nitrogen concentration of herbage dry matter. The figures show an average of 100 kilograms of nitrogen removed from the irrigated area each year under the cut and carry system (range 77 to 126 kgs, 2008-09 to 2015-16).

Table 4. *Nitrogen removal by cut and carry pasture management*

Year	Dry Matter (tonnes)	%N in Herbage	Total Nitrogen Removed (kg)	Nitrogen Removed (kg/ha)
2015-16	171	1.7	2,907	86
2014-15	210	1.8	3,780	111
2013-14	188	1.4	2,632	77
2012-13	170	2.1	3,570	105
2011-12	194	2.2	4,268	126
2010-11	174	2.4	4,176	123
2009-10	154	2.1	3,234	95
2008-09	146	1.9	2,774	82
Average	**185**	**2.0**	**3,418**	**101**

Of the applied plant available nitrogen, a major loss of nitrogen in the land treatment system occurs via volatilisation of nitrogen, predominantly as ammonia gas and to a lesser extent, denitrification as nitrogen gas. The volatilisation of nitrogen occurs from the treated wastewater as it is irrigated. Estimates of nitrogen loss due to volatilisation vary from 23% (PDP, 2013)[8] to 38% (CPG, 2011)[9] of the total nitrogen loading in primary treated meatworks wastewater. Assuming volatilisation accounts for 25% of the applied nitrogen loading on the Silver Fern Farms Mossburn irrigation area, the proposed maximum nitrogen loading of 250 kg N/year effectively reduces to 187.5 kg N/year potentially available for plant uptake or conversion to oxidisable nitrogen (e.g. nitrate).

Given nitrogen removal under the cut and carry operation, application of wastewater at the maximum proposed loading of 250 kg N/year would therefore result in an excess of between 110.5 and 61.5 kg N/ha/year across the land disposal area (i.e. 187.5 kg N/ha/year minus N removed by cut and carry operations).

Soil moisture water balance calculations for the irrigated area reported by SoilWork (2016) indicate an annual water surplus of between 248 and 480 mm across the irrigation area between the 2008-09 and 2015-16 seasons. Assuming that all nitrogen applied to land in excess of that removed in herbage is ultimately converted to oxidisable nitrogen (i.e. nitrate), Table 5 provides an estimate of potential nitrate concentrations in soil drainage water under the irrigation area using the annual average nitrogen excess and soil moisture surplus. Results of this assessment indicate an annual average nitrate concentration in soil drainage water of 28.6 g/m^3 assuming wastewater application at the maximum rate of 250 kg N/ha.

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[8] PDP, 2013; *Wallace Corporation Limited Resource Consent Applications and Assessment of Environmental Effects*. Report prepared for Wallace Corporation Limited, November 2013

[9] CPG, 2011; *Land Application of Meatworks Process Wastewater at Byreburn Farm, Fielding. Resource Consent Application and Assessment of Environmental Effects*. Report prepared for AFFCO Manawatu, February 2011

Table 5. *Estimated nitrate concentration in soil drainage water between 2008-09 and 2015-16 assuming wastewater application at the maximum rate of 250 kg N/ha.*

Year	Maximum N application rate (kg/ha)	Effective N application rate[a] (kg/ha)	N removed (kg/ha)	Excess N (kg/ha)	Moisture Surplus (m^3/ha)[b]	Nitrate concentration in soil drainage (g/m^3)
2015-16	250	187.5	86	102	2,680	37.8
2014-15	250	187.5	111	77	4,000	19.1
2013-14	250	187.5	77	111	4,800	23.0
2012-13	250	187.5	105	83	4,070	20.3
2011-12	250	187.5	126	62	3,540	17.4
2010-11	250	187.5	123	65	3,400	19.0
2009-10	250	187.5	95	93	3,230	28.6
2008-09	250	187.5	82	106	2,480	42.5
Average			**101**	**87**	**3,530**	**28.6**

[a] assuming losses due to volatilisation account for 25% of the applied N load

[b] based on annual average water surplus listed in SoilWork (2016)

It is noted that the figures listed in table 5 provide a very conservative estimate of potential nitrate concentrations in soil drainage water under the Silver Fern Farms Mossburn wastewater irrigation area given:

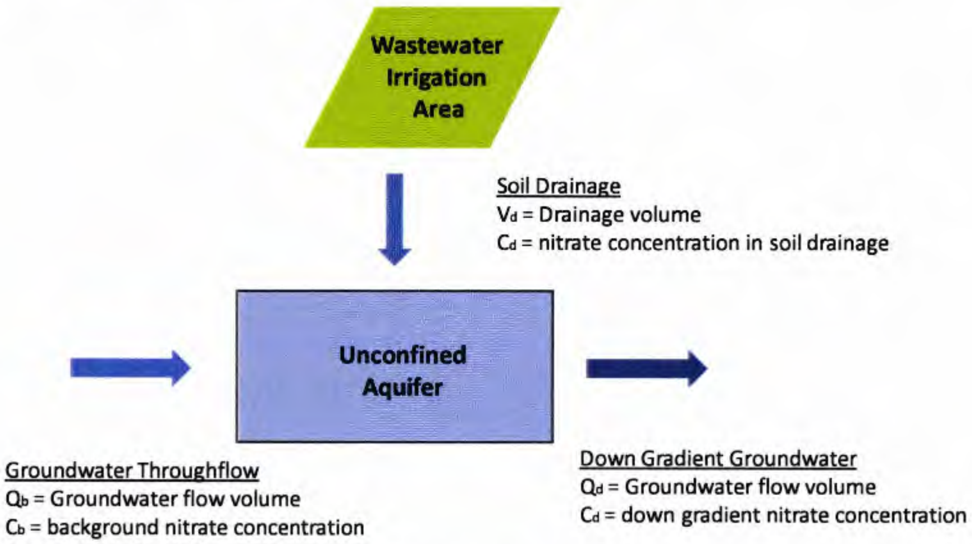
- Losses due to volatilisation are likely to be higher than the assumed 25% of applied N load, particularly given the time taken for ammonification and nitrification processes to occur within the soil (due to the primarily organic form of applied nitrogen);
- Assumed losses do not account for nitrogen retention within the soil organic nitrogen pool;
- Application of wastewater up at a maximum of 250 kg N/ha would require hydraulic loadings >30% higher than actual loadings occurring during the 2008-09 to 2015-16 seasons. This extra wastewater would increase season water surplus increasing assumed drainage volumes and thereby increasing dilution of the oxidisable nitrogen in the soil zone; and
- The wider irrigation area encompasses a total area of approximately 46 ha, of which wastewater is applied to 34 ha. Given the whole area is managed under the cut and carry system, nitrogen losses from the non-irrigated area will be very low and effectively offset concentrations in soil drainage from the irrigated area. Taking into account the additional recharge from dryland parts of the irrigation area (i.e. areas between and at the end of irrigation blocks including buffer zones), calculated nitrate concentrations in soil drainage water would reduce by around 35%.

3.1.1 Effects on down gradient nitrate concentrations

The concentration of nitrate-nitrogen in groundwater underlying, and immediately down gradient of, Silver Fern Farms Mossburn wastewater irrigation area will be determined by two primary factors:

1. The volume and concentration of nitrate-nitrogen in soil drainage from the irrigation area;
2. The volume and nitrate-nitrogen concentration of groundwater flowing through the unconfined aquifer underlying the irrigation area.

Figure 4 below illustrates a simple mass balance model used to estimate groundwater nitrate concentrations downgradient of the Silver Fern Farms Mossburn wastewater irrigation area. This model assumes the unconfined aquifer acts as a 'bucket' where all groundwater flowing through the aquifer is completely mixed with drainage from the overlying land area. As noted in Section 1.3 above, the estimated throughflow in the unconfined aquifer underlying the irrigation area is approximately 1,900 m^3/day or 693,500 m^3/year[10].



$$C_d = ((V_d \times C_d) + (Q_b \times C_b)) / Q_d$$

Figure 4. *Schematic illustration of simple mass balance used to estimate groundwater nitrate concentrations down gradient of the Silver Fern Farms Mossburn wastewater irrigation area*

Assuming a +/- 10 percent variation in aquifer throughflow between 'wet' and 'dry' years and adopting minimum and maximum drainage and soil water nitrate concentration figures from Table 5 above, mass balance calculations for three scenarios are shown in Table 6 below; a worst-case assuming minimum soil drainage and throughflow and highest soil water nitrate concentration, a best-case assuming maximum soil drainage and throughflow and lowest soil water nitrate concentration, and an estimate based on annual average values for the 2008-09 to 2015-16 seasons[11].

[10] For context, this volume is equivalent to the estimated dryland recharge to an area of approximately 190 ha (assuming 370 mm annual average recharge per year).

[11] The calculation assumes an up-gradient groundwater nitrate concentration of 2 g/m^3, consistent with the limited data held by Environment Southland for the general area surrounding the irrigation area.

Table 6. *Groundwater nitrate concentrations down gradient of the Silver Fern Farms Mossburn wastewater irrigation area estimated using a mass balance approach.*

Scenario	Soil drainage volume (m^3)	Nitrate concentration in soil drainage (g/m^3)	Groundwater throughflow (m^3/year)	Up-Gradient nitrate concentration (g/m^3)	Down-Gradient nitrate concentration (g/m^3)
Worst case	2,480	42.5	624,150	2.0	6.8
Best case	4,800	17.4	762,850	2.0	4.7
Average	**3,530**	**28.6**	**693,500**	**2.0**	**5.9**

Results of the mass balance assessment indicate the average nitrate concentration down gradient of the irrigation area is likely to be of the order of 5.9 mg/L. This figure is just over 50% of the Maximum Acceptable Value (MAV) for nitrate in drinking water listed in the Drinking Water Standards for New Zealand, and lower than that resulting from many forms of intensive agriculture undertaken as a permitted activity in the Southland Region.

Figure 5 shows a plot of the location of bores recorded on the Environment Southland groundwater database in the vicinity of the Silver Fern Farms wastewater irrigation area. The figure shows a single bore (E44/0234) located approximately 600 metres down gradient (i.e. south-east) of the irrigation area. This bore is screened between 30.8 and 33.8 metres below ground below a claybound gravel layer. As noted in Section 1.3 above this claybound gravel layer is spatially extensive across a majority of the Oreti Basin, forming an aquitard over deeper water-bearing alluvial sediments. The static water level of 22.1 metres below ground recorded on the bore log indicates limited hydraulic connection with the overlying unconfined aquifer which contains a water table between 3 to 5 metres below ground (as observed in the Mossburn Landfill monitoring bore (E44/0016) located approximately 750 metres north-east of E44/0234). Groundwater quality data provided by Environment Southland record a nitrate concentration of 2.6 mg/L in E44/0234 in a sample collected in 2003. No other bores or wells are recorded within 3 kilometres down gradient of the wastewater irrigation area.

It is also noted that Murray Creek is perched above the water table across the Castlerock Terrace. As a consequence this waterway is unlikely to receive baseflow from the unconfined aquifer down gradient of the wastewater irrigation area. This waterway primarily gains flow from surface runoff and shallow tile drains servicing areas of more poorly drained soils west of Mossburn Hill.

Figure 5. Location of existing bores in the vicinity of the Silver Fern Farms Mossburn irrigation area

3.1.2 Total Phosphorus Loadings

Wastewater quality data reported by SoilWorks (2016) indicates wastewater from the Mossburn plant contains an average Total Phosphorus loading of 6 g/m^3. Assuming application of effluent at the maximum rate to achieve a nitrogen loading of 250 kg N/ha (i.e. 147 mm/year or 1,470 m^3/ha/year), the corresponding Total Phosphorus load from wastewater application would be 8.8 kg P/ha/yr.

Phosphorus applied to land is typically immobilised through binding with soil particles, with limited losses to freshwater other than via direct run-off or soil erosion except where the phosphorus retention capacity of the soil is exceeded. As noted in the SoilWorks annual reports, due to the removal of herbage via cut and carry operations soil Olsen P values on the wastewater disposal area are typically low, and in some years application of additional phosphorus is required to maintain soil fertility. Even in years such as 2014-15 when phosphorus application rates reached 6 kg P/ha, Olsen P values remained below 13 µg/ml.

Overall, given the relatively low Phosphorus loadings in the wastewater and the removal of significant quantities of P via cut and carry operations (reflected in low soil Olsen P values) and the limited potential for soil erosion or particulate transport to surface water, it is unlikely that Phosphorus in wastewater applied to the irrigation area will result in adverse effects on the environment.

3.1.3 Discharge of microbial contaminants

Reflecting its origin, wastewater generated in the Mossburn plaint contains elevated loadings of microbial contaminants. Wastewater sampling data indicate an average Faecal Coliform concentration of 2.0 x 10^6 cfu/100 mL.

Attenuation of micro-organisms in wastewater occurs via a range of processes including natural die-off, ultraviolet light exposure, adsorption within soil and subsoil and filtration associated with saturated flow through porous media (vadose zone and below the water table). Figures reported by Pang (2009)[12] indicate typical attenuation rates of between 4 (Faecal Coliforms) and 2 (*Salmonella* phage) log/m in silt loam soils, 10^{-1} log/m in coarse-grained vadose zone materials such as those at the Mossburn site and 10-1 to 10^{-2} log/m reduction in sand and gravel aquifers.

Given the likely attenuation associated with movement through porous media, and the significant distance (>600 m) to the nearest down gradient receptor, discharge of wastewater to land at the Silver Fern Farms Mossburn plant has limited potential to result in adverse effects on groundwater quality (particularly given the high microbial loadings associated with intensive stocking or wastewater disposal in similar agricultural settings in rural Southland). Similarly, the limited potential for run-off from the wastewater irrigation area to Murray Creek significantly decreases the potential for adverse effects on surface waterways.

3.1.4 Trace metals and other contaminants

As outlined in Section 2.1 above, due to the largely organic nature of wastewater generated in the Mossburn plant, concentrations of trace metals and other contaminants are typically low to very low and unlikely to result in more than minor effects on the quality of receiving waters, particularly given the potential for adsorption and ion exchange within the soil zone.

3.2 Maximum hydraulic loading rates

The existing wastewater discharge consent for the Silver Fern Farms Mossburn plant specifies a maximum hydraulic loading of 20 mm per application, with a minimum return period of 7 days. The applicant wishes to retain the hydraulic loading rate specified on the existing consent to enable continued use of the existing infrastructure.

However, as summarised in Table 3.1 of SoilWork (2016), historical irrigation return periods have averaged between 43 and 90 days per year, with a minimum recorded return period of 24 days for a single irrigation block during the 2006-07 year. As previously noted, even assuming wastewater application up to the maximum nitrogen loading of 250 kg N/year, the irrigation average return period would remain above 40 days. On this basis it is proposed to increase the minimum return period to 30 days, effectively meaning that the maximum hydraulic loading would be 20 mm/month with a resultant

[12] Pang, L; *Microbial Removal Rates in Subsurface Media Estimated from Published Studies of Field Experiments and Large Intact Soil Cores.* Journal of Environmental Quality 38:1531–1559 (2009).

nutrient loading of 33.6 kg N/ha/month (based on the average wastewater composition listed in Table 1 above).

The analysis listed in Table 2 above indicate that between 15 to 20% of the nitrogen loading in Mossburn wastewater is likely to occur in the ammonia form. A significant proportion (>50%) of this load will undergo volatilisation during irrigation, with the balance readily converted to the mobile oxidised form (i.e. nitrate) by bacterially mediated nitrification within the soil zone. This fraction of the ammonia load not lost via volatilisation is therefore potentially available for pasture uptake (or leaching during periods of excess soil moisture). The remaining nitrogen load (80 to 85% of the total) occurs in the organic form which is relatively immobile in the subsurface environment.

Organic nitrogen undergoes bacterially mediated mineralisation followed by nitrification in the soil zone which ultimately converts it to the oxidised (nitrate) form. However, soil processes involved in the conversion of mineral nitrogen to nitrate take time to occur, particularly when soil temperatures are low. As a result, while the ammonia fraction of the applied wastewater which is not volatilised may be readily converted to the oxidised (nitrate) form shortly following irrigation, the bulk of the applied nitrogen load is only slowly converted to the oxidised form (i.e. nitrate). This potentially means that only a fraction of the nitrogen load applied in a single irrigation rotation occurs in the mobile nitrate form at any given time, increasing the potential for a greater higher percentage of the applied nitrogen load to be taken up by pasture growth or volatilised, compared to the situation where the entire nitrogen load is applied in the oxidised form at a single time.

The slow transformation of organic nitrogen to nitrate, also reduces the potential for large losses of nitrate in response to periods of high rainfall (either prolonged periods of high rainfall or large rainfall events) as, at any given time, only a fraction of the applied nitrogen load occurs in the nitrate form.

Overall, given the composition of the wastewater, only a proportion of the applied nitrate load will be in the mobile nitrate phase at any given time, with the balance in the relatively immobile organic form or removed from the soil via volatilisation or plant uptake. As a consequence, nutrient losses from the irrigation area are not particularly susceptible to short-term rainfall variability and potential effects on down gradient groundwater quality are best assessed on a seasonal basis. Similarly, potential leaching losses are not particularly sensitive to the hydraulic loading rate (due to the largely organic form of nitrate contained in the wastewater which has to undergo mieralisation and nitrification to be converted to nitrate).

During the winter months the potential for losses via leaching increase during periods when soil moisture is at or near field capacity (typically during winter/early spring). However, the magnitude of such losses during this period are to some extent mitigated by the larger water surplus (thus increasing drainage volumes and reducing nitrate concentrations in soil drainage) and lower soil temperatures which reduce the rate at which organic nitrogen is converted to nitrate. The proposed amendment to the minimum irrigation return period to 30 days will restrict the maximum nitrogen load to just over 30 kg ha/month (based on average wastewater concentrations).

Given down gradient nitrate concentrations are also determined by mixing with groundwater throughflow in the underlying aquifer, seasonal mass balance calculations (as outlined in the previous section) are an appropriate means of assessing the potential magnitude of effects on groundwater quality down gradient of the disposal area.

3.2.1 Extreme weather events

The water balance data calculated by SoilWork for the Mossburn irrigation area is only provided in annualised form. However, daily (dryland) soil moisture water balance data is available for the irrigation area from the calculations undertaken by Chanut (2014), although only for the period spanning 1977 to 2007. As previously noted, median moisture surplus (i.e. groundwater recharge) from the Chanut (2014) model show good agreement with the SoilWork calculations so are assumed to be equally representative of dryland conditions at the irrigation area.

In order to estimate the likely nitrate loss in response to significant recharge events, two main parameters are required: the volume of recharge and the mass of nitrogen in the oxidised form that may be mobilised in soil drainage. Figure 6 shows a plot of calculated daily soil moisture drainage in the vicinity of the irrigation area calculated by the Chanut (2014) model. The data show a majority of large recharge events are of the order of 20 mm/day (recharge following the November 1999 rainfall event being a notable exception). A recharge event of this magnitude equates to a recharge volume of approximately 200 m³/ha.

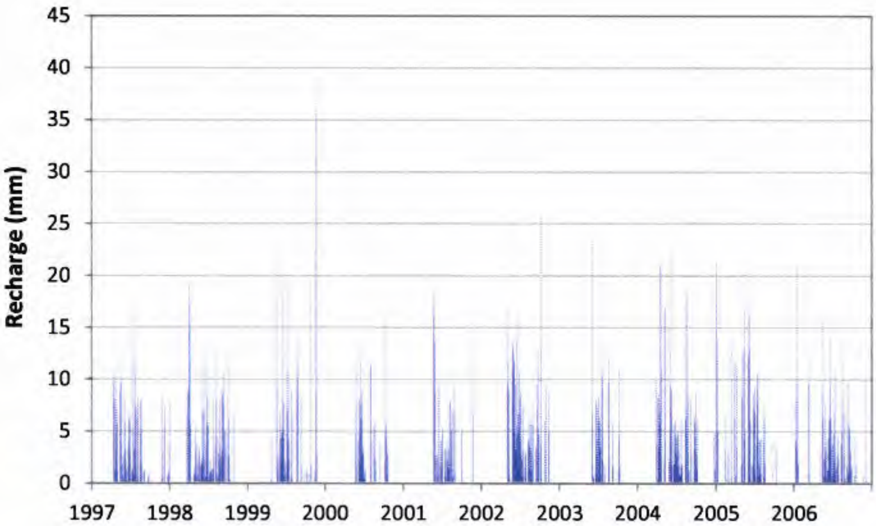


Figure 6. *Dryland groundwater recharge for the Silver Fern Farms Mossburn irrigation 1997-2007 (calculated from the daily soil water balance model of Chanu (2014)*

As noted in the previous section, due to the largely organic nature of the wastewater only a portion of the applied nitrogen load occurs in the oxidised for at any given time. To illustrate the effect of a significant recharge event occurring during or shortly following irrigation it is assumed that 50% of the applied nitrogen load which is in ammoniacal form can be rapidly nitrified and is therefore susceptible to leaching (i.e. assuming the remaining 50% of the maximum 8.2 kg N/ha load which occurs in the ammoniacal form is lost via volatilisation during or shortly following irrigation). On this basis assuming a nitrate mass of 4.1 kg is lost in response to a 20 mm recharge event, the resulting nitrate concentration in soil drainage water is 20.5 g/m^3. Soil concentrations of this order are similar to those calculated on an annualised basis and therefore are unlikely to result in greater impacts on groundwater nitrate concentrations down gradient of the irrigation area[13].

4. Summary

Meat processing wastewater has been discharged to land from the Silver Fern Farms Mossburn plant for an extended period. Historical monitoring of this discharge indicates nitrogen loading rates have been relatively modest, particularly when forage removed via cut and carry operations is accounted for. Historical wastewater disposal is also observed to have resulted in moderate improvements in soil conditions.

Mass balance calculations indicate that discharge of wastewater up to the maximum proposed nitrogen loading of 250 kg N/ha are unlikely to result in elevated nitrate concentrations (i.e. >50% MAV) in groundwater down gradient of the irrigation area (assuming continuation of cut and carry operations). Irrigation of wastewater up to the proposed maximum nitrogen loading is also assessed as unlikely to result in more than minor effects associated with Phosphorus, Sodium, trace metal and microbial components of the wastewater.

The predominantly organic form of nitrogen in the wastewater reduces the potential sensitivity of nutrient losses due to weather-related events as, at any given time, only a relatively minor proportion of the nitrogen load occurs in the soluble nitrate form. It is however, recommended that the minimum irrigation return period is increased to 30 days to limit the maximum nitrogen load during periods when the potential for nutrient losses are elevated.

Yours Sincerely

Brydon Hughes
Hydrogeologist

[13] Actual soil water concentrations will be slightly lower than the figure listed given the calculation does not take account of additional recharge associated with wastewater application. Figures listed in SoilWork annual reports indicate that historical wastewater disposal has increased total recharge by an average of 50 mm/year (from the data available it is not possible to determine additional recharge associated with individual recharge events other).