BEFORE THE ENVIRONMENT COURT
CHRISTCHURCH REGISTRY

ENV-2016-CHC-014

IN THE MATTER	of an appeal under Section 120 Resource Management Act 1991
BETWEEN	**SCHRADER MAINS LIMITED**
	Appellant
AND	**SOUTHLAND REGIONAL COUNCIL**
	Respondent

BRIEF OF EVIDENCE OF KATE LOUISE SCOTT

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1.0 Executive Summary

1.1 The proposal by Schrader Mains Limited requires a number of regional council consents, including consents for change of land use, construction of a bore, construction of an effluent storage pond, abstraction of groundwater, and the discharge of effluent to land. The overall activity status is for a **Discretionary Activity**.

1.2 The potential effects of the proposed activities have been assessed as being low to moderate. The proposed Farm Environmental Management Plan (FEMP) and conditions of consent will be instrumental in respect to managing many of the potential effects associated with the conversion of the land to dairying and the associated discharge of effluent to land. The FEMP adopts Good Management Practices (GMP's) for avoiding effects on water quality including managing critical source areas, and managing key contaminant pathways (overland flow and artificial drainage). Subject to appropriate conditions, no significant adverse effects would arise from the conversion of the land and associated discharges to land.

1.3 The proposal will also give rise to positive effects in regards the applicant's ability to provide for their social and economic wellbeing as well as contributing to the regional economy through wages and increased expenditure.

1.4 Various national and regional planning documents are relevant to determining the proposal. The proposal has been assessed against these instruments, and is considered to be consistent with the directions set out in these documents. The proposal is consistent with the National Policy Statement for Freshwater Management, with the proposal having been assessed as maintaining (and potentially enhancing) water quality within the receiving environment.

1.5 The National Environmental Standard for Sources of Human Drinking Water Regulations 2007 (NES – Drinking Water) and the Resource Management (Measurement and Reporting of Water Takes) Regulations 2010 would both be met.

1.6 An assessment of the proposal against the operative and proposed Regional Policy Statements has been undertaken, and in my opinion the proposal is consistent with the objectives and policies of both these documents.

1.7 In regards to the Regional Water Plan, and Regional Effluent Land Application Plan the provisions regarding water quality, water quantity, wetlands, agricultural effluent, soil health and fertility, are considered of most relevance. I consider the application is in accordance with the policy framework and assessment provisions of these planning instruments.

1.8 In June 2016 the Proposed Southland Water and Land Plan was publicly notified, and in accordance with Section 104 (1) (b) (vi) I have considered this to be a relevant matter for consideration. Whilst the proposed activity will result in modelled lower N losses and modelled higher P losses, when considered in the context of the proposed GMP's that will be adopted by the applicant, I consider that the proposal is not inconsistent with the objectives and policies of the PRWP.

1.9 The specific matters regarding discharges for consideration under Sections 105 and 107 of the Resource Management Act 1991 have been assessed, and with appropriate conditions for mitigation and monitoring, will be satisfied.

1.10 In terms of Part 2 RMA considerations, the proposal represents an efficient use and development of a natural resource that will result in positive benefits in terms of the applicant's ability to provide for their social and economic wellbeing, as well as contributing to the regional economy in terms of wages and increased expenditure. There will however be potential adverse effects that arise, including effects on water quality. I consider that the effects of the activities have been adequately identified and assessed, and that on balance such effects will be at an acceptable level through project design (i.e. effluent pond design parameters), monitoring programs for assessing water quality, the implementation of a FEMP for identifying and implementing GMP's and through conditions of consent, all of which will avoid, remedy or mitigate those effects.

1.11 Overall I conclude that the proposal is consistent with Sections 6, 7 and 8, and the sustainable management purpose of the Act.

2.0 Qualifications & Expertise

2.1 My full name is Kate Louise Scott and I am the Managing Director at Landpro Limited, a firm of consulting planners, surveyors and engineers. I have held this position since 2007.

2.2 I hold the qualification of BA (Geography) and BA (Political Science) from Victoria University, Wellington. I have 14 years' experience in planning and resource management, and I also hold qualification of 'approved provisional auditor' for ISO140001 Environmental Management Systems Certification. As a consultant I have provided advice on a broad range of developments and resource management issues to a range of clients, a number of which have involved presenting planning evidence to councils.

2.3 I hold professional memberships with the Resource Management Law Association (RMLA), New Zealand Institute of Management (NZIM), New Zealand Institute of Primary Industry Management (NZIPIM) and the New Zealand Institute of Directors (NZIOD).

2.4 My recent project work has included advising on a number of dairy conversion proposals, including undertaking environmental effects assessments, preparing consent applications and consultation with affected and interested parties. This work has also involved the development of a number of management plan frameworks, including Farm Environmental Management Plans. In addition, I have also been involved in a number of large scale projects throughout the South Island in the mining and irrigation sectors.

3.0 Code of Conduct

3.1 I have read the Code of Conduct for Expert Witnesses within the Environment Court Consolidated Practice Note 2014 and I agree to comply with that Code. This evidence is within my area of expertise, except where I state I am relying on what

I have been told by another person. To the best of my knowledge I have not omitted to consider any material facts known to me that might alter or detract from the opinions I express.

4.0 Involvement in Project

4.1 I am familiar with the project and resource consent application by Schrader Mains Limited to convert land at 514 Rimu Seaward Downs Road, Invercargill. I have visited the site on at least two occasions, and am familiar with the broader region through other work undertaken in the area over the past 10 years.

4.2 In September 2014 Schrader Mains Limited approached Landpro Limited to assist them in obtaining resource consent(s) for the conversion of their dairy support block to a dairy platform.

4.3 I was involved in an initial meeting with Schrader Mains Limited at which we discussed the resource consent process as well as details about the information which would be required in support of an application for resource consent. Mrs. Hunter was also in attendance at this meeting.

4.4 I did not prepare the resource consent application or Assessment of Environmental Effects (AEE) for the proposal to convert the land to dairying personally. This was completed by Rebecca Gibson and reviewed by me. As Managing Director of Landpro I take overall responsibility for these documents. I became more actively involved with the project at the time of the consent hearing.

4.5 Since 2014 I have visited the subject property on at least two occasions, and I am familiar with the site and the proposal to change land use.

4.6 In preparing this evidence I have reviewed the application and accompanying technical reports and have read all the other evidence to be provided to the Court on behalf of Schrader Mains Limited.

5.0 Scope of Evidence

5.1 My statement provides an overview of the proposal, sets out the statutory planning context for the application, including an analysis of the relevant statutory documents and an assessment of the anticipated effects of the proposal in accordance with Section 104 Resource Management Act (RMA) to convert the land to dairying on the environment. My assessment of the effects of the activities is informed by the technical assessments and evidence of others. My evidence also addresses the proposed conditions of consent and monitoring. Draft conditions are attached as Appendix 2.

5.2 My evidence is structured around the following key areas;

- The proposal; including project background and the existing environment;

- The statutory context; which provides details of the required approvals and the relevant matters for assessing the application under the Resource Management Act 1991 ("RMA" or "The Act") including the applicable plan and policy statement provisions, and the actual and potential effects on the environment and consideration of alternatives[1].

- Conditions and monitoring; Assessment of the conditions as proposed by Schrader Mains Limited, including associated monitoring;

- Conclusions.

5.3 In preparing this statement I have reviewed the following planning instruments;

- National Environmental Standard for Sources of Human Drinking Water Regulations 2007 (NES – Drinking Water);

[1] In accordance with section 105 of the Act.

- Resource Management (Measurement and Reporting of Water Takes) Regulations 2010;
- National Policy Statement for Freshwater Management 2014 (NPSFW);
- Operative Regional Policy Statement 1997
- Proposed Regional Policy Statement 2012
- Te Tangi a Tauira – Ngai Tahu ki Murihiku Natural Resource Management Plan 2008;
- Regional Water Plan for Southland 2010;
- Regional Effluent Land Application Plan 1998;
- Proposed Southland Water and Land Plan, June 2016.

6.0 Proposal

Background

6.1 The application site is located at 514 Rimu Seaward Downs Road, Invercargill. The site comprises approximately 110 hectares of modified farm land which has been owned by the Applicant for approximately 16 years. The property is located within the upper reaches of the Waituna Catchment.

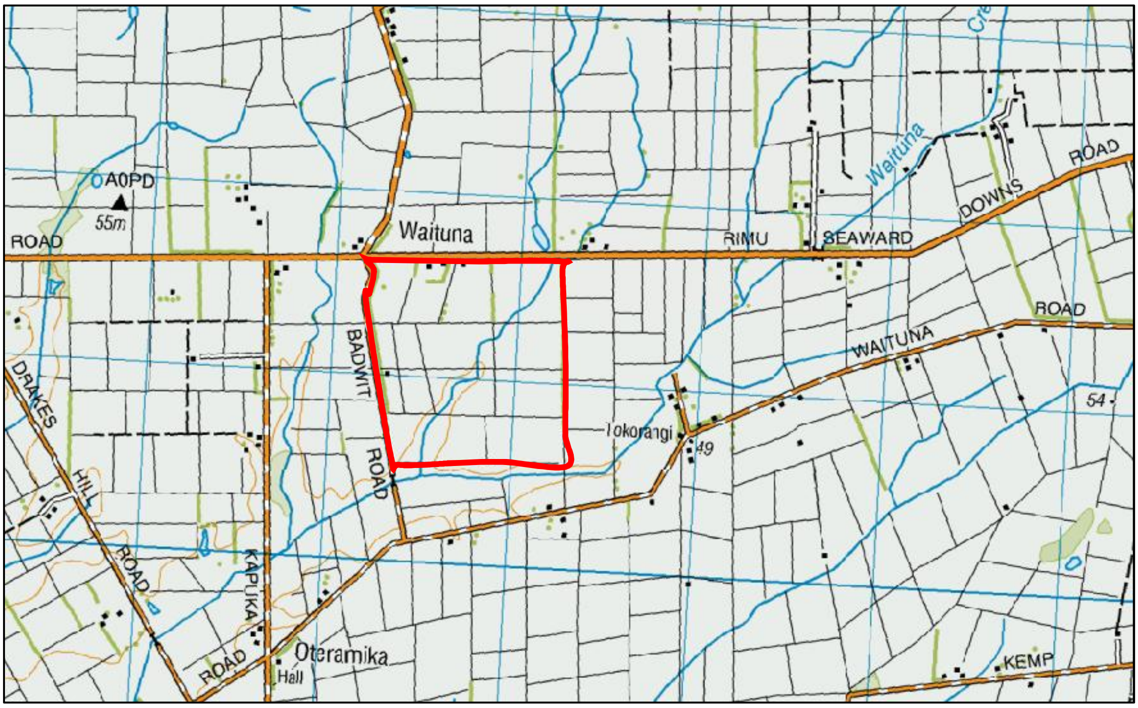

Figure 1: Site Location Plan [Source: LINZ Topo 50 Series]

6.2 An application and AEE were filed with Environment Southland in June 2015 in association with the proposal to convert the land to dairying. The application was publicly notified on 18 September 2015 with three submissions received. The applicant and submitters attended a pre-hearing meeting on 12 November 2015 during which proposed conditions were discussed. A hearing was subsequently held in Invercargill on 15 January 2016. A copy of the pre-hearing report is attached as Appendix 3.

6.3 The site is described as being generally flat to undulating, underlain by artificial drainage (tile drains) through much of the property. Vegetation cover is primarily improved ryegrass pastures, with exotic trees located along property boundaries and throughout internal farm boundaries. The property has been run as a dairy support (including winter grazing) unit by the applicant for the past 5 years, although prior to that the property was leased by the applicant for 11 years and run as a beef grazing block.

6.4 Soils on the property are comprised of both Wooldands and Dacre soils which are known to have various vulnerabilities as indicated in the assessment of environmental effects (AEE) submitted in support of the application[2], including moderate to severe potential for waterlogging.

6.5 The property is traversed by one primary water body, known as McMillan Creek, a tributary of the Waituna Creek, which flows into the Waituna Lagoon approximately 12 kilometres downstream of the property. This water body is fenced on both sides, with riparian planting having been established by the applicant on one side, with the other side maintaining a grass buffer as this creek is subject to regular drainage maintenance by Environment Southland.

6.6 The Waituna Lagoon is recognised as being one of the best remaining examples of natural coastal lagoon in New Zealand, and is part of the internationally recognised 20,000 ha Awarua Wetlands. The lagoon and immediately surrounding wetland are known as the Waituna Scientific Reserve, designated as a RAMSAR Wetland of International Importance. The evidence in chief of Ms. Karen Wilson provides greater detail as to the status of the lagoon at Paragraphs 11 – 15.

Project Description

6.7 Schrader Mains Limited propose to convert an existing 110-hectare dairy grazing (young stock and wintering) block to dairying.

6.8 The proposed herd size is 306 cows to be run over the approximately 103 effective hectares of the 110-hectare property. This equates to a proposed stocking rate of 2.97 cows/hectare (effective). The cows will be milked through a 24 a-side herringbone milking shed twice daily throughout the typical milking season of 1 August – 31 May with no winter milking proposed.

6.9 The proposal makes provision for the wintering of 90 cows on farm with the remaining animals to be wintered outside of the Waituna Catchment.

[2] Schrader Mains Limited AEE Section 2, Page 13-14.

6.10 The economic feasibility of the project is described in the evidence of Mr. Tony Robertson.

6.11 The proposal also includes the establishment of a concrete standoff pad/feed pad which will be used primarily on the shoulders of the season to hold stock off paddock where there is an increased potential for the discharge of contaminants, particularly via overland flow and artificial drainage to surface water[3] and soil damage.

6.12 Effluent from the shed and standoff pad/feed pad area is to be directed to a 930 cubic metre synthetically lined earth pond. The volume of storage required has been calculated using the Massey University Dairy Effluent Storage Calculator, the details of which were submitted in support of the consent application[4].

6.13 The design of the pond and effluent system has been undertaken by a suitably qualified person, as set out in the report by RD Agritech Limited, and also includes a pre-cast stone trap and solids bunker for the removal and temporary storage of solids. A dish drain is provided at the front of the solids bunker to direct any run off liquid back to the stonetrap and to avoid uncontrolled discharge to land from this part of the effluent system[5].

6.14 Effluent will be discharged to the identified effluent disposal area comprising of 93 hectares of the subject site. The proposed application system is a low rate Larral System. The Larral System is capable of discharging large volumes of effluent at very low application depths utilising pulsating technology.

6.15 The applicant is seeking to abstract groundwater for the purposes of stock and shed water use at a rate not exceeding 2 litres per second. The total daily volume to be abstracted will not exceed 36.72 cubic meters. This water may be abstracted from one of two locations, one being an existing bore located adjacent to the applicants dwelling, the second via a proposed new bore to be established

[3] Evidence in Chief Ms K Wilson, Paragraph 43
[4] Schrader Mains Limited AEE Appendix C.
[5] Schrader Mains Limited AEE Appendix C.

immediately adjacent to the proposed cowshed. The application includes consent to construct a new bore.

Existing Environment

6.16 The subject site is located at 514 Rimu – Seaward Downs Road in the Waituna Catchment. The site is located approximately 25 kilometres to the east of Invercargill and approximately 10 kilometres from the southern coast of New Zealand. The property is located approximately 12 kilometres from the Waituna Lagoon complex. The general landscape surrounding the proposed site is largely described as being highly modified farmland with sporadic pockets of remnant native vegetation, with farming being the predominant land use. A variety of farming systems surround the subject site, including dairying, dairy support, and sheep and beef operations.

6.17 The existing environment is described in Section 2 of the AEE and covers; current land use, topography, soils and climate, vegetation and wildlife, surface and groundwater, and water quality. Outlined below are the key aspects of the existing environment.

6.18 The property currently operates as a dairy grazing (young stock grazing and dairy cow wintering) and beef unit, which includes the cropping of approximately 17 hectares of fodder crop annually. The modelled (Overseer®) Nitrogen and Phosphorous losses for the current operations include Total Farm N Loss of 4337kg or 39 kg/N/ha/year and Total Farm P Loss of 44kg P and an average P Loss per hectare of 0.4 kg/P/ha/year[6].

6.19 The property has two key soils types, Woodland Soils which comprise approximately 84% of the property and Dacre Soils which make up the remaining 16%.[7] Given the nature of these soils coupled with annual average rainfall of 1070 mm/year the property is extensively drained with tile drains.

[6] Evidence in Chief Mrs Hunter, Paragraph 12, Page 4.
[7] Schrader Mains Limited AEE Section 2, Page 13-14.

6.20 The subject property is flat to very gently undulating, containing a few shallow swale areas. All existing waterways on the property are fenced off with one side having been subject to riparian planting. The other side of the creek retains long grass (as opposed to trees and shrubs) to facilitate regular waterway clearance work. All drainage maintenance work within this water body is undertaken by Environment Southland[8] on an approximately 3 yearly cycle. Environment Southland last completed stream clearance activities in February 2015[9]. Photographs of the subject site are included as Appendix 4.

6.21 Since the lodgement of the application and AEE, Environment Southland have developed a series of 'physiographic zones' as detailed in the evidence of Ms Wilson. The subject property is classified as being within the 'Gleyed Physiographic Zone' which notes that soils within this zone have the ability to remove some or all nitrogen via denitrification.

6.22 Ms Wilson provides a summary of both existing groundwater and surface water quality.

7.0 Required Consents

7.1 The proposal to convert the land to dairying requires the applicant to obtain a number of resource consents from Environment Southland (ES) under the Operative Regional Water Plan 2010 (RWP) and the Operative Regional Effluent Land Application Plan 1998 (RELAP). Following the notification of the Proposed Southland Water and Land Plan (PWLP) in June 2016, and in accordance with Section 104 (1) (b) (vi) I have also assessed the consenting requirements under the PWLP.

7.2 Consents are required as follows;

[8] Section 42A Report, Page 10.
[9] Pers. Coms. Hank Schrader

Table 1: Summary of Required Consents

Activity	Status	Rule	Plan
The conversion of the land to dairy farming	Discretionary Activity	Rule 17A	RWP
Taking and use of groundwater	Discretionary Activity	Rule 23	RWP
Construction of an effluent storage pond	Restricted Discretionary Activity	Rule 49 (a)	RWP
Construction of a bore	Controlled Activity	Rule 22	RWP
The discharge of dairy shed and stand-off/feed pad effluent to land	Discretionary Activity	Rule 5.4.6	RELAP
New or expanded dairy farming	Discretionary Activity	Rule 22	PWLP
Construction of an effluent storage pond	Restricted Discretionary Activity	Rule 32	PWLP
The discharge of dairy shed and stand-off/feed pad effluent to land	Discretionary Activity	Rule 35 (c)	PWLP
Construction of a bore	Controlled Activity	Rule 53	PWLP
Abstraction and use of groundwater	Permitted Activity	Rule 54	PWLP

7.3 In terms of the RWP and the RELAP the overall status of the application is considered to be a **Discretionary Activity**.

7.4 In respect of the PWLP the overall status of the applications would also be considered to be a **Discretionary Activity**. Under this plan the same consents are required as are required under the RWP and RELAP save for the taking and use of groundwater which is a permitted activity under the PWLP. Under the PWLP an application would need to include a Management Plan prepared and implemented in accordance with Appendix N. The FEMP required as a condition of the proposed consents is consistent with the requirements of Appendix N.

8.0 Effects on Environment

8.1 The potential effects of the proposed activity on the environment can be broadly grouped as including;

- Effects on Water Quality [Groundwater & Surface Water];
- Effects on Water Quantity
- Effects on Soil Health
- Effects of Odour
- Cumulative Effects
- Positive Effects

Effects on Water Quality

8.2 The process of converting the land to dairying and the associated abstraction of water, construction of an agricultural effluent storage pond, construction of a bore and discharge of effluent to land can give rise to environmental effects including effects on Water Quality.

8.3 The effects of the proposal are detailed in Section 5 of the AEE, and within the supporting documents appended to the application. The technical water quality assessment which accompanied the application[10] described the actual and potential effects of the proposed activities on both groundwater and surface water quality. The evidence in chief prepared by Ms. Wilson notes the inherent difficulties in assessing the potential effects of the proposal in terms of overall water quality and notes that numerical catchment modelling is not appropriate given that the property represents less than 0.6 percent of the total catchment area, and given

[10] Technical Water Quality Assessment, June 2015; Appendix D AEE

the relatively small changes in modelled nutrient loss. Such modelling would not show any appreciable outcome in terms of potential effects on water quality. Given these limitations Ms. Wilson has undertaken a qualitative risk based assessment.

8.4 Ms. Wilson notes the following in respect to actual or potential effects of the proposed activities;

"Overseer® modelling suggests the average farm modelled nitrogen loss in drainage water will be 6.3 mg/L under the proposed dairy conversion. As most of this loss is expected to occur as leaching in the form of nitrate (as NO_3-N). The modelled farm loss of 6.3 mg/L is well within the maximum acceptable value in the Drinking Water Standard for New Zealand (DWSNZ)."

8.5 Based on the assessment by Ms. Wilson, I am of the view that the effects on water quality, specifically human health receptors will be acceptable given that the modelled nitrogen loss is well below the maximum acceptable value set out in the DWSNZ.

8.6 In terms of the actual or potential effects of the proposal on surface water, the two main critical pathways have been identified as overland flow and artificial drainage for phosphorus and leaching for nitrogen.[11] Studies have indicated that the majority of nitrate loss from properties in Southland occurred during spasmodic events, typically between May and the end of July when soils were near field capacity.[12] The proposed conversion responds to this risk by wintering off of all but 90 animals over this high risk period, and adopting the 'good management practices' (GMP's) outlined by Mrs. Hunter and detailed within the proposed Farm Environmental Management Plan. Mrs Hunter states that there is a "significant opportunity to reduce the P loss through targeted good management practices that are not modelled through Overseer®"[13]. In terms of the GMP's that the applicant will be adopting (M Hunter Evidence, Paragraph 21) and their potential effectiveness to

[11] Evidence in Chief Ms K Wilson, Paragraph 40.
[12] Evidence in Chief Ms K Wilson, Paragraph 44.
[13] Evidence in Chief Mrs Hunter, Page 8.

reduce P losses as presented in the paper by R McDowell and D Nash titled *A Review of the Cost-Effectiveness and Suitability of Mitigation Strategies to Prevent Phosphorous Loss from Dairy Farms in New Zealand and Australia, 2012* (copy attached as Appendix 5) the overall ability of the measures proposed by the applicant to reduce P losses range from 5 to 50 percent.

8.7 The receiving environment in this case includes the existing grazing operation and in my opinion the specialist grazing alternative discussed by Mrs Hunter and Mr Robertson. It has been difficult for the Mrs Hunter and Ms Wilson to quantify the relative effects of the proposed conversion against the receiving environment. Having considered each of the relevant matters I am of the view that the actual or potential effects to water quality are likely to be low when assessed against the receiving environment. The proposed conversion reduces the stocking rate and area under crop at the higher risk time of year (winter) reducing the risk of overland flow and losses via artificial drains due to adverse weather conditions.

8.8 As detailed in the evidence of Mrs. Hunter, N loss has been modelled to reduce under the conversion scenario, while modelled P loss will increase. Obviously given the constraints of Overseer, these numbers need to be considered carefully as discussed in the Evidence of Mrs Hunter. However, based on the evidence of Mrs Hunter, P loss from the proposed farm system is likely to be reduced compared to modelled losses via adoption of targeted GMP's.

8.9 A mitigation tool proposed by the applicant is the Farm Environmental Management Plan (FEMP) which outlines the GMP's that will be adopted for the site, as well as documenting the site management processes and environmental management measures to ensure compliance with proposed conditions of consent. The FEMP also documents proposed monitoring to enable ongoing assessment of the effects of the activity and therefore enable GMP's to be adapted over time to improve their efficacy. These tools would in my view enable the proposed conversion and subsequent use of the land for dairying purposes to occur in a way which would avoid, remedy or mitigate any adverse effects associated with the conversion.

Effects on Water Quantity

8.10 Schrader Mains have applied for consent to abstract up to 36,720 litres of groundwater per day which is based on a daily volume of 120 litres per cow per day.[14] At the time of application, the proposed abstraction of water was considered to be from the Waihopai Groundwater Management Zone, which had a total remaining allocation of 94.7%[15]. However, at the time of writing this statement the Proposed Water and Land Plan (PWLP) had reclassified the property as being underlain by the Awarua Groundwater Management Zone[16]. The Awarua Groundwater Management Zone is considered to have a total available primary allocation of approximately 32.29Mm^3. On the basis that allocation of water is available within the relevant groundwater zone and the total proposed rate of abstraction is in accordance with documented 'reasonable use' guidelines, the overall effects of the abstraction of water are considered to be negligible. I note for completeness that under the PWLP the abstraction would be considered a Permitted Activity.

Effects on Soil Health

8.11 The three key elements of the proposal which may results in effects on soil health relate to the change in land use, the construction of the effluent pond and the discharge of effluent to land.

8.12 The applicant has sought to establish an agricultural effluent storage pond that meets the 90th percentile storage volume as specified by the Massey Effluent Pond Calculator so as to enable the extended storage of effluent so that effluent will only be discharged to land in appropriate conditions (i.e. when the soil is not at field capacity). The storage pond should be irrigated from daily when conditions allow and should not be used to defer irrigation when irrigation potential is present"[17]. The construction of an appropriately sized storage facility will in my opinion limit

[14] Section 5.4 AEE, Page 35.
[15] Section 42A Report, Page 16.
[16] Evidence in Chief K Wilson, Paragraph 10, Page 2.
[17] Schrader Effluent Design Report, RD Agritech, Section 4.1, Page 6.

the potential for adverse effects on soil health which might otherwise arise in the event that the pond was smaller than recommended by the Massey Effluent Pond Calculator.

8.13 In terms of the risk of pond failure or for the pond to leak, the pond has been designed by a suitably qualified person in accordance with the *Environment Southland Code of Practice for Design and Construction of Agricultural Effluent Ponds* and the IPENZ Practice Note 21 as documented in the report by RD Agritech Limited attached as Appendix C to the Application. The pond design makes provision for a number of measures to mitigate the potential effects of pond failure or leakage which may impact on soil health, including installation of a synthetic 1.5mm HDPE liner, which has a minimum 20-year life.[18]

8.14 In regards to the application of farm dairy effluent to land, RD Agritech have noted that if the instantaneous irrigation rate is higher than the Ksat value the soil cannot absorb it fast enough which will result in ponding on the surface[19], and therefore the potential for discharge via artificial drainage or overland flow. To manage the potential risk of this, the discharge of effluent has been designed so that during the wetter parts of the year the system can be pulsed to apply effluent at a rate of 2mm/hr which is a very low rate designed to avoid over application and the potential for discharge via overland flow or artificial drainage.

8.15 Overall the risks to soil health from inappropriate pond design and application of effluent to land are considered to be acceptable and able to be avoided, remedied or mitigated through the proposed effluent system design and conditions of consent. I will discuss the specific conditions of consent later in this evidence.

8.16 In my opinion the greatest risk in terms of soil health and the application of effluent to land is through the day to day operation of the effluent system. The AEE included an Effluent Management Plan (EMP) as part of the overall Farm Environmental Management Plan (Section G FEMP). This plan documents the methods to be

[18] Schrader Effluent Design Report, RD Agritech, Section 4, Page 7.
[19] Schrader Effluent Design Report, RD Agritech, Section 4.1, Page 7.

employed by the applicant to ensure that staff were appropriately trained, effluent was applied in accordance with the design recommendations and to meet underlying soil conditions, i.e. testing of soil moisture content prior to the disposal of effluent. The EMP also made provision for the documentation of effluent disposal areas, times and dates to ensure nutrient application did not exceed optimal levels.

8.17 The evidence in chief of Mrs. Hunter notes that the high risk period for nutrient loss in this region is during the winter. Given this is when stock are intensively break fed there is also potential for effects on soil health to arise from pugging. The proposal to winter only 90 cows on the property and have all other stock wintered outside of the Waituna Catchment is a mitigating factor. Particularly when considered relative to the potential risks associated with the current or alternative land use scenarios, under which higher winter stocking rates will occur.

8.18 The methods for managing the effects of the conversion on soil health have been documented in the Farm Environmental Management Plan and consent conditions, and include measures such as break fencing, and the development of a standoff/feed pad. The reduction in total cropped area under the conversion scenario is also considered to be beneficial to soil health.

8.19 Overall I consider the effects of the proposed conversion activity on soil health to be minor.

Effects of Odour

8.20 The effects of odour are most likely to occur from the discharge of farm dairy effluent (FDE) or from the storage of effluent where it may be encountered beyond the boundary of the site. RD Agritech Ltd notes that ponds of this size [930m3] will stagnate and cause odour, as well as Biological Oxygen Demand problems when applied to soil resulting in increased de-nitrification in the soil, unless oxygenated by means of mechanical stirring, or aeration of the fluid is conducted.[20] Amongst other things the design of the effluent pond accounted for mechanical stirring as

[20] Schrader Effluent Design Report, RD Agritech, Section 4.1, Page 8.

well as the appropriate siting of the infrastructure some 400 metres from the nearest property boundary and 1000 metres from the nearest dwelling not located on the property. The applicant has also proposed the use of low rate application technology in the form of a Larral Smart Hydrant system which can apply effluent at a rate of between 2mm an 10mm/hour[21].

8.21 The applicant also proposes not to discharge effluent within the following buffer zones from sensitive activities or receiving environments;

(a) 20 metres of any surface watercourse;

(b) 100 metres of any potable water abstraction point;

(c) 200 metres of any residential dwellings other than residential dwellings located on the subject property;

(d) 20 metres from any property boundaries

8.22 The physical location of the effluent infrastructure coupled with the proposed low application rate Larral Smart Hydrant system and effluent discharge buffers means, there is little risk of adverse effects from odour and spray drift on surrounding land owners and occupiers. As such the effects of odour are avoided, or mitigated through conditions of consent as discussed in Section 14 of this statement.

Cumulative Effects

8.23 An assessment of the potential for cumulative effects to arise as a result of the proposal is appropriate, specifically in the context of potential effects on water quality and the location of the property within a sensitive catchment. As outlined in the Evidence of Ms. Wilson, the property area represents less than 0.6% of the

[21] Personal coms. RD Agritech, December 2015.

total catchment area, and given the relatively small changes in nutrient loss estimated by Overseer® modelling any numerical assessment of the effects on water quality are unlikely to be measurable.

8.24 In considering the potential for cumulative effects I am of the view that the cumulative effects can be avoided, remedied or mitigated through conditions of consent such that the overall cumulative effects of the proposal are likely to be lower than those that might accumulate under alternative land use scenarios.

Positive Effects

8.25 The proposal to convert the land will give rise to a number of benefits for the applicants, including those which provide for their social and economic wellbeing. This has been quantified in the evidence of Mr. Robertson as including an increase in profit from $50,696 per annum under the current land use to $199,137 per annum under the proposed conversion.

8.26 Beyond the benefits gained by the applicant there are also anticipated to be regional and local benefits, including provision of employment opportunities. Currently the Schrader's do not employ any staff on the property, however the conversion of the property would see the employment of a full time manager along with another part time (or more) equivalent. [22]

8.27 I assess these benefits to be significant to the applicant and their ability to provide for their economic and social wellbeing and moderate in terms of the overall contribution to the region and its economy through increased employment and profitability created directly and indirectly as a result of this proposal.

[22] Evidence in Chief Mr A Robertson, Paragraph 7.

9.0 Relevant Planning Documents

9.1 I have assessed the relevant environmental standards, plans and policies statements, starting with the national planning framework, followed by those which apply to the region.

National Environmental Standards & Regulations

9.2 There are two relevant National Environmental Standards or Regulations to this application, those being;

- National Environmental Standard for Sources of Human Drinking Water Regulations 2007 (NES – Drinking Water)

- Resource Management (Measurement and Reporting of Water Takes) Regulations 2010

9.3 Regulations 6, 7 and 8 of the Resource Management (National Environmental Standards for Sources of Human Drinking Water) Regulations 2007 (NES – Drinking Water) apply to water and discharge permits issued by Regional Councils. The proposed discharge is not in the vicinity/upstream of a registered drinking-water supply.

9.4 As outlined by Ms. Karen Wilson, *Overseer®* modelling suggests the average farm modelled nitrogen loss in drainage water will be 6.3 mg/L under the proposed dairy conversion. As most of this loss is expected to occur as leaching in the form of nitrate (as NO_3-N). The modelled farm loss of 6.3 mg/L is well within the maximum acceptable value in the Drinking Water Standard for New Zealand (DWSNZ) (Ministry of Health 2008).

9.5 The discharge is not directly to water and it is accepted that a 100 m buffer zone from potable water abstraction points will apply and be secured through conditions of consent.

9.6 In regards the Resource Management (Measurement and Reporting of Water Takes) Regulations 2010, as the proposed abstraction of Groundwater is at a rate less than the 5 litres/second outlined in regulations, the regulations are not applicable to the application. However, metering of the groundwater take is proposed in conditions of consent.

National Policy Statement for Freshwater Management

9.7 The National Policy Statement for Freshwater Management 2014 (NPSFM) sets out both water quantity and quality objectives as well as objectives regarding integrated management and provision for reasonable opportunity for Iwi and hapu involvement in overall freshwater management.

9.8 The objectives and policies of the NPSFM that are relevant to the application are:

Objectives A1, A2, B1, B3, B4, C1 and D1

Policies A3, A4, B5, B6, B7, C1 and D1.

9.9 In my opinion the proposal is not inconsistent with Objective A1 which seeks to safeguard the life-supporting capacity, ecosystem processes and indigenous species including their associated ecosystems, of fresh water and the health of people and communities, in sustainably managing land use and discharges of contaminants. The conversion of the land to dairying and the discharge of effluent is to be undertaken in accordance with best practice guidelines (GMP's), the management of which is outlined in the FEMP, and through conditions of consent. The FEMP approach allows for management of the discharge so as to ensure that the discharge occurs in accordance with current best practice and in a sustainable manner for the duration of the consent. Effluent is to be collected from the dairy shed and feed pad and discharged to land using a low rate Larral Smart Hydrant System. This system was chosen because it minimises the risk to water quality from overland and preferential flow, in accordance with the '*recommended minimum criteria for a land applied effluent management system'* [Houlbrooke and

Monaghan 2009], attached as Appendix 6. On which basis the potential for contamination of water bodies is reduced therefore enabling the objectives of the NPSFM to be met by the proposal.

9.10 Objective A2 requires that the overall quality of freshwater within a region is maintained or improved, while protecting the significant values of fresh water in water bodies that have been degraded by human activities to the point of being over-allocated. The Council have not as yet identified limits that enable an assessment of whether a waterbody is allocated (or overallocated) in terms of water quality, therefore it is difficult to fully assess the matter of allocation. The applicant's property is located within a sensitive catchment, and whilst the catchment and creek have not been classified as being overallocated, the sensitive nature of the Waituna Catchment is a consideration in respect to whether freshwater can be maintained or improved under the proposal. Having considered all of the information available to me, I am of the opinion that subject to the inclusion of conditions of consent the activity is considered consistent with Objective A2.

9.11 Policies A2, A3 and A4 require the Council to set objectives and limits to assist in the improvements of water quality in water bodies. The Waituna Creek catchment does not yet have water quality limits. Environment Southland are currently working towards setting limits through the *Water and Land 2020 & beyond* project. Environment Southland have released a schedule for rolling out freshwater limits in the Southland Region and they have stated that the Waituna catchment limit setting process will occur in conjunction with the Mataura catchment between July 2017 and 2019 (Environment Southland 2015). Whilst objectives and limits have yet to be set, it is accepted that in the event that consent is granted, any activity at the time of limit setting will be required to meet the stated objectives and limits.

9.12 Objectives B1, B3, B4 and C1 of the NPSFM are satisfied as the proposed abstraction of groundwater represents an efficient and reasonable use of the resource that will not result in over allocation.

9.13 The Application gave due consideration to Te Tangi a Tauira (Murihiku Iwi Management Plan)[23] and in addition Te Ao Marama on behalf of Ngai Tahu submitted on the application. The consideration of Te Tangi a Tauira and the involvement with Ngai Tahu through the submission process are considered to show consistency with Objective D1 and Policy D1.

Regional Policy Statement (RPS)

9.14 The Regional Policy Statement (RPS) became operative in 1997, but is subject to revision via the Proposed Southland Regional Policy Statement (PRPS) which was notified in 2012. The decisions of the PRPS were notified on 6 June 2015, however due to a number of appeals of the decision, the policy statement currently remains inoperative.[24]. An assessment against the PRPS is included starting at Paragraphs 9.31.

9.15 In terms of the relevant policies and objectives detailed in the Regional Policy Statement, it is considered that the proposed activities are consistent with the provisions of the statement and the overall intent of the RPS. I have undertaken an assessment of the relevant provisions grouped by topic heading below.

9.16 I have not included the full text of the relevant objectives and policies but I have noted the relevant provisions and assessed whether the application is in accordance with the provisions or not. Attached at Appendix 7 is the full text of the relevant objectives and policies.

Takata Whenua

9.17 Relevant objectives include 1.1, 1.2, 1.3, and 1.4 and Policy 1.2.

9.18 Recognition of the relationship of mana whenua with their ancestral lands, water sites, waahi tapu and other taonga has been provided for, the extent of which has been determined largely by the direction set in the Ngai Tahu ki Murihiku Natural

[23] Section 6.2 AEE, Page 39.
[24] Environment Southland Website, www.es.govt.nz, July 2016.

Resource and Environmental Management Plan Te Tangi a Tauira (2008). An assessment of this document is included in Paragraphs 9.49 to 9.51.

Water Quantity

9.19 Water quantity objectives of the RPS which are of relevance to this application include 4.1, 4.2, 4.3 and 4.4 and 4.5; whilst the relevant Policies are 4.3, 4.4, 4.5 and 4.6.

9.20 My assessment of these matters is that the application is consistent with these provisions because the volume of water being sought represents an efficient allocation of resources, and the taking of water will not result in the over allocation of groundwater.

Water Quality

9.21 Water quality objectives of the RPS which are of relevance to this application include 5.1, 5.2, 5.3 and 5.4; whilst the relevant Policies are 5.5 and 5.8.

9.22 The proposal is consistent with Objective 5.1 in that the overall proposal, including conditions of consent proposed by the applicant will enable the safeguarding of water quality. A continuation of the alternative land uses are likely to be inconsistent with this objective despite being permitted activities.

9.23 The proposal provides for the mitigation of potential effects on water quality as outlined in proposed conditions of consent and FEMP, therefore I consider the application to be consistent with Objective 5.2 RPS.

9.24 In respect to Policy 5.5 and the assessment of potential cumulative effects, a change in land use subject to the proposed conditions will have no net negative effect on the Waituna catchment.

Lakes, Rivers and Wetlands

9.25 Objectives and policies of the RPS that relate to Lakes, Rivers and Wetlands which are of relevance to the application by Schrader Mains Limited include Objectives 6.1 and 6.2 and Policies 6.1, 6.4, 6.6, and 6.11.

9.26 As the application is located within the Waituna Creek catchment which feeds into the regionally and internationally significant Waituna Lagoon wetland the provisions of Section 6 RPS are considered relevant. The application has demonstrated that the proposal to convert to dairying will contribute to the protection of the wetland ecosystem through a modelled reduction in nutrient loading to the catchment (i.e. from 39 kg N /ha/year to 29 kg N /ha/year). Whilst modelled losses of P suggest an increase the Overseer® model does not recognise many of the GMP's that will be employed to reduce P loss. Mrs Hunter's evidence identifies the mitigation methods to be adopted on the application site as having significant potential to reduce P loss. In my opinion the application is not inconsistent with these provisions, including Policies 6.1 and 6.6.

Soils

9.27 Objectives and policies of the RPS that relate to Soils which are of relevance include Objectives 8.1, 8.2, 8.3, 8.4 and 8.5 and Policies 8.1, 8.2, 8.4 and 8.5.

9.28 The proposal by Schrader Mains Limited is considered to be consistent with the RPS in respect to matters relating to the use of the soil resource. The method of discharge of effluent, including provision of storage to enable deferred application is in accordance with current best practice guidelines. Both the current and specialist grazier land use options may give rise to inconsistencies with the Soil Chapter of the RPS compared to the proposed conversion of the land to dairying.

9.29 When considering the provisions of the RPS collectively, they set a broad framework for assessment of the proposed conversion of land to dairy. Specifically, in relation to effects on soil health, water quantity and water quality, odour, and cumulative effects.

9.30 The RPS focuses on the potential for adverse effects on the environment. In terms of the effects of the proposed activity I am informed by the assessments and statements of those experts (as referenced in this evidence), and their conclusions as to adverse effects being able to be avoided, remedied or mitigated. I have also considered the range of conditions proposed (and subsequently modified) and taking all of these matters into account I am of the opinion that the proposal is consistent with the objectives and policies of the RPS.

Proposed Regional Policy Statement (PRPS)

9.31 The Proposed Regional Policy Statement was publicly notified in 2012. The decisions of the PRPS were notified on 6 June 2015, however due to a number of appeals of the decision, the policy statement currently remains inoperative,[25] however as directed by Section 104(1)(b)(vi) RMA I have given due considered to the PRPS and the matters of relevance set out within the statement.

9.32 I consider the following objectives and policies of the PRPS are relevant to the application;

- Chapter 3: Tangata Whenua; Objective TW.2, TW.3, Policy TW.3 and Policy TW.4
- Chapter 4: Water; Objectives and policies for water quality WQUAL.1, WQUAL.2, Policy WQUAL.1, WQUAL.2, WQUAL.3, WQUAL.4, WQUAL.6, WQUAL.7, WQUAL.8, WQUAL.9, WQUAL.10 and objectives and policies for water quantity, WQUAN.1, WQUAN.2, Policy WQUAN.2, WQUAN.6, WQUAN.7
- Chapter 5: Rural Land/Soils; Objective RURAL.1, RURAL.2 and Policies RURAL.1, RURAL.2, RURAL.5
- Chapter 6: Biodiversity; Objective Bio.1, Bio.2, Bio.3 and Policy Bio.1.

[25] Environment Southland Website, www.es.govt.nz, July 2016.

9.33 The proposal is deemed consistent with Chapter 3 PRPS. The relationship of Tangata Whenua with their ancestral lands, water sites, waahi tapu and other taonga has been provided for, the extent of which has been determined largely by the direction set in the Ngai Tahu ki Murihiku Natural Resource and Environmental Management Plan, *Te Tangi a Tauira* (2008).

9.34 In terms of an assessment of the application in respect to Chapter 4: Water I am of the view that the application is consistent with the WQUAL and WQUAN objectives and policies in that the adoption of GMP's as proposed by the applicant will result in the maintenance and potentially the improvement of water quality as modelled by Overseer®. In regards water quantity, the volume of water being sought by the applicant is considered fair and reasonable and will not result in the over allocation of the groundwater resource.

9.35 In regards the Rural Land and Soils objectives and policies, the application is considered to be consistent with the provisions set out in the PRP as the application provides for the sustainable use of the rural land resource.

Regional Water Plan (RWP)

9.36 My overall assessment of the application in terms of the RWP is that it is generally in accordance with the objectives and policies of this plan.

9.37 The relevant objectives, and policies of the Regional Water Plan are discussed under topic headings below. My discussion focuses on how the application is considered to be consistent with these provisions, and I have not repeated the full text of the objectives and policies.

Water Quality

9.38 The matters of most relevance include Objectives 3, 4, 8, Policy 1, 4, 6, 7, 13,13A, and 25.

9.39 Objective 3 relates to the maintenance and enhancement of water quality. The proposal is considered consistent with this objective. The proposed land use is for a farm system that reduces risks to water quality from the activities on the land.

9.40 Objective 4 stipulates that best environmental practices shall be encouraged to improve water quality of surface water bodies. The application by Schrader Mains Limited proposes to adopt GMP's which will result in a reduction in nutrient discharge and potential for overland flow of sediment and contaminants, therefore contributing to an overall improvement in water quality. The GMP's to be adopted represent current best practice and the annual review and audit of the proposed FEMP will ensure that new GMP's are adopted as they evolve.

9.41 Policy 13A relates to the establishment of new dairy farms whilst recognising the risks to water quality which may arise as a result of the activity. The risks are to be managed through proposed conditions of consent and the adoption of best management practices in the design and implementation of the conversion of the property and during subsequent operation. Most of the risks have been provided for through a combination of farm system development and the infrastructure that will be installed. The balance are addressed through the land management techniques set out in the FEMP.

9.42 The policy also provides direction to the council about what should be considered when determining whether or not a conversion should be granted. In my opinion the application is consistent with this policy as the application includes a FEMP. In this instance all of the requirements of a CEMP are captured within the FEMP, which identifies the actual and potential risks and sets out the methods to manage these risks.

Water Quantity

9.43 The matters of most relevance in terms of Water Quantity include Objectives 5, 6, 7, and 9, and Policy 14 ,21, 22 ,23, 26, 28, 29, 30 and 31.

9.44 Overall the application is considered to be in accordance with the objectives and policies relating to water quantity as the volume of water to be abstracted are recognised as efficient volumes, and the construction of the bore will be undertaken in accordance with the appropriate standards.

Wetlands

9.45 The matters of most relevance in terms of Wetlands are Objectives 2 and 4, and Policies 38, 39 and 40.

9.46 Overall I consider the application is consistent with the objectives and policies of the RWP. The proposed conversion would enable the land to be used in a manner which would have lower modelled N losses than the existing land use, and whilst the proposal has higher modelled P losses, as outlined by Mrs Hunter, Overseer® does not account for all of the GMP's proposed by the applicant. It is expected that the proposal will result in an overall maintenance or improvement in water quality.

Agricultural Effluent

9.47 Policy 41 seeks to avoid the adverse effects of agricultural effluent storage ponds. The pond has been designed in accordance with relevant code of practice by an IPENZ certified engineer, which ensures that the pond is wholly consistent with this policy.

Regional Effluent Land Application Plan (RELAP)

9.48 My overall assessment of the application in terms of the RELAP is that it is consistent with the objectives and policies of this plan. The applicant is proposing to adopt best management practices in terms of the design and operation of the effluent system, including providing sufficient storage based on the Massey Effluent Pond Calculations to enable deferred application of effluent, the inclusion of a low rate effluent application system, and an effluent disposal area which is approximately four times larger than recommended best practice of 8 hectares per 100 cows.[26]

Te Tangi a Tauira

9.49 The Ngai Tahu ki Murihiku Natural Resource and Management Plan 2008 has been considered in the preparation of the applications for resource consent. The Iwi Management Plan outlines a number of policies which are of relevance to the applications associated with dairy conversion activities, including policies regarding farm effluent management and water quality.

9.50 The application is considered to be consistent with the relevant policies of Te Tangi a Tauira, particularly Policies 4, 7, 8, 9, 11, 12, 13, 14, 15 as they relate to farm effluent management as the proposal allows for;

- The provision of buffer zones to water abstraction sites and waterways
- The identification of tile drains
- The application of effluent in a manner which avoids surface water run-off or overland flow through the provision of sufficient effluent storage and the use of low rate application systems
- The adoption of best management techniques in association with the conversion and subsequent operation of the property as a dairy unit.

9.51 In respect to the polices relating to Water Quality and Water Quantity The application is considered to be consistent with Te Tangi a Tauira Policies1, 2, 3, 4, 5, 6, 8 and 1, 4, 11, 16, 17, and 18 as the applicant is seeking to adopt methods which will avoid adverse effects on receiving environment, and in terms of the abstraction of water the volumes being sought are consistent with what is considered a fair and efficient volume of water for stock and shed water purposes.

[26] Farm Dairy Effluent Best Practice Guidelines, Environment Southland, May 2007

Proposed Water and Land Plan (PWLP)

9.52 The Proposed Southland Water and Land Plan (PWLP) was publicly notified on 3 June 2016, with submissions set to close on the 1 August 2016. Despite this plan not being notified at the time of application, I have undertaken an assessment of the proposal against the relevant provisions of the PWLP given it had legal effect from the date of notification, and the direction of Section 104(1)(b)(vi) RMA.

9.53 The PWLP sets out its purpose as being to provide direction and guidance regarding the sustainable use, development and protection of water and land resource in the Southland Region.[27]

9.54 The most relevant objectives of the PWLP in relation to the proposal by Schrader Mains Limited include Objectives 1 to 3, 6, 11, 13, 17 and 18;

Objective 1 — *Land and water associated ecosystems are managed as integrated natural resources recognising the connectivity between surface water and groundwater, and between freshwater, land and the coast.*

Objective 2 — *Water and land is recognised as an enabler of the economic, social and cultural wellbeing of the region.*

Objective 3 — *The mauri (inherent health) of waterbodies provide for te hauora o te tangata (health of the environment) and te hauora o te wai (health of the waterbody).*

Objective 6 — *There is no reduction in the quality of freshwater and water in estuaries and coastal lagoons, by:*

(a) Maintaining the quality of water in waterbodies, estuaries and coastal lagoons, where the water quality is not degraded; and

[27] Proposed Southland Water and Land Plan (Pg. 7)

(b) Improving the quality of water in waterbodies, estuaries and coastal lagoons, that have been degraded by human activities.

Objective 11 Water is allocated and used efficiently.

Objective 13 Enable the use and development of land and soils provided:

(a) The quantity, quality and structure of soil resources are not irreversibly degraded through land use activities and discharges to land;

(b) The discharge of contaminants to land or water that have significant or cumulative effects on human health are avoided; and

(c) Adverse effects on ecosystems (including diversity and integrity of habitats), amenity values, cultural values and historic heritage values are avoided, remedied or mitigated to ensure these values are maintained or enhanced.

Objective 17 The natural character values of wetlands, rivers and lakes including channel form, bed rapids, seasonably variable flows and natural habitats, are protected from inappropriate use and development.

Objective 18 All activities operate at "good (environmental) management practice" or better to optimise efficient resource use and protect the region's land, soils, and water from quality and quantity degradation.

9.55 The conversion of the land to dairying, the construction of an effluent storage pond and discharge of effluent to land, as well as the construction of a bore and associated abstraction of groundwater are consistent with the objectives of the

PWLP in my opinion. The applicant has indicated that they will be adopting the GMP's as outlined in the evidence of Mrs Hunter as directed by Objective 18, while the proposal will enable the applicant to provide for the economic and social wellbeing as sought by Objective 2. In regards Objective 6 the modelled nutrient losses under the proposed dairy conversion show that in terms of N losses, there will be no net reduction in water quality, and in terms of modelled P losses whilst the modelling indicates a potential increase in P losses, the adoption of GMP's (including those methods which are not recognised in Overseer®) is not expected to result in a decrease in water quality. As Ms Wilson has pointed out it is difficult to quantify water quality effects when this individual site will contribute so little to the overall catchment. Therefore, the assessment has focussed on the opportunities to minimise the risks of the proposed land use activities. The proposed land use provides the most opportunity to reduce risks to water quality.

9.56 The region wide polices of the PWLP that are of relevance to the proposed application include policies 2, 6, 13, 14, 15, 16, 17, 18, 20, 22, 27, 33, 34, 39, 40, 41 and 42.

Policy 2 *Take into account iwi management plans*

Any assessment of an activity covered by this plan must:

1. *Take into account any relevant iwi management plan; and*
2. *Assess water quality and quantity based on Ngai Tahu indicators of health.*

9.57 The application has considered the relevant iwi management plan (Te Tangi a Tauira) and is therefore consistent with Policy 2 PWLP.

Policy 6 *Gleyed Physiographic Zone*

In the Gleyed Physiographic Zone, avoid, remedy or mitigate adverse effects on water quality from contaminants, by:

1. Requiring implementation of good management practices to manage adverse effects on water quality from contaminants transported via artificial drainage, and overland flow where relevant;

2. Having particular regard to adverse effects on water quality from contaminants transported via artificial drainage, and overland flow where relevant when assessing resource consent applications and preparing or considering management plans.

Policy 13 *Management of land use activities and discharges*

Manage land use activities and discharges (point source and non-point source) to land and water so that quality and the health of humans, domestic animals and aquatic life is protected.

Policy 14 *Preference for discharges to land*

Prefer discharges to land, rather than direct discharges to water.

9.58 The proposal includes a FEMP which outlines the GMP's that the applicant will adopt to avoid, remedy or mitigate any actual or potential effects of the proposed activity. The plan is consistent with Policy 6 for the Gleyed Physiographic Zone. The management techniques set out within the FEMP and proposed conditions of consent manage critical source areas, artificial drains and overland flow also ensuring that the proposal is achieving the purpose of Policy 6.

9.59 The applicant has adopted best practice principles in the design of the effluent system, including provision of effluent storage and low rate effluent application systems which in conjunction with the proposed management techniques documented in the FEMP will enable the activities to be undertaken and managed so that they minimise potential effects on water quality. In my opinion the proposal is consistent with Policy 13 as the modelled farm loss of 6.3 mg/L is well within (approximately 56%) the maximum acceptable value for nitrate in the Drinking Water Standard for New Zealand (DWSNZ) (Ministry of Health 2008) and is less than the modelled weighted average nitrogen concentration from the current land use (8.5 mg/L) and alternative land use (8.7 mg/L). [28]

9.60 The proposal to discharge effluent to land is consistent with Policy 14.

Policy 15 *Maintaining and improving water quality*

Maintain and improve water quality by:

1. *Despite any other policy or objective in this Plan, avoiding new discharges to surface waterbodies that will reduce water quality beyond the zone of reasonable mixing;*
2. *Avoiding point source and non-point source discharges to land that will reduce surface or groundwater quality, unless the adverse effects of the discharge can be avoided, remedied or mitigated;*
3. *Avoiding land use activities that will reduce surface or groundwater quality, unless the adverse effects of the discharge can be avoided, remedied or mitigated; and*
4. *Avoiding discharges to artificial watercourses that will reduce water quality in a river, lake or modified watercourse beyond the zone of reasonable mixing;*

So that:

1. *Water quality is maintained where it is better than the water quality standards specified in Appendix E "Water Quality Standards"; or*
2. *Water quality is improved where it does not meet the water quality standards specified in Appendix E "Water Quality Standards"; and*

[28] Evidence in Chief Ms K Wilson, Paragraph 44.

3. Water quality meets the Drinking Water Standards for New Zealand 2005 (revised 2008); and

4. ANZECC sediment guidelines (as shown in Appendix C of this plan) are met.

Policy 16 *Farming activities that affect water quality*

1. Minimising the environmental effects (including on the quality of waters in rivers, coastal lakes, lagoons, tidal estuaries, salt marshes and coastal wetlands, and groundwater) from farming activities by:

(a) Strongly discouraging the establishment of new dairy farming or new intensive winter grazing activities in close proximity to sensitive waterbodies identified in Appendix Q;

(b) Strongly discharging applications to establish new, or further intensify existing dairy farming of cows or intensive winter grazing activities where the effects on the quality of water, including cumulatively, of groundwater, waterbodies, coastal lakes, lagoons, tidal estuaries, salt marshes and coastal wetlands cannot be avoided or fully mitigated or in areas where water quality is already degraded to the point of being overallocated.

2. Requiring all farming activities, including existing activities, to:

(a) Either implement a Management Plan, as set out in Appendix N, or be listed on the Environment Southland Register of Independently Audited Self-Management Participants;

(b) Actively manage sediment run-off risks from farming and hill country development by requiring setbacks from waterbodies, riparian planting, limits on areas or

duration of exposed soils and the prevention of stock entering surface water bodies;

(c) Manage collected and diffuse run-off and leaching of nutrients, microbial contaminants and sediment through the identification and management of higher risk physiographic zones on a regional scale, and critical sources areas within individual properties.

9.61 The proposed conditions of consent and Farm Environmental Management Plan (FEMP) are the primary methods for ensuring that good environmental management practices are documented and implemented. The adoption of a FEMP is consistent with the requirements of the policy 16.

Policy 17 *Effluent Management*

1. *Avoid adverse effects on water quality, and avoid as far as practicable other adverse effects of the operation of, and discharges from effluent management systems.*
2. *Manage effluent systems and discharges from them by;*
   (a) *Designing, constructing and locating systems appropriately in accordance with standards;*
   (b) *Maintaining and operating effluent systems in accordance with best practice guidelines;*
   (c) *Avoiding any surface run-off/overland flow, ponding or contamination of water resulting from the application of agricultural effluent to pasture;*
   (d) *Avoiding the discharge of raw sewage and untreated agricultural effluent to water.*

Policy 18 *Stock exclusion from waterbodies*

Reduce sedimentation and microbial contamination of waterbodies and improve river and riparian ecosystems and habitats by;

1. *Requiring progressive exclusion of all stock, except sheep, from all waterbodies, including artificial watercourses, on land with a slope of less than 16º by 2025, and the management of sheep in critical source areas;*
2. *Requiring the adoption of management plans that set out methods and timeframes to achieve these outcomes;*
3. *Encouraging the establishment and enhancement of healthy vegetative cover in riparian areas, particularly through use of indigenous vegetation;*
4. *Ensuring that when stock access waterbodies, including artificial watercourses, this is managed in a manner that avoids significant adverse effects on water quality, bed and bank integrity and stability, mahinga kai, and aquatic, river and riparian ecosystems and habitats.*

Policy 20 *Management of water resources*

Policy 22 *Management of the effects of groundwater and surface water use*

9.62 In my opinion the application is consistent with Policies 17, 18, 20 and 22. The effluent management system has been designed by an appropriately qualified person and in accordance with best management practice in terms of low rate application via the Larral Smart Hydrant system and deferred storage. The applicant is also proposing an effluent disposal area exceeding both the minimum 4 hectares per 100 cows and the recommended best practice of 8 hectares per 100 cows[29]. All waterways on the property are fenced off from stock, achieving the purpose of Policy 18. In terms of the proposal to abstract water, the volumes of water to be abstracted are an efficient use of the resource, and are within the permitted activity threshold under the PWLP which signals that the proposal is consistent with Policy 20. Similarly, the permitted activity status of the proposed groundwater abstraction under the PWLP in my opinion confirms that the proposal

[29] Schrader Mains limited will be providing an effluent disposal area the equivalent of 30ha/100cows

is consistent with Policy 22, whereby the abstraction of water would be considered to be an efficient use of the resource.

Policy 27 *Bore construction and management*

9.63 The proposal is consistent with Policy 27 as the standards for the construction of the bore and will be given effect to via proposed conditions of consent.

Policy 33 *Adverse effects on wetlands*

Policy 34 *Restoration of existing wetlands and the creation of wetlands*

9.64 There are no wetlands located within the property, and given the highly modified nature of the existing environment no land drainage or vegetation clearance within wetland areas is required. In regards the restoration of existing wetlands and creation of new wetlands as outlined in Paragraph 19 of the evidence in chief of Mrs. Hunter, and as documented in the FEMP Schrader Mains Limited propose to explore the installation of tile drain amendments. A number of tile drain amendment options have been specified in the paper by Richard McDowell and David Nash titled *A Review of the Cost-Effectiveness and Suitability of Mitigation Strategies to Prevent Phosphorous Loss from Dairy Farms in New Zealand and Australia (attached as Appendix 5)* This paper discusses a number of specific treatment options including the development of 'treatment beds' at the end of tile drains with P-sorptive materials like steel slag or volcanic tephra. These treatments are not well explored in New Zealand compared to other treatment methods.

Other treatment methods referred to as 'edge of field mitigations' can include the use of sorbents such as P Socks which have been found to be an effective removal strategy at low flows. The installation of sediment traps and the development of constructed wetlands are also methods recognised for reducing P loss which will be investigated for use by the applicant. In my opinion the proposal achieves Policy 33 and 34.

Policy 39 *Application of the permitted baseline*

When considering any application for resource consent for the use of land for a farming activity, Environment Southland will consider all adverse effects of the proposed activity on water quality, whether or not this Plan permits an activity with that effect.

Policy 40 *Determining the term of resource consents*

Policy 41 *Matching monitoring to risk*

Policy 42 *Consideration of water permit applications*

9.65 The proposal achieves the purpose of policies 39 to 42. With specific reference to matching monitoring to risk Schrader Mains Limited have set out within the FEMP details of monitoring which is proposed to be undertaken to help measure the effectiveness of the GMP's adopted and allow these methods to be improved over time. In terms of the permitted baseline, the assessment of effects and risks of the proposal has not disregarded any effects on the basis of whether they are permitted by the plan.

9.66 The proposed conditions of consent and Farm Environmental Management Plan (FEMP) are the primary methods for ensuring that good environmental management practices are documented and implemented by the applicant.

10.0 Section 104 RMA

10.1 Section 104(1)(a) of the RMA requires, subject to Part 2, a consent authority to have regard to the actual and potential effects on the environment of allowing the activity. In Section 8 of this statement I have assessed the effects of the proposed activity reaching the conclusion that the overall effects of the proposed activity are moderate to low, and that any effects will be avoided, remedied or mitigated by conditions of consent.

10.2 The effects on the environment have been discussed in the evidence of other experts as well as within Section 5 of the AEE, and are supported by the technical reports appended to the application. Having considered this information, I am of the opinion the proposal, subject to conditions of consent will avoid or adequately mitigate the actual and potential effects. Appendix 2 of my evidence includes a suite of proposed conditions of consent which, in my view, are appropriate to manage the effects of the proposed activity. Section104(1)(b) of the RMA requires regard to be had to the relevant provisions of any national environmental standard, other regulations, national policy statement, New Zealand Coastal Policy Statement, regional policy statement or proposed regional policy statement and plan or proposed plan. I have considered the relevant provisions of the, National Environmental Standard for Sources of Human Drinking Water Regulations 2007 (NES – Drinking Water); Resource Management (Measurement and Reporting of Water Takes) Regulations 2010;the National Policy Statement for Freshwater Management 2014 (NPSFW); the Southland Regional Policy Statement (RPS), and Proposed Southland Regional Policy Statement (PRPS); the Regional Plan Water; the Regional Effluent Land Application Plan; the Proposed Southland Water and Land Plan (PWLP); and Te Tangi a Tauira. It is my opinion that the Project is generally consistent with the relevant provisions as discussed throughout Section 9 of this statement.

10.3 In terms of "other matters" relevant for consideration under Section 104 (1) (c) RMA, the *Waituna Lagoon Technical Report 2011 and Action Plan 2015* are matters to be considered. I rely on the evidence of Ms. Wilson with respect to these documents.

10.4 Section 104 (2) sets out that when assessing any actual or potential effects of an activity, that the decision maker may disregard an effect of an activity on the environment where it is a permitted activity. The RWP details that the conversion of the land to dairying requires resource consent, however all other forms of farming, including intensive winter grazing and heifer grazing are permitted activities. The effects of the permitted activities are readily comparable with the proposed activity. In my opinion the permitted baseline is relevant to the assessment of the application. The consentable activity of dairying will however be subject to greater control through conditions of consent compared to the permitted activities. However, when considering the proposal against the objectives, polices and rules of the Proposed Water and Land Plan, Policy 39 directs that when considering any application for resource consent for the use of land for a farming activity, that all adverse effects shall be considered whether they are permitted or not.

10.5 Policy 39 of the PWLP directs a decision maker to consider all adverse effects of a proposed activity whether or not the plan permits an activity with the same effect.[30] I am of the opinion that the permitted baseline is a relevant matter especially when the current and alternative land uses (specialist grazier) are permitted activities under both the RWP and the PWLP and both have been modelled to have a greater N loss and are at greater risk of P losses.

10.6 Having assessed all of the matters I am off the opinion that the application is largely in accordance with the relevant policies and objectives of the documents set out above, and that having regard to all the matters under Section 104 that the proposal achieves the purpose of the RMA. Subject to conditions of consent any effects of the activities will be avoided, remedied or mitigated.

11.0 Section 105 & 107 RMA

11.1 The matters under Sections 105 and 107 of the Act need to be considered. In this instance they concern the proposed discharge of effluent to land.

11.2 Under section 105(1), a consent authority must have regard to: the nature of the discharge and the sensitivity of the receiving environment to adverse effects; and the applicant's reasons for the proposed choice; and any possible alternative methods of discharge, including discharge into any other receiving environment.

11.3 The proposal involves the discharge of effluent to land within a sensitive catchment, however the effects on the sensitive catchment are minimised when the discharge is carried out in accordance with the proposed conditions of consent

[30] Proposed Southland Water and Land Plan, Page 38.

(Appendix 2). The discharge can be undertaken in a manner which avoids contaminants from entering water through controls on application method and conditions of consent, including the adoption of best practice management techniques as outlined in the Farm Environmental Management Plan, a copy of which is attached as Appendix 8.

11.4 The Water Quality and Nutrient Assessment Reports included with the application and evidence of Ms. Wilson and Mrs. Hunter specifically address the potential effects of these discharges on the receiving environments, concluding that in respect to modelled phosphorous losses that "*established riparian margins and management of critical source areas (such as swales) will provide the largest benefit on this property. Laneway management and amendments to bridges will also assist in reducing losses from non-block sources. There is also the opportunity to explore the practicality of putting in place tile drain amendments on the major tile systems (approximately 3) to run drainage outflow into bigger zones prior to entering the waterway. These measures are not modelled through Overseer®. Therefore, I believe that the Overseer® model is highly likely to be over predicting the P loss. Research …would suggest that the likely reductions will be significant, albeit difficult to accurately quantify*[31]". Ms. Wilson concludes that there will be a negligible change in water quality as a result of the proposal.

11.5 The applicants reason for the proposed discharge are multi-faceted, firstly there is a direct benefit to the property through the return of nutrients to land as a method for improving fertility, and secondly the discharge of dairy shed effluent to land is considered to be the best method for avoiding adverse effects on water as might otherwise occur in the event that the discharge was directly to water.

11.6 In this case the alternative discharge options will either result in a worse environmental outcome (discharge to water) or they are not practicable (trucking of effluent offsite), and they transfer risks to another receiving environment.

[31] Evidence in Chief Mrs. M Hunter, Page 9.

11.7 Overall it is my conclusion that the requirements of Section 105 of the Act are met having had regard to those expert opinions, proposed mitigation and monitoring, and the matters set out in Section 105 (1) (a) – (c).

11.8 I conclude similarly in respect of the effects identified in Section 107 (1) (c) – (g) arising as a consequence of the proposed discharges that because the proposed discharge will not give rise to the matters set out in (c) to (g) that Section 107 is not a relevant matter.

12.0 Consideration of Alternatives

12.1 Schrader Mains Limited have considered a number of alternatives to the proposed conversion of the land as described in the evidence of Mrs. Hunter and Mr Robertson, including the next best alternative land use that will be adopted in the event that consent for the conversion of the land is not granted.

12.2 The next best alternative is described as being a 'Specialist Grazier' option which would involve growing 48 hectares of fodder crop, the wintering of 900 cows annually and the grazing of 150 yearlings.[32] The 'Specialist Grazier' option could be undertaken under the Operative Regional Water Plan as a permitted activity. Under the Proposed Water and Land Plan this activity could also be carried out as a permitted activity subject to the implementation of a Farm Environmental Management Plan, as the proposed plan allows for intensive winter grazing of up to 50 hectares of land without the need to obtain consent within the Gleyed Physiographic Zone.

12.3 In assessing the alternative options for the subject site, both economic and environmental considerations have been taken into account, including the estimated nutrient loss (as an indicator of potential effects on water quality) which under Overseer® estimates losses of 43 kg N/ha/year and 0.5 kg P/ha/year[33] which represents a higher nitrogen loss than both the current land use and the proposed conversion, a higher modelled phosphorus loss when compared to

[32] Evidence in Chief M Hunter, Paragraph 22, Page 10.
[33] Evidence in Chief M Hunter, Paragraph 22, Page 10.

current land use and a slightly lower modelled phosphorus loss when compared to the proposed conversion. However, the higher land area under crop would increase the potential risks of effects on water quality as outlined by Ms Wilson. Economically the specialised grazing option whilst giving a greater return on investment at 2.6% than the current operation (1.5%) this is still a significantly lower return that the proposed dairying scenario.[34]

12.4 Considering the statement of Mrs Hunter that under both the conversion and specialist grazier option that good management practices that are the same will be required to be adopted, coupled with the fact that under the specialist grazier option that more stock (i.e. 1050 total stock numbers compared to 90) will be carried on the property during the highest risk period in terms of managing effects on water quality the applicant's decision to proceed with the proposed conversion represents the best use of the land both economically and environmentally.

13.0 Part 2 RMA

Section 5 – Purpose

13.1 Section 5 RMA sets out the principles of sustainable management which in the context of the RMA means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural wellbeing and for their health and safety while;

(a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and

(b) Safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and

[34] Evidence in Chief A Robertson, Paragraph 12, Page 6.

(c) *Avoiding, remedying, or mitigating any adverse effects of activities on the environment.*

13.2 The effects of the conversion have been assessed as ranging from de minimus to moderate across the range of consentable activities, however my concluding judgement is that the proposal will enable the sustainable use of the natural and physical resources (land and water) and will avoid, remedy or mitigate effects thus enabling the activities to be undertaken in a manner which will safeguard the life-supporting capacity of water, soil and ecosystems,

13.3 Subsection (b) and (c) require the applicant to safeguard the life-supporting capacity of air, water, soil and ecosystems, while avoiding, remedying and mitigating any adverse effects on the environment. The proposal by Schrader Mains Limited will in my opinion achieve the purpose of the Act in Section 5. The potential adverse effects are able to be sufficiently avoided, remedied and mitigated by the proposed conditions.

Section 6 – Matters of National Importance

13.4 I consider the relevant matters under Section 6 to be;

(a) *The preservation of the natural character of the coastal environment, wetlands and lakes and rivers and their margins, and the protection of them from inappropriate subdivision, use and development;*

(b) *The protection of areas of significant vegetation and significant habitats of indigenous fauna;*

(c) *The relationship of Maori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, and other toanga.*

13.5 Whilst the proposed activities do not directly impact upon the coastal environment, wetlands, lakes, rivers and their margins the wider receiving environment including the Waituna Lagoon means an assessment against this matter is appropriate.

13.6 Subsection (a) to (c) are important as the property is located within a catchment which flows into the Waituna Lagoon. Subsection (c) is relevant as the Waituna Lagoon is considered to be of cultural significance to Ngai Tahu. Increased nutrient loading is a concern as the Lagoon itself is considered to be in a compromised state in terms of water quality. The proposal to convert the land to dairying will result in an overall reduction in the discharge of nutrients to the property compared to current land use and minimise the risks of water quality from land use activities. On this basis the proposal will contribute in a positive manner to the matters of national importance identified.

Section 7 – Other Matters

13.7 Section 7 of the Act lists a number of other matters that decision makers must have particular regard to when considering an application;

(a) Kaitiakitanga;

(b) The efficient use and development of natural and physical resources;

(c) The maintenance and enhancement of amenity values;

(d) Intrinsic values of ecosystems;

(e) Maintenance and enhancement of the quality of the environment;

(f) Any finite characteristic of natural and physical resources;

(g) The protection of the habitat of trout and salmon;

13.8 All of the subsections are relevant to this proposal in my opinion.

13.9 In particular, section 7 (b) relating to the efficient use and development of natural and physical resources is important considering the sensitivity of the catchment that the farm is located within. The proposal is consistent with subsection 7(e) relating to the maintenance and enhancement of the quality of the environment.

13.10 Section 7(a), has been addressed through adherence to the policies and objectives within the Regional Policy Statement, Proposed Regional Policy Statement and Te Tangi o Tauira. The proposed development is considered to achieve Section 7 (a).

13.11 With respect to Section 8 of the Act, I assess that due care and consideration has been given to the Treaty of Waitangi through the RPS, PRPS and Te Tangi o Tauira, and Sections 6(c) and 7(a) of the Act. I therefore conclude that the proposal is consistent with Section 8 of the Act.

14.0 Proposed Consent Conditions & Monitoring

14.1 As part of the Council consent hearing a suite of conditions were provided[35] . These conditions were informed by previous knowledge gained from similar applications, the evaluations and recommendations of technical experts and also discussions held with submitters and Environment Southland. A fully copy of proposed conditions is attached as Appendix 2.

14.2 Overall the proposed conditions of the land use consent for a bore, and construction of an effluent storage pond, and the water permit for the abstraction of groundwater reflect the ‘standard’ conditions which would normally be attached to consents for these activities. In my opinion the conditions are appropriate for managing the activities covered by the relevant consents.

14.3 The conditions of the permit to discharge effluent to land and the land use consent for the conversion of the property to dairying are more complex, reflecting the need

[35] K Scott Hearing Evidence, December 2015.

to carefully manage any actual or potential effects of the proposed activities and to provide greater detail and certainty as to the scale and intensity of the activity that can be carried out under the consents.

14.4 A key element of the proposed conditions is the provision to 'link' the effluent discharge consent (proposed Condition 3) and land use consent (proposed Condition 2) so that the consent holder is unable to operate without holding concurrently holding consents for both activities. This ensures that the land use and discharge activity are carried out in an integrated way under a consistent suite of conditions. The condition was also proposed to overcome a concern expressed by the Council that the land use consent could be surrendered following establishment of the dairy farm. The consequence of this would be that conditions controlling the land use aspect of the activity would no longer need to be complied with.

14.5 The conditions of both the discharge permit (Condition 11 to 14) and land use consent (Condition 3 and 4) also make provision for the consent holder to prepare and comply with a Farm Environmental Management Plan, which is the key tool for controlling how the consent holder will avoid, remedy or mitigate effects. These conditions also direct that the FEMP shall be reviewed by a suitably qualified person on an at least annual basis. This ensures that the FEMP remains up to date and allows new GMP's to be incorporated where they will improve environmental outcomes. A copy of the FEMP is attached as Appendix 8, and has been drafted to meet the criteria in the proposed conditions of consent. It has also been reviewed following notification of the PWLP to ensure that it is consistent with Appendix N.

14.6 Condition 13 (c) of the discharge permit and Condition 3 (c) of the land use consent also direct that the applicant undertake detailed ground and surface water monitoring to assess effects on water quality from the proposed operations, as well as preparing annual nutrient budgets for the property.

15.0 Conclusion

15.1 On the basis of my assessment as set out in this statement, and as informed by the expert analysis, assessment and statements of others, and subject to conditions of consent proposed, including the Farm Environmental Management Plan, in my opinion the proposal will promote the sustainable management of natural and physical resources in a manner that is consistent with the purpose of the Act.

Kate Scott

Managing Director – Landpro Limited

29 July 2016

APPENDIX 1

REFERENCES

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APPENDIX 2

PROPOSED CONDITIONS OF CONSENT

Land Use Consent – Bore Consent

1. This consent is granted for a period of 5 years.

2. This resource consent authorises the construction of a bore at or about N: 4851096 E: 1264657 (NZTM), within the area shown on the map attached as Appendix A.

3. Where the bore/well is to be maintained as a permanent installation, construction shall comply with NZS4411:2001. In particular:

   (a) The top of the bore/well casing shall extend at least 300 mm above ground level.

   (b) A seal, made of concrete or similar material, is to be placed at ground level around the outside of the casing. The seal shall be sufficient to prevent foreign material, surface water, spillage or other leakage entering the space between the casing and the wall of the borehole.

   (c) The top of the casing shall be sealed to prevent the entry of contaminants.

   (d) Flowing artesian bores/wells shall be fitted with headworks to control artesian pressures and avoid the uncontrolled discharge of water.

   (e) The following shall be provided;

      (i) A filter pack comprising clean, washed sand (typically 2 to 4 mm) shall be placed around the screened interval. The filter pack shall extend at least 200 mm above the screened interval;

      (ii) A bentonite seal (typically bentonite pellets) shall be placed above the filter to prevent ingress of water via the bore annulus. The bentonite seal shall typically extend >2 m above the filter pack;

      (iii) The remainder of the bore annulus can be back-filled with clean material.

(f) Bores/wells intended for water abstraction or groundwater monitoring shall comply with the following:

(i) The screened interval should be placed near the estimated lowest water table depth.

(ii) A structure shall be placed around the bore/well to exclude stock from the immediate vicinity of the bore/well.

In the event that the bore/well is not to be maintained as a permanent installation, decommissioning and filling shall also be in accordance with NZS4411:2001.

4. Prior to the expiry of this consent, the following information shall be provided to the Consent Authority:

(a) Details of the bore/well location(s) (GPS reference or site plan)

(b) Details of bore/well construction including:
- Drilled depth
- Casing depth
- Screened intervals; and
- Casing and screen materials

(c) Geological logs, including water table depth

(d) Details of pumping tests carried out.

5. Where more than one aquifer is encountered during drilling, the bore/well shall be constructed so that groundwater is drawn from one primary aquifer, and so that leakage between zones of differing pressure or water quality is prevented.

6. In the event of discovery, or suspected discovery, of a site of cultural importance (Waahi Taonga/Tapu), the consent holder shall immediately cease operations in that location and inform the local iwi authority (Te Ao Marama Inc., Phone: (03)

931 1242). Operations may recommence with the written permission of the Consent Authority. The discovery of Koiwi (human skeletal remains) or Taonga or artefact material (e.g. pounamu/greenstone) would indicate a site of cultural importance. *Note: A protocol outlining the process in the event of such a discovery can be obtained from Environment Southland.*

Land Use Consent – Pond Storage

1. This consent is granted for a period of 5 years.

2. This consent authorises the construction of an agricultural effluent pond, as described in the application for resource consent dated 30 June 2015 with capacity to store at least 930 cubic metres of effluent.

3. (a) The effluent storage pond must be designed, and the construction supervised, by a suitably qualified person. The pond shall be constructed of suitable materials, and shall be designed and constructed in such a manner that it is structurally sound and will not leak.

   (b) The supervising suitably qualified person shall, upon completion of the construction, confirm in writing to the Consent Authority that the pond has been designed and constructed in accordance with the conditions of this consent and the "Environment Southland Code of Practice for Design and Construction of Agricultural Effluent Ponds, March 2009" (escompliance@es.govt.nz).

   (c) No effluent may be stored in the pond until the confirmation required by Condition 3(b) is received by the Consent Authority.

4. The effluent pond shall not be constructed within:
   - 50 metres of any surface watercourse;
   - 100 metres of any water abstraction point;
   - 50 metres of any property boundary;
   - 200 metres of any residential dwelling, other than residential dwellings on the property.

5. All practicable measures are taken to prevent the discharge or leakage of contaminants to water, or onto or into land in circumstances where they may enter water, both during construction of the pond and once the pond is completed.

6. If an event (such as effluent overflow to water or pond collapse) occurs that may have significant adverse effect on water quality, particularly at the abstraction point of a registered drinking-water supply, the consent holder shall notify, as soon as reasonably practicable, the following:

   - The Consent Authority (Ph: 03 211 5115 or 03 211 5225 after hours);

7. The consent holder shall pay an annual administration and monitoring charge to the Consent Authority, payable on invoice. This charge may include the costs of inspecting the operation of this resource consent.

8. In the event of discovery, or suspected discovery, of a site of cultural importance (Waahi Taonga/Tapu) during the effluent pond construction, the consent holder shall immediately cease operations in that location and inform the local iwi authority (Te Ao Marama Inc., Phone: (03) 931 1242). Operations may recommence at a time as agreed upon in writing with the Consent Authority. The discovery of Koiwi (human skeletal remains) or Taonga or artefact material (e.g. pounamu/greenstone) would indicate a site of cultural importance. *Note: A protocol outlining the process in the event of such a discovery can be obtained from Environment Southland.*

Water Permit – To Abstract Groundwater for Stock and Shed Water Purposes

1. This consent is granted for a period of 15 years.

2. The permit authorises the taking of groundwater from up to two bores located at;

   N: 4851615 E: 1264514 (NZTM)
   N: 4851096 E: 1264657 (NZTM)

3. The rate of abstraction shall not exceed:

   - 2 litres per second;
   - 36,720 litres per day; and
   - 13,403 cubic metres per year.

   For the purpose of this consent a 'year' shall be 1 July to 30 June in the following calendar year.

4. Prior to the first exercise of this consent, the consent holder shall install a backflow prevention device or take other appropriate measures to ensure water and/or contaminants cannot return to the water source.

   (a) Prior to the first exercise of this consent, the consent holder shall install a water meter to record the water take, within an error accuracy range of +/- 5% over the meter's nominal flow range, and datalogger with at least 24 months data storage to record the rate and volume of take, and the date and time this water was taken. The consent holder shall forward a copy of the installation certificate to the Consent Authority within one month of installing the water meter and datalogger.

   (b) The water meter shall be installed in a straight length of pipe, before any diversion of water occurs. The straight length of pipe shall be part of the pump outlet plumbing, easily accessible, have no fittings and obstructions in it. There shall be a straight length of pipe on either side of the water meter:

on the upstream side there shall be a distance that is 10 times the diameter of the pipe and on the downstream side there shall be a distance of 5 times the diameter of the pipe.

(c) The consent holder shall ensure the full operation of the water meter and datalogger at all times during the exercise of this consent. All malfunctions of the water meter and/or datalogger during the exercise of this consent shall be reported to the Consent Authority within 5 working days of observation and appropriate repairs shall be performed within 5 working days. Once the malfunction has been remedied, a Water Measuring Device Verification Form completed with photographic evidence must be submitted to the Consent Authority within 5 working days of the completed of repairs.

(d) If a mechanical insert water meter is installed it shall be verified for accuracy each and every year from the first exercise of this consent;

(i) Any electromagnetic or ultrasonic flow meter shall be verified for accuracy every five years from the first exercise of this consent;

(ii) Each verification shall be undertaken by a Consent Authority approved operator and a Water Measuring Device Verification Form shall be completed and supplied to the Consent Authority with receipts of service. These shall be supplied within 5 working days of the verification, and at any time upon request.

(e) The consent holder shall provide records from the datalogger to the Consent Authority via a system that can automatically send the data into the Consent Authority's computer database in CSV format, Hilltop or Tideda format, or XML formatted as required by Hilltop software. The consent holder shall provide records from the datalogger to the Consent Authority by 31 July each year and at any other time on request.

5. The consent holder shall pay an administration and monitoring charge to the Consent Authority collected in accordance with Section 36 of the Resource Management Act, payable in advance on 1 July each year.

6. The Consent Authority may, in accordance with Sections 128 and 129 of the Resource Management Act 1991, serve notice on the consent holder of its intention to review the conditions of this consent during the period 1 February to 30 September each year, or within two months of any enforcement action being taken by the Consent Authority in relation to the exercise of this consent, or on receiving monitoring results, for the purpose of:

   (a) Adjusting the consented rate or volume of water under Condition 3, should monitoring under Condition 4(a) or future changes in water use indicate that the consented rate or volume is not able to be fully utilised; or

   (b) Determining whether the conditions of this consent are adequate to deal with any adverse effect on the environment which may arise from the exercise of the consent and which it is appropriate to deal with at a later stage; or

   (c) Ensuring the conditions of this consent are consistent with any National Environmental Standards Regulations, relevant plans and/or the Environment Southland Regional Policy Statement; or

   (d) Adjusting or altering the method of water take data recording and transmission.

Land Use Consent – To Establish a Dairy Farm

1. This consent authorises the conversion and establishment of the subject land for use as a dairy farm as described in the application for resource consent dated 30 June 2015 “Schrader Mains Ltd” – Application for Resource Consent, and the further information dated 11 September 2015, and as amended by these conditions. The scope of the dairy farm activity to be established is described in the application as being:

   (a) The twice per day milking of up to 306 cows during a period of 1 August to 30 June (inclusive) of the following calendar year;

   (b) The discharge to land of feed pad/stand-off pad effluent generated from the use of the pad as follows;

      (i) Up to 306 cows during the period 1 August to 30 June (inclusive) of the following calendar year; and
      (ii) Up to 90 cows during the period 1 June to 31 July (inclusive) in any given year.

   (c) The dairy herd shall be comprised of Friesian Jersey Crossbreed cattle.

   (d) The construction, maintenance and operation of a dairy milking shed and feedpad/standoff pad;

   (e) The construction, maintenance and operation of an effluent storage pond and Larral Smart Hydrant system or equivalent low rate system.

   (f) The discharge of dairy shed effluent and feed pad/stand-off pad effluent to a discharge area of no more than 93 hectares as per the plan attached as Appendix 1;

   (g) Cultivation of up to 4 hectares for fodder crop annually.

(h) Wintering of no more than 90 cows between 1 June and 31 July in any calendar year.

2. This consent shall be exercised at all times in conjunction with discharge consent [CONSENT NUMBER] (or any subsequent renewals) authorising the discharge of dairy herd effluent and feed pad/stand-off pad effluent.

3. The Consent Holder shall at all times comply with the Farm Environmental Management Plan (FEMP) dated 27 July 2016, or subsequent amendments to the FEMP as submitted to the Consent Authority upon completion of the annual review of the FEMP. The FEMP shall include (but not be limited to);

(a) The details of the Dairying Operation as set out in Condition 1 above.

(b) Methods for Identifying and Managing Critical Source Areas to avoid overland flow and soil / sediment and phosphorus losses to ground and surface water, including:
   (i) Paddock selection;
   (ii) Cultivation technique;
   (iii) Preventing stock access to and maintaining the riparian margins of any watercourses on the property;
   (iv) Map identifying Critical Source Areas
   (v) Temporary Fencing of Critical Source Areas;
   (vi) Strategic Grazing Management to reduce the impact of grazing of Critical Source Areas and minimise the potential for run off from these areas;
   (vii) Buffer Strips from surface water bodies
   (viii) Effluent Irrigation Management in accordance with Discharge Consent [CONSENT NUMBER] to avoid discharges to artificial drainage or run off of effluent;
   (ix) Lane way construction (including bridges) and management to avoid run off of effluent and sediment to surface water;

(c) Annual monitoring to be undertaken to assess effects on water quality. Details of the farm monitoring program are to be developed by a suitably qualified person and carried out by the consent holder for the purpose of improving understanding of the effects of land use, and the discharge of effluent on water quality and to identify areas for improvement in management practices and further development of the FEMP. The monitoring program will include but not be limited to;

(i) Baseline sampling (i.e. prior to the dairy conversion);

(ii) Instream monitoring including in high flow events;

(iii) Monitoring of discharges from tile drains;;

(iv) Soil sampling;

(v) Details regarding sampling methods and recording requirements for the information above;

(vi) The steps to be taken if monitoring identifies an increase in contaminants, particularly dissolved forms of nitrogen and phosphorous in water exiting the farm as compared to the quality of the water entering the farm;

(vii) The frequency of monitoring;

(viii) The parameters of monitoring including but not limited to;

- (Nitrate +Nitrite) – Nitrogen
- Total Ammonimical Nitrogen
- Dissolved Reactive Phosphorous
- *E.coli*

(ix) The frequency of reporting.

(d) Agricultural Good Practices to be employed on farm to minimise nutrient losses and mitigate effects on water quality. Implementation of industry agreed good management responses to avoid, remedy or mitigate any farm specific environmental risks to water quality and progress toward implementation of those management responses.

(e) Nutrient Management including;

(i) preparation and review of Overseer Budgets by a suitably qualified person to ensure that nutrient losses remain consistent with those proposed;'

(ii) Process for preparation and review of Overseer Budgets to account for changing versions of Overseer.

(iii) Application rates, locations and timing of fertiliser application;

(iv) Application rates and locations of dairy effluent application; Specify and implement a nutrient management system for the property, which is consistent with on farm management proposed in Overseer modelling submitted with the consent application;

(v) Maintenance of the following records for each year between 1 July and 30 June:

- Fertiliser application, including rates;
- Types of crops, including winter feed / forage crops;
- Cultivation methods;
- Stock units by reference to type, age and breed;
- Prediction of realistic crops yields that are used to determine crop requirements and all other inputs to the Overseer nutrient budgeting model.

(vi) Fertiliser and soil management, including management and application of fertiliser in accordance with 'The Code of Practice for Nutrient Management (With Emphasis of Fertiliser Use)' Fertiliser Association, 2013, ISBN 978-0-473-28345-2' or any subsequent updates;

(f) Effluent Management Plan (EMP) in accordance with Condition 11 Discharge Consent [CONSENT NUMBER].

(g) Water Quality Management techniques.

(h) Methods for Achieving Consent Compliance.

(i) Records to be kept to demonstrate compliance with conditions of this consent and Discharge Consent [CONSENT NUMBER].

4. The Consent Holder shall have the FEMP reviewed by a suitably qualified person on an at least annual basis. The review shall include (but not be limited to) an assessment of;

(a) Verification of compliance with Condition 1 of Landuse Consent [CONSENT NUMBER].

(b) Details of the implementation of Good Management Practices

(c) Overseer parameter inputs report to confirm that the activity is being carried out in accordance with Condition 1 and nutrient losses remain consistent with those proposed at the time consent was sought.

Advice note: It is recognised that changes to the Overseer model may give rise to changes in the modelled losses for the application site. Therefore this condition does not require modelled nutrient losses to remain exactly the same as those modelled at the time consent was sought. Reviews of the Overseer Parameter Reports will enquire into and confirm that the farm system being applied by the consent holder is consistent with that promoted at the time the application for consent was sought whilst allowing for minor adjustments to be made to take account of varying climatic, soil conditions etc. that arise during the usual course of operating a dairy farm but that do not fundamentally alter the nature of the operation.

(d) A property specific environmental risk assessment, including a description of the risks to water quality, which shall be prepared by a suitably qualified person and which identifies any farm specific environmental risks along with measures to mitigate the identified risks.

(e) Review of the data obtained from the monitoring undertaken in accordance with the FEMP as set out in Condition 3(c) Land Use Consent [CONSENT NUMBER] and any changes made or to be made to farming practices as a consequence of that monitoring.

(f) A report detailing items (a) – (e) above shall be submitted to the consent authority no later than the 31 July each year and shall include an updated version of the FEMP if any amendments have been made.

(g) A report shall be prepared every three years by a suitably qualified independent person, i.e. a person who is a Certified Nutrient Management Advisor (or equivalent qualification and accreditation), and provided to the Southland Regional Council, Te Ao Marama and Southland Fish & Game by 31 July (2019, 2022, 2025, 2028 and 2031) to demonstrate, using Overseer modelling, that nutrient losses remain consistent with those proposed at the time the consent was sought.

5. Results obtained from the monitoring undertaken in accordance with the FEMP shall be provided to the Consent Authority by 31 July each year in accordance with Condition 4 (f) Land Use Consent [CONSENT NUMBER] or no later than 2 weeks following a written request by the Southland Regional Council.

6. Subject to Condition 3 and 4, the Consent Holder shall at all times comply with the FEMP and any subsequent amendments or updates to the mitigation measures as required by conditions of consent or as a result of the annual review of the FEMP.

7. Prior to the exercise of this consent, all permanent waterways shall be fenced in such a way to exclude stock access at all times. Fences shall be set back from the waterways to create a minimum buffer zone of 3 metres between waterways and grazed pasture. 3 metres shall be measured horizontally from the outside edge of the wet bed of the waterway. For clarity this shall apply to both sides of a waterway.

8. The Consent Authority may, in accordance with Sections 128 and 129 of the Resource Management Act 1991, serve notice on the consent holder of its intention to review the conditions of this consent during the period 1 February to 30 September each year, or within two months of any enforcement action being

taken by the Consent Authority in relation to the exercise of this consent, or on receiving monitoring results, for the purposes of:

(a) Determining whether the conditions of this permit are adequate to deal with any adverse effect on the environment, including cumulative effects, which may arise from the exercise of the permit, and which it is appropriate to deal with at a later stage, or which become evident after the date of commencement of the permit; or

(b) Ensuring the conditions of this consent are consistent with any National Environmental Standards Regulations, relevant plans and/or the Environment Southland Regional Policy Statement.

(c) Providing for review in the event that nutrient limits are determined for the Waituna Catchment.

Discharge Permit – To Discharge Agricultural Effluent to Land from a Dairy Shed and Feed Pad/Standoff Pad

1. This consent is granted for a period of 15 years.

2. This consent authorises the discharge of dairy shed effluent and feed pad/stand-off pad effluent onto land, via a land disposal system, as described in the application for resource consent dated 30 June 2015 "Schrader Mains Ltd" – Application for Resource Consent, and the further information dated 11 September 2015, and as amended by these conditions. The scope of the activity is described as being:

   (a) The discharge to land of dairy shed effluent generated from the twice per day milking of no more than 306 cows during a period of 1 August to 30 June (inclusive) of the following calendar year.

   (b) The discharge to land of feed pad/stand-off pad effluent generated from the use of the pad as follows;

      (i) Up to 306 cows during the period 1 August to 30 June (inclusive) of the following calendar year; and
      (ii) Up to 90 cows during the period 1 June to 31 July (inclusive) in any given year.

   (c) The dairy herd shall be comprised of Friesian Jersey Crossbreed cattle.

   (d) The discharge of dairy shed effluent and feed pad/stand-off pad effluent to land via a Larral Smart Hydrant system or equivalent low rate system.

   (e) The discharge of dairy shed effluent and feed pad/stand-off pad effluent to 93 hectares of land as per the plan attached as Appendix 1.

   (f) Cultivation of up to 4 hectares for fodder crop annually.

(g) Wintering of no more than 90 cows between 1 June and 31 July in any calendar year.

3. This consent shall be exercised at all times in conjunction with a current land use consent [CONSENT NUMBER] authorising the use of the establishment and use of the land for dairying purposes.

4. All cows (excluding 90 which may remain at the application site in accordance within Condition 2) must be transported out of the Waituna Catchment for grazing during 1 June and 31 July each year. The consent holder shall maintain and provide records to confirm that stock were grazed outside the catchment by 31 July each year in accordance with Condition 13 (i) and Condition 14 Discharge Consent [CONSENT NUMBER].

5. The discharge authorised by this consent shall not exceed the following rates at any time:

   (a) A maximum depth of application of 20 millimetres for each daily application;

   (b) The effluent is to be applied via a pulsed system with a maximum pulsed depth rate of 10mm/hr;

   (c) The maximum loading rate of nitrogen onto any land area shall not exceed 150 kilograms of nitrogen per hectare per year.

6. There shall be no discharge when the soil moisture content of the soils is at or above field capacity. The consent holder shall measure soil moisture levels on farm prior to each effluent application to assess the suitability of the soils for receiving effluent in accordance with Condition 11 (f) Discharge Consent [CONSENT NUMBER]. The consent holder shall keep a record of each measurement and the volume of effluent applied to the paddock, which shall be provided to Council by 31 July each year for the preceding 12 month period.

7. Effluent shall not be discharged within:

(a) 20 metres of any surface watercourse;

(b) 100 metres of any potable water abstraction point;

(c) 200 metres of any residential dwelling other than residential dwellings on the subject property; and

(d) 20 metres from any property boundaries;

Where there is inconsistency between the plan shown in Appendix 1 and the conditions of this consent, the conditions of this consent shall prevail.

8. Prior to exercising this consent the consent holder shall provide at least 930m^3 of effluent storage capacity for the purpose of avoiding irrigation of effluent when soils are at or above field capacity.

9. No effluent shall be discharged to any surface watercourse by overland flow, run-off, or via a pipe, nor shall there be any surface run-off/overland flow, ponding or contamination of water resulting from the exercise of this consent.

10. There shall be no odour beyond the boundary of the site as a result of the exercise of this consent that is offensive or objectionable.

11. The consent holder shall at all times operate in accordance with the Effluent Management Plan (EMP). For the avoidance of doubt the EMP will form part of the Farm Environmental Management Plan as set out in Condition 3 Landuse Consent [CONSENT NUMBER} and Condition 13 Discharge Consent [CONSENT NUMBER]. The EMP shall include (but not be limited to);

(a) Details regarding how the effluent disposal system at the farm shall be managed and maintained, including:
- Application rates;
- Application depths

- Maintenance programme for the effluent system; and

(b) Methodology for monitoring and completing calibration tests of the effluent system to ensure the system is operating in accordance with the conditions of this consent.

(c) Details regarding how effluent will be managed when soils are at or above field capacity;

(d) Details regarding the management of effluent generated from the operation of the feed pad/stand-off pad or any other associated infrastructure;

(e) Details of the measures to be taken to avoid contamination of surface waterways and subsurface drains with effluent;

(f) Details of the methodology for undertaking soil moisture monitoring prior to the application of Farm Dairy Effluent.

(g) Identification of artificial drains and critical source areas in the effluent disposal area, so that appropriate management procedures can be implemented to avoid contaminant loss from those areas; and

(h) Details of records to be kept to demonstrate compliance with the conditions of this consent.

12. The Consent Holder shall review the EMP on an at least annual basis for the duration of this resource consent. The review shall consider whether the Effluent Management Plan still accurately reflects good management practice of on-site activities and whether any improvements to management and contingency procedures need to be made. The results of the review shall be reported to the Consent Authority by the 31 July each year, and shall include an updated EMP if any amendments have been made.

13. The Consent Holder shall at all time comply with the Farm Environmental Management Plan (FEMP) dated 18 February 2016, or subsequent amendments to the FEMP as submitted to the Consent Authority upon completion of the annual review of the FEMP. The FEMP shall include (but not be limited to) details of;

(a) The details of the Dairying Operation as set out in Condition 2 above;

(b) Methods for Identifying and Managing Critical Source Areas to minimise overland flow of effluent and phosphorus losses, including;

(i) Map identifying Critical Source Areas;

(ii) Temporary Fencing of Critical Source Areas;

(iii) Strategic Grazing Management to reduce the impact of grazing of Critical Source Areas and minimise the potential for run off of effluent from these areas;

(iv) Buffer Strips from surface water bodies

(v) Effluent Irrigation Management in accordance with Discharge Consent [CONSENT NUMBER] to avoid discharges to artificial drainage or run off of effluent;

(vi) Lane way construction (including bridges) and management to avoid run off of effluent and sediment to surface water;

(c) Annual Monitoring to be undertaken by the consent holder to assess effects on Water Quality. The FEMP shall provide details of the farm monitoring program to be carried out by the Consent Holder for the purpose of assessing the effectiveness of, and demonstrating compliance with good management practices and to identify areas for improvement in management practices which may reduce the effects of the discharge of effluent on water quality as on-going development of the FEMP. The monitoring program will include but not be limited to;

(i) Monitoring of Critical Source Areas and tile drain discharge from the property; Bi-annual (i.e. at least twice per year) sampling of discharge from a minimum of 3 tile-drain outlets per sampling occasion is to occur when soil moisture is at or above 75% of field capacity and there is (or predicted) more than 10 mm of rainfall over a 24-hour period or when flow in Environment Southland's Waituna Creek at Marshall Road monitoring site is above 5,000 litres per second. The tile-drain sampling sites shall be measured for:

- Flow
- Total suspended solids
- Nitrate + Nitrite – Nitrogen
- Total ammoniacal nitrogen
- Dissolved organic nitrogen
- Total nitrogen
- Dissolved reactive phosphorous
- Total dissolved phosphorus
- Total phosphorus
- *E. coli*
- Electrical conductivity

Water quality samples are to be analysed by an ISO accredited laboratory and samples taken in accordance with the United States Geological Survey (USGS) National Field Manual for the Collection of Water-Quality Data (October 2015)

(ii) Monitoring of Groundwater Quality; A groundwater sample is to be taken between 1st September and 31st October and between 1st March and 30th April each year. All samples shall be tested for:

- Nitrate + Nitrite – Nitrogen
- Dissolved reactive phosphorous
- *E. coli*
- Electrical conductivity
- Total chloride

The first year of sampling shall also include:

- Total iron
- Total manganese
- Total ammoniacal nitrogen

Water quality samples to be analysed by an ISO accredited laboratory and samples taken in accordance with the United States Geological Survey (USGS) National Field Manual for the Collection of Water-Quality Data (October 2015).

(iii) The consent holder shall ensure that a bore or well is available onsite for the purpose of monitoring groundwater quality as set out in (ii) above. The b ore or well shall;

- Be located downstream of the discharge area, as shown on the plan attached as Appendix 1 to this consent, or at an alternative location agreed in writing with the Consent Authority;
- Be 4-5 metres below the static groundwater level, and screened on the bottom 2 metres;
- Have an internal diameter of between 50 and 100 millimetres;
- Be used solely for monitoring purposes, or otherwise as agreed upon in writing with the Consent Authority.

(iv) If groundwater sampling results indicate that nitrate concentrations exceed 8.5 mg/L (i.e. 75% of the maximum acceptable level for the New Zealand Drinking Water Standards) and/or if the averaged tile drain load exceeds 29 kg N/ha/year or 0.6 kg P/ha/year (or equivalent if the Overseer version changes), then an investigation into the cause of nutrient loss must be undertaken by a suitably qualified person(s) within 2 weeks of receiving the lab results. The investigation may consist of, but not be limited to:

- a farm inspection to identify likely contaminant sources, including and elevation of Critical Source Areas

- Additional water quality monitoring (e.g. upstream and downstream of the property) to determine whether the issue is occurring on the property, and/or sampling of additional water quality parameters to help identify the contaminant source(s)
- The result of the investigation including any changes in farm management practices, must be reported to Environment Southland within 2 weeks of the completion of the investigation and must be incorporated within the annual review of the FEMP.

(v) Annual soil sampling; A representative soil sample at a block level will be undertaken at least once during any 12-month period for the duration of the consent to establish the nutrient status of the soils. All samples are to be analysed by an ISO accredited laboratory.

(vi) A monitoring report shall be provided to Environment Southland by the 31st July each year and shall consist of, but not be limited to:

- field sampling notes
- lab results

(d) Agricultural Good Practices to be employed on farm to minimise nutrient losses and mitigate effects on water quality. Implementation of industry agreed good management responses to avoid, remedy or mitigate any farm specific environmental risks to water quality and progress toward implementation of those management responses.

(e) Nutrient Management including;

(i) preparation and review of Overseer Budgets by a suitably qualified person to ensure that nutrient losses remain consistent with those proposed;’

(ii) Process for preparation and review of Overseer Budgets to account for changing versions of Overseer.

(iii) Application rates, locations and timing of fertiliser application;

(iv) Application rates and locations of dairy effluent application; Specify and implement a nutrient management system for the property, which is consistent with on farm management proposed in Overseer modelling submitted with the consent application;

(v) Maintenance of the following records for each year between 1 July and 30 June:

- Fertiliser application, including rates;
- Types of crops, including winter feed / forage crops;
- Cultivation methods;
- Stock units by reference to type, age and breed;
- Prediction of realistic crops yields that are used to determine crop requirements and all other inputs to the Overseer nutrient budgeting model.

(vi) Fertiliser and soil management, including management and application of fertiliser in accordance with 'The Code of Practice for Nutrient Management (With Emphasis of Fertiliser Use)' Fertiliser Association, 2013, ISBN 978-0-473-28345-2' or any subsequent updates;

(f) Effluent Management Plan in accordance with Discharge Consent [CONSENT NUMBER].

(g) Water Quality Management Techniques.

(h) Methods for Achieving Consent Compliance.

(i) Records to be kept to demonstrate compliance with conditions of this consent and Land Use Consent [CONSENT NUMBER].

14. The Consent Holder shall have the FEMP reviewed by a suitably qualified person on an at least annual basis. The review shall include (but not be limited to) an assessment of;

(a) Verification of compliance with Condition 2 of Discharge Consent [CONSENT NUMBER].

(b) Details of the implementation of Good Management Practices.

(c) Overseer parameter inputs report to confirm that the activity is being carried out in accordance with Condition 2 and nutrient losses remain consistent with those proposed at the time consent was sought.

Advice note: It is recognised that changes to the Overseer model may give rise to changes in the modelled losses for the application site. Therefore this condition does not require modelled nutrient losses to remain exactly the same as those modelled at the time consent was sought. Reviews of the Overseer Parameter Reports will enquire into and confirm that the farm system being applied by the consent holder is consistent with that promoted at the time the application for consent was sought whilst allowing for minor adjustments to be made to take account of varying climatic, soil conditions etc. that arise during the usual course of operating a dairy farm but that do not fundamentally alter the nature of the operation.

(d) A property specific environmental risk assessment, including a description of the risks to water quality, which shall be prepared by a suitably qualified person and which identifies any farm specific environmental risks along with measures to mitigate the identified risks.

(e) Review of the data obtained from the monitoring undertaken in accordance with the FEMP as set out in Condition 13 (c) Discharge Consent [CONSENT NUMBER], and any changes made or to be made to farming practice as a consequence of that monitoring.

(f) A report detailing items (a) – (e) above shall be submitted to the consent authority no later than the 31 July each year and shall include an updated version of the FEMP if any amendments have been made.

15. The Consent Holder shall at all times comply with the FEMP and any subsequent amendments or updates to the mitigation measures as required by conditions of consent or as a result of the annual review of the FEMP.

16. Prior to the exercise of this consent, the consent holder shall notify the Consent Authority of who is the assigned operator of the effluent disposal system. If a new operator is appointed, the consent holder shall notify the Consent Authority within five working days.

17. The Consent Authority may, in accordance with Sections 128 and 129 of the Resource Management Act 1991, serve notice on the consent holder of its intention to review the conditions of this consent during the period 1 February to 30 September each year, or within two months of any enforcement action being taken by the Consent Authority in relation to the exercise of this consent, or on receiving monitoring results, for the purposes of:

    (a) Determining whether the conditions of this permit are adequate to deal with any adverse effect on the environment, including cumulative effects, which may arise from the exercise of the permit, and which it is appropriate to deal with at a later stage, or which become evident after the date of commencement of the permit; or

    (b) Ensuring the conditions of this consent are consistent with any National Environment Standards Regulations, relevant plans and/or the Environment Southland Regional Policy Statement; or

    (c) Amending the monitoring programme to be undertaken; or

    (d) Adding or adjusting compliance limits; or

(e) Requiring the consent holder to adopt the best practicable option to remove or reduce any adverse effect on the environment arising as a result of the exercise of this permit.

APPENDIX 3

PRE-HEARING MEETING REPORT

Report on pre-hearing meeting

Section 99 of the Resource Management Act 1991

From: Michael Durand – Team Leader Consents, Environment Southland

To: Commissioners Mike Freeman, Peter Jones and Neville Cook; Schrader Mains Ltd, Department of Conservation, Fish & Game New Zealand, Te Ao Marama Incorporated

Date: 2 December 2015

Application: APP-20158099 – Schrader Mains Ltd

EXECUTIVE SUMMARY

This report follows a pre-hearing meeting on the notified resource consent application to Environment Southland from Schrader Mains Ltd for a dairy farm conversion and associated activities.

The outcomes of the meeting were that:

- The reporting officer and submitters could potentially support the application if good farming practices are adhered to.

- However, there was dispute over whether a consent holder could be held to such practices by any consent granted on an ongoing basis.

- This is because the relevant rule framework requires a land use consent for the *establishment* of a dairy farm only, and not for the ongoing land use activity of dairy farming. This means if consent were granted, conditions relating to good farming practices (generally) would need to be incorporated into a long term permit that has a different and specific purpose (e.g. a discharge permit for discharge of farm dairy effluent). The suitability of a discharge permit for controlling farm management was not agreed.

- Despite this, the applicant and submitters left the meeting agreeing on the areas of farm management that would be important to control nutrient losses from the proposed farm and agreeing to discuss potential conditions between themselves.

- All noted, however, that a decision rested with the hearing commissioners on whether or not such conditions could be included in any resource consent other than the land use consent to establish the farm. The applicant and submitters agreed to discuss potential conditions despite the risk that decision makers may deem such conditions appropriate.

INTRODUCTION

Pre-hearing meeting

1. On 9 November 2015 Environment Southland (ES), conducting its function as consent authority under the Resource Management Act 1991 (RMA), invited the following parties to meet at a pre-hearing meeting:

    a. Schrader Mains Ltd (applicant)

    b. Department of Conservation (neutral submitter)

    c. Fish & Game New Zealand (opposing submitter)

    d. Te Ao Marama Incorporated (opposing submitter)

2. At that stage the application had been notified (on 18 September 2015), submissions closed (on 16 October), three submissions received, and two submitters opposing the application indicated they wished to be heard at a hearing. The requested meeting was therefore a pre-hearing meeting held under section 99 of the RMA.

3. The meeting was requested by ES at the suggestion of the applicant for the purpose of both clarifying and facilitating the resolution of matters and issues arising from the application and submissions. The meeting agenda (circulated on 9 November) outlined these matters and issues as being:

    a. Sensitivity of the receiving environment

    b. Measures to address risks associated with the artificially drained nature of the land

    c. Phosphorus losses as modelled by the Overseer budget

    d. Use of 'Best Practice' methods

    e. Cumulative effects on the receiving environment

    f. Water quality concerns

4. The meeting was held on 12 November at the Environment Southland office and those present were:

    a. Consent authority

        i. Joanna Gilroy (Reporting Officer on the application; Senior Consents Officer, Environment Southland)

        ii. Hilary Lennox (Consents Manager, Environment Southland)

    b. Applicant

        i. Hank Schrader (Applicant)

        ii. Sandra Schrader (Applicant)

iii. Bridget Irving (Partner, Gallaway Cook Allan Lawyers)

iv. Kate Scott (Managing Director, Landpro Ltd)

v. Miranda Hunter (Agribusiness Consultant)

c. Submitters

i. Dean Whaanga (Te Ao Marama Incorporated)

ii. Stevie Ray Blair (Te Ao Marama Incorporated)

iii. Jacob Smyth (Fish & Game New Zealand)

iv. Apology: Department of Conservation

d. Chair: Michael Durand (Team Leader Consents, Environment Southland)

5. There were no additional matters raised by the attending parties.

Statutory and procedural matters in section 99

6. The procedure for a pre-hearing meeting and the status of the report produced are dictated in some detail by section 99. Each of these matters were discussed in the meeting and I do not consider that any procedural issues were identified. For completeness, the outcome of each procedural question is outlined below.

Requiring and requesting attendance

7. Section 99(2) allows consent authorities to request an applicant, a submitter or any other person it considers appropriate to attend a pre-hearing meeting. This can be either at the request of the applicant or submitters or on its own initiative. In this case the applicant requested the meeting to be held and for submitters to attend and ES agreed this was appropriate.

8. If attendance is requested (as opposed to required), any party's decision to attend can be made without prejudice. In this case the Department of Conservation decided not to attend.

Attendance of those delegated to make decisions

9. Section 99(4) states that an officer of the authority who has the power to make the decision on the application may attend, subject to the agreement of all the parties. All the parties in the meeting agreed to the presence of Hilary Lennox.

Chairperson to prepare this report

10. The chairperson of the meeting is to prepare a report outlining the issues that were agreed and the issues that are outstanding. These are outlined throughout the report and summarised in Table 1.

ACCOUNT OF DISCUSSIONS

Main areas of discussion

11. Early in discussions all the parties agreed that it would not be necessary to follow the agenda items strictly in order for them to be addressed effectively. The discussion therefore began with the applicant outlining pertinent aspects of the proposal and the submitters broadly stating their reasons for interest and attendance at the meeting.

12. It was agreed that the receiving environment is known for its water quality issues. The particular sensitivity of the Waituna Lagoon was recognised by the applicants and not disputed by any of the parties. The main reason for the attendance of parties at the pre-hearing meeting was to understand more about how this particular application might affect water quality there. This was essentially an effort to seek clarification – to understand more clearly whether or not the intended land use is appropriate.

13. Three main parts of the meeting followed. These were:

    a. <u>Overseer model losses vs. real life losses and effects</u>: This was a discussion broadly covering the Overseer modelling results for both the status quo and the applicant's proposal. This covered the assumptions behind Overseer modelling, and how these relate to on-farm management practices. Essentially, this discussion explored the question of whether the establishment of a dairy farm will increase losses of N and P to the Waituna Lagoon, by looking at how well the real life situation of an additional dairy farm is reflected in the Overseer model results.

    b. <u>Holding the applicant to account on modelled losses</u>: The Overseer discussion established that actual losses will depend on management practices adopted across the whole farm on an ongoing basis. However, the rule framework under the Regional Water Plan for Southland (RWP) is problematic and does not clearly support Council oversight of farm management practices. Any ongoing consents granted will be for farm dairy effluent discharge (FDE) and water takes only. Whether or not broader management practices (e.g. fencing, management of critical source areas) can be the subject of conditions on a discharge permit, even if the applicant volunteers those conditions, was a point that was disputed and not resolved.

    c. <u>Conditions of consent</u>: This discussion focused on the type of conditions that could be volunteered, <u>if</u> it was accepted that conditions on an FDE discharge permit could stipulate requirements for particular farm management practices, outside of effluent collection, storage and discharge.

Overseer model losses vs. real life losses and effects

14. A discussion of the Overseer modelling approach was lead by Miranda Hunter. Points discussed related to the limitations of the model in helping to understand the effects of the proposed farm and the current activities in the site. Primarily these were as described below.

15. The status quo has been modelled and best practice assumed. The existing activity is relatively well defined and nutrient losses can be demonstrated with overseer results.

16. The modelled results of the proposed dairy conversion are consistent with those seen in trial data. Modelled N losses elsewhere have previously been verified in real life tests, and can therefore be used with relative confidence in an assessment of a dairy conversion.

17. However, Overseer has limitations for modelling some aspects of dairy farming. Significantly, it does not account for good practices that can reduce or avoid P discharges to surface water from overland flow. P is bound to sediment and has various loss pathways, so its losses are a lot more difficult to model and are uncertain. In trials the management of critical sources areas had reduced P losses by up to 80%.

18. This means the potential for favourable outcomes (if good practices were adopted on an going basis by the applicants) are not possible to demonstrate with modelled P losses.

19. Best practice methods proposed by the applicants include set backs from surface water and management of critical source areas, though wintering may occur on the farm in Waituna or elsewhere, depending on availability of winter grazing.

20. Despite this it was widely recognised that the Overseer model results do not describe water quality outcomes: they describe losses from the site, not the receiving environment or the effect of the losses upon it. In the absence of other work, this makes the applicant and the Council's job of assessing the effects of the application difficult. Whether the overall effects of the land use upon the catchment could be readily assessed and understood was a point of contention but was not debated at length.

21. The significant outcome of this discussion was that that Joanna Gilroy and the submitters could potentially view the application favourably if, on an ongoing basis, the modelled N and P losses could be guaranteed.

Holding the applicant to account on modelled losses

22. A potentially favourable view from Joanna Gilroy and submitters was, however, very much tentative. The reason for uncertainty in this area stems from the unusual rule framework in the RWP. Rule 17A, *Transitional rule relating to the establishment of new dairy farms*, is a regional land use rule requiring a discretionary consent for "the establishment of a new dairy farm." This is the only plan rule requiring consent to undertake a farming activity per se, as opposed to a water take or discharge (for example). It is also unusually limited in its scope because it controls establishment of the farm only and not the ongoing activity of dairy farming.

23. The discharge of farm dairy effluent, construction of effluent ponds and other activities that make up the full extent of a dairy farm operation require consents through other rules (e.g. FDE discharge). Others are permitted by specific rules (e.g. fertiliser discharge) or by the absence of relevant controls in the RWP (see section 9(2) of the RMA).

24. Previously ES has held that rule 17A applies when a person wants to create a dairy farm. Land use consents have been granted on that basis but subsequently been surrendered once the farm is established and consent is no longer needed.

25. This means consent holders are only required to comply for a short time period with any farm management practices stipulated in the land use consent. Once the consent is relinquished, it renders immaterial any management practices agreed between the applicant and consent authority at the time of the application. Any ongoing requirements upon the consent holder for compliance with resource consents come about only through the conditions of other permits. For example, the size

of the dairy farm has been partly managed by proxy by the FDE discharge permit (which allows discharge only to the nominated areas – but doesn't manage the overall extent of the farm); herd size has been managed by the cow numbers stated in the FDE permit (but again, this does not limit the land where cows can graze). Section 127 applications can provide a route to change these areas and herd sizes, but ES has limited power to require consistency with any best practices that do not relate directly to effluent discharges.

26. In light of this rule structure and interpretation, a lengthy discussion covered the question of:

    a. Assuming a consent were granted for the proposed activity, how could nutrient losses that are greater than the modelled loses be avoided in the future?

27. The applicants' position was quickly established, and was that conditions of consent on the FDE permit could hold the applicant to certain methods of farm management. The applicants suggested this would provide ongoing certainty for the council and for submitters.

28. However, the efficacy and appropriateness of this approach was challenged by Hilary Lennox, who stressed that ES had already discussed this rule at length through other applications and had no choice but to conclude the land use consent deals only with farm establishment. Essentially this means:

    a. ES cannot control dairying as an ongoing farming activity.

    b. The FDE discharge permit cannot control good practice methods for anything other than an FDE discharge.

    c. If a conversion were to be allowed because decision makers were banking on a future management technique, this provides little certainty. A farmer's vision for farm management can change over time, as can ownership.

29. Support for this position was not reached around the table. The applicant viewed the situation differently and continued to stress that they would like the council to be able to hold them to account – essentially to meet conditions requiring best practices to be adopted. They suggested that conditions of consent could be volunteered to that effect, and therefore could be incorporated into a discharge permit without any legal issues arising.

Conditions of consent

30. Despite the lack of agreement it was decided that a useful discussion could nevertheless take place around the types of management techniques the applicant could use, were it accepted that these could be enforced through consent conditions. This was, therefore, a hypothetical discussion around the question:

    a. To meet the Overseer budget on a long term basis, what would you do?

31. Broadly around the table the following were agreed.

32. To manage and control P losses, important aspects of farm operations are:

    a. Buffer zones around P pathways: swales, watercourses, critical source areas

    b. Stock access to waterways: fencing of waterways, bridging of stream crossings, cambering of tracks

c. Fertiliser use: the timing, rate, placement and recording of fertiliser application

d. Effluent: Low rate of effluent application

33. To manage and control N losses:

a. Cow numbers

b. Fertiliser application rate, timing, placement and recording

c. Enforcement and monitoring requirements – e.g. monitoring of tile drain discharges

d. Re-running of Overseer modelling annually as part of a Farm Management Plan (suggested by Fish and Game, but not broadly agreed)

34. It was agreed by all (except where indicated) that these factors would be included in a description of best practice that seeks to control nutrient losses from a dairy farming operation.

35. However, it was not agreed that these management practices could be included on, or enforced by, conditions of a discharge permit for FDE.

36. It was noted, however, that past commissioner decisions have included conditions that strictly fall outside of the control of FDE discharges. The cases cited were limited in scope, for example relating to winter grazing periods, and were not extensive requirements relating to farm management more broadly.

37. Joanna Gilroy stressed that the uncertainties around the proposal remain significant:

a. uncertainties exist in relation to the effects of the activity;

b. the manner in which a consent could control those effects is also uncertain;

c. these uncertainties are leading her to a position where the application could be either supported or opposed in her s42A report.

Conclusion to meeting

38. At the conclusion of the meeting it was agreed that the applicant and submitters could beneficially use the time to discuss potential consent conditions and explore areas of potential agreement.

39. It was acknowledged by all, however, that this exercise was speculative: that commissioners may deem that land use conditions are not appropriate for a discharge permit, and therefore that farm management techniques would not be able to be enforced by ES on an ongoing basis. If that were determined, then what that means for the potential grant or decline of the applications was also speculative.

SUMMARY OF AGREED AND OUTSTANDING ISSUES

40. Agreed and outstanding issues at the conclusion of the meeting, except where indicated elsewhere in this report, were as follows.

Table 1: Agreed and outstanding issues

Issue (from Agenda)	Agreed	Not agreed
Sensitivity of the receiving environment	That the receiving environment has particular sensitivities	
Measures to address risks associated with the artificially drained nature of the land	Not discussed explicitly	
Phosphorus losses as modelled by the Overseer budget	That Overseer does not take account of land management practices. That good management practices can result in lower real life losses than those modelled	
Use of 'Best Practice' methods	Best practice methods are overall likely to help keep actual nutrient losses close to or less than the modelled results	That long term adoption of farm-wide best practice methods can be required by any consent granted; best practice could only relate to specific activities that need a long term consent (e.g. FDE discharge)
Cumulative effects on the receiving environment	That cumulative effects are difficult to assess, measure, model and understand. That Overseer's contribution to the understanding of cumulative effects is relatively limited, because it models losses from a single farm only and does not model catchment level losses or the effects of nutrients on specific water bodies or ecosystems.	That difficulty of the work means it cannot or should not be done
Water quality concerns	That dairy farming poses risks to water quality and that this particular catchment is relatively sensitive to nutrient losses.	

CONCLUSION

Status of this report and next steps

41. Section 99(6) requires the chairperson to send this report to the consent authority and all the parties so that they have it at least 5 working days before the hearing. The report was sent by email and hard copy to the parties on 2 December. At the time of writing, no parties have advised that they no longer wish to be heard, and the application is scheduled to be heard on 15 January 2016.

42. Section 99(7) **requires** the consent authority to **have regard to** this report in making the decision on the application.

Michael Durand 2 December 2015

APPENDIX 4

SITE PHOTOGRAPHS

Figure 1: McMillan Creek looking upstream of bridge

Figure 2: Tile Drain Outlet to McMillan Creek

Figure 3: McMillan Creek upstream of bottom culvert crossing

Figure 4: Existing Fencing and Planting McMillan Creek

Figure 5: McMillan Creek - unplanted edge to facilitate ES stream clearing works looking south from bridge

Figure 6: Old Cattle Yards - Location of Proposed Cowshed

Figure 7: Young stock - looking towards southern property boundary

Figure 8: view looking east towards McMillan Creek from tanker track

APPENDIX 5

MCDOWELL & NASH RESEARCH PAPER

Journal of Environmental Quality SPECIAL SECTION

EMERGING TECHNOLOGIES TO REMOVE NONPOINT P SOURCES FROM SURFACE WATER AND GROUNDWATER

A Review of the Cost-Effectiveness and Suitability of Mitigation Strategies to Prevent Phosphorus Loss from Dairy Farms in New Zealand and Australia

Richard W. McDowell* and David Nash

The loss of phosphorus (P) from land to water is detrimental to surface water quality in many parts of New Zealand and Australia. Farming, especially pasture-based dairying, can be a source of P loss, but preventing it requires a range of fully costed strategies because little or no subsidies are available and the effectiveness of mitigation strategies varies with different farm management systems, topography, stream density, and climate. This paper reviews the cost-effectiveness of mitigation strategies for New Zealand and Australian dairy farms, grouping strategies into (i) management (e.g., decreasing soil test P, fencing streams off from stock, or applying low-water-soluble P fertilizers), (ii) amendments (e.g., alum or red mud [Bauxite residue]), and (iii) edge-of-field mitigations (e.g., natural or constructed wetlands). In general, on-farm management strategies were the most cost-effective way of mitigating P exports (cost range, $0 to $200 per kg P conserved). Amendments, added to tile drains or directly to surface soil, were often constrained by supply or were labor intensive. Of the amendments examined, red mud was cost effective where cost was offset by improved soil physical properties. Edge-of-field strategies, which remove P from runoff (i.e., wetlands) or prevent runoff (i.e., irrigation runoff recycling systems), were generally the least cost effective, but their benefits in terms of improved overall resource efficiency, especially in times of drought, or their effect on other contaminants like N need to be considered. By presenting a wide range of fully costed strategies, and understanding their mechanisms, a farmer or farm advisor is able to choose those that suit their farm and maintain profitability. Further work should examine the potential for targeting strategies to areas that lose the most P in time and space to maximize the cost-effectiveness of mitigation strategies, quantify the benefits of multiple strategies, and identify changes to land use that optimize overall dairy production, but minimize catchment scale, as versus farm scale, nutrient exports.

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Excessive phosphorus (P) concentrations in surface waters is an increasingly important environmental issue in New Zealand (McDowell et al., 2009) and Australia (Davis and Koop, 2006), where algal blooms cost AUD 180 to 240 million annually (Atech, 2000). Pasture-based farming is an important source of P loss to freshwaters in both countries. For instance, Larned et al. (2004) found that among land uses, water quality had deteriorated the most in rivers and streams draining grazed pasture. A similar statistical relationship was observed between grazed pasture, P losses, and the quality of New Zealand lakes (Abell et al., 2011). Among pastoral land uses, intensive dairy farming is often highlighted as the main contributor. For example, in a survey of 37 catchment-scale studies in New Zealand, McDowell and Wilcock (2008) found P losses from dairy-dominated catchments ranging from 1 to 10 kg P ha^{-1} annually, depending on geographical features (e.g., soils, topography, climate) and management factors (e.g., irrigated or dryland and the need to use or dispose of dairy shed effluent). The range of P losses from sheep or sheep and beef farmed land was much narrower at 0.1 to 2.2 kg P ha^{-1} yr^{-1}. Australian studies present a similar picture (Barlow, 2003; Barlow et al., 2005; Dougherty et al., 2004; Nash et al., 2005; Nash, 2002; Nash and Halliwell, 1999; Tham, 1983). However, in Australia, where dairy and beef farming occur on adjacent properties, the differences are generally minor (D. Nash, unpublished data).

The wide range of geographic features and climate within New Zealand and Australian dairy farms means that P can be lost by many pathways and in dissolved and particulate forms. Figure 1 outlines many of these pathways and how they interact with different P sources. However, management of New Zealand and, to a lesser extent, Australian dairy farms is different from dairy farms in most other parts of the world, even grazed systems, which can influence pathways and source of P loss accordingly. In New Zealand, nearly all dairy farms are operated as year-round grazed systems using a combination of cool-season grasses (i.e., ryegrass, *Lolium* spp.) and legumes (i.e., clover, *Trifolium* spp.) designed to yield high-quality

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Assigned to Associate Editor Anthony Buda.

Abbreviations: BMP, best management practice; DRP, dissolved reactive phosphorus; DP, dissolved phosphorus; FDE, farm dairy effluent; RPR, reactive phosphate rock; poly-DADMAC, poly-diallyldimethylammonium chloride; PP, particulate phosphorus; TP, total phosphorus.

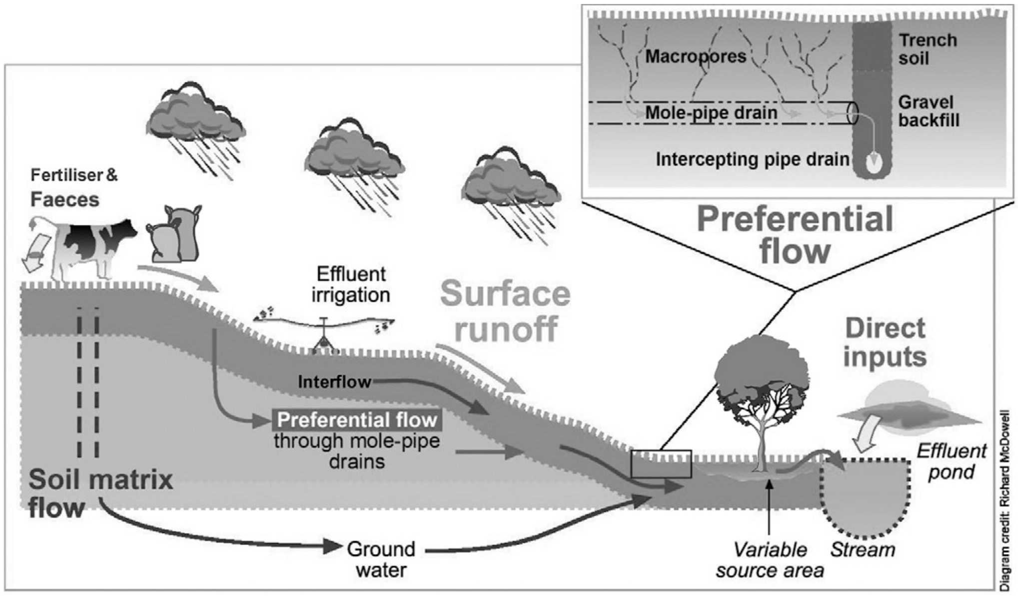

Fig. 1. Conceptual diagram of potential sources and processes that transport phosphorus from the dairy pastures to surface water (adapted from McDowell et al., 2004).

forage under the prevailing climate (with or without irrigation) and soils. Australian dairy farms operate on a similar pasture base, although there is increasing use of feed pads and supplementary feeds, which account for approximately 40% of the total ration (Dairy Australia, 2010; Victorian Department of Primary Industries, 2010).

The interaction of animals rotationally grazing different parts of the farm brings with it challenges, such as avoiding pugging and compaction of pastures when soils are wet, common in winter or spring, which can enhance P losses via surface runoff (Nguyen et al., 1998). Such pugging is less important in a partially confined operation where animals are able to be brought indoors or in the low-rainfall areas of southern Australia where irrigation is practiced, such as northern Victoria. An advantage of year-round grazed systems over confined operations is that there is less likely to be an excess of manure relative to the land area available for application, thereby decreasing the potential build-up of soil P concentrations and associated enhanced P losses (Sharpley et al., 1998). However, grazing operations can have problems with excretal-derived P by direct deposition of dung into streams or surface runoff of dung. Furthermore, P in dung collected when cows are brought onto hard surfaces for milking (i.e., dairy shed effluent) can be lost when applied to pastures during wet periods or when applied to sloping land where there an enhanced risk of loss via surface runoff or to land with subsurface drainage (Houlbrooke et al., 2004).

Although the source of P exported from grazing farms is important when considering mitigation options, so too is the form of P. Whereas work in the United Kingdom has suggested that, for grassland systems, the proportion of total P as particulate P (PP) (>0.45 μm) was underestimated (Bilotta et al., 2007), Australian research has indicated that dissolved P (DP) (i.e., <0.45 μm) accounts for most P loss from well managed dairy pastures (e.g., Nash [2002]). In New Zealand, a similar picture emerges for flat pastures, especially those under flood irrigation, where a lack of erosive force causes DP to be lost in preference to particulate P (Carey et al., 2004). However, particulate P can account for a majority of total P loss in New Zealand, especially in pastures with slopes >5° or where cows graze forage crops in winter (McDowell et al., 2005; McDowell and Houlbrooke, 2009).

Dissolved reactive P (DRP) is the major form of P lost from Australian dairy farms (Dougherty et al., 2004; Fleming and Cox, 1998; Nash et al., 2000). Dissolved reactive P is composed of mainly orthophosphate and some organic P forms (Halliwell et al., 2000), is readily available for uptake by aquatic organisms, and can be adsorbed by sediments (Sharpley et al., 1981). On the other hand, P adsorbed to soil or contained within particles (i.e., particulate P) must be released through enzymatic or physicochemical processes before it is available to plants and algae (McDowell et al., 2004). Hence, DRP is of concern in fast-flowing streams and rivers (Biggs, 2000). In contrast, total P (TP) is of concern in lentic systems (Chapra 1997), where slow-flowing rivers and lakes, reservoirs, ponds, and marshes with high residence times (i.e., lentic systems) allow particles (including PP) to settle out and release dissolved nutrients. It follows that a range of options is required to match a mitigation strategy to the process of P mobilization, form, and loss pathway.

Although the magnitude and form of P losses from New Zealand and Australian dairy farms can differ compared with others around the world, commonalities exist in the approach to mitigation. One concept that aids in the mitigation of P losses, irrespective of the farming system, is that of critical source areas (Pionke et al., 2000). This concept ranks areas according to the potential to act as a P source and the potential to transport or lose P. Areas, termed "critical source areas," are those that have a high source and transport potential and can account for the majority of the P losses despite coming from a minority of the catchment's area. For example, 43% of P losses came from 8% of a New York catchment, whereas 50% of the fine sediment load (and entrained P) in a New Zealand catchment came from 23% of the catchment during one storm event (McKergow et al., 2010; Rao et al., 2009). This concept allows mitigation strategies to be targeted to smaller areas of land, thereby improving their efficiency compared with use across an entire farm or an entire catchment.

Because New Zealand and Australia maintain largely subsidy-free dairy industries (research excluded), the cost-effectiveness of any mitigation strategy is central to their voluntary uptake. Even under a regulatory framework that requires discharges from dairy farmed land to meet a certain P concentration, social research has shown that the first mitigations, or best management practices (BMPs), to be adopted are those that are the most cost effective (Bewsell and Brown, 2009). The decision to use a mitigation strategy should not only consider suitability to a particular loss pathway or P form, but targeting mitigation strategies to critical source areas should also improve their cost-effectiveness.

There is a wide range of pathways and variation of P forms that exist for P losses from New Zealand and Australian dairy farms. Strategies exist, or are being tested and developed, to remove P from water using an array of technologies, but little information is available on their cost-effectiveness ($ per kg P conserved) in comparison to more traditional management approaches. In addition to reviewing cost-effectiveness, we have classified mitigation strategies so that they can be considered within the spatially explicit critical source area concept. The mitigation strategies examined in this review are those that (i) instigate better management of existing resources/inputs, (ii) apply amendments to decrease losses, and (iii) mitigate losses after they have left the field (edge of field). Examining cost-effectiveness in a spatial context is essential as part of informing farmers, advisors, or regulators so that they may mix and match strategies that suit their system and maximize water quality improvements without impairing profitability. Changes to land use are not specifically considered in this review.

Management Mitigations

Optimum Soil Test Phosphorus Concentration

Of the many methods available to minimize P losses to waterways from pastures, one simple approach is to ensure that soil test P concentration is maintained within the range considered optimal for pasture production. Because the magnitude of P losses from soil via surface runoff or subsurface flow is generally proportional to soil P concentration (McDowell et al., 2003a; Gillingham and Gray, 2006), maintaining a soil test P concentration in excess of the optimum for pasture production represents an unnecessary source of P loss.

To ensure P is not accumulating in soils, a nutrient budget should be used to account for all P inputs and outputs and to estimate P fertilizer requirements to maintain optimum soil P status (e.g., Wheeler et al., 2006). However, maintaining optimal soil test P concentration does not prevent P losses from occurring, especially in soils low in P-sorptive Al and Fe oxides (i.e., Podzols), which can lose 4 kg P ha^{-1} yr^{-1} (McDowell and Condron, 2004). Furthermore, if a soil is already P enriched, then it can take many years for soil P concentrations to decline at a rate proportional to the P balance of the soil (Schulte et al., 2010).

Cultivation is one way of redistributing P-enriched topsoil within the plow layer (Morrison and Chichester, 1994; Pezzarossa et al., 1995; Rehm et al., 1995; Sharpley, 2003). In one study of irrigated pastures in the Gippsland Region of southeastern Australia, after 3 yr, laser grading, an extreme form of cultivation, was shown to lower surface soil P concentration and total DP and TP concentrations in irrigation runoff by 40 and 41%, respectively (Nash et al., 2007).

Phosphorus Fertilizer Management

Under best management practice, direct losses from fertilizers on New Zealand and Australian dairy farms (McDowell et al., 2007a) have been estimated to be approximately 10% of total farm losses (Nash and Hannah, 2011). Best practice requires P fertilizers (i.e., superphosphate, ammonium phosphates) to be applied during a period when surface runoff is unlikely. This is because most inorganic fertilizers contain orthophosphate, which is highly water soluble, and while it is sitting on the soil surface diffusing into the soil solution, there is a high risk of P loss should runoff occur. The risk of P loss declines exponentially with time as P is sorbed onto the soil matrix (Dougherty et al., 2006) (Nash et al., 2003a). Several authors have defined this period of enhanced potential loss to last from 7 to 60 d (mean, 21 d) depending on the soil type and climatic conditions (e.g., McDowell et al., 2003b; Nash et al., 2004; Sharpley and Syers, 1979) and the fertilizer's water-soluble P concentration (McDowell and Catto, 2005).

Among P fertilizers, reactive phosphate rock (RPR) has little water-soluble P but has a similar or greater total P concentration to single superphosphate (Zapata and Roy, 2004). Compared with superphosphate, the use of RPR was shown to decrease P losses by about a third from field plots grazed by dairy cattle (McDowell, 2010) and in a 12-ha catchment grazed by sheep in New Zealand (McDowell et al., 2010). Reactive phosphate rock can be used where annual rainfall is >800 mm and soil pH is <6 (Sinclair et al., 1990). However, work in New Zealand and Australia has shown that there is a lead-in time where plant-available P increases by a third per annum such that pasture production in plots receiving RPR is the same as superphosphate by year 4 (e.g., Sale et al., 1997). This, coupled with restrictions where the product could be used, may deter the widespread use of RPR.

An alternative to using low-solubility P fertilizers during periods of high runoff potential is to apply formulations that, through their properties (e.g., they are hygroscopic), rapidly transfer P into soil away from the runoff zone or form reaction products that are less easily mobilized (Nash et al., 2003b, 2004; McBeath et al., 2009). This approach to mitigating P losses from fertilizers has not been fully evaluated, and its success depends on the hydrology of the site in question.

Stream Fencing

Livestock access to streams damages the stream bank and bed and allows for the direct deposition of P contained in soil and excreta into streams. McKergow and Hudson (2007) classified key factors influencing the load of P as (i) livestock management in riparian areas (mob stocking or strip grazing) and (ii) soil type, topography, and climate. In addition to anecdotal evidence, James et al. (2007) reported a 32% decrease in stream P loads when fencing occurred in the Cannonsville catchment in New York. Line (2002) also showed that the dominant form of P lost from a grazed catchment changed over a period of

8 yr from PP (via erosion damage) to DP as the proportion of stream fencing increased. In New Zealand, McDowell (2008) reported a decrease of 90% in TP concentrations once a headwater stream had been fenced off from red deer.

In an effort to increase the adoption of fencing, the New Zealand dairy cooperative-Fonterra, the Ministry for the Environment, the Ministry of Agriculture and Forestry and Local Government New Zealand signed the "Dairying and Clean Streams Accord" in 2003. One of the Accord's targets was that "dairy cattle would be excluded from 50% of streams, river and lakes by 2007, and 90% by 2012." As of 2009, 78% of waterways on farms were fenced off from stock (Ministry of Agriculture and Forestry, 2009). However, even if the accord reaches 100%, it is questionable, in some catchments, whether substantial decreases in P losses (e.g., 30–90%) will be achieved due to the exclusion, under the accord, of streams that are narrower than "a stride" and shallower than approximately 30 cm. These small streams and ephemeral channels may account for large parts of catchment runoff and hence P losses.

To improve the water quality of areas too costly to fence or of those that do not fit within the rules of the Accord (e.g., drystock), strategies are being trialed to deter stock from using streams for drinking or thermoregulation. Provision of water troughs, shade, and shelter are often thought to benefit water quality, but data have been mixed. For example, studies in the United States have indicated that the time spent near a stream and stream loads of DRP and TP decreased when water troughs and shade were provided (Byers et al., 2005), but the provision of watering sites away from the stream did not deter cattle from using the stream or riparian areas for shade in studies in Waikato, New Zealand (Bagshaw et al., 2008) or Victoria, Australia (Thompson et al., 2003). Although riparian vegetation, especially where trees are included, has clear benefits for water quality (National Riparian Lands & Research Program, 2011), the provision of shade adjacent to the stream has had an unexpected side effect. Animals tend to congregate (camp) in the shade, which increases fecal loads and soil P concentrations adjacent to the stream, particularly in more extensive systems. Additional research is required to ensure that the benefits of structural changes, such as establishment of stream-side reserves, are not undermined.

Restricted Grazing of Cropland

Unlike in Australia, where alternative sources of competitively priced fodder are generally available, in areas of New Zealand where pasture growth in winter is poor, 10 to 15% of the farm is sown in a *Brassica* crop as forage to allow stock to remain on farm year-round. Data from studies (McDowell et al., 2003c, 2005; McDowell and Houlbrooke, 2009) of grazing cropland in winter indicated that P losses were (i) greater from winter-grazed forage cropland than winter-grazed pasture; (ii) dependent on soil moisture status and soil type, whereby wetter soils lost more P, but if near their plastic limit, hoof prints decreased the loss of PP by settling-out sediment during runoff; and (iii) greatly influenced by dung deposition as a function of stocking rate and grazing time. Restricting cattle and sheep to their maintenance feed requirement (3–4 h instead of 24 h) before moving them to a stand-off area decreased treading damage and the number of dung deposits on the soil surface. This decreased P losses in dissolved and particulate forms by about a third (Fig. 2). The disadvantage is that runoff from the stand-off area needs to be collected and, if applied back to land, must be applied with consideration of the receiving area's potential for P loss. Otherwise, farm-scale P losses may not be decreased but just transferred to another part of the farm.

Irrigation Management

The effects of irrigated dairying on the environment have been well reviewed elsewhere (Nash and Barlow, 2009). Border-check (dyke) irrigation systems are common in dry and flat areas and use 20- to 100-m-wide bays separated by raised borders that are periodically flooded with water from one end. Irrigation-inlet gates are usually left open until the bay is nearly all irrigated. Water exiting the bays (outwash) can enter the stream network. Measurements of irrigation water lost in outwash vary from 25 to 50% of that applied. The lost irrigation water carries with it about 3 to 5 kg P ha^{-1} yr^{-1} but carries up to 20 kg P ha^{-1} yr^{-1} if superphosphate has been recently applied (Bush and Austin, 2001; Carey et al., 2004; Barlow et al., 2005; Nash et al., 2004).

A mitigation strategy examined by Houlbrooke et al. (2008a) found that if bays were laser-leveled and widened, they lost, on average, only 10% of inflow water as outwash and decreased P loss by about 40%. Greater (60%) mitigation (D. Houlbrooke, unpublished data) could be achieved by matching irrigation scheduling to specific soil infiltration rates or by installing bunds at the end of bays to prevent outwash (but not leaching). However, these latter two options could decrease pasture production. In Australia, more common mitigation measures include the use of recycling systems to divert outwash for use in another part of the farm, making stock watering and entry points high in the bay, and not irrigating an entire bay after fertilizer has been applied.

To improve irrigation water efficiency (i.e., production per unit), there is increasing use of spray irrigation and interest in subsurface drip irrigation infrastructure over border-check irrigation. The limited studies comparing border-check and spray irrigation suggest that it is irrigation management, especially the timing of irrigation in relation to rainfall, that determines runoff volumes and nutrient exports (Nash and Halliwell, 1999). Hence, good management (e.g., consideration of infiltration rates, soil types, and application depths) is required for spray systems if P losses are to be minimized.

Greater Effluent Pond Storage and Low-Rate Effluent Application

The risk of waterway contamination via land application of farm dairy effluent (FDE, otherwise known as dairy shed effluent) is high on soils with a propensity for preferential flow, rapid drainage via artificial drainage or coarse structure, or surface runoff via an infiltration or drainage impediment or application to rolling or sloping land (Houlbrooke et al., 2006; Monaghan and Smith, 2004). Accordingly, strategies such as deferred irrigation, which involves storing FDE in ponds when soil moisture is close to or at field capacity, and applying low rates (<10 mm h^{-1}) to land otherwise, have proven effective at decreasing P losses (Houlbrooke et al., 2006; Houlbrooke et al., 2004; Monaghan and Smith, 2004). Research in the Manawatu, New Zealand by Houlbrooke et al. (2008b) found that 2 kg P ha^{-1} was lost in mole and pipe drainage from a single, badly managed irrigation under "standard" practice with wet soil conditions, compared with P lost via deferred irrigation (<0.1 kg P ha^{-1}), and for the remainder of the year (0.65 kg P ha^{-1}). The uptake of strategies such as deferred irrigation and low FDE application rate tools has been high in the dairy regions of Southland and Otago in New Zealand where soil and landscape conditions often make it difficult to keep effluent P in the root zone with sump and spray effluent management practices.

In Australia, where subsurface drainage is less prevalent, there has been less research on optimizing FDE application because it is assumed that the primary pathway for P loss is surface runoff. Irrigation of summer crops with effluent has proven a particularly useful way of using FDE, with yield improvements of up to 50 kg dry matter per mm of FDE applied, depending on the growing conditions (Jacobs and Ward, 2006).

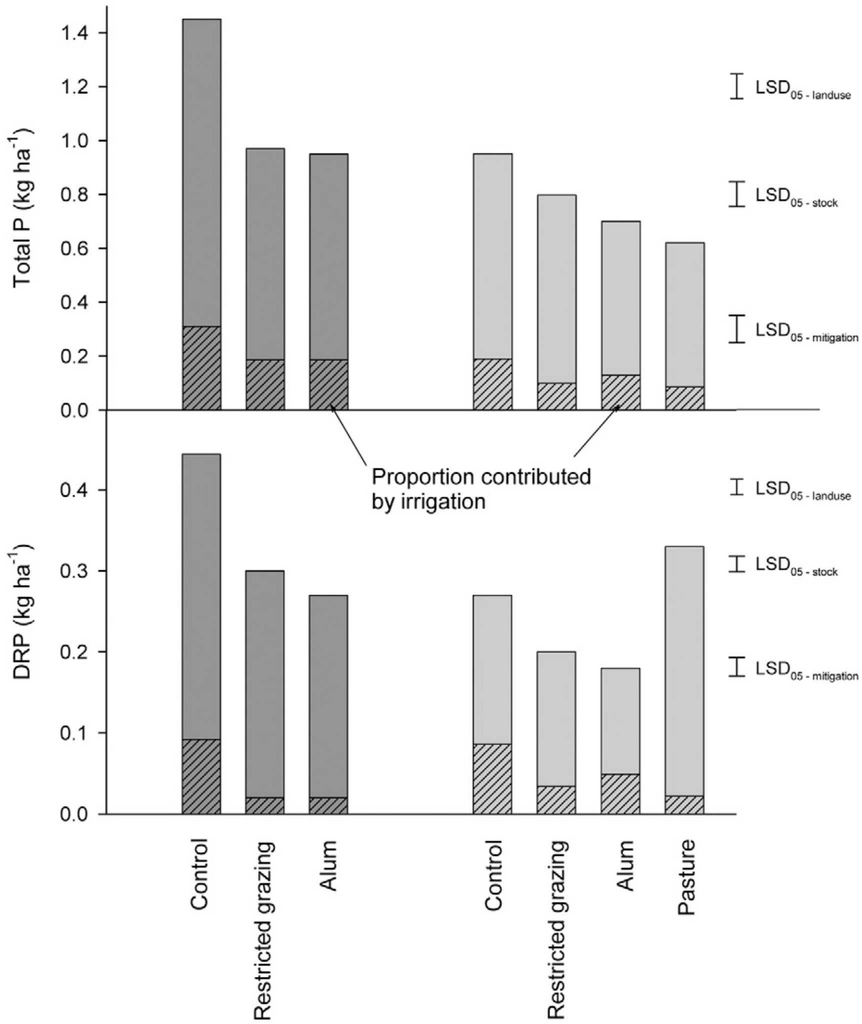

Fig. 2. Annual phosphorus losses associated with the grazing of winter forage crops from an irrigated site in North Otago. Treatments refer to a control with unrestricted grazing, grazing restricted to 3 h per day, and alum applied at 20 kg Al ha^{-1}. Phosphorus losses due to irrigation-induced runoff are represented by hatched bars. DRP, dissolved reactive phosphorus. Data from McDowell and Houlbrooke (2009).

Amendments

Tile Drain Amendments

The use of tile drain amendments for P loss mitigation is largely restricted to New Zealand. Several studies have shown that P-rich, well drained, or structured soils lose much P in drainage waters (e.g., Sharpley et al., 1994; Sims et al., 1998). Furthermore, if a soil has a large number of macropores, then these can act as a direct conduit for P loss to tile drains (Nash et al., 2002). Monaghan et al. (2000) also showed that the installation of drainage in hydrologically isolated plots (0.05 ha), receiving no nitrogen and grazed by dairy cattle, resulted in P losses that were similar to losses via surface runoff from undrained plots. Consequently, some P loss in tile-drained land is inevitable; therefore, a cheap and effective method of mopping-up P in drainage water is desirable.

Over the past two decades, by-product materials rich in P-sorptive Ca, Al, and Fe have been identified as decreasing P loss from soils with varied success (Vlahos et al., 1989; O'Reilly and Sims, 1995; Haustein et al., 2000; Stout et al., 2000). These include, but are not limited to, zeolites, aluminum sulfate, water treatment residuals, and fluidized bed bottom-ash and fly ash from coal-fired power plants (e.g., Reichert and Norton, 1994; Sakadevan and Bavor, 1998; Moreno et al., 2001; Callahan et al., 2002). When considering each by-product for use, three criteria must be considered: (i) the cost of the material (Does it need to be mined, or is there a readily available and cheap source?), (ii) toxicity to the environment (Does it contain heavy metals, or is the material caustic?), and (iii) the efficacy of sequestering P.

McDowell et al. (2008) tested fly ash, melter, and basic steel slag for their cost, toxicity to the environment, and ability to sorb P. A mixture of steel melter slag (90%) and basic slag proved good at sequestering P and was cheap and nontoxic; the caustic pH of basic slag was buffered by the greater proportion of steel melter slag. The mixture was installed as a backfill at 20 to 70 cm depth, above and around a tile drain at 70 cm depth, and covered with topsoil from 0 to 20 cm depth. Mean DRP and TP concentrations from greywacke (inert sedimentary rock) backfilled drains were 0.33 and 1.20 mg L^{-1}, respectively. In contrast, slag backfilled drains had significantly lower DRP and TP concentrations ($P < 0.05$) (0.09 and 0.36 mg L^{-1}, respectively). Drainage data from a farm with drains that had had melter slag used as a backfill up to 13 yr before sampling suggested that slag would continue to remove P for about 25 yr. Similar work by Hanly et al. (2008) tested the efficacy of 1- to 4-mm diameter volcanic tephra as a fill for mole channels and as a backfill to tile drains. During the winter drainage season, P losses were decreased from a paddock grazed by dairy cattle by 45 and 47%, respectively, compared with a standard mole-pipe drainage system. However, both materials suffer from being localized, meaning that the cost of the mitigation technology is limited by transport costs. Where P-sorptive materials like steel slag are not available, we hypothesize that some P loss may be prevented by installing drains about 10 cm from the bottom of the fill to allow particles to settle out, thereby decreasing PP loss and the potential for drain blockage.

Application of Alum to Pasture and Cropland

One possible strategy to mitigate P loss from topsoil, and therefore drainage or runoff, is to decrease the availability of P by spreading P-sorbing agents on the surface of grazed pasture. These agents increase the sorption capacity of the soil and decrease solubility in dung pats. Of several agents that have been trialed, one of the safest, most effective, cheapest, and readily available is aluminum sulfate (alum). Alum has been used around the world to flocculate P from water columns (e.g., adding to lakes and reservoirs; Paul et al., 2008) and in the United States to decrease the water solubility of P in manures applied to land (Smith et al., 2001) and P loss in runoff at plot and catchment scales (Moore and Edwards, 2007). It does not impair pasture growth (Warren et al., 2006), and ingestion at rates of 10 to 40 kg Al ha^{-1} yr^{-1} is unlikely to impair animal performance (Mora et al., 2006; Moore and Edwards, 2007). However, work needs to establish that, if runoff from alum-treated soil occurs, the Al concentration of receiving streams does not each a level that results in ecological consequences (Pilgrim and Brezonik, 2005).

Work in New Zealand has focused on the use of alum after the grazing of pasture or a winter forage crop. Annual losses associated with the application of 20 kg Al ha^{-1} after grazing a winter forage crop were equivalent to those lost via restricted grazing and a third less than unrestricted grazing of the same site (Fig. 2) (McDowell and Houlbrooke, 2009). However, application of 20 kg Al ha^{-1} to pasture on the West Coast of the South Island did not significantly decrease P losses (McDowell, 2010). This was probably due to Al being washed off in surface runoff (annual rainfall of 4–5 m and runoff of 1–2.2 m) before it could bind to the soil. In situations where alum was allowed to bind to the soil before being washed off, additional unpublished data (R. McDowell) have suggested that, for five volcanic and sedimentary soils, P losses were decreased by about 30 to 50% compared with untreated soil for at least 40 d after application.

Application of Red Mud (Bauxite Residue)

Red mud is a by-product of refining bauxite into alumina. It is alkaline (pH 10–13) and contains up to 60% Fe oxide, along with lesser amounts of Al, Si, and Ca. In Western Australia, red mud is sold as a soil amendment under the name Alkaloam (Alcoa, Kwinana Refinery, Kwinana, Western Australia) to increase soil pH and prevent P loss via leaching from sandy soils (Harris and Howard, 2010). Concerns over toxicity have largely centered on the presence of heavy metals or radionuclides, but the concentrations, when applied at the recommended rate of up to 20 Mg ha^{-1}, are small and unlikely to be detrimental to livestock (Summers, 2001). However, any product with a high pH should use a stand-down period before stock can graze pastures; otherwise, rumen pH could increase, adversely affecting the digestion of feed (Dewes et al., 1995).

Laboratory column and field studies (up to 1600 ha) in Western Australia have found that decreases in P loss increase with application rates from 30% at 20 Mg ha^{-1} to 98% at 200 Mg ha^{-1} (Summers et al., 1996; Vlahos et al., 1989). The cost-effectiveness of red mud is greatest when used on acid (pH 4.5) sandy soils. The application of red mud to these soils increases soil pH and decreases P loss. The resulting increase in yield is similar to that achieved by applying lime ($\sim$50% at 20 Mg ha^{-1}) and offsets the cost of the material ($\sim$12 to \$15 Mg^{-1}) (Summers et al., 2002). However, transport costs strongly effect cost-effectiveness and restrict its use to areas close to the source of production. Most dairy farming occurs on the coastal plains south of Perth, a considerable distance from refineries, and on heavier soil types that are less conducive to this mitigation strategy. Products in development with similar properties to red mud that may prove environmentally useful include neutralized used acid and lime-amended bio-clay.

Application of Other Soil Amendments

Compared with alum, steel slag, and red mud, other amendments have shown mixed results. Churchman (2002) found that the addition to soil of a water-soluble polymer (poly-diallyldimethylammonium chloride [poly-DADMAC]), which is used for the treatment of potable water, yielded a clay–polymer complex that strongly sorbed anionic pollutants like P. However, although showing some promise at an application rate of 0.006 g polymer per g of soil in rainfall simulation studies of boxed soil, analysis of P concentrations in runoff from a 2.3-ha catchment with poly-DADMAC applied at approximately 1 kg ha^{-1} showed no significant decrease in P losses compared with a control (Churchman et al., 2007). The discrepancy between data from the laboratory and the field was attributed to the formation of weak complexes with moist soil in the field. However, the authors also concluded that, in addition to uncertainty about its efficiency, the high cost of poly-DADMAC may prohibit its use as an amendment to prevent P loss.

An alternative strategy is the use of polymers like poly-DADMAC and latex to decrease soil hydrophobicity and erosion from wheat/fallow plots in South Australia (Bernas et al., 1995). Although not specifically tested by Bernas et al. (1995), less surface runoff may have also decreased P loss. However, when hydrophobicity was examined under cattle-grazed pastures in South Australia, Cox et al. (2005) found that, although the application of gypsum at 15 Mg ha^{-1} significantly changed soil structure (e.g., increased aggregate stability), thereby decreasing surface runoff and increasing interflow, it had little effect on P loss.

Edge of Field Mitigations

Buffer Strips

Grass buffer strips decrease P loss in surface runoff by a combination of filtration, deposition, and improving infiltration (Dillaha et al., 1989). The upslope edge of the strip is where most large particles and PP are filtered out, and the speed of surface runoff slows enough that deposition occurs. If the hydrology allows, a more important mechanism that decreases P loss is infiltration. This deposits particulate material onto the soil surface or vegetation and increases the interaction and sorption of DP with the soil (Dosskey, 2001). However, buffer strips do have major flaws: (i) The strip can quickly become clogged with sediment; (ii) they function poorly in areas that are often saturated due to limited infiltration, such as near stream areas where the benefit is gained from fencing-off, not from the buffer strip itself; (iii) they function best under sheet flow, whereas most surface runoff tends to converge into small channels that can bypass or inundate strips (Verstraeten et al., 2006); and (iv) grassed buffer strips function best when the number of tillers (i.e., stalks) is greatest, which generally occurs where biomass is harvested (i.e., under grazing). In a sense, one could consider well managed pasture as a big grassed buffer.

Riparian and grass buffer strips have been widely trialed in New Zealand. For example, Smith (1989) established buffer strips on a Waikato drystock farm and noted a 40 to 50% decrease in flow-weighted P concentration but concluded that the effect was due not to filtration of P in surface runoff but to a decreased quantity of P in the strips due to fencing off stock. To improve their performance, Redding et al. (2008) applied water treatment residual (largely alum) and polyacrylamide. This increased P retention within a 2.1-m-wide strip by up to 40%. However, Longhurst (2009) later reported that, in the field, the installation of small buffer strips in ephemeral channels did little to decrease P loss due to channelization of flow and topsoil erosion. To avoid this, Longhurst (2009) trialed filter strips with spreaders and sediment traps in an ephemeral channel and noted a small (5–20%) decrease in P losses. McKergow et al. (2007b) trialed the installation of grass buffer strips within, not at the edge of, paddocks. Two surface runoff events were monitored from fenced-off areas and exhibited a 40% decrease in P losses compared with a grazed control area. However, although further work aims to create less grazed areas by sowing unpalatable grasses, practical impediments, such as a loss of production and the cost associated with creating and fencing the strips, will limit their adoption.

Sorbents in and Near Streams

Management practices to decrease P in stream flow are limited. Techniques applicable to lakes, such as dosing with altered bentonite clays (e.g., Phoslock [Phoslock Water Solutions Ltd, Sydney, New South Whales, Australia) (McIntosh, 2007) to sorb P, may not be applicable to streams because they rely on P attached to the adjuvant remaining on the stream bed or rely on the material to cap the bed and block P dissolution from sediment (Cooke et al., 1993; Wrigley, 2001; Robb et al., 2003; Steinman et al., 2004). This may not occur because materials can be lost downstream during high-flow events. Furthermore, the input and deposition of new P-rich sediment frequently negates the cap's effectiveness (Moore et al., 1998).

Encasing steel melter slag in a mesh, McDowell et al. (2007b) installed "P socks" on the stream bed of the Mangakino stream in the Lake Rerewhakaaitu catchment in New Zealand. After the P socks were installed, concentrations of DRP and TP decreased on average 35 and 21%, respectively, and loads decreased by 44 and 10%, respectively. This was an effective removal strategy at low flows, but little P was retained at flow rates >20 L s^{-1}. However, it may be possible to engineer a solution that increases the proportion of low flow, or the interaction between the slag and streamflow, and maximizes P removal.

Stream areas and areas connected to the stream are important sources of P loss to most waterways that could be addressed by sorbents. Work by Hively et al. (2005) and Lucci et al. (2010) found that the potential for P loss from areas such as gateways, lanes, and around barns and troughs was much greater than from the rest of a grazed paddock. For a sheep and beef grazed catchment in southern New Zealand, McDowell and Srinivasan (2009) confirmed that infiltration-excess surface runoff from these areas was a major source of P during summer and autumn months when waterways are at most risk from algal growth. Similarly, McDowell (2007) traced 90% of the P loss within a subcatchment of the Mangakino stream back to surface runoff from a stream crossing where daily traffic by cows to and from the milking parlor resulted in regular dung deposition. The installation of slag on the side of the lane resulted in a decrease, via filtration, of >90% PP entering the stream over 1 yr (Table 1). Although some of this decrease would have been due to the different contributing areas (600 vs. 1000 m^2), yielding different runoff volumes, concentrations mirrored loads, implying that most of the difference was caused by treatment effects, not catchment size. In this example, due to the concentration of runoff to one point, the cost-effectiveness of using a material such as steel melter slag can be much better than installation of P socks.

Sediment Traps

In-stream sediment traps are useful for the retention of coarse-sized sediment. Hudson (2002) concluded that a coarse sediment trap should be 1.5 times the inflowing channel width, 10 times as long, and excavated 1.5 m below the existing channel bed. If cleaned twice a year, depending on sediment load, this would remove up to 90% of fine sand. For systems receiving silt-sized particles, the ratio of volume to inflowing water should be between 0.1 and 1, with a residence time of at least 1 d (Griffin, 1979). However, few data are available in New Zealand or Australia on the performance of coarse sediment traps for retaining P. Data from McDowell et al. (2006), and subsequent measurements, showed a 10% decrease in TP concentration in water exiting a trap compared with sediment-rich inflowing

Table 1. Loads of runoff, phosphorus fractions, suspended sediment, and *Escherichia coli* in the slag (1000 m^2) and control (600 m^2) races and the percentage mitigation (i.e., the fraction of load from altered steel melter slag versus control races). Data from McDowell (2007).

Parameter†	Mean load for altered steel melter slag	Mean load for control	Percent decrease
Runoff, L	15,665	35,950	56
DRP, g	1.5	19.8	93
DOP, g	2.4	2.6	8
PP, g	3.6	136.9	97
TP, g	7.4	159.3	95
SS, kg	2.0	173.0	99
Escherichia coli, cfu	2.22×10^8	1.54×10^9	86

† DOP, dissolved organic phosphorus; DRP, dissolved reactive phosphorus; PP, particulate phosphorus; TP, total phosphorus; SS, suspended sediment.

water from a stream draining red deer wallows. The removal rate was lower than expected due to the greater enrichment of P in fine, as opposed to coarse, suspended sediment (Stone and Murdoch, 1989). Although potentially beneficial for sediment and P removal, it was noted by Maxted et al. (2005) that the inclusion of six small ponds in a stream in the Auckland region caused an increase in PP (exported as algae) and low dissolved oxygen levels that were detrimental to aquatic life.

Dams and Water Recycling

Another strategy that uses settling-out of P involves coupling a retention dam with the reuse of water on a farm, where possible. Examples of this strategy are plentiful in Australia's irrigation districts and can result in farms that have little P loss by surface runoff. For example, Barlow et al. (2005) studied P loss from an irrigated farm in southeastern Australia and reported that, although P losses were up to 23 kg P ha^{-1} yr^{-1} from field plots, effective reuse of this water via a retention dam decreased P loss by 48% in an average year and by 98% in a drought year. However, studies (e.g., Nash and Clemow, 2003) from southeastern Australia suggested that retention dams were less effective in retaining P on-farm in rain-fed systems, where events are episodic and retention times are short. This is particularly true in a high rainfall zone where outflow from the system into nearby streams is more frequent. Furthermore, in terms of overall water quality, in rain-fed agriculture, retention dams may adversely affect environmental flows (Environment Australia, Department of Natural Resources, and Environment and Melbourne Water, 2002). In Australia it would appear that, although farm dams used for irrigation or stock water may inadvertently lessen P exports, especially PP exports, at a cost of \$2000 to \$2500 ML^{-1} (B. Bradshaw, Victorian Department of Primary Industries, personal communication), such structures are unlikely to be established primarily for on-farm P mitigation.

As part of a reuse system or feeding a retention dam, artificial open channel drains have been found to be both a source and a sink of P. For example, Nguyen et al. (2002) found that when a solution containing P was injected into a farm drain, the P concentration decreased by 56% over a distance of 150 m. However, Barlow et al. (2003) found that P increased by 4.4 mg P L^{-1} down a pasture-lined drain but decreased by 1.2 mg P L^{-1} down an earthern drain. Subsequent modeling suggested that bare earth drains could decrease P exports by 9 to 19% over a distance of 180 m, depending on factors such as soil type, flow velocity, and water depth (Barlow et al., 2004; Barlow et al., 2006). Management such as drain clearing can cause significant, but temporary, increases in P concentrations (Smith et al., 2006). Until further work is done, manipulation of a drainage network cannot be relied on as a strategy to mitigate P loss.

Natural and Constructed Wetlands

Wetlands, depending on factors such as loading rates and layout, can be sinks or sources of P (Reddy et al., 1999). The retention of PP associated with sediment deposition is usually large, especially if the input is sediment rich (e.g., from cropland or derived largely from surface runoff). However, with time the ability of wetlands to retain PP decreases as the wetland becomes choked with sediment. Compared with PP, the retention of DP by wetlands tends to be poor, often requiring large areas to maximize residence times and a P-sorptive substrate. However, processes that retain PP and DP can be antagonistic if, for example, P-rich sediment is retained within the wetland where it desorbs and acts as a source of DP. Several examples exist whereby concentrations of DP (and TP over time) are greater exiting than entering a wetland (Tanner et al., 2005; Sukias et al., 2006).

Compared with many natural wetlands, constructed wetlands can be designed to remove P from waterways by (i) decreasing flow rates and increasing contact with vegetation and thereby encouraging sedimentation; (ii) improving contact between inflowing water, sediment, and biofilms to encourage P uptake; and (iii) creating anoxic and aerobic zones to encourage bacterial processing. However, three experimental wetlands that have been constructed in New Zealand (one each in Waikato, Northland, and Southland) exhibit little to no uptake of P due to sediment-poor inflow and anoxic conditions in wetland sediments (Sukias et al., 2006). The inclusion of a P-sorptive material, insensitive to changes in redox conditions, may aid in P removal. Ballantine and Tanner (2010) reviewed a number of materials for inclusion in constructed wetlands ranging from tephra to sand but concluded that porous materials (e.g., shell-sand) or materials enriched with Al or Fe (e.g., melter slag) were the best candidates. Monitoring over 10 yr at the Waiuku wastewater treatment plant near Auckland, New Zealand has seen approximately 70% of P applied retained by melter slag during the first 5 yr of operation (Shilton et al., 2006).

An extension of constructed wetlands has seen the inclusion of scrubbers to periodically remove the algal turf (periphyton) and associated P. However, the effectiveness of this technique is dependent on the original concentration of inflowing water and flow rate. For instance, Craggs et al. (1996) noted removal rates of 0.44 g P m^{-2} d^{-1} from P-rich wastewater, whereas Adey et al. (1993) calculated a removal rate of 0.12 g P m^{-2} d^{-1} for less P-enriched agricultural runoff. The diversion of stream water through a watercress bed was found to remove 33% of DRP inflow (0.016 g P m^{-2} d^{-1}) at low flow and 16% of DRP inflow (0.074 g P m^{-2} d^{-1}) at high flow, probably due to sediment trapping (Sukias and McKergow, 2010). Another adaptation has led to the inclusion of floating wetlands (emerging wetland plants grown hydroponically on floating mats) removing 20 to 51% of DRP from artificial urban stormwater compared with unplanted mats (Headley and Tanner, 2007). However, Tanner (2001) notes that, although the regular harvesting and removal of plants growing on wetland sediments (not mats) may increase P removal from the wetland, unless the biomass has an economic value, harvesting is not a cost-effective strategy.

Cost-Effectiveness of Strategies to Mitigate Phosphorus Loss to Water

Table 2 summarizes the potential range in effectiveness (as % decrease compared with a control) of each mitigation strategy listed above for grazed pasture farms. The cost-benefit analysis data are derived from the method outlined below and research performed in a number of papers (e.g., Houlbrooke et al., 2008b; McDowell 2008, 2010; McDowell et al., 2008, 2009;

Monaghan et al., 2004, 2007, 2008, 2009a,b). For all strategies, except red mud, sediment traps, and dams and water recycling, these papers have used the BMP Toolbox or components therein to generate the output (Monaghan, 2009). No equivalent technology has been developed in Australia. Briefly, the BMP Toolbox combines P loss estimates (calibrated via field data) from the nutrient budgeting model Overseer (Wheeler et al., 2006) and percent decreases, as summarized in this review and by McKergow et al. (2007a), with financial estimates (earnings before interest and tax and inclusive of material, labor, and opportunity costs) using the UDDER farm systems modeling tool (Larcombe, 1999) for low-, average-, and high-producing farms across New Zealand (Fig. 3). The double bottom line (environmental and economic) output is expressed as a range of costs per kilogram of nutrient conserved for the average farm. The BMP Toolbox does not include red mud, sediment traps, and dams and water recycling among the suite of strategies offered. Instead, a simplified financial analysis was conducted as the sum of the cost of capital or application and production benefits, including the cost of labor and maintenance, depreciated over 20 yr. Dividing the cost by the load of P conserved gave a metric comparable to those generated by the BMP Toolbox. However, the financial estimates accounted for fewer variables than captured within the UDDER model and therefore should be interpreted with caution.

One generality, evident from Table 2, is that the cost-effectiveness of strategies tended to be better when focused on management as opposed to amendments or edge-of-field strategies. Our conclusion from this is that, due to increasing complexity and the number of flow pathways, the opportunity to remove or mitigate the impact of P decreases with increasing scale while the cost increases. Hence, the cheapest mitigation strategies focus on decreasing P loss at the source. However, although decisions can be made on a purely $ per kg P conserved basis, farm and environmental decisions should cast a wider net, and mitigation strategies may have multiple benefits. For example, wetlands have other benefits, such as N removal and modification of peak flows (Tanner et al., 2005), and irrigation reuse systems are good insurance against reduced water allocations.

The multiple pathways and sources that exist within New Zealand and Australian dairy farms make it possible that more than one mitigation strategy can be used. Examples exist where the cost–benefit analysis has been used not only to determine the most cost-effective strategy but also to provide options to farmers, advisors, and regulators that are more socially acceptable. An example of the latter is stream fencing, which may not prove to be the most cost-effective strategy but is favored by many due to the aesthetic improvement of not having animals in steams (Bewsell and Brown, 2009). In addition, Table 2 gives a cost–benefit analysis that was conducted for the Waikakahi catchment in Canterbury, New Zealand. The 4100-ha catchment is flat and dominated by flood-irrigated (border-dyke) dairy farms. Of the mitigation strategies considered practical (some strategies, such as winter cropping, tile drains, or red mud are not practiced, are absent, or are unavailable), farmers have focused on stream fencing, less P fertilizer use to decrease soil test P concentrations, and more recently, the creation of wider, more efficient irrigation bays. However, examination of Table 2 shows that if cost-

Table 2. Summary of efficacy and cost of phosphorus mitigation strategies for low-, average-, and high-producing farms and for an average farm in the Waikakahi, a dairy farmed catchment in New Zealand.

Strategy	Main targeted P form(s)	Effectiveness (% total P decrease)	Cost, range ($ per kg P conserved)†	Cost, Waikakahi ($ per kg P conserved)†
Management				
Optimum soil test P	dissolved and particulate	5–20	highly cost-effective‡	(15)
Low solubility P fertilizer	dissolved and particulate	0–20	0–20	0
Stream fencing	dissolved and particulate	10–30	2–45	14
Restricted grazing of cropland	particulate	30–50	30–200	na
Greater effluent pond storage/application area	dissolved and particulate	10–30	2–30	13
Flood irrigation management§	dissolved and particulate	40–60	2–200	4
Low rate effluent application to land	dissolved and particulate	10–30	5–35	27
Amendment				
Tile drain amendments	dissolved and particulate	50	20–75	na
Red mud (bauxite residue)	dissolved	20–98	75–150	na
Alum to pasture	dissolved	5–30	110 to >400	na
Alum to grazed cropland	dissolved	30	120–220	na
Edge of field				
Grass buffer strips	dissolved	0–20	20 to >200	30
Sorbents in and near streams	dissolved and particulate	20	275	na
Sediment traps	particulate	10–20	>400	>400
Dams and water recycling	dissolved and particulate	50–95	(200) to 400¶	200
Constructed wetlands	particulate	−426 to 77	100 to >400#	300
Natural seepage wetlands	particulate	<10	100 to >400#	na

† Numbers in parentheses represent net benefit, not cost. Data taken as midpoint for average farm in Monaghan et al. (2009a).

‡ Depends on existing soil test P concentration.

§ Includes adjusting clock timings to decrease outwash <10% of inflow, installation of bunds to prevent outwash, and releveling of old borders.

¶ Upper bound only applicable to retention dams combined with water recycling.

Potential for wetlands to act as a source of P renders upper estimates for cost infinite.

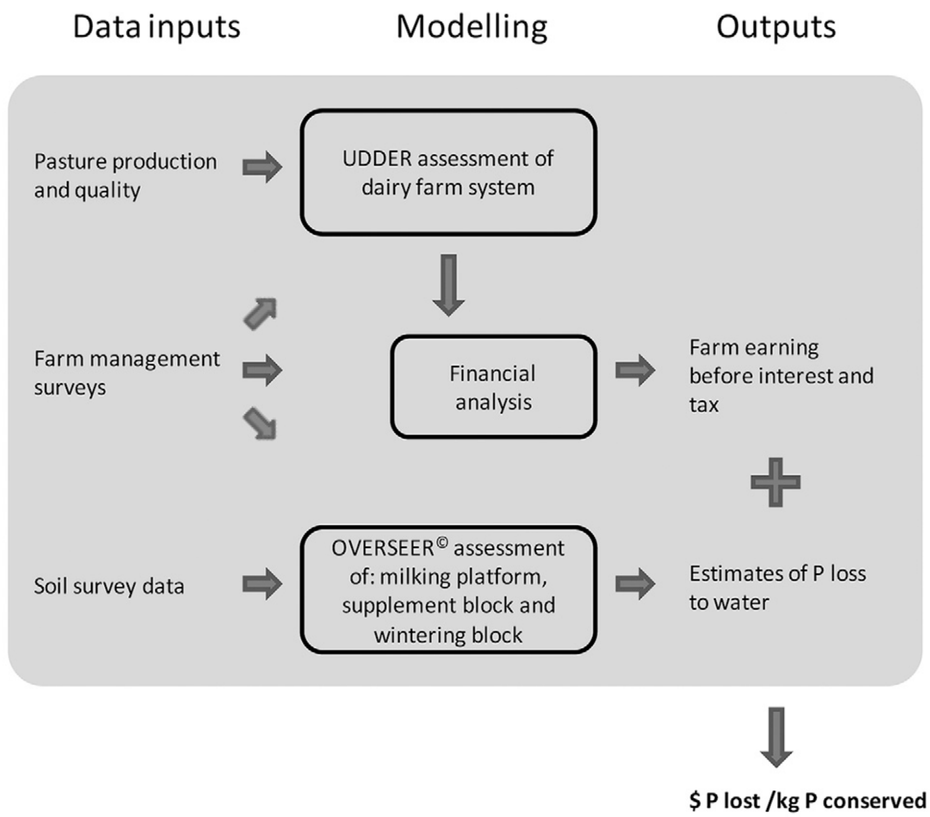

Fig. 3. Conceptual diagram of the BMP Toolbox (adapted from Monaghan, 2009).

effectiveness were the only consideration, soil P adjustment (less P fertilizer) would be practiced first, followed by the creation of wider, more efficient irrigation bays; effluent management; and stream fencing. Nevertheless, the combination of strategies has, since 2001, when monitoring of the Waikakahi stream and biannual farm surveys began, prevented the increase of P concentrations despite milk solids production now being 40% greater. An alternative metric would see P loss expressed as 3.1 kg P lost per ton of milk solids in 2001 and 2.1 kg P ha^{-1} lost per ton of milk solids in 2009 (Campbell et al., 2010).

Other examples exist where more than one mitigation strategy has been combined to decrease P loss. Decreases of 64 and 25% have been seen in the New Zealand dairy farmed catchments Toenepi and Waiokura due to the adoption of stream fencing and the shift from direct pond discharge to land application of dairy shed effluent, both calculated to be highly cost-effective strategies by Monaghan et al. (2009b). However, these strategies are classified in Table 2 as management strategies, and, although it is possible to use multiple management strategies on one farm, they are usually spatially discrete. Limited opportunity exists to impose more than one management strategy in the same place due to the possible overlap of targeted pathways, which in turn may decrease the cost-effectiveness of the second strategy. One exception may be the use of optimum soil P concentrations. Decreasing soil P affects all runoff losses of P throughout the year, whereas other management strategies, such as restricted grazing of cropland or low-solubility P fertilizer, focus on discrete time periods of enhanced loss.

A large opportunity to decrease P loss lies in the adoption of multiple strategies not within a group but between groups. This optimizes the capture of P losses with scale. For instance, decreasing soil P concentration (management strategy) can be combined with an amendment to decrease P losses further. Any P lost from the paddocks in runoff can then be mopped up with an edge-of-field strategy, such as a wetland or sorbent in the stream. The cost-effectiveness of some of these mitigation strategies will also be improved by targeting the right strategy to critical source areas. Work by Srinivasan and McDowell (2007) estimated that in near-stream areas, which were found to be critical source areas, decreasing soil P to an agronomic optimum and using a low-water-soluble P fertilizer to maintain it could decrease P losses by 10% and improve profitability. Such work needs to examine the interrelationships between mitigation strategies across classifications according to their cost benefits.

Furthermore, strategies need to be considered for their suitability at different times of the year. For instance, the use of low-water-soluble P fertilizer relies on the premise that enhanced losses occur from the application of high-water-soluble P fertilizers during times of year when runoff is likely (McDowell et al., 2010). However, modeling has indicated that P losses from high-water-soluble P fertilizer can be similar to those from low-water-soluble P fertilizers if applied at a time of year when runoff is unlikely (McDowell and Catto, 2005).

Phosphorus exports from intensive pasture systems are a conundrum. Phosphorus is an essential element for plants, which extract it from soil water. However, when we lose soil water, we lose P. Therefore, by definition, we cannot eliminate P losses, but we can mitigate or minimize them. Farms are complex biological systems where P losses are determined by the interactions of management, fixed assets such as soil type and capital infrastructure, and chance events like weather patterns. Hence, it is not only important what you do, but when and where you do it (i.e., critical source areas). Uninformed management decisions to mitigate P losses in one farming system may exacerbate them in another. The current focus on individual mitigation practices, rather than on farming systems with multiple intervention points, is not helping progress. Risk management technologies, such as Bayesian Networks (McDowell et al., 2009; Nash and Hannah, 2011; Nash et al., 2010), provide a mechanism for us to investigate our dairy systems. When integrated with GIS data (Department of Primary Industries, 2007), these technologies can produce maps of relative P loss that link the management of critical source areas to complex farming systems and pathways at different scales. Although a full discussion of these tools is outside the scope of this review, which focuses mitigations an individual landholder may undertake, clearly identifying critical source areas where specific mitigation measures (or changes to land use) are likely to have the greatest overall impact on P exports is fundamental for optimizing policy and mitigation measures.

Conclusions

The issue of mitigating P loss is not as simple as testing the efficiency of a particular strategy in isolation. Several factors need to be considered, including (i) the different pathways and forms of P lost and the suitability of a mitigation strategy, (ii) the cost of the strategy, and (iii) the acceptance of a strategy by those having to implement it. The consideration of the cost-effectiveness is especially important in New Zealand and Australian dairy farms where little or no subsidies exist. This review highlights the general trend that the mitigation of P losses is more cost effective by management strategies than strategies that use amendments or focus on mopping up P losses once they have left the edge of the field. This does not preclude the use of a combination of strategies. However, due to the complexity of matching suitable and cost-effective strategies in time and space to a farm or catchment, it is clear that these strategies need to be considered within a concept such as critical source area allocation. This avoids a piecemeal or blanket approach to the implementation of mitigation strategies and enables strategies to be targeted and nested within a wider farm systems approach to minimizing P loss while maintaining profitability.

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APPENDIX 6

HOULBROOKE & MONAGHAN PAPER

Farming, Food and Health. First

Te Ahuwhenua, Te Kai me te Whai Ora. Tuatahi

The influence of soil drainage characteristics on contaminant leakage risk associated with the land application of farm dairy effluent

Prepared for Environment Southland

October 2009

New Zealand's science. New Zealand's future.

The influence of soil drainage characteristics on contaminant leakage risk associated with the land application of farm dairy effluent.

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D J Houlbrooke, R M Monaghan

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1. Summary

The impact of dairy farming on the aquatic environment has come under increasing scrutiny in recent times. It is widely believed that intensive dairy farming is responsible for accelerated contamination of waterways by nutrients, sediment and faecal micro-organisms. In particular, farm dairy effluent (FDE) is frequently implicated as a major contributor to the degradation of surface water quality. Poorly managed FDE land treatment systems may generate nutrient-rich surface runoff and drainage waters which have the potential to pollute surface and ground waters. The risk of direct contamination of water bodies associated with FDE application is dependent on the transport mechanism of water and, therefore, solutes and suspended solids. Three primary mechanisms exist for the transport of water (containing solutes and suspended solids) through soil: matrix flow, preferential flow and overland flow. Soils that exhibit preferential or overland flow are capable of considerable direct contamination loss of FDE when applications are made when soils are considered too wet (insufficient soil water deficit to store incoming moisture) and/or when the application rate of FDE is too high for the receiving soil's infiltration rate. Preferential or overland flow provides little soil contact time and decreased opportunity to attenuate the applied contaminants. Critical landscapes with a high degree of risk include soils with artificial drainage or coarse soil structure, soils with either an infiltration or drainage impediment, or soils on rolling/sloping country.

Soils that exhibit matrix flow show a very low risk of direct contamination loss of FDE under wet soil moisture conditions. Matrix flow involves the relatively uniform migration of water through and around soil aggregates (so called 'piston' type displacement) and therefore provides a greater soil contact time and opportunity for nutrient attenuation and filtering of sediments and faecal micro-organisms. Such soils are typically well-drained with fine soil structure and high porosity. Research conducted in New Zealand suggests there is a low risk of direct contamination from FDE applied to well-drained soils. However, well drained soils typically have an inherently higher N leaching risk associated with the direct deposition of animal urine patches to land as a result of the smaller denitrification influence and smaller water holding capacities often associated with such soils. Therefore, the extent and impact from N inputs added as FDE to free draining soils that leach to ground water indirectly should be kept in context as FDE makes up approximately 10% of the daily nutrient load from cattle excreta. Therefore, effective mitigation techniques for N loss on these free draining soils should target the cumulative effects of autumn-applied urine patches during animal grazing.

The effectiveness of current effluent best management practices (deferred irrigation and low application rate tools) varies between soil types depending on their inherent risk of direct contamination from land-applied FDE. Best practice management should therefore be targeted where it will be most effective. It is, however, acknowledged that there have

been no targeted field studies to assess the risk of FDE application to shallow well-drained land when soil moisture contents are close to or at field capacity.

2. Introduction

The safe application of farm dairy effluent (FDE) to land has proven to be a challenge for dairy farmers and Regulatory Authorities throughout New Zealand. Recent research in Manawatu and Otago has identified that poorly performing FDE systems can have large deleterious effects on water quality, particularly when direct losses of FDE with high concentrations of contaminants (phosphorus, nitrogen and faecal microbes) discharge, drain or run-off directly to surface water bodies (Houlbrooke et al. 2008b, Muirhead et al. 2008, Houlbrooke et al. 2004a, Monaghan and Smith 2004). In particular, land application of FDE has proven difficult when it has occurred on soils with a high degree of preferential flow, soils with artificial drainage or coarse structure, soils with infiltration or drainage impediments, or when applied to soils on rolling/sloping country (McLeod et al. 2008, Houlbrooke et al. 2006, Monaghan and Smith 2004). The effect of these conditions can be exacerbated by climate, where high rainfall can further contribute to the poor environmental performance of such land application systems. In comparison, well drained soils with fine to medium soil structure tend to exhibit matrix rather than preferential drainage flow; even under soil moisture conditions close to or at field capacity (McLeod et al. 2008). These soils are therefore likely to pose a lower risk of direct loss of effluent contaminants. However, there is only limited research conducted in New Zealand on these soil types. The issue of hydrophobicity and its potential impact on rapid re-wetting of dry well drained is soils in Southland are still somewhat unknown.

A literature review of New Zealand data by Houlbrooke et al. (2004b) on land-applying FDE, and its effects on water quality, has shown that between 2 and 20% of both the nitrogen (N) and phosphorus (P) applied in FDE is lost either in runoff or via leaching. Losses of FDE can be measured in the direct drainage of untreated or partially-treated effluent immediately following irrigation events and/or in the indirect drainage that occurs in the following winter/spring period. Indirect losses of nutrients associated with land application of FDE are the result of nutrient enrichment of the soil during the summer-autumn period followed by leaching during the subsequent winter-spring drainage period. Indirect drainage losses therefore reflect a soil's fertility level and cannot be managed using effluent application best management practices. Effluent best management practices have been developed to specifically address the risk of direct drainage losses of effluent contaminants on soils with a critical limitation, as described above. A full description of two key effluent best management practices (deferred irrigation and low rate tools) will be provided in section 4.

In 2008, Horizons Regional Council engaged the services of AgResearch Ltd to report on potential best management practices (BMPs) for land application of FDE in the Manawatu-Wanganui region (Houlbrooke et al. 2008b). As part of this report, a decision tree was developed that took account of soil and landscape features when recommending best management practices and associated pond storage requirements. Following subsequent discussion with Environment Southland, the decision tree (slightly adapted for Southland conditions) was provided to Environment Southland for consideration for their region. This original version of the decision tool is presented in Figure 1.

Recommendations regarding management practice and storage requirements using the decision tree considered a soils inherent risk for direct losses of FDE contaminants during land application. For the soil and landscape features that contained an inherent risk of direct FDE loss, the proposed BMP also reflected minimum appropriate practice based on the potential for environmental effect. However, storage recommendations for the original well drained soil flow chart were made assuming a cautious approach to ensure FDE was not applied to wet soil and also to capture the benefits associated with labor rationalisation during the busy wetter spring period on a farm when calving takes place. Recommendations did not, therefore, reflect minimum requirements for an effects-based strategy managing FDE on well drained soils. Nor did they capture the appropriate storage requirement to implement a full deferred irrigation strategy. Hence, the recommendations were a compromise between an effects-based approach and perceived best practice. Subsequently, Environment Southland has expressed some concern with regard to the potential for ground water contamination if FDE was applied to well drained soils overlying shallow groundwater tables during wet conditions. Therefore, the aim of this report is to further investigate the effect of soil drainage mechanisms on the likelihood of direct drainage losses of applied FDE. The scope of this investigation included a review of international literature, although due to the contrasting nature of animal effluents and manures, few relevant studies were found.

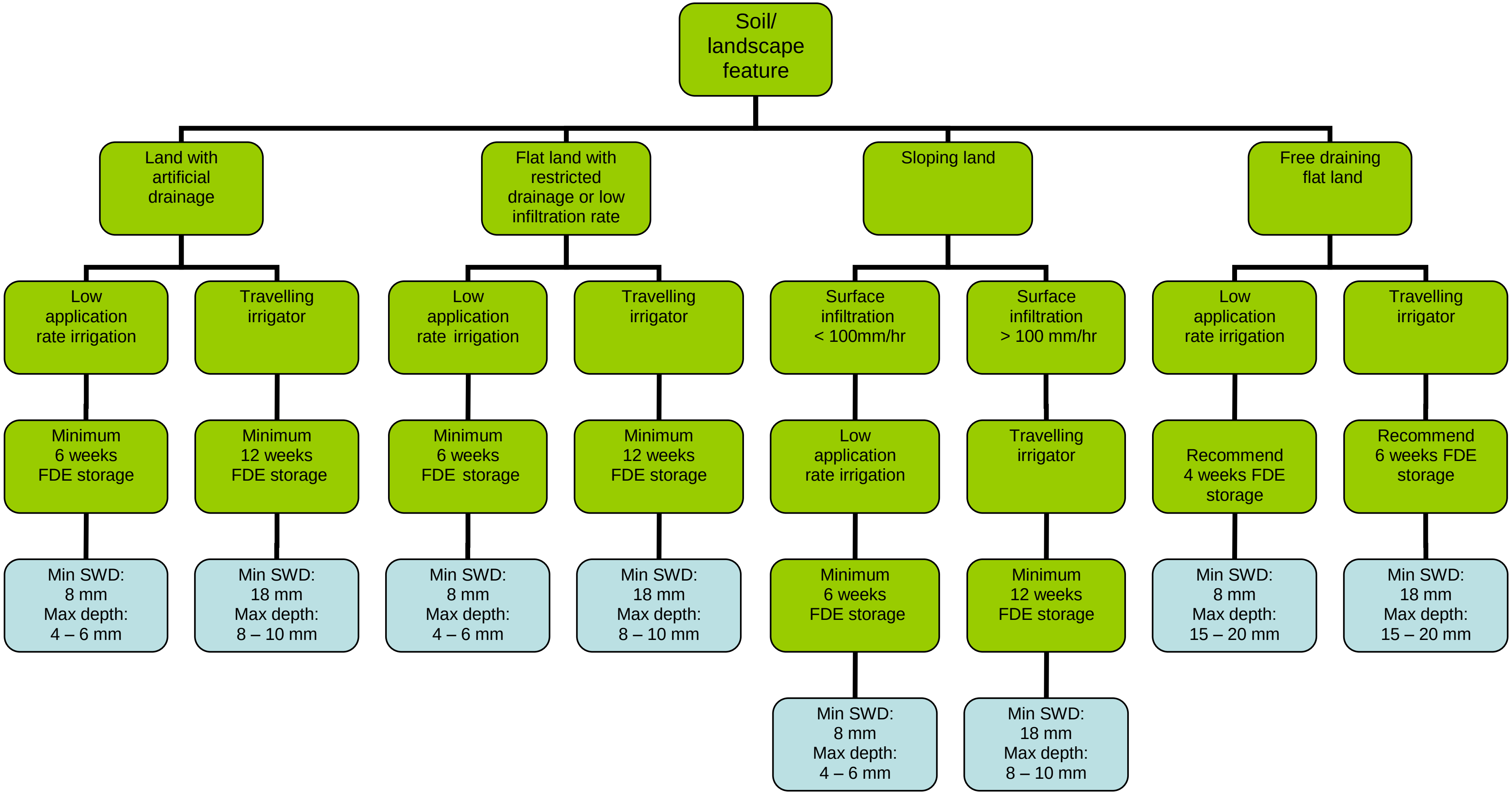

Figure 1. Original flow chart to guide proposed best management practice for land application of FDE.

3. Water and solute transport mechanisms in soil

The transport pathway of solutes and suspended solids in drainage water is dictated by soil hydrology. A soil's drainage capacity is usually determined by factors such as soil texture, pore continuity and proximity to water tables. Water movement through the soil is measured as hydraulic conductivity usually in units of mm hr^{-1} or m s^{-1}. Hydraulic conductivity is an important component of Darcy's Law which states that a flux of water is proportional to the hydraulic gradient multiplied by the conductivity of a soil (McLaren and Cameron, 1996). In general, the finer a soil texture the less continuity of pores. Hence a sandy soil will have a greater drainage capacity than a fine-grained silt or clay soil (Hillel, 1980). However many exceptions occur as soil texture is strong factor in governing unsaturated flow, however, saturated flow is largely governed by soil density, macroporosity and soil structure. Three mechanisms for the movement of excess soil water are described below.

3.1 Matrix flow

In saturated soils the force of gravity creates a hydraulic gradient that drives water downward. In unsaturated soils the process of diffusion means that soil water will flow from areas of high potential to low potential in order to come to equilibrium (McLaren and Cameron 1996). Soils that are draining excess water have soil moisture contents greater than field capacity and do so under saturated flow conditions. If water drains through the soil body in a relatively even manner, wetting the whole soil profile, then it is termed matrix flow. Matrix flow moves water through micropores within and around soil aggregates, rather than rapidly around soil aggregates. Soils with a fine and spheriodal structure typically exhibit rapid drainage under a well distributed matrix flow (Figure 2).

Matrix flow is often called a piston flow effect where soil surface inputs displace and drain water situated deeper in the soil profile. This will allow applied FDE to have a suitable residence time to attenuate potential contaminants (McLeod et al. 2008). In reality, a sharp wetting front caused by piston displacement will be somewhat distorted by the process of hydrodynamic dispersion reflecting microscopic non-uniformity of the water-conducting pore dimensions, and therefore, flow velocity (Hillel, 1998). Figure 3 demonstrates the likely nature of soil matrix flow whereby one pore volume of drained water (equivalent to the sum of total water holding capacity for a given depth) will represent a mixture of the incoming soil solution and the displaced previous water (Hillel, 1998). It would, therefore, be expected that an application of FDE to a soil at field capacity would have to be greater than 50% of a pore volume before any direct losses of FDE contaminants could be expected in drainage waters given matrix flow conditions. As an example, a typical fine to medium textured soil with soil moisture at field capacity of 35% v/v has a total water holding capacity of 105 mm depth in the top 300 mm of soil (dominant root zone). It should therefore require an application depth to a wet soil of at least 50 mm in order to result in direct drainage of FDE contaminant losses. Figure 4 presents a diagrammatic example of an idealised breakthrough curve (plot of relative solute concentration in drainage vs. cumulative drainage in pore volumes). The matrix flow curve demonstrates the passage (piston effect) of an applied solute between 0.5 and 1.5 pore volumes of cumulative drainage. The peak in relative concentration at c. 30% demonstrates the attenuation of the applied solute during the matrix flow.

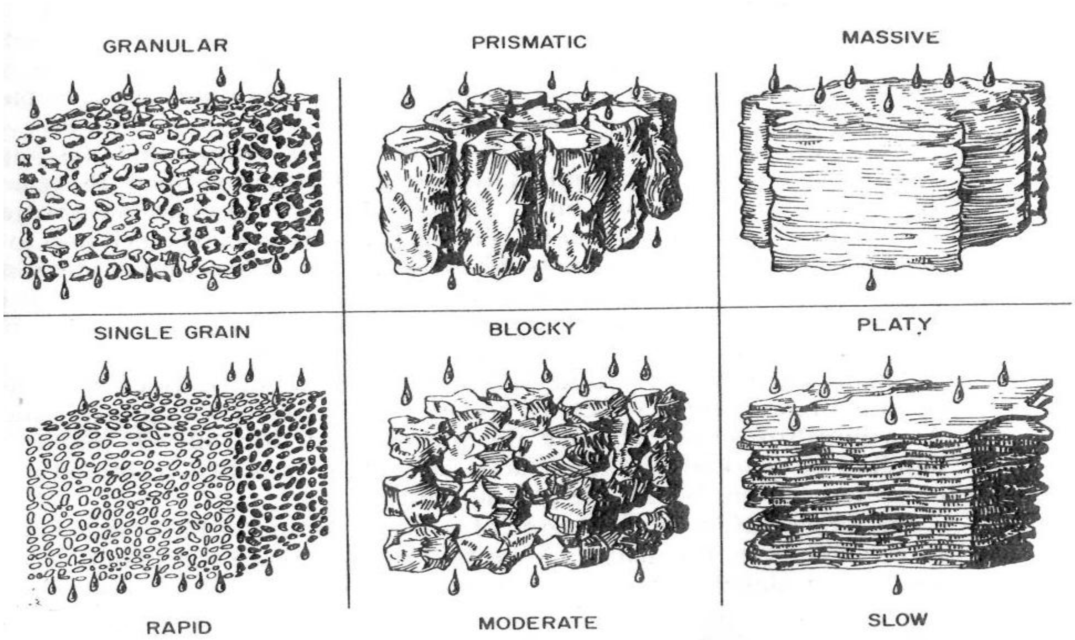

Figure 2. Diagram of the influence of soil structure on drainage (Bowler 1980).

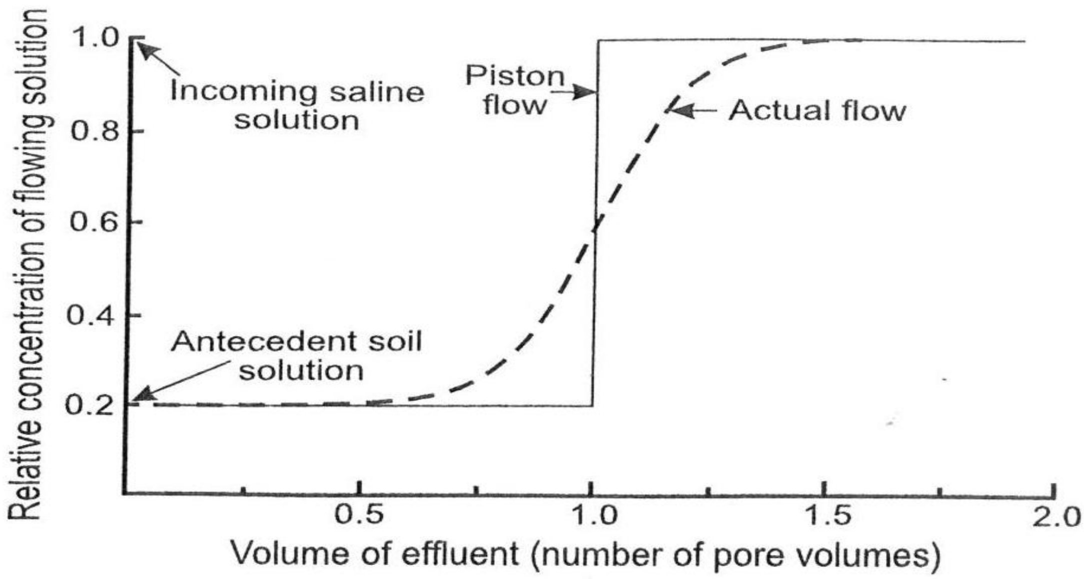

Figure 3. Graphic illustration of theoretical vs. actual piston flow drainage flux of an applied solution (Hillel 1998).

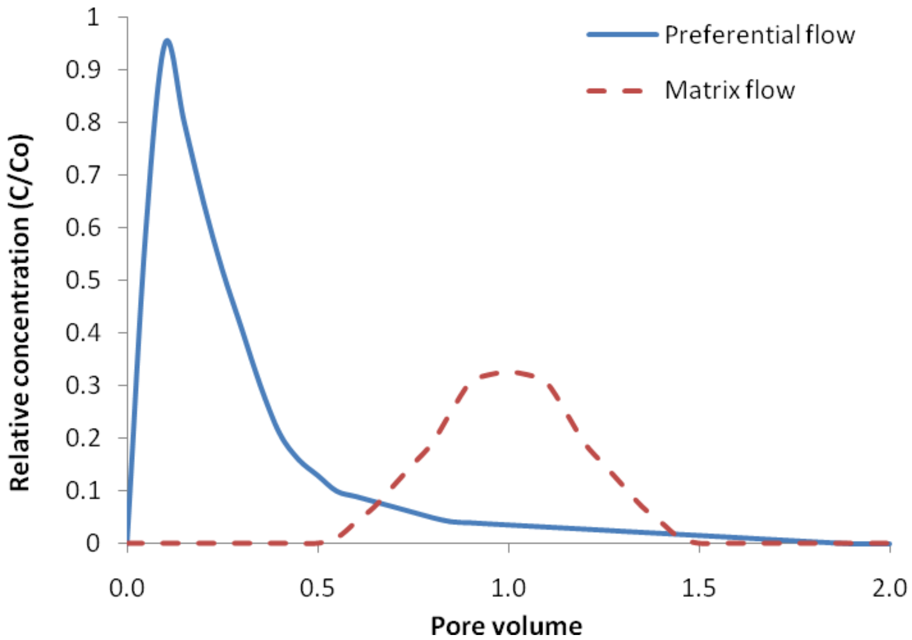

Figure 4. Illustration of breakthrough curves for preferential vs. matrix flow

3.2 Preferential flow

Preferential flow means that, water favors movement down preferred pathways when soils are draining (Hillel 1998). This phenomenon is also commonly called bypass flow, as it results in a large proportion of the soil matrix being bypassed during the drainage process. Preferential flow typically takes place down large continuous cracks or a series of intermittent and somewhat connected soil cracks or channels with large pore space. Such cracks or channels are commonly caused by earthworms or plant roots. Soil cracks may also occur as a result of freeze-thaw processes and wetting and drying cycles, particularly in very fine textured soils with a drainage impediment (McLeod et al. 2008, Hillel 1998). Soil structure also has an influence on preferential flow processes where soils with coarser prismatic or large blocky structures (Figure 2) and firm clay coated peds can inhibit micropore flow (McLeod et al. 2008, McLeod et al. 2004, Magesan et al. 1999, Wells 1973).

Preferential flow paths can also be induced by the installation of artificial drainage (Monaghan and Smith 2004). In particular, mole-pipe drainage systems can considerably change soil hydrology from a poorly drained to relatively well-drained status. This occurs by the creation of macropores and preferential flow paths linking to mole drains typically spaced at two meter intervals, and in turn, a receiving pipe line (Figure 5). Mole drains are installed into the soil by a mole plough at approximately 450 mm depth. The installation of mole-pipe drainage has agronomic and soil physical advantages associated with decreased water-logging and the subsequent time that a soil is wet and prone to animal treading damage (Bowler, 1980). However, the preferential nature of soil drainage (as demonstrated in Figure 6) creates a considerable risk of direct losses of FDE contaminants (Houlbrooke et al. 2004a, Monaghan and Smith 2004). The preferential flow curve presented in Figure 4 demonstrates the potential for high concentrations of solutes to be rapidly eluted in bypass flow, compared to the piston effect observed under matrix flow.

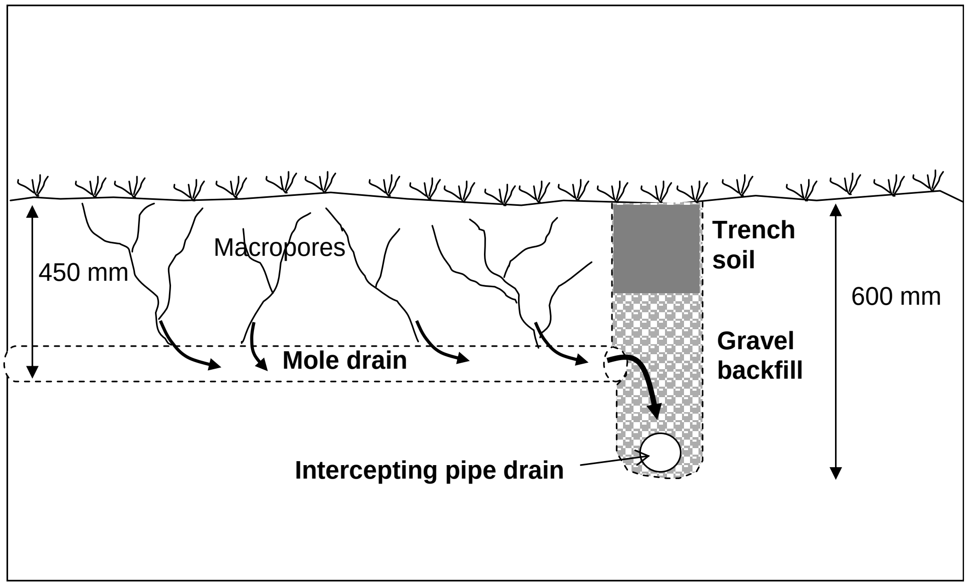

Figure 5. Diagrammatic representation of a mole-pipe drained soil.

Figure 6. Field example of preferential flow through a Pallic soil containing remnants of old mole drains.

3.3 Overland flow

Overland flow can be generated by two different processes. The first process is termed 'infiltration excess' flow commonly also referred to as 'Hortonian' overland flow (Horton, 1940). Infiltration excess conditions imply that rainfall (or irrigation) intensity exceeds the soils surface infiltration rate. On flat land this condition will result in surface ponding (Needelman et al., 2004). A suitable lag time is required post rainfall for all of the ponded surface water to infiltrate the soil body. However, on sloping land ponded water will move downslope, hence creating surface runoff or overland flow (Srinivasen et al., 2002; Needelman et al., 2004). Natural soil properties can influence infiltration excess conditions such as soil infiltration rate, as can animal grazing-induced soil physical damage (Greenwood and McKenzie, 2001; Kurz et al., 2006). Soils with massive or platy soil structure are prone to infiltration excess overland flow generation (Figure 2). The second process that results in overland flow generation is known as ‘saturation excess’ flow. This condition requires a fully saturated soil , often as a result of a high water table or a slowly permeable subsoil layer that restricts drainage (Needelman et al., 2004). Saturated soils are filled beyond field capacity to the point that all large and typically air-filled pores are filled with water. Once all pores are storing water, the soil has no capacity to infiltrate further water and so overland flow conditions are created and water ponds or flows downslope (Srinivasen et al., 2002). Flow conditions will stop once the water source is removed. However, saturated soil profiles can only be alleviated by drainage or evapotranspiration (Hillel, 1980).

4. Existing best management practices for land application of farm dairy effluent

For a land treatment system to be sustainable it must be efficient in both the retention of effluent in the soil and the subsequent plant uptake of nutrients applied in the effluent. The longer the effluent resides in the soil’s active root zone, the greater the opportunity for the soil to physically filter the effluent whilst attenuating potential contaminants and making the nutrients available to plants. Two effluent management technologies described below provide New Zealand dairy farmers with tools which will assist the aim of keeping applied nutrients in the root zone and, therefore, minimise potential environmental effects.

4.1 Deferred irrigation

To help overcome the problems associated with the spray irrigation of FDE to artificially drained soils and soils with drainage limitations, an improved treatment system called ‘deferred irrigation’ was developed (Houlbrooke et al. 2004a). Deferred irrigation involves storing effluent in a pond then irrigating it strategically when there is a suitable soil water deficit, thus avoiding the risk of generating surface runoff or direct drainage of effluent. When applied effluent remains in the soil as plant available water (rather than exiting the soil as drainage water), the soil-plant system’s ability to remove soluble nutrients via plant uptake and immobilisation processes is maximised (Houlbrooke et al. 2004a, Monaghan and Smith 2004).

The application criteria for spray irrigation of FDE if drainage is to be avoided are presented in the following equations:

$$E_i + \theta_i Z_R \leq \theta_{FC} Z_R \quad \text{eq. 1}$$

$$E_i \leq Z_R\ (\theta_{FC} - \theta_i) \quad \text{eq. 2}$$

Where E_i is the depth of FDE (mm) applied on day *i*, $Z_{R,}$ is the effective rooting depth (mm), θ_{FC} is the soil water content at field capacity ($m^3\ m^{-3}$), and θ_i is the soil water content on day *i* ($m^3\ m^{-3}$) (Houlbrooke et al. 2004a). Both of these equations effectively state that the existing soil moisture deficit in the root zone plus the depth of applied FDE is required to be less than maximum soil water storage (field capacity).

In Southland, regular soil water deficits greater than 10 mm mainly occur between the months of October and May. However, the generation of FDE starts at the beginning of lactation in late winter (late July/August). Consequently, having sufficient storage for FDE is essential to ensure that spray irrigation to soils with an inherent risk only occurs during times when an adequate soil water deficit exists. Whilst storage is the most important infrastructural requirement, the accurate scheduling of FDE to coincide with soil moisture deficits is also critical.

Houlbrooke et al. (2004a) reported the results of a 3-year research trial at Massey University that assessed direct losses of nutrients in mole and pipe drainage when FDE was applied to land according to deferred irrigation criteria. When averaged over all three lactation seasons (2000/01 to 2002/03), FDE application to the soil generated drainage equivalent to 1.1% of the total volume of effluent applied. Over the three seasons a range of different application depths were assessed. The strategy of irrigating smaller quantities of FDE, more frequently (7 events at an average of 9 mm depth) in 2001/02, resulted in zero drainage of applied effluent through the mole and pipe drainage system, and consequently, no direct loss of nutrients. Average annual nutrient losses from direct drainage of FDE following irrigations using the deferred irrigation criteria over three lactation seasons were c. 1.1 kg N ha^{-1} and 0.2 kg P ha^{-1}. Similar environmental performance has also been reported in the Otago region by Monaghan and Smith (2004) when FDE was stored and applied at appropriate soil water deficits. This shows that an improved FDE land application system, such as a deferred irrigation strategy, can minimise the environmental risk associated with a daily application system. However, if insufficient storage is available to fully implement deferred irrigation practice, then FDE should be applied at the lowest depths possible (< 10 mm) during the critical times of the season to reduce the risk of FDE drainage and run-off.

4.2 Low application rate tools

Low rate applicators such as K-Line and Larall are temporarily fixed in one place and deliver at rates of approximately 4 mm per hour. Therefore, a one hour application would deliver only 4 mm of FDE to the soil. Such applicators allow FDE to be applied in smaller amounts and more often during periods of low soil moisture deficit (<10 mm) In principle, any tool capable of delivering FDE at a rate less than 10 mm/hr can be considered 'low rate' (McLeod et al. 1998). For soils that exhibit a high degree of preferential flow, a drainage limitation, or are situated on sloping land, the application rate of an irrigator has a strong influence on environmental performance. Different soils have different infiltration rates and abilities to absorb and drain water. Where there is a risk of surface water contamination, FDE application rates should be matched to a soil type's ability to absorb or infiltrate effluent. Travelling irrigators typically have very high instantaneous application rates, usually greater than 100 mm/hr (Houlbrooke et al. 2004c). If the average depth of applied FDE is divided by the whole time for one complete pass of the irrigator (including time when trays do not receive FDE because of donut pattern) then the application rate would be approximately 20 mm/hr. Low rate applicators apply FDE at rates of only 4 mm/hr or less and therefore reduce the risk of exceeding a soil's infiltration capacity, thus preventing ponding and surface runoff of freshly applied FDE. Furthermore, the slower application rates increase the likelihood of retaining the applied nutrients in the root zone as the low application rate decreases the likelihood of preferential flow and allows a greater volume of applied FDE to move through smaller soil pores via matrix flow, thus allowing for greater attenuation of effluent contaminants (Houlbrooke et al. 2006, McLeod et al. 1998).

5. Contaminant leakage risk under contrasting soil types

5.1 Soils that exhibit overland flow

The combination of low soil infiltration rates and wet soil conditions on sloping land will provide the greatest risk for overland flow generation (McDowell et al. 2008). In some circumstances, intensive dairy farm operations in the Southland Region are located on rolling country (c.>7°) with low surface infiltration. These soils typically belong to the Pallic soil order which are characterised by high density, slowly permeable subsurface horizons often over a fragipan which has a highly restricted permeability (Hewitt 1998). The low infiltration rates (< 100 mm/hr) of many of these soils in combination with sloping land poses a high risk of surface ponding and subsequent overland flow and surface redistribution when FDE is applied using high application rate travelling irrigators. Low rate irrigation tools have application rates more suitable for these soil types and thus allow for infiltration and hence storage and subsequent filtration of contaminants in the applied

FDE. For a number of practical and environmental reasons, it is recommended that such systems are run in accordance with the principles of deferred irrigation.

Houlbrooke et al. 2006 reported on a South Otago trial established on sloping land with poor surface infiltration. Applications of FDE made at this site under moisture conditions close to field capacity resulted in 78% of the volume of FDE applied using a rotating travelling irrigator being generated as overland flow, compared to 44% when using low rate (K-Line) irrigation. The relative concentrations of ammonium N, Total N and P in overland flow generated following the application of FDE using a travelling irrigator were all greater than 90% of the concentration applied as raw FDE. In contrast, the relative concentrations of these contaminants in overland flow generated following the application of FDE using a low rate system were considerably lower (between 20 to 45%). The low application rate and associated decrease in surface ponding of FDE allowed a greater volume of applied FDE to move into the soil body, thus allowing for greater attenuation of effluent contaminants.

5.2 Soils that exhibit preferential flow

There are a number of published New Zealand studies outlining the considerable risk of direct drainage of FDE contaminants on soils that exhibit preferential flow characteristics. Some of these studies have identified mole and pipe drainage systems as the cause of direct losses of FDE contaminants in drainage waters (Houlbrooke et al. 2008a, Houlbrooke et al. 2006, Houlbrooke et al. 2004a, Monaghan and Smith 2004, McLeod et al. 2003). Other studies have identified coarse soil structure (large structural cracks) or soils with a drainage impediment (containing wetting and drying cracks) as contributing to direct losses of FDE contaminants via preferential flow (McLeod et al. 2008, McLeod et al. 2004, Aislabie et al. 2001, McLeod et al. 1998).

Preferential flow has often been identified as the early presence (<0.1 of a pore volume) of a change in solute concentration during a breakthrough curve (McLeod et al. 2008) or as the uneven and elongated depth distribution of an applied tracer (Monaghan et al. 1999, McLeod et al. 1998). McLeod et al. (2008) has provided a summary of previous research conducted by Landcare Research investigating the potential for preferential flow across a wide range of New Zealand soil types and characteristics. The following soil characteristics or soil orders/subgroups in the New Zealand Soil Classification (Hewitt, 1998) were identified as having a ***high preferential flow risk***:

- Organic soils,
- Ultic soils
- Granular soils
- Melanic soils
- Podzol soils

- Gley and perch-gley soils
- mottled subsoils
- peaty soils
- skeletal and pedal soils
- soils with a slowly permeable layer
- soils with coarse soil structure
- soils with a high K_{SAT}:K_{-40} ratio.

The following soil characteristics or soil orders in the New Zealand Soil Classification were identified as having a ***medium preferential flow risk*** (McLeod et al. 2008):

- Brown soils
- Pallic soils
- Oxidic soils

The categorisation of the Brown soil order as medium risk for preferential flow may seem intriguing, considering its often well drained. However, its inclusion results from research conducted on a Typic Brown Southland soil (Waikiwi silt loam) by McLeod et al. (2003) where a peak in its breakthrough curve was reported at only 0.15 of a pore volume. The soil at the site of lysimeter collection was described as well drained but yet the remnant of a mole and pipe drainage system was reported. However the Waikiwi silt loam is a Firm Brown soil and hence has a coarse nearly massive underlying horizon that impedes drainage and hence fulfils one requirement for risk of preferential flow. Furthermore, the presence of a reported well developed structure of blocky peds (albeit only fine to medium in size) which may have contributed some preferential flow paths. The results presented by McLeod et al. (2003) also contrast with those of Monaghan et al. (1999) who reported that 95% of simulated urine applications to the Waikiwi silt loam were contained within the top 300 mm of the soil. We recommend that for the Brown soil class that each soil may have to be considered on a case by case basis to determine if it contains features that are likely to result in a risk of preferential flow drainage characteristics.

Wells (1973) discussed the suitability of different soil properties (using the old New Zealand genetic soil classification system) to receive effluents. In 1973 there was very little land treatment of FDE and much of the discussion was likely related to a range of effluent types including agricultural and industrial sources. The publication reported that soils with very poor, poor and imperfect drainage classes were considered unsuitable for the application of effluents, as were soils with coarse soil structures (prisms, column or blocks) or very fine textures (clay). Reported unsuitability based on drainage class, soil texture and aggregate structure was related to perceived permeability and the likelihood of regularly high soil moisture contents. We believe that with the adherence to some best management practices such as deferred irrigation and low rate tools, these limitations on such critical soil types can largely be overcome.

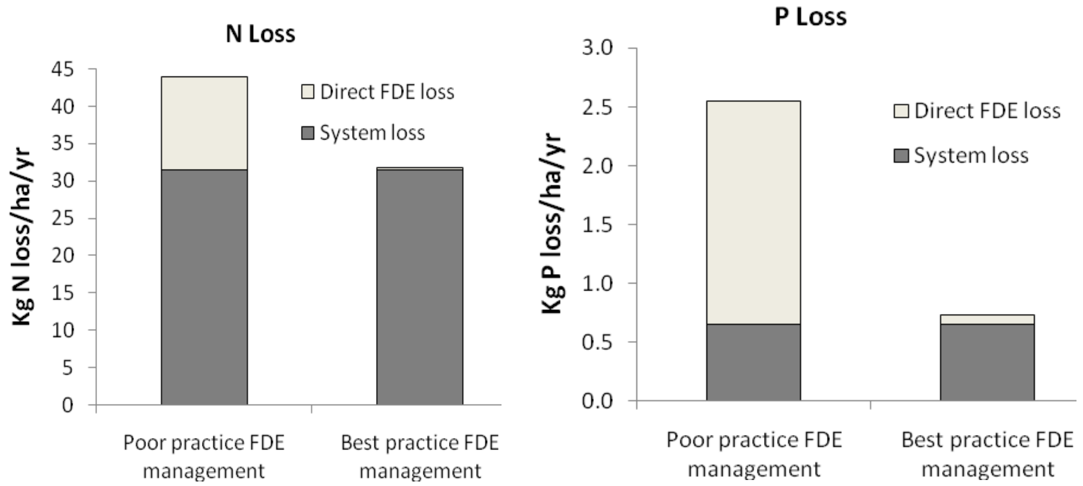

Figure 7. Direct drainage losses of FDE under deferred irrigation and compared for a one off poor FDE application. Direct losses of FDE are presented on top dairy land use loss of N and P (not derived directly from FDE application (Houlbrooke et al. 2008a, Houlbrooke et al. 2004).

A comparison of direct FDE N and P losses in mole and pipe drainage and overland flow from best practice (deferred irrigation) is compared with losses from a one-off poorly timed Houlbrooke et al. (2004a & 2008a) on a Manawatu Pallic soil. Losses reported in Figure 7 from poor practice represent direct contaminant loss from one 25 mm application of FDE when the soil moisture content was close to field capacity. These losses of N and P were approx 30 times greater than direct losses reported under deferred irrigation practice for a one year period (80 mm over four irrigation events). The losses of N and P were the equivalent of 40% and 290% of reported whole farm losses the adjacent area that did not receive FDE inputs respectively.

Low rate effluent irrigation technology in the form of ’K-Line’ has been evaluated as a tool for applying FDE to land and its environmental performance compared with that of a traditional rotating travelling irrigator (Houlbrooke et al. 2006). Drainage monitoring of a mole and pipe drained Pallic soil in West Otago showed that concentrations of contaminants in artificial drainage were much reduced when comparing the low rate applicator with a rotating travelling irrigator. Specifically, much of the P, ammonium-N and *E. coli* bacteria contained in the FDE was filtered by the soil when FDE was using low rate technology. Concentrations of total P, ammonium N and *E. coli* measured in drainage induced by the application of the FDE using K-line at 4 mm/hr were, on average, only 5, 2 and 25% of that found in the applied FDE, respectively (Figure 8). This was in contrast to that observed when FDE was applied using a travelling irrigator (mean application depth of 9 mm), where concentrations of total P, ammonium N and *E. coli* measured in drainage induced by the application of the FDE were 33, 30 and 85% of that found in the applied effluent (Monaghan & Smith, 2004). The greater attenuation under low rate irrigation is attributed to the greater filtration of nutrients in the FDE, compared to that achieved under the high instantaneous rate of application observed under a rotating travelling irrigator

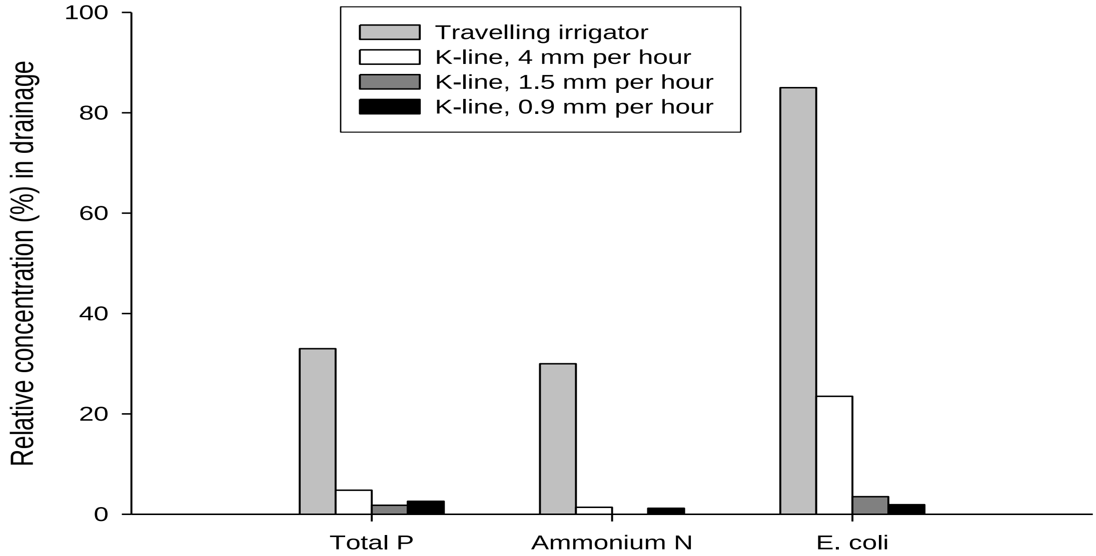

Figure 8. Relative concentrations of total P, ammonium N and *E. coli* in drainage waters collected following the irrigation of FDE to a mole-pipe drained soil using a travelling irrigator or K-line irrigation system (Houlbrooke et al. 2006).

An investigation of the effect of irrigation application rate on the incidence of preferential flow in a well drained Allophanic soil and poorly drained Gley soil was conducted by McLeod et al. (1998). Water irrigations of 25 mm depth containing a tracer dye were applied using a range of application rates from 5-20 mm/hr. Some preferential flow was observed for both soil types when application rates were >10 mm/hr, although the magnitude of preferential flow was greater in the poorly drained Gley soil than the well drained Allophanic soil which was limited to some conduits caused by earth worm burrowing. For both soil types, application rates ≤10 mm/hr resulted in all of the applied 25 mm depth remaining in the top 200 mm of soil. Pulsing applications (on-off) at the higher application rate of 40 mm/hr also created preferential flow and was not as effective as sustained low rate application at keeping FDE in the topsoil. The potential for preferential flow in the topsoil of well drained soils caused by earthworm activity is worth noting, however, its activity is usually restricted to the A horizon and the mixed A and B horizons. Therefore, preferential flow pathways will not be continuous out of the dominant root zone (c. 300 cm).

5.3 Soils that exhibit matrix flow

There has been no research undertaken in New Zealand to determine the direct loss of contaminants associated with FDE application to wet but well drained land. However, there have been numerous studies that have investigated either transport pathways of land-applied FDE in well drained soil, or the fate of multiple N inputs (including FDE). In a review of the potential for preferential flow across a wide range of New Zealand soil types and characteristics, McLeod et al. (2008) reported that the following soil orders in the New Zealand Soil Classification were identified as having a ***low preferential flow risk***:

- Recent soils,
- Pumice soils
- Allophanic soils
- Semi-arid soils

The categorization of the above soil orders as having low preferential flow risk was derived from research conducted assessing breakthrough curves on a range of well drained soils (Barton et al. 2005, McLeod et al. 2004, Aislabie et al. 2001, McLeod et al. 2001, Magesan et al. 1999). In these studies effluent (dairy or municipal) was applied to the soil surface (typically 25 mm depth at 50 mm/hr) followed by the application of a further pore volume of irrigation water at a rate of 5 mm/hr to simulate rainfall conditions. All of these assessments for well-drained soil resulted in breakthrough curves with minimal or no preferential flow, indicative of a very high degree of soil matrix flow. These experiments leached only very small amounts of microbial tracer or none at all (McLeod et al. 2008). The common soil characteristics were a weakly developed spherical soil structure comprised of fine peds and a high uniform porosity. The fine nature of these soil peds and discontinuous nature of macropores provided large opportunity to block and filter out faecal microbes added in FDE (McLeod et al. 2008).

While well drained, porous soils that exhibit matrix flow appear to have a low direct contaminant risk from applied FDE, they are typically leaky in nature with regards to the leaching loss of nitrogen (in particular nitrate-N). Well drained soils often deliver greater amounts of drainage water than poorly drained soils, providing more opportunity to leach mobile nitrate-N in soil solution. Furthermore, poorly drained soils suffer higher denitrification (gaseous) loss than well drained soil and so the concentration of nitrate-N in drainage water is often lower than for well drained soils (McLaren and Cameron 1996, Scholefield et al. 1993).

With little or no likely direct drainage contribution, the extent and impact from N inputs added as FDE to free draining soils that leach to ground water indirectly should be kept in context. Much of the total annual N loss associated with land receiving FDE will be a result of N cycling inefficiency within the soil-plant system and would be considered an indirect loss (Ledgard et al. 1999). As FDE makes up approximately 10% of the daily nutrient load from cattle excreta, nutrient loading from animal excreta deposited in the field is usually the main contributor to N leaching losses (Monaghan et al. 2007). Well drained soils with high total inputs of N are often characterised by high nitrate-N losses (Ledgard et al. 1999). However, FDE contributes a only component of the total N inputs that are mineralised into nitrate-N and subsequently leached from the root-zone (Houlbrooke et al 2008a). Therefore, effective mitigation techniques for controlling N losses on these free draining soils should target the cumulative effect of autumn-applied urine patches during animal grazing (Monaghan et al. 2007). Furthermore, the nutrient loads into groundwater will differ from that which left the root zone and will reflect the potential time for further attenuation (depth to water table) and any denitrification that may take place throughout the vadose zone.

The report on suitable soil properties to receive land applications of effluent by Wells (1973) suggested that well drained soils with a silt loam texture were the most suitable for disposal of effluents. However, Wells also stated that soils classified as ‘somewhat excessively drained’ were only suitable to receive effluent with a low nutrient concentration and that soils classified as ‘excessively drained’ were unsuitable to receive effluents. The excessively drained class related to soils mapped as lithosols (shallow soils with no or poor horizon definition on steep slopes). Such soils will not currently be receiving applications of FDE in New Zealand. There is no longer a ‘somewhat excessively drained’ drainage class as these have been incorporated into the ‘well drained’ category (Lynn et al. 2009). These soils would likely have been well-drained flat land with a shallow soil profile and very low clay content. We believe that the recommendation for only low nutrient concentration effluents relates more to the inherent N ‘leakiness’ of these soils under high inputs of N, rather than a perceived risk of direct losses given the likely matrix flow. In this manner, Barton et al. (2005) reported considerable N drainage losses (173 kg/ha over 2 years) from a well drained Recent soil which received 772 kg N/ha over a two year period from municipal effluent. This drainage loss was predominantly organic N (87%); this was not, however, derived from N contained in the applied effluent but, rather from increased leaching of the native soil organic N as a result of the high N loading rate. Such high loading rates of effluent N are not reflective of dairy farm operations which are usually capped at N loading rates of either 150 or 200 kg N/ha/yr (Houlbrooke et al. 2004b). However considering these soils have a low water holding capacity and the potential for water repellency when very dry, it is recommended that application depths should be kept as low as possible on these soils (< 10 mm per application).

A large amount of research has been conducted at Lincoln University investigating the effect of a range of different N inputs (including urine patches, fertiliser and FDE) on subsequent nitrogen (in particular nitrate-N) leaching losses. These studies were undertaken using lysimeters with well-or moderately well-drained Canterbury soils. Breakthrough curves presented for these studies clearly suggest a matrix flow drainage mechanism, with no evidence of preferential flow resulting from the different N sources applied (Di and Cameron 2007, Di and Cameron 2004, Di and Cameron 2002, Silva et al. 1999, Di et al 1998, Fraser et al. 1994). The overwhelming theme of this line of research was that urine patches deposited directly on the paddock surface were responsible for the majority of subsequent N leached from the deep lysimeters (Di and Cameron 2002, Silva et al. 1999). Furthermore Di et al. 1998 measured greater losses associated with ammonium- N fertiliser applications than for FDE containing approximately 66-75% organic-N. The Lismore stony silt loam (Orthic Brown soil) is very similar in nature to the well drained Gore stony silt loam. High N leaching losses under the border dyke irrigated Lismore soil (between 112 to 162 kg N/ha/yr depending on amount and form of N) were attributed to its low water holding capacity and shallow profile (20-30 cm) underlain by coarse gravels (Di and Cameron 2002). Recommended mitigation for this high N loss was to target the effect of urine patch inputs by the use of a nitrification inhibitor to decrease the conversion of ammonium-N to nitrate-N, thus decreasing farm N drainage losses (Di et al. 2007 & 2004).

Because well-drained soils have typically high infiltration rates without drainage impediments, combined with predominantly matrix flow, direct losses of FDE are unlikely, even during periods of low soil water deficit. Direct drainage losses are therefore only likely at close to soil saturation (-1 KPa) when all soils exhibit a greater degree of preferential flow through large water conducting pores > 300 µm (Jarvis et al. 2007; Silva et al. 2000) or if application depth exceeds the soil's water holding capacity. In reality, well-drained soils that do not have drainage or infiltration limitations will struggle to reach a true state of saturation. However, the combination of prolonged heavy rainfall and application of FDE (particularly large depths) may be enough to induce temporary saturation conditions. It is, therefore, recommended that a small amount of storage (approx. 3-6 days) combined with a strategy of low application depth (irrigator set at fastest travel speed) would be sufficient to avoid any direct losses of FDE during conditions of low soil water deficit (close to field capacity). In order to prevent macropore flow through large pores (> 300 µm) typically at low suctions (-1 KPa or less) then it is recommended that soils should be withheld from FDE application for a drainage period of at least 24 hours post the attainment of soil saturation.

Some operators may still wish to include a greater FDE storage in order to remove all risk associated with applying FDE to wet soil and in order to rationalise staffing during the traditionally busy and wet calving period and such a practice should still be considered best practice. In summary, when drainage and runoff pathways to surface water bodies are limited, then the current practice using a high application rate travelling irrigator with minimal storage is likely to be suitable with regards to minimising potential environmental effects.

Considering Environment Southland's concern regarding the application of FDE to shallow well-drained soil when wet (close to or at field capacity), it is important to discuss the potential implications of wetting front instability. Figure 9 demonstrates the variable rate but uniform nature of drainage when water is applied to dry soil with either a uniform coarse or fine texture or soils with a distinct texture contrast of coarse over fine material. However, where fine textured soil overlies coarse textured material there is a likelihood of preferential finger flow developing once drainage water enters the coarse textured layer if the coarse layer was previously dry (Brady and Weil 2007, Hillel 1998). The mechanism for such wetting front instability is associated with a low matrix potential in the fine textured overlaying layer until large pore spaces fill up and the soil becomes saturated (Hillel 1998, McLaren and Cameron 1996). Essentially, this mechanism provides a check valve for drainage waters and ensures matrix flow of draining solutes (McLaren and Cameron 1996). Therefore, it will be important to run travelling irrigators at their fastest speed (lowest depth) on such shallow soils overlaying a coarse-textured layer, such as, gravels in order to ensure that the applied depth is less than the water holding capacity of the fine textured horizon(s) and, therefore prevent the preferential flow of FDE through the coarse gravel layer.

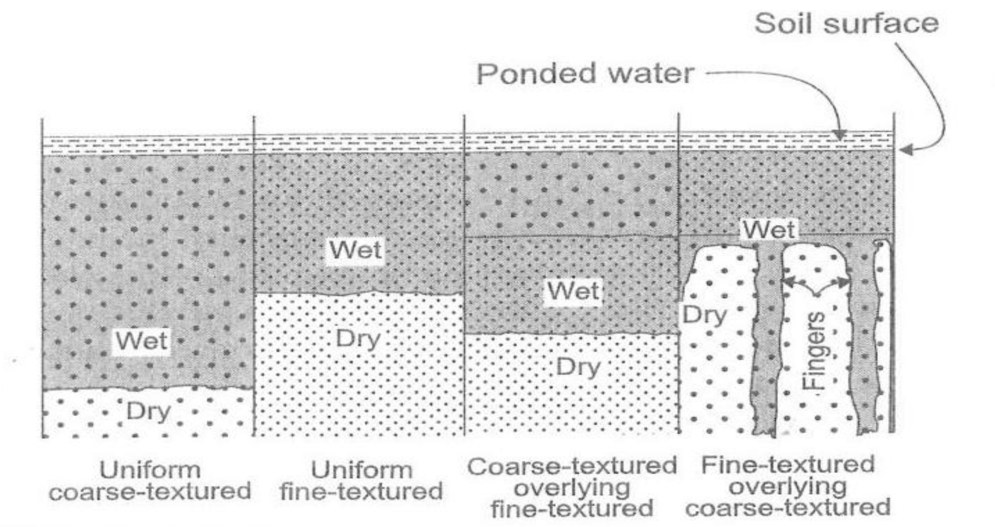

Figure 9. The influence of soil texture on expected wetting fronts during drainage (Hillel 1998).

5.4 Modelling assessment of the influence of soil type on P loss from land applied farm dairy effluent

An assessment of the environmental performance of a range of FDE management practices has been made using the Overseer nutrient budgets® model for two different soil types. Overseer® captures the effect of effluent management practices on P loss as drainage and/or surface runoff. Losses of N are not able to be assessed in a similar manner as the Overseer model does not currently determine direct (non nitrate) N losses in drainage/runoff. The assessments were established with the following conditions:

- Fixed rate of N and P inputs as either FDE or fertiliser (145 kg N/ha and 48 kg P/ha)
- Olsen P of 42 on FDE block and rest of milking platform
- Poorly drained soil = Pukemutu silt loam (Fragic Pallic soil, NZSC)
- Well drained soil = Gore stony silt loam (Orthic Brown soil , NZSC)
- Milking platform = 150 ha, FDE block = 40 ha
- Stocking rate = 2.8 cows/ha.
- Milk solids = 1220 kg/ha/yr

The poorly-drained Pukemutu silt loam is a mole and pipe drained soil found extensively in the Southland region. It is typical of undulating loess-covered terrace soils. The Gore stony silt loam is a shallow well-drained soil overlying sandy gravelly sub-soils. The Gore soil is situated in low alluvial river terraces in Southland and is typical of many Southland well-drained alluvial river terrace soils. Five different effluent management scenarios have been evaluated over the two different soil types in order to test the influence and inherent risk of soil and landscape features on the effectiveness of FDE best management practices:

- Sump slow = Daily application using a travelling irrigator set with high depth per application (> 24 mm).
- Sump fast = Daily application using a travelling irrigator set with lowest depth per application (< 12 mm).
- Sump low rate = Daily application using a low application rate irrigator
- Deff irr fast = Pond storage and deferred irrigation using a travelling irrigator set with lowest depth per application (< 12 mm).
- Deff irr low rate = Pond storage and deferred irrigation using a low application rate irrigator.

Effluent management practice had a considerable influence on whole farm P losses (Figure 10a). The practice of daily application using a travelling irrigator at slow speed on a mole and pipe drained soil contributed approx. 60% of whole farm P losses or 5 kg P/ha/yr from the FDE block (Figure 9b). Increasing the speed of the irrigator (decreasing depth applied) decreased this loss to 40% of whole farm losses or 2 kg P/ha/yr from the FDE block. Implementing a deferred irrigation strategy was predicted to decrease the direct loss of P to 3% of whole farm losses at a rate of only 0.1 kg P/ha/yr from the FDE block. The combination of deferred irrigation with low application rate irrigators predicts a zero direct loss of P from FDE on a soil that has a high inherent risk of preferential flow and direct losses. In summary, incremental improvements in the management practice resulted in decreased whole farm P losses on the Pukemutu silt loam.

It is important to note that the following results are therefore simulations based on the assumptions on the mechanisms for water balance and P loss imbedded in the Overseer model. Estimated losses for daily application of FDE using a travelling irrigator at slow and fast speed on a well-drained Gore soil was predicted to make up 30% and 20% respectively of whole farm P losses (Figure 10a). However, as whole farm P losses are very small in magnitude on well drained soils (0.1 kg P/ha/yr compared with 0.6 kg P/ha/yr from the poorly drained Pukemutu silt loam), these losses corresponded to a direct FDE P loss of only 0.2 and 0.1 kg P/ha/yr from the FDE block. The inclusion of either deferred irrigation and/or low rate tools was predicted to eliminate all direct P loss from FDE.

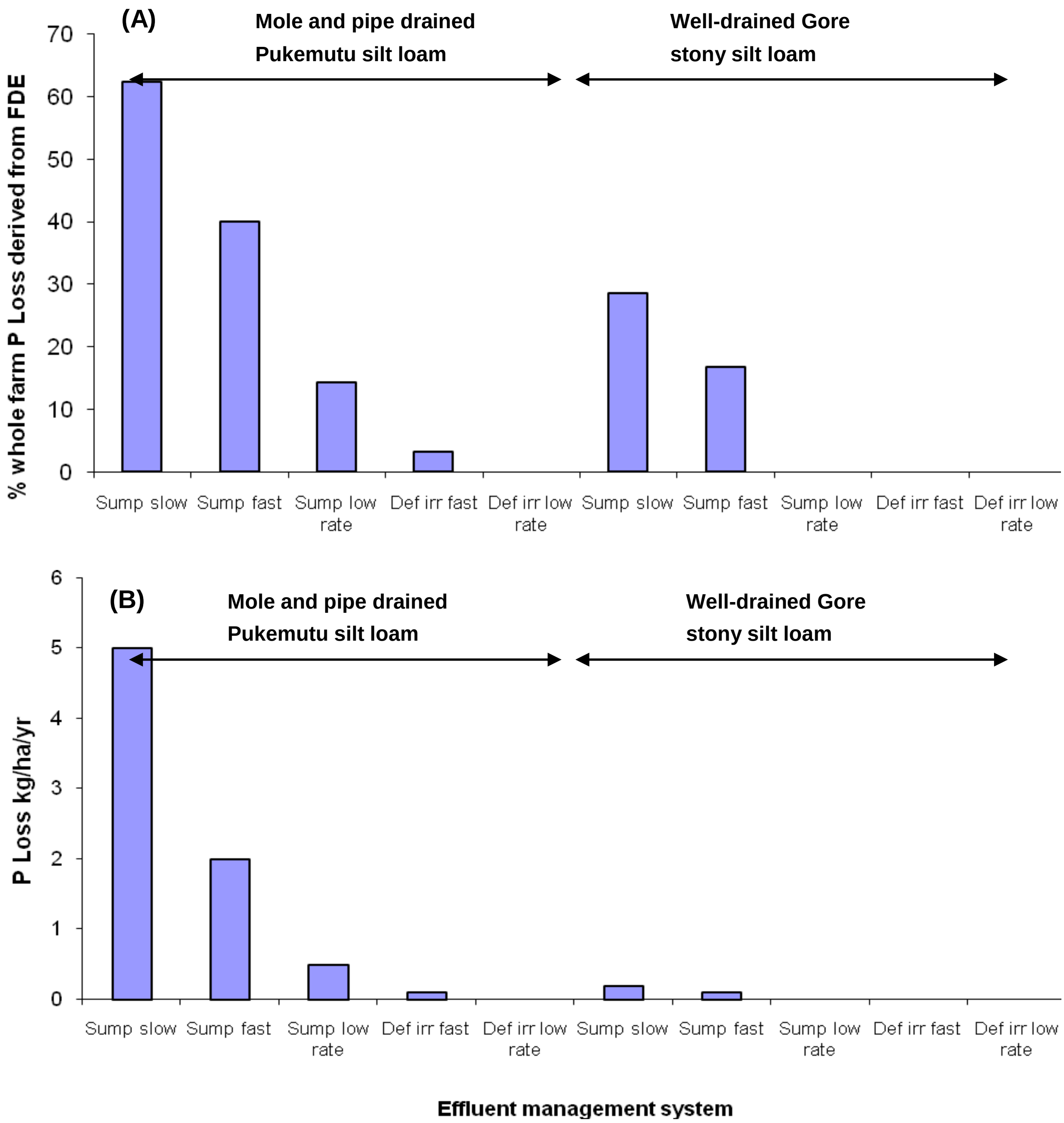

Figure 10. The influence of different effluent management practices on estimated whole farm P losses (A) % derived whole farm loss from direct loss of FDE (B) loads from direct loss of FDE in the effluent application area in units of kg P/ha/yr

6. Recommendations to Environment Southland

6.1 Minimum criteria for effluent management systems

Considering the risk/effects-based assessment of different soil and landscape features, minimum management criteria can be defined to avoid direct losses of land-applied FDE (Table 1). It should be noted that these criteria may differ from those recommended under BMP and are considered the minimum conditions that should be adhered to. An example of the difference between minimum criteria and BMP would be the recommendation for use of low application rate tools on soils with artificial drainage/coarse soil structure or soils with impeded drainage/low infiltration rate. The adoption of this BMP would decrease the management risk associated with these soil and landscape features. However, it is possible for these risks to be adequately managed given a judicious approach to the stated minimum criteria (e.g. through the use of adequate storage with appropriate application depths).

Table 1. Minimum criteria for a land applied effluent management system to achieve.

Soil and landscape feature	Artificial drainage or coarse soil structure	Impeded drainage or low infiltration rate	Sloping land (>7°)	Well drained flat land (<7°)	Other well drained but very stony[x] flat land (<7°)
Application depth (mm)	< SWD*	< SWD	< SWD	< 50% of WHC[#]	≤ 10 mm
Application rate (mm/hr)	N/A**	N/A**	< soil infiltration rate	N/A	N/A
Storage requirement	Apply only when SWD exists	Apply only when SWD exists	Apply only when SWD exists	24 hours drainage post saturation	24 hours drainage post saturation
Maximum N load	150 kg N/ha/yr	150 kg N/ha/yr	150 kg N/ha/yr	150 kg N/ha/yr	150 kg N/ha/yr

* SWD = soil water deficit,

[#] WHC = water holding capacity in the top 300 mm of soil,

[x] Very stony= soils with > 35% stone content in the top 200 mm of soil

** N/A = Not an essential criteria, however level of risk and management is lowered if using low application rates

6.2 Implementation of policy taking into account soil and landscape features

It is recommended that soil and landscape features are taken into account when determining appropriate FDE management practice. The original best management practice decision tree presented in Figure 1 has been modified and presented below as Table 2, in order to better represent the minimum appropriate management criteria for farm dairy effluent land application whilst still taking into account soil and landscape features below. This decision tool varies in four places from the original charts:

i) The inclusion of a clause for coarse soil structure has been added to the artificial drainage category to reflect the high degree of preferential flow of applied FDE in soils with coarse structure, as reported by McLeod (2008). In essence, the installation of artificial drainage modifies the drainage properties of a soil to behave similarly to those with a well developed coarse soil structure. By definition, coarse soil structure is well developed with large pore spaces, strong pedality (peds >10 mm) and often contains clay, silt and translocated organic matter coatings (McLeod et al. 08). Coarse soil structure favours pore size exclusion when transporting microbes. For the purpose of this report any soils with 80% or more peds captured on a 10 mm sieve within the topsoil (A Horizon) is considered to have coarse soil structure

ii) The recommended threshold for sloping land has been increased from 5° to 7°. This was changed in order to be consistent with the Land Use Capability Survey Handbook (Lynn et al. 2009).However, this does not imply that LUC mapping should be used to determine slope criteria as slopes will vary considerably within existing mapped LUC classes.

iii) The earlier best practice storage requirements listed for well-drained land have been changed to reflect minimum appropriate management criteria considering the low potential environmental risk of this category. The caveat for the low or minimal storage recommendation is that travelling irrigators should be run at their fastest speed when soil moisture is close to, at, or beyond field capacity.

iv) The inclusion of a fifth soil/landscape class has been added to clearly identify that very stony, well drained land should receive FDE applications of no more than 10mm depth no matter what the antecedent soil water content is. This restriction at very dry soil water contents will also help mitigate any potential adverse effects of water repellency.

In addition to the criteria stated in table 1, and the implementation guidance provided in table 2, we recommend that a minimum withholding period of 4 days between grazing and application should be adhered to when using a high application rate irrigation system (>10 mm/hr). Such a withholding period will allow for some initial recovery from soil treading damage (such as surface sealing) and increase surface infiltration rates that may have been depressed during animal grazing. It is recommended that paddocks that have been considerably pugged and damaged during wet grazing events should be spelled from FDE irrigation for a period of approximately 6 months in order to allow substantial recovery of soil physical condition. Furthermore, it is recommended that the maximum application depth to be applied at any one time should in accordance with industry best practice described for soils of different texture in the DEC Manual (2006). Single applications of greater than 30 mm depth are not recommended, even if large soil water deficits exist and total N loading would remain below 150 kg N/ha, as research has shown an increased risk of small volume but high concentration direct losses often associated with soil cracking preferential flow paths (Houlbrooke et al. 2004a).

Table 2. Revised decision tool for matching FDE management practice (suggested minimum criteria) with soil and landscape features in the Southland region.

Soil and landscape feature	Artificial drainage or coarse soil structure		Impeded drainage or low infiltration rate		Sloping land (>7°)			Well drained flat land (<7°)		Other well drained but very stony[X] flat land (<7°)	
Infiltration rate (mm/hr)	N/A		N/A		<100	> 100		N/A		N/A	
Irrigator hardware	LR[XX]	HR[#]	LR	HR	LR	LR	HR	LR	HR	LR	HR
Minimum SWD* (mm)	8	15	8	15	8	8	15	0	0	0	0
Storage guide (weeks)	8	12	8	12	8	8	12	3 days	6 days	3 days	6 days

[#] HR = High rate irrigator, [XX]LR = low rate irrigator, * SWD = soil water deficit, [X]Very stony= soils with > 35% stone content in the top 200 mm of soil. Low rate irrigation ≤ 10 mm/hr instantaneous application rate

6.3 Further research

The review of literature conducted for this report has identified some potential research gaps with regards to FDE management in New Zealand and its impact on the receiving environment. In particular, there is a shortage of targeted field scale research studies that investigate potential direct contaminant losses (P, ammonium-N, organic-N and faecal micro-organisms) of surface and ground waters following land application of FDE to well-drained soils at moisture contents close to or at field capacity. Furthermore, there is a need to determine the potential effectiveness of existing BMPs to mitigate possible losses such as the use of low rate tools. This research is needed to more robustly evaluate the framework presented in table 1. Some further questions remain concerning wetting front instability associated with fine textured soils overlaying coarse textured layers and the potential impact of water repellency, particularly on dry well-drained soils with a high sand content.

7. Conclusions

- Three primary mechanisms exist for the transport of water (containing solutes and suspended solids) through soil: matrix flow, preferential flow and overland flow.
- The potential risk of direct contamination from land-applied FDE varies with water transport mechanisms and therefore varies between soil and landscape features.

- Soils that exhibit preferential or overland flow can lose considerable amounts of FDE under unfavorable soil moisture conditions. Critical landscapes include soils with artificial drainage or coarse soil structure, soils with either an infiltration or drainage impediment, or soils on rolling/sloping country.
- Soils that exhibit matrix flow show a very low risk of FDE losses under unfavorable soil moisture conditions. Such soils are typically well drained with fine soil structure and high porosity.
- The environmental effectiveness of current best management practices (deferred irrigation and low application rate tools) will vary between soil types depending on their inherent risk of direct contamination from land applied FDE
- Research conducted in New Zealand suggests that there is a low risk of direct water contamination from FDE applied to well-drained soils. However, well-drained soils tend to have an inherently higher N leaching risk associated with the deposition of animal urine patches to land, particularly those deposited shortly prior to winter rainfall.
- There is a research gap regarding targeted field studies to assess the risk of FDE application to shallow well-drained soils when soil moisture contents are at or beyond field capacity.

8. Acknowledgements

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APPENDIX 7

FULL TEXT OBJECTIVES & POLICIES

NATIONAL POLICY STATEMENT FOR FRESHWATER MANAGEMENT (2014)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
	O A1	To safeguard: a) the life-supporting capacity, ecosystem processes and indigenous species including their associated ecosystems, of fresh water; and b) the health of people and communities, at least as affected by secondary contact with fresh water; in sustainably managing the use and development of land, and of discharges of contaminants.
	O A2	The overall quality of fresh water within a region is maintained or improved while: a) protecting the significant values of outstanding freshwater bodies; b) protecting the significant values of wetlands; and c) improving the quality of fresh water in water bodies that have been degraded by human activities to the point of being over-allocated.
	O B1	To safeguard the life-supporting capacity, ecosystem processes and indigenous species including their associated ecosystems of fresh water, in sustainably managing the taking, using, damming, or diverting of fresh water.
	O B3	To improve and maximise the efficient allocation and efficient use of water
	O B4	To protect significant values of wetlands and of outstanding freshwater bodies.

NATIONAL POLICY STATEMENT FOR FRESHWATER MANAGEMENT (2014)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
	O C1	To improve integrated management of fresh water and the use and development of land in whole catchments, including the interactions between fresh water, land, associated ecosystems and the coastal environment.
	O D1	To provide for the involvement of iwi and hapū, and to ensure that tāngata whenua values and interests are identified and reflected in the management of fresh water including associated ecosystems, and decision-making regarding freshwater planning, including on how all other objectives of this national policy statement are given effect to.
	P A3	By regional councils: a) imposing conditions on discharge permits to ensure the limits and targets specified pursuant to Policy A1 and Policy A2 can be met; and b) where permissible, making rules requiring the adoption of the best practicable option to prevent or minimise any actual or likely adverse effect on the environment of any discharge of a contaminant into fresh water, or onto or into land in circumstances that may result in that contaminant (or, as a result of any natural process from the discharge of that contaminant, any other contaminant) entering fresh water.
	P A4	By every regional council amending regional plans (without using the process in Schedule 1) to the extent needed to ensure the plans include the following policy to apply until any

NATIONAL POLICY STATEMENT FOR FRESHWATER MANAGEMENT (2014)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		changes under Schedule 1 to give effect to Policy A1 and Policy A2 (freshwater quality limits and targets) have become operative: 1. When considering any application for a discharge the consent authority must have regard to the following matters: a. the extent to which the discharge would avoid contamination that will have an adverse effect on the life-supporting capacity of fresh water including on any ecosystem associated with fresh water and b. the extent to which it is feasible and dependable that any more than minor adverse effect on fresh water, and on any ecosystem associated with fresh water, resulting from the discharge would be avoided. 2. When considering any application for a discharge the consent authority must have regard to the following matters: a. the extent to which the discharge would avoid contamination that will have an adverse effect on the health of people and communities as affected by their secondary contact with fresh water; and

NATIONAL POLICY STATEMENT FOR FRESHWATER MANAGEMENT (2014)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		b. the extent to which it is feasible and dependable that any more than minor adverse effect on the health of people and communities as affected by their secondary contact with fresh water resulting from the discharge would be avoided. 3. This policy applies to the following discharges (including a diffuse discharge by any person or animal): a. a new discharge or b. a change or increase in any discharge – of any contaminant into fresh water, or onto or into land in circumstances that may result in that contaminant (or, as a result of any natural process from the discharge of that contaminant, any other contaminant) entering fresh water. 4. Paragraph 1 of this policy does not apply to any application for consent first lodged before the National Policy Statement for Freshwater Management 2011 took effect on 1 July 2011. 5. Paragraph 2 of this policy does not apply to any application for consent first lodged before the National Policy Statement for Freshwater Management 2014 takes effect.

NATIONAL POLICY STATEMENT FOR FRESHWATER MANAGEMENT (2014)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
	P B5	By every regional council ensuring that no decision will likely result in future over-allocation – including managing fresh water so that the aggregate of all amounts of fresh water in a freshwater management unit that are authorised to be taken, used, dammed or diverted does not overallocate the water in the freshwater management unit.
	P B6	By every regional council setting a defined timeframe and methods in regional plans by which over-allocation must be phased out, including by reviewing water permits and consents to help ensure the total amount of water allocated in the freshwater management unit is reduced to the level set to give effect to Policy B1.
	P B7	By every regional council amending regional plans (without using the process in Schedule 1) to the extent needed to ensure the plans include the following policy to apply until any changes under Schedule 1 to give effect to Policy B1 (allocation limits), Policy B2 (allocation), and Policy B6 (over-allocation) have become operative: 1. When considering any application, the consent authority must have regard to the following matters: a. the extent to which the change would adversely affect safeguarding the life-supporting capacity of fresh water and of any associated ecosystem and

NATIONAL POLICY STATEMENT FOR FRESHWATER MANAGEMENT (2014)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		b. the extent to which it is feasible and dependable that any adverse effect on the lifesupporting capacity of fresh water and of any associated ecosystem resulting from the change would be avoided. 2. This policy applies to: a. any new activity and b. any change in the character, intensity or scale of any established activity – that involves any taking, using, damming or diverting of fresh water or draining of any wetland which is likely to result in any more than minor adverse change in the natural variability of flows or level of any fresh water, compared to that which immediately preceded the commencement of the new activity or the change in the established activity (or in the case of a change in an intermittent or seasonal activity, compared to that on the last occasion on which the activity was carried out). 3. This policy does not apply to any application for consent first lodged before the National Policy Statement for Freshwater Management 2011 took effect on 1 July 2011.

NATIONAL POLICY STATEMENT FOR FRESHWATER MANAGEMENT (2014)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
	P C1	By every regional council managing fresh water and land use and development in catchments in an integrated and sustainable way, so as to avoid, remedy or mitigate adverse effects, including cumulative effects.
	P D1	Local authorities shall take reasonable steps to: a) involve iwi and hapū in the management of fresh water and freshwater ecosystems in the region; b) work with iwi and hapū to identify tāngata whenua values and interests in fresh water and freshwater ecosystems in the region; and c) reflect tāngata whenua values and interests in the management of, and decision-making regarding, fresh water and freshwater ecosystems in the region.

REGIONAL POLICY STATEMENT (1997)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
Takata Whenua	O 1.1	To protect wahi tapu from the adverse effects of resource use activities.
	O 1.2	To recognise the importance of wahi tapu, wahi taoka, mahika kai and the customary use of water to Kai Tahu.

REGIONAL POLICY STATEMENT (1997)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
	O 1.3	To incorporate Maori cultural and traditional spiritual values where appropriate into resource management decision making processes.
	O 1.4	To have particular regard to the concept of kaitiakitanga in relation to managing the use, development and protection of natural and physical resources.
	P 1.2	Recognise "Te Whakatau Kaupapa O Murihiku" as a Kai Tahu resource management reference planning document for the Region.
Water Quantity	O 4.1	To sustain the quantity of the Region's water resources so as to – a. meet the needs of a range of uses, including the reasonably foreseeable needs of future generations b. safeguard the life-supporting capacity of water and related ecosystems.
	O 4.2	To manage the use and development of water and land resources so as, wherever practicable, to maintain and enhance flow regimes.
	O 4.3	To ensure the taking, use, damming and diversion of water does not compromise environmental standards established for the Region.
	O 4.4	To achieve the efficient use of water extracted from water bodies.
	O 4.5	To recognise the relationship of Maori with water.

REGIONAL POLICY STATEMENT (1997)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
	P 4.3	Manage abstraction of water and the transferability of permits on the basis of the effects of that abstraction, or transfer, taking into account the standards set for the water body and the use to which the water is to be put.
	P 4.4	Encourage the conservation of water and its efficient allocation and use.
	P 4.5	In preparing, implementing and administering Regional and District Plans and in considering resource consents, local authorities shall assess the effects of land use and development on the quantity and sustainability of water in water bodies and provide for any adverse effects to be avoided wherever practicable, or remedied or mitigated.
	P 4.6	Manage the Region's water resources in ways that recognise and provide for the values that Maori place on water.
Water Quality	O 5.1	To sustain the quality of the Region's water resources so as to: a. meet the needs of a range of uses, including the reasonably foreseeable needs of future generations b. safeguard the life-supporting capacity of water and related ecosystems.
	O 5.2	To ensure that in the use and development of water and land resources, and the discharge of contaminants, water quality is maintained and wherever practicable enhanced.
	O 5.3	To ensure the taking, use, damming, diversion of water and the discharge of contaminants into water does not compromise water quality standards established for the region.

REGIONAL POLICY STATEMENT (1997)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
	O 5.4	To recognise the relationship of Maori with water.
	P 5.5	In preparing, implementing and administering Regional and District Plans and in considering resource consents, local authorities shall assess the effects of land use and development on ground water and surface water quality, including both point and non-point source discharges, and provide for any adverse effects to be avoided, remedied or mitigated.
	P 5.8	Manage the Region's water resources in ways that recognise and provide for the values that Maori place on water.
Lakes Rivers & Wetlands	O 6.1	To protect the natural character, heritage values and outstanding natural features of lakes, rivers and wetlands in the Region.
	O 6.2	To recognise and provide for the relationship of Maori and their culture and traditions with lakes, rivers and wetlands.
	P 6.1	Protect the following wetland ecosystems from inappropriate subdivision, use and development: • Awarua Plain - Southland Estuaries including: Waituna Scientific Reserve Seaward Wetlands adjoining Awarua Bay

REGIONAL POLICY STATEMENT (1997)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		Wetlands adjoining Bluff Harbour New River Estuary Fortrose Harbour (including lower Mataura River) • Bayswater Bog • Big Bay - Waiuna • Borland Mire • Castle Downs (Hamilton Burn) • Drummond Peat Swamp (Isla Bank) • Fiordland National Park (World Heritage site) including: Back Valley Grebe Valley Lower Hollyford Sutherland Sound • Five Mile Swamp (wetland in ancient Lake Wakatipu lake outlet) • Freshwater Valley including: Freshwater Flats Ruggedy Flat • The following wetlands in the Garvie Mountains

REGIONAL POLICY STATEMENT (1997)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		Blue Lake wetland Gow Lake wetland Scott Lake wetland • Haldane Estuary and reservoir • Lake George • Lake Vincent, near Fortrose • Lake Brunton, Otara • Mount Tennyson string bog • Redcliffe Reserve • So Big Swamp • Silver Lagoon • Table Hill • Te Anau Basin wetland complex including: Kepler Mire Dome Mire - Dismal Swamp Dunton Swamp Tekaro Wetland Amoeboid Swamp

REGIONAL POLICY STATEMENT (1997)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		Kakapo Swamp Snowdon Forest Dale Lake Lake Luxmore Lagoon Creek • Toetoes Flats • Waiau River - Te Waewae Lagoon • Waikawa Estuary • Waimatuku wetland • Wairaki Lagoon (Waiau River) • Waterloo (Aparima).
	P 6.4	Consult with the takata whenua and provide for Maori cultural and traditional spiritual values in relation to the use and management of lakes, rivers and wetlands.
	P 6.6	Enhance the water quality, amenity and instream values of lakes, rivers and wetlands and promote bank stability.
	P 6.11	Manage the effects of activities that could adversely impact on the quality and quantity of water in rivers and lakes used for public and rural water supplies, and the structures used to draw such waters.

REGIONAL POLICY STATEMENT (1997)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
Soils	O 8.1	To promote the sustainable management of all soils.
	O 8.2	To avoid, wherever practicable, adverse effects arising from sedimentation and nutrient runoff from land into water bodies.
	O 8.3	To encourage land management techniques that avoid, wherever practicable, adverse effects on air quality.
	O 8.4	To avoid contamination of soils.
	O 8.5	To avoid, remedy or mitigate any adverse effects of the use or development of land on wahi tapu, wahi taoka and archaeological sites.
	P 8.1	Maintain and enhance Southland's soil resource by avoiding, remedying or mitigating the adverse effects of activities.
	P 8.2	Provide for the sustainable management of the most versatile soils of the Region.
	P 8.4	Recognise and provide for Maori cultural and traditional spiritual values and consult the takata whenua, when making statutory decisions on soil issues and preparing a Regional Sustainable Land Management Plan.
	P 8.5	Promote land use practices which avoid the contamination of soils.

PROPOSED REGIONAL POLICY STATEMENT (2012)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
Takata Whenua	O TW.2	**Provision for iwi management plans** All local authority resource management processes and decisions take into account iwi management plans.
	O TW.3	**Tangata whenua spiritual values and customary resources** Mauri and wairua are sustained or improved where degraded, and mahinga kai and customary resources are healthy, abundant and accessible to tangata whenua.
	O TW.4	**Sites of cultural significance** Wāhi tapu, wāhi taonga and sites of significance are appropriately managed and protected.
	P TW.3	**Iwi management plans** Take iwi management plans into account within local authority resource management decision making processes.
	P TW.4	**Decision making** When making resource management decisions, ensure that local authority functions and powers are exercised in a manner that: (a) recognises and provides for:

PROPOSED REGIONAL POLICY STATEMENT (2012)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		(i) traditional Māori uses and practices relating to natural resources (e.g. mātaitai, kaitiakitanga, manaakitanga, matauranga, rāhui, wāhi tapu, taonga raranga); (ii) the ahi kā (manawhenua) relationship of tangata whenua with and their role as kaitiaki of natural resources; (iii) mahinga kai and access to areas of natural resources used for customary purposes; (iv) mauri and wairua of natural resources; (v) places, sites and areas with significant spiritual or cultural historic heritage value to tangata whenua; (vi) Māori environmental health and cultural wellbeing. (b) recognises that only tangata whenua can identify their relationship and that of their culture and traditions with their ancestral lands, water, sites, wāhi tapu and other taonga.
Water Quantity	O WQUAN.1	**Sustainably managing the region's water resources** Flows, levels and allocation regimes of surface water and groundwater in the region are developed in accordance with the National Policy for Freshwater Management 2014 to: (a) safeguard the life-supporting capacity of water, catchments and related ecosystems;

PROPOSED REGIONAL POLICY STATEMENT (2012)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		(b) support the maintenance or improvement of water quality in accordance with Policy WQUAL.1; (c) meet the needs of a range of uses, including the reasonably foreseeable social, economic and cultural needs of future generations; (d) comply with limits or targets set to achieve freshwater objectives.
	O WQUAN.2	**The efficient allocation and use of water** The allocation and use of Southland's water resources: (a) is efficient; (b) recognises and makes provision for the existing Manapōuri and Monowai hydro-electric generation schemes in the Waiau catchment and the resultant modified flows and levels.
	P WQUAN.2	**Overallocation** Avoid over-allocation of surface water and groundwater, and resolve any historical instances of over-allocation, while recognising the special provisions made for the Waiau catchment.
	P WQUAN.6	**Efficient use of water** (a) Ensure that any water taken from surface water or groundwater is used efficiently.

PROPOSED REGIONAL POLICY STATEMENT (2012)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		(b) Where fresh water bodies are approaching full allocation, consider establishing management provisions to maximise the benefits of using any available water.
	P WQUAN.7	**Social, economic and cultural benefits** Recognise the social, economic and cultural benefits that may be derived from the use, development or protection of water resources.
Water Quality	O WQUAL.1	**Water quality goals** Water quality in the region: (a) safeguards the life-supporting capacity of water and related ecosystems; (b) safeguards the health of people and communities; (c) is maintained, or improved in accordance with freshwater objectives formulated under the National Policy Statement for Freshwater Management 2014; (d) is managed to meet the reasonably foreseeable social, economic and cultural needs of future generations.
	O WQUAL.2	**Lowland water bodies** Halt the decline, and improve water quality in lowland water bodies and coastal lakes, lagoons, tidal estuaries, salt marshes and coastal wetlands in accordance with freshwater objectives formulated in accordance with the National Policy Statement for Freshwater Management 2014.

PROPOSED REGIONAL POLICY STATEMENT (2012)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
	P WQUAL.1	**Overall management of water quality** (a) Identify values of surface water, groundwater, and water in coastal lakes, lagoons, tidal estuaries, salt marshes and coastal wetlands, and formulate freshwater objectives in accordance with the National Policy Statement for Freshwater Management 2014; and (b) Manage discharges and land use activities to maintain water quality, or improve it, to ensure freshwater objectives are met.
	P WQUAL.2	**All waterbodies** In managing water quality, particular regard will be had to the following contaminants: (a) nitrogen; (b) phosphorus; (c) sediment; (d) microbiological contaminants.
	P WQUAL.3	**Wetlands and outstanding freshwater bodies** Identify and protect the significant values of wetlands and outstanding freshwater bodies.
	P WQUAL.4	**Improve catchment water quality** Improve water quality by: (a) identifying water bodies that are not meeting freshwater objectives;

PROPOSED REGIONAL POLICY STATEMENT (2012)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		(b) specifying targets to improve water quality within these water bodies and implementing management frameworks to meet the targets within defined timeframes taking into account; (i) the values supported by the water body/ies; (ii) national or legislative standards and requirements; (iii) the benefits and costs associated with achieving improvement in water quality.
	P WQUAL.6	**Social, economic and cultural benefits** Recognise the social, economic and cultural benefits that may be derived from the use, development or protection of water resources.
	P WQUAL.7	**Preference for discharge to land** Prefer discharges of contaminants to land over discharges of contaminants to water, where: (a) a discharge to land is practicable; (b) the adverse effects associated with a discharge to land are less than a discharge to water.
	P WQUAL.8	**Untreated human and animal wastes** Avoid the direct discharge of sewage, wastewater, industrial and trade waste and agricultural effluent to water unless these discharges have undergone treatment.

PROPOSED REGIONAL POLICY STATEMENT (2012)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
	P WQUAL.9	**Siting and operation** Where practicable, manage the siting and operation of activities that result in point source discharges of contaminants to land to ensure that adverse effects on groundwater, surface water and coastal water quality are avoided, remedied or mitigated.
	P WQUAL.10	**Sources of community water supplies** Avoid, as far as practicable, remedy or mitigate the risks that the adverse effects of land use activities and discharges of contaminants have on the sources of community water supplies.
Rural Land & Soils	O RURAL.1	**Sustainable use of rural land resource** Achieve sustainable use of Southland's rural land resource, in respect of: (a) agriculture and primary sector activities; (b) subdivision, use and development activities; (c) earthworks and vegetation clearance activities; (d) the use of soil resources; (e) mineral extraction activities; and (f) on-site wastewater systems.
	O RURAL.2	**Life-supporting capacity of soils**

PROPOSED REGIONAL POLICY STATEMENT (2012)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		Safeguard the life-supporting capacity, mauri and health of soils in rural areas, and prevent or minimise soil erosion and sedimentation from land use soil disturbance.
	P RURAL.1	**Social, economic and cultural wellbeing** Recognise that use and development of Southland's rural land resource enables people and communities to provide for their social, economic and cultural wellbeing.
	P RURAL.2	**Land use change and land development activities** Manage subdivision, land use change and land development activities in rural areas of Southland, in a way that maintains or enhances rural amenity values and character.
	P RURAL.5	**Effects of rural land development** The effects of rural land development shall be sustainably managed and land management practices encouraged so that: (a) soil properties are safeguarded; (b) soil erosion is minimised; (c) soil compaction and nutrient and sediment loss is minimised; (d) soil disturbance is reduced; (e) water quality is maintained or enhanced; (f) indigenous biodiversity is maintained or enhanced; (g) the mauri of water and soils is safeguarded.

PROPOSED REGIONAL POLICY STATEMENT (2012)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
Biodiversity	O BIO.1	**Understand and identify** Understand the extent of loss of indigenous ecosystems and habitats across the Southland Region and identify those at risk to further loss and degradation.
	O BIO.2	**Maintain and protect** Maintain indigenous biodiversity in Southland and protect areas of significant indigenous vegetation and significant habitats of indigenous fauna for present and future generations.
	O BIO.3	**Enhance** Enhance the range, extent and condition of indigenous biodiversity in Southland, with a particular emphasis on those areas most at risk to further loss or degradation.
	P BIO.1	**Identification of significant areas** Identify areas of significant indigenous vegetation and significant habitats of indigenous fauna using the following: (a) the Schedule of Threatened, At Risk and Rare Habitat Types in Appendix 2 which provides an indication of areas likely to be significant. (b) Ecological assessments undertaken by a suitably qualified ecologist using the ecological significance criteria listed in Appendix 3 to ascertain whether an area listed is significant or otherwise.

PROPOSED REGIONAL POLICY STATEMENT (2012)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		(c) the ecological significance criteria listed in Appendix 3 which incorporate the following matters: (i) representativeness; (ii) rarity or distinctiveness; (iii) diversity and pattern; and (iv) ecological context; (d) in collaboration with landowners the investigation and identification of areas of indigenous vegetation on private land that are likely to be significant.

REGIONAL WATER PLAN (2010)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
Water Quality	O 3	**Surface water bodies other than in Natural State Waters** To maintain and enhance the quality of surface water bodies so that the following values are protected where water quality is already suitable for them, and where water quality is currently not suitable, measurable progress is achieved towards making it suitable for them.

		In surface water bodies classified as mountain, hill, lake-fed, spring-fed, lowland (hard bed), lowland (soft bed) and Mataura 1, Mataura 2 and Mataura 3: (a) bathing, in those sites where bathing is popular; (b) trout where present, otherwise native fish; (c) stock drinking water; (d) Ngāi Tahu cultural values, including mahinga kai; (e) natural character including aesthetics. **In surface water bodies classified as mountain lakes and hill lakes:** (a) bathing (b) trout (c) Ngāi Tahu cultural values, including mahinga kai (d) natural character including aesthetics **In surface water bodies classified as lowland/coastal lakes:** (a) native migratory fish; (b) stock drinking water; (c) healthy aquatic habitats; (d) Ngāi Tahu cultural values, including mahinga kai; (e) natural character including aesthetics
	O 4	**Gradual improvement in surface water quality parameters**

		To manage the discharge of contaminants and encourage best environmental practice to improve the water quality in surface water bodies classified as hill, lowland (hard bed), lowland (soft bed) and spring fed, and in particular to achieve a minimum of 10 percent improvement in levels of the following water quality parameters over 10 years from the date this Plan became operative (January 2010): (a) microbiological contaminants (b) nitrate (c) phosphorus (d) clarity
	O 8	**Drinking Water Standard Other relevant sections:** (a) To maintain groundwater quality in aquifers that already meet the Drinking-Water Standards for New Zealand 2000; and (b) To enhance groundwater quality in aquifers degraded by land use and discharge activities (with the exception of those aquifers where ambient water quality is naturally less than the Drinking-Water Standards for New Zealand 2000) to ensure general compliance with the Drinking-Water Standards for New Zealand 2000 by the year 2010.
	P 1	**Surface water body classes** (a) Recognise the different characteristics of the following surface water body classes when managing discharges: (i) Natural State Waters (ii) Lowland (hard bed)

		(iii) Lowland (soft bed) (iv) Hill (v) Mountain (vi) Lake-fed (vii) Spring-fed (viii) Mataura 1 (ix) Mataura 2 (x) Mataura 3 (xi) Lowland/coastal lakes and wetlands (xii) Hill lakes and wetlands (xiii) Mountain lakes and wetlands (b) Apply water quality standards established under any Water Conservation Order.
	P 4	**Surface water bodies outside Natural State Waters** For surface water bodies outside Natural State Waters, manage point source and non-point source discharges to meet or exceed the water quality standards referred to in Rule 1 and specified in Appendix G "Water Quality Standards", unless it is consistent with the promotion of the sustainable management of natural and physical resources, as set out in Part 2 of the Resource Management Act 1991, to do so and so avoid levels of contaminants in water and sediments that could harm the health of humans, domestic animals including stock and/or aquatic life.
	P 6	Non-regulatory methods

		(a) Use non-regulatory methods, in addition to rules, to maintain and enhance surface water and groundwater quality, and to avoid, remedy or mitigate adverse effects on soil quality. (b) Assess on an ongoing basis whether the adoption of non-regulatory methods has resulted in improvements to water or soil quality, and consider the introduction of other interventions if improvements have not resulted.
	P 7	**Prefer discharges to land** Prefer discharges to land over discharges to water where this is practicable and the effects are less adverse.
	P 13	**Discharge of untreated effluent** Avoid the point source discharge of raw sewage, foul water and untreated agricultural effluent to water.
	P 13A	**Transitional policy relating to the establishment of new dairy farms** (a) Recognise that the establishment of new dairy farms poses risks to water quality, including the quality of water in coastal lakes, lagoons, tidal estuaries, salt marshes and coastal wetlands, that need to be addressed when establishing a new dairy farm. (b) Manage the risk posed by the establishment of new dairy farms by requiring resource consent and requiring the documentation of risks and measures to avoid or mitigate them in a Conversion Environmental Plan.

		(c) Consideration should be given to, but not be limited to, the following matters; (i) the assimilative capacity and drainage characteristics of the soil and consequential effects on water quality; (ii) the risks posed by the establishment of a new dairy farm to the water quality of water bodies, coastal lakes, lagoons, tidal estuaries, salt marshes and coastal wetlands; (iii) the extent to which those risks can be avoided or mitigated through measures proposed in the Conversion Environmental Plan; (iv) the likely effectiveness of the measures contained in the Conversion Environmental Plan; (v) how, and within what timeframe, those measures will be implemented. (d) Where the risks to the water quality of water bodies, coastal lakes, lagoons, tidal estuaries, salt marshes and coastal wetlands cannot be avoided or mitigated, the Council may decline consent for the establishment of a new dairy farm.
	P 25	**Adverse effects arising from point source and non-point source discharges** To avoid, remedy or mitigate the adverse effects arising from point source and non-point source discharges so that there is no deterioration in groundwater quality after reasonable mixing, unless it is consistent with the promotion of the sustainable management of natural and physical resources, as set out in Part 2 of the Resource Management Act 1991, to do so.

Water Quantity	O 5	**Sufficient water availability** To have sufficient water to support the reasonably foreseeable needs of current and future generations and enable people and communities to provide for their social, economic and cultural wellbeing while protecting aquatic ecosystem health, life supporting capacity, natural character and historic heritage values of surface water bodies.
	O 6	**The Waiau catchment** To provide for the national importance of the existing hydro-electric generation in the Waiau catchment, and recognise the resultant modified flow and level regime.
	O 7	**Efficient Water** To maximise the efficiency of water use.
	O 9	**Sustainable abstraction** To ensure that the total volume and rate of groundwater abstraction is sustainable.
	P 14	**Manage the taking, use, damming or diversion of surface water** While recognising the positive effects resulting from the use and development of water resources, manage the taking, use, damming or diversion of surface water so as to avoid where practicable, remedy or mitigate significant adverse effects on: (a) the quality and quantity of aquatic habitat; (b) natural character, natural features, and amenity, aesthetic and landscape values; (c) areas of significant indigenous vegetation and significant habitats of indigenous fauna;

		(d) recreational values; (e) the spiritual and cultural values and beliefs of the tangata whenua; (f) water quality, including temperature; (g) the rights of lawful existing users; (h) groundwater quality and quantity; (i) historic heritage.
	P 21	**Reasonable use of water** To ensure that the rate of abstraction and abstraction volumes specified on water permits to take and use water are no more than reasonable for the intended end use.
	P 22	**Water measuring devices** Require, where appropriate, the installation of water measuring devices on all new permits to take and use water.
	P 23	**Review of water permits** Impose a condition enabling the review of consent conditions in accordance with Sections 128 and 129 of the Resource Management Act 1991 on all new permits to take and use water.
	P 26	**Adverse effects of bores and wells**

		To avoid the adverse effects on groundwater quality and quantity arising from bores and wells by ensuring that bores and wells are appropriately designed, constructed and maintained in a way that adverse effects are avoided to the extent practicable.
	P 28	**To manage groundwater abstraction** To manage groundwater abstraction to avoid significant adverse effects on: • long-term aquifer storage volumes • existing water users • surface water flows and aquatic ecosystems and habitats • groundwater quality
	P 29	**Stream depletion effects** (a) Manage the stream depletion effect of any groundwater abstraction with a rate of take exceeding 2 litres per second as follows: (i) where there is a direct hydraulic connection between the groundwater source and an adjacent surface water body, the stream depletion effect will be determined as the maximum instantaneous rate of take and will be managed in the same manner as a surface water abstraction for flow and allocation purposes. The abstraction will therefore be subject to any relevant minimum flow regime; (ii) where there is a high degree of hydraulic connection between the groundwater source and an adjacent surface water body, the stream depletion effect will be determined as the greater of:

		1. the effect of 150 days pumping at the continuous pump rate required to deliver the seasonal volume; 2. the effect of continuous pumping at the maximum permitted pump rate over the period required to deliver the seasonal volume. The calculated rate of stream depletion will be managed in the same manner as a surface water abstraction for allocation purposes with the remainder of the abstraction included in the allocation volume for the relevant groundwater zone. Where the calculated rate of stream depletion exceeds 2 litres per second, the abstraction will be subject to any relevant minimum flow regime; (iii) where there is a moderate degree of hydraulic connection between the groundwater source and an adjacent surface water body, the stream depletion effect will be determined as the effect of 150 days of pumping at the continuous pump rate required to deliver the seasonal volume. The calculated rate of stream depletion will be managed in the same manner as a surface water abstraction for allocation purposes with the remainder of the abstraction included in the allocation volume for the relevant groundwater zone; (iv) where there is a low degree of hydraulic connection between the groundwater source and an adjacent surface water body, the stream flow effect is considered to be minor and the individual abstraction will not be taken into account in determining surface water allocation but will be included in the allocation volume for the relevant groundwater zone.

		For the purposes of this policy, the degree of hydraulic connection is classified as follows: **Direct:** Where the stream depletion effect of seven days continuous abstraction at the maximum permitted rate on an adjacent surface water body is greater than or equal to 80 percent of the maximum pump rate. **High:** Where the stream depletion effect of seven days continuous abstraction at the maximum permitted rate on an adjacent surface water body is less than 80 percent of the maximum pump rate and the stream depletion effect of 150 days of pumping at the average continuous rate required to deliver the seasonal volume is greater than or equal to 60 percent of the average continuous pump rate. **Moderate:** Where the stream depletion effect of seven days continuous abstraction at the maximum permitted rate on an adjacent surface water body is less than 80 percent of the maximum pump rate and the stream depletion effect of 150 days of pumping at the average continuous rate required to deliver the seasonal volume is either: (a) less than 60 percent but greater than or equal to 30 percent of the average continuous pump rate; or (b) has an overall magnitude greater than 5 litres per second. **Low:** Where the abstraction is not classified as having a direct, high or moderate degree of hydraulic connection. (b) Minimise the cumulative stream depletion effect of groundwater abstraction by:

		(i) imposing minimum flows on resource consents for groundwater abstraction where there is a direct or high degree of hydraulic connection and the stream depletion effect exceeds two litres per second in accordance with any relevant surface water minimum flow regime (including those established under any Water Conservation Order); Objectives/Policies - Page 6 Regional Water Plan for Southland Objectives/Policies (ii) managing the total stream depletion effect of groundwater abstractions greater than two litres per second with a direct, high or moderate degree of hydraulic connection in accordance with any relevant surface water allocation regime (including those established under any Water Conservation Order); (iii) ensuring the total stream depletion effect of groundwater abstractions greater than two litres per second with a direct, high or moderate degree of hydraulic connection does not result in surface water flows less than prescribed minimum flows or surface water allocation regimes being exceeded.
	P 30	**Groundwater abstraction** (a) Use a staged management approach to allocate groundwater for abstraction in Southland to allow the knowledge gained by the progressive development of the region's groundwater resources to be built into its future management. (b) Recognise the different characteristics of the following aquifer types when managing groundwater abstraction:

		(i) riparian aquifers; (ii) terrace aquifers; (iii) lowland aquifers; (iv) confined aquifers; (v) fractured rock aquifers. (c) Use an assessment of available hydrogeological information from resource consent applications supplemented by investigations and monitoring undertaken by the Council, on a case-by-case basis, to determine if an aquifer is confined. Where an aquifer is determined to be sufficiently confined to warrant management as a separate groundwater resource a preliminary allocation volume shall be determined on the basis of aquifer throughflow. (d) Provide for: (i) a level of permitted groundwater abstraction where there is a minimal risk of adverse effects; (ii) a primary allocation for consented water abstraction and use; and (iii) a supplementary allocation for consented water abstraction and use. (e) Require resource consent applications for groundwater abstractions to be supported by a level of information that corresponds to the level of risk of adverse environmental

		effects. Information to be supported by a conceptual hydrogeological model that corresponds to the level of allocation from the aquifer. (f) Where appropriate, impose minimum level and/or flow cut-offs and seasonal recovery triggers on resource consents for groundwater abstraction. (g) Impose monitoring on resource consents for groundwater abstractions that corresponds to the level of risk of adverse environmental effects. (h) Where monitoring shows adverse environmental effects are occurring in a specific groundwater zone, remedy or mitigate those effects using one or more of the following methods: (i) reviewing the conditions of existing groundwater abstraction consents for that groundwater zone in accordance with Section 128 of the Resource Management Act 1991; (ii) ceasing any further allocation of groundwater from that groundwater zone; and (iii) temporarily restricting the abstraction of water from that groundwater zone by issuing a water shortage direction under Section 329 of the Resource Management Act 1991. (i) Ensure that groundwater abstractions that have a high risk of adverse environmental effects will not result in:

		(i) a long-term decline in groundwater levels; (ii) surface water allocation regimes being exceeded[35].
	P 31	**Interference effects** (a) Limit the cumulative interference effect of any new groundwater abstraction (in conjunction with other lawfully established groundwater takes) to no more than 20 percent of the available drawdown in any unconfined aquifer or up to 50 percent of the potentiometric head in any confined aquifer. The effects on any neighbouring bore will be considered where that bore is lawfully established and an assumption will be made that the bore fully penetrates the aquifer. An increased volume or increased pumping rate for any lawfully established groundwater abstraction will be considered a new groundwater abstraction under this policy. (b) Limit the cumulative interference effect of any new groundwater abstraction on any bore that is notified to the Council and utilised for long-term monitoring of water levels to no more than 10 percent of the available drawdown in a unconfined aquifer, or no more than 20 percent of the available potentiometric head in a confined aquifer that exists 50 percent of the time during natural conditions when no pumping is occurring. An increased volume or increased pumping rate for any lawfully established groundwater abstraction will be considered a new groundwater abstraction under this policy.

		(c) An exception to clause (a) and (b) above may be appropriate for aquifer testing and necessary infrastructure works, and in certain Objectives/Policies - Page 12 Regional Water Plan for Southland Objectives/Policies circumstances for mining activities where dewatering occurs for a short duration.
Wetlands	O 2	**Maintain water quality** To manage water quality so that there is no reduction in the quality of the water in any surface water body, beyond the zone of reasonable mixing for discharges, below that of the date this Plan became operative (January 2010).
	O 4	**Gradual improvement in surface water quality parameters** To manage the discharge of contaminants and encourage best environmental practice to improve the water quality in surface water bodies classified as hill, lowland (hard bed), lowland (soft bed) and spring fed, and in particular to achieve a minimum of 10 percent improvement in levels of the following water quality parameters over 10 years from the date this Plan became operative (January 2010): (a) microbiological contaminants (b) nitrate (c) phosphorus (d) clarity
	P 38	**Adverse effects of activities** Avoid, remedy or mitigate the adverse effects of activities on wetlands through an integrated management approach with the Southland territorial authorities.

	P 39	**Promote best management practice** Use non-regulatory methods to promote best management practice in relation to retaining or enhancing the natural values of wetlands.
	P 40	**Restoration of existing wetlands and the creation of wetlands** Encourage the maintenance and restoration of existing wetlands and the creation of new wetlands.
Agricultural Effluent	P 41	**Adverse effects of agricultural effluent ponds** Avoid adverse effects on water quality, and avoid as far as possible other adverse environmental effects, associated with the location, design, construction, operation and maintenance of agricultural effluent ponds.

REGIONAL EFFLUENT LAND APPLICATION PLAN (1998)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
Soil Health and Fertility	O 4.1.1	**Soil** 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.
	P 4.2.1	**Sustainability of the soil ecosystem** Protect the sustainability of the soil ecosystem from adverse effects of effluent and sludge discharges onto or into land.

REGIONAL EFFLUENT LAND APPLICATION PLAN (1998)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
	P 4.2.2	**Discharge to land** Utilise land treatment of effluent and sludge where this can be undertaken in a sustainable manner and without significant adverse effects.
Water Quality	O 4.1.2	**Water** 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.
	P 4.2.3	**Avoid where practicable, remedy or mitigate adverse effects on water** 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.
Other	O 4.1.4	**Amenity values** To ensure that amenity values are not adversely affected by discharges of effluent and sludge onto or into land.
	O 4.1.5	**Takata whenua** To recognise and provide for the relationship of takata whenua with ancestral sites, wahi tapu and other taoka.

REGIONAL EFFLUENT LAND APPLICATION PLAN (1998)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
	P 4.2.4	**Precautionary approach** Adopt a precautionary approach to the discharge of effluent and sludge onto or into land where there are uncertainties regarding adverse effects.
	P 4.2.7	**Good practice and maintenance** Promote good practice and regular maintenance of effluent and sludge systems.
	P 4.2.8	**Takata whenua** Recognise and provide for takata whenua concerns related to the discharge of effluent and sludge onto or into land.
	P 4.2.9	**Amenity values** Avoid where practicable, remedy or mitigate any adverse effects on amenity values from discharges of effluent and sludge systems onto or into land.

TE TANGI A TAUIRA (2008)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
Farm Effluent Management	P 4	Sustain and safeguard the life supporting capacity of soils for future generations.

TE TANGI A TAUIRA (2008)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
	P 7	Require soil risk assessments (type and percolation of the soils) prior to consent for discharge to land, to assess the suitability and capability of the receiving environment. Effluent should be applied at rates that match the ability of land to absorb it.
	P 8	Require best practice for land application of managing farm effluent, in order to minimise adverse effects on the environment. This includes: a. application rates that are specific to region and soil type; b. use of low rate effluent irrigation technology; c. use of appropriate irrigation technology to avoid irrigating over tile drains (e.g. K-line); d. storing effluent when the soil is too wet or heavy to irrigate; e. storing effluent when heaving pugging by stock has occurred; f. sealed storage ponds to avoid leaching of nutrients to groundwater; g. avoiding ponding of effluent on paddocks; h. monitoring of soils and groundwater (see Policy 16); i. developing contingency plans (e.g. for exceptionally wet years).
	P 9	Require that farm management plans include the location and extent of tile drains on the farm, in order to ensure that farm workers know where drains are when they irrigate.

TE TANGI A TAUIRA (2008)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
	P 11	Avoid any surface run off /overland flow, ponding or contamination of water resulting from the application of dairy shed effluent to pasture.
	P 13	Require the establishment of appropriate buffer zones between discharge activities and waterways (including ephemeral and waterways
	P 14	Require the establishment of buffer zones of at least 100m between discharge activities and bores.
	P 15	All spray drift, as a product of spray irrigation of effluent, must be managed and contained within the boundaries of the consent area.
Rivers	P 4	Management of our rivers must take into account that each waterway has its own mauri, guarded by separate spiritual guardians, its own mana, and its own set of associated values and uses.
	P 5	Adopt a precautionary approach for any activity involving a waterway where there is an absence of detailed knowledge of that waterway (ecology, flow regimes, species, etc).
	P 6	Require that rivers recognised as Statutory Acknowledgements be recognised for their special associations to Ngāi Tahu beyond the expiry date of 20 years. This means that places identified as Statutory Acknowledgements should continue to be:

TE TANGI A TAURIA (2008)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		– Identified in relevant district and regional plans and policy statements as notice of their cultural importance to Ngāi Tahu (noting on plans). – Considered a trigger for a notice of application to Ngāi Tahu with respect to resource consents relating to, or impacting on, such areas (notice of applications). – Given regard to by Councils, the Environment Court and Historic Places Trust when decisions are made about who has the right to comment and be listened to, or to appear in court (Standing). – Accepted as evidence of the relationship of Ngāi Tahu with a particular area in any proceedings under the RMA or Historic Places Act.
Water Quality	P 1	The role of Ngāi Tahu ki Murihiku as tangata whenua and kaitiaki of water must be recognised and provided for in all water quality management.
	P 2	Strive for the highest possible standard of water quality that is characteristic of a particular place/waterway, recognising principles of achievability. This means that we strive for drinking water quality in water we once drank from, contact recreation in water we once used for bathing or swimming, water quality capable of sustaining healthy mahinga kai in waters we use for providing kai.
	P 3	Require cumulative effects assessments for any activity that may have adverse effects of water quality

TE TANGI A TAUIRA (2008)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
	P 4	Avoid compromising water quality as a result of water abstractions.
	P 5	Avoid the use of water as a receiving environment for the direct, or point source, discharge of contaminants. Generally, all discharge must first be to land.
	P 6	Avoid impacts on water as a result of inappropriate discharge to land activities.
	P 7	When assessing the effects of an activity on water quality, where the water source is in a degraded state, the effects should be measured against the condition that the water source should be, and not the existing condition of the water source
	P 8	Promote the restoration of wetlands and riparian areas as part of maintaining and improving water quality, due to the natural pollution abatement functions of such ecosystems.
	P 9	Require the use of buffer zones, riparian areas, bunds and other mechanisms to prevent stormwater and other wastewater from entering waterways.
	P 10	Water quality definitions, categories, and standards must be determined, measured, and assessed with cultural values and indicators alongside scientific information. Such indicators and values centre on the ability of the waterway to support life, and the fitness of water for cultural uses.

TE TANGI A TAUIRA (2008)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
	P 11	Require robust monitoring of discharge permits, to detect non-compliance with consent conditions. Noncompliance must result in appropriate enforcement action to discourage further non-compliance.
Water Quantity	P 4	In the Southland Plains region, the preference of Ngāi Tahu ki Murihiku is for water takes from bores, as opposed to surface water abstractions.
	P 11	Avoid excessive drawdown of aquifer levels as a result of groundwater abstractions, and to ensure that abstractions do not compromise the recovery of groundwater levels between irrigation seasons.
	P 16	Encourage the installation of appropriate measuring devices (e.g. water meters) on all existing and future water abstractions, to accurately measure, report, and monitor volumes of water being abstracted, and enable better management of water resources.
	P 17	Advocate for durations not exceeding 25 years on resource consents related to water abstractions.
	P 18	Require, where necessary, a consent condition providing for a review of the volumes able to be abstracted from the bores on the basis of the observed seasonable recovery of groundwater levels. Also include a provision for review of both the annual recovery

TE TANGI A TAUIRA (2008)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		between individual irrigation seasons and the cumulative eff ects on longer-term water level recovery.

PROPOSED WATER & LAND PLAN (2016)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
Region Wide Objectives	O 1	Land and water and associated ecosystems are managed as integrated natural resources, recognising the connectivity between surface water and groundwater, and between freshwater, land and the coast.
	O 2	Water and land is recognised as an enabler of the economic, social and cultural wellbeing of the region.
	O 3	The mauri (inherent health) of waterbodies provide for te hauora o te tangata (health of the people), te hauora o te taiao (health of the environment) and te hauora o te wai (health of the waterbody).
	O 6	There is no reduction in the quality of freshwater, and water in estuaries and coastal lagoons, by: (a) maintaining the quality of water in waterbodies, estuaries and coastal lagoons, where the water quality is not degraded; and

PROPOSED WATER & LAND PLAN (2016)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		(b) improving the quality of water in waterbodies, estuaries and coastal lagoons, that have been degraded by human activities.
	O 11	Water is allocated and used efficiently.
	O 13	Enable the use and development of land and soils, provided: (a) the quantity, quality and structure of soil resources are not irreversibly degraded through land use activities and discharges to land; (b) the discharge of contaminants to land or water that have significant or cumulative effects on human health are avoided; and (c) adverse effects on ecosystems (including diversity and integrity of habitats), amenity values, cultural values and historic heritage values are avoided, remedied or mitigated to ensure these values are maintained or enhanced.
	O 17	The natural character values of wetlands, rivers and lakes including channel form, bed rapids, seasonably variable flows and natural habitats, are protected from inappropriate use and development.
	O 18	All activities operate at “good (environmental) management practice” or better to optimise efficient resource use and protect the region’s land, soils, and water from quality and quantity degradation.
Region Wide Policies	P 2	**Take into account iwi management plans**

PROPOSED WATER & LAND PLAN (2016)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		Any assessment of an activity covered by this plan must: 1. take into account any relevant iwi management plan; and 2. assess water quality and quantity based on Ngāi Tahu indicators of health.
	P 6	**Gleyed** In the Gleyed physiographic zone, avoid, remedy, or mitigate adverse effects on water quality from contaminants, by: 1. requiring implementation of good management practices to manage adverse effects on water quality from contaminants transported via artificial drainage, and overland flow where relevant; 2. having particular regard to adverse effects on water quality from contaminants transported via artificial drainage, and overland flow where relevant when assessing resource consent applications and preparing or considering management plans.
	P 13	**Management of land use activities and discharges** Manage land use activities and discharges (point source and non-point source) to land and water so that water quality and the health of humans, domestic animals and aquatic life, is protected.
	P 14	**Preference for discharges to land** Prefer discharges to land, rather than direct discharges to water.

PROPOSED WATER & LAND PLAN (2016)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
	P 15	**Maintaining and improving water quality** Maintain and improve water quality by: 1. despite any other policy or objective in this Plan, avoiding new discharges to surface waterbodies that will reduce water quality beyond the zone of reasonable mixing; Proposed Southland Water and Land Plan Page 30 2. avoiding point source and non-point source discharges to land that will reduce surface or groundwater quality, unless the adverse effects of the discharge can be avoided, remedied or mitigated; 3. avoiding land use activities that will reduce surface or groundwater quality, unless the adverse effects can be avoided, remedied or mitigated; and 4. avoiding discharges to artificial watercourses that will reduce water quality in a river, lake or modified watercourse beyond the zone of reasonable mixing; so that: 1. water quality is maintained where it is better than the water quality standards specified in Appendix E "Water Quality Standards"; or

PROPOSED WATER & LAND PLAN (2016)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		2. water quality is improved where it does not meet the water quality standards specified in Appendix E “Water Quality Standards”; and 3. water quality meets the Drinking-Water Standards for New Zealand 2005 (revised 2008); and 4. ANZECC sediment guidelines (as shown in Appendix C of this Plan) are met.
	P 16	**Farming activities that affect water quality** 1. Minimising the environmental effects (including on the quality of water in rivers, coastal lakes, lagoons, tidal estuaries, salt marshes and coastal wetlands, and groundwater) from farming activities by: (a) strongly discouraging the establishment of new dairy farming or new intensive winter grazing activities in close proximity to sensitive waterbodies identified in Appendix Q; (b) strongly discouraging applications to establish new, or further intensify existing dairy farming of cows or intensive winter grazing activities where the effects on the quality of water, including cumulatively, of groundwater, waterbodies, coastal lakes, lagoons, tidal estuaries, salt marshes and coastal wetlands cannot be avoided or fully mitigated or in areas where water quality is already degraded to the point of being overallocated.

PROPOSED WATER & LAND PLAN (2016)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		2. Requiring all farming activities, including existing activities, to: (a) either implement a Management Plan, as set out in Appendix N, or be listed on the Environment Southland Register of Independently Audited Self-Management Participants; (b) actively manage sediment run-off risk from farming and hill country development by requiring setbacks from waterbodies, riparian planting, limits on areas or duration of exposed soils and the prevention of stock entering surface waterbodies; (c) manage collected and diffuse run-off and leaching of nutrients, microbial contaminants and sediment through the identification and management of higher risk physiographic zones on a regional scale, and critical source areas within individual properties.
	P 17	**Effluent management** 1. Avoid adverse effects on water quality, and avoid as far as practicable other adverse environmental effects of the operation of, and discharges from effluent management systems. 2. Manage effluent systems and discharges from them by:

PROPOSED WATER & LAND PLAN (2016)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		(a) designing, constructing and locating systems appropriately and in accordance with standards; Proposed Southland Water and Land Plan Page 31 (b) maintaining and operating effluent systems in accordance with best practice guidelines; (c) avoiding any surface run-off/overland flow, ponding or contamination of water resulting from the application of agricultural effluent to pasture; (d) avoiding the discharge of raw sewage and untreated agricultural effluent to water.
	P 18	**Stock exclusion from waterbodies** Reduce sedimentation and microbial contamination of waterbodies and improve river and riparian ecosystems and habitats by: 1. requiring progressive exclusion of all stock, except sheep, from all waterbodies, including artificial watercourses, on land with a slope of less than 16° by 2025, and the management of sheep in critical source areas; 2. requiring the adoption of management plans that set out methods and timeframes to achieve these outcomes; 3. encouraging the establishment and enhancement of healthy vegetative cover in riparian areas, particularly through use of indigenous vegetation;

PROPOSED WATER & LAND PLAN (2016)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		4. ensuring that when stock access waterbodies, including artificial watercourses, this is managed in a manner that avoids significant adverse effects on water quality, bed and bank integrity and stability, mahinga kai, and aquatic, river and riparian ecosystems and habitats.
	P 20	**Management of water resources** Manage the taking, abstraction, use, damming or diversion of surface water and groundwater so as to: 1. avoid, remedy or mitigate adverse effects from the use and development of surface water resources on: (a) the quality and quantity of aquatic habitat; (b) natural character values, natural features, and amenity, aesthetic and landscape values; (c) areas of significant indigenous vegetation and significant habitats of indigenous fauna; (d) recreational values; (e) the spiritual and cultural values and beliefs of tangata whenua; (f) water quality, including temperature and oxygen content; (g) the rights of lawful existing users;

PROPOSED WATER & LAND PLAN (2016)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		(h) groundwater quality and quantity; (i) historic heritage values; (j) mātaitai, taiāpure and nohoanga; 2. avoid, remedy or mitigate significant adverse effects from the use and development of groundwater resources: (a) long-term aquifer storage volumes; (b) the reliability of supply for existing groundwater users; Proposed Southland Water and Land Plan Page 33 (c) surface water flows and levels, particularly in spring-fed streams, and aquatic ecosystems and habitats; and (d) water quality; 3. ensure water is used efficiently and reasonably by requiring that the rate of abstraction and abstraction volumes specified on water permits to take and use water are no more than reasonable for the intended end use; 4. recognise the positive effects resulting from the use and development of water resources.

PROPOSED WATER & LAND PLAN (2016)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
	P 22	**Management of the effects of groundwater and surface water use** Manage the effects of surface and groundwater abstractions by: 1. avoiding allocating water to the extent that the base flow of any waterway is depleted, in order to protect the mauri of that waterway and mahinga kai or taonga species; 2. ensuring interference effects are acceptable, in accordance with Appendix L.3; 3. utilising the methodology established in Appendix L.2 to: (a) manage groundwater abstractions with a daily volume exceeding 86 cubic metres per day on surface waterbodies; and (b) assess and manage the effects of groundwater abstractions with a daily volume exceeding 86 cubic metres per day in groundwater management zones other than those specified in Appendix L.5.
	P 27	**Bore construction and management** Require minimum standards for the construction, operation and maintenance of bores and wells.
	P 33	**Adverse effects on wetlands**

PROPOSED WATER & LAND PLAN (2016)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		Prevent the reduction in area, function and quality of wetlands, including through drainage and vegetation removal.
	P 34	**Restoration of existing wetlands and the creation of wetlands** Recognise the importance of wetlands and indigenous biodiversity, particularly the potential to improve water quality, through encouraging: 1. the maintenance and restoration of existing wetlands and the creation of new wetlands; and 2. the establishment of wetland areas, including on-farm, in subdivisions, on industrial sites and for community sewage schemes; and 3. offsetting peak flows and assisting with flood control.
	P 39	**Application of the permitted baseline** When considering any application for resource consent for the use of land for a farming activity, Environment Southland will consider all adverse effects of the proposed activity on water quality, whether or not this Plan permits an activity with that effect.
	P 40	**Determining the term of resource consents** When determining the term of a resource consent consideration will be given, but not limited, to:

PROPOSED WATER & LAND PLAN (2016)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		1. granting a shorter duration when there is uncertainty regarding the nature, scale, duration and frequency of adverse effects from the activity or the capacity of the resource; 2. relevant tangata whenua values and Ngāi Tahu indicators of health; 3. the duration sought by the applicant, plus material to support the duration sought; 4. the permanence and economic life of any capital investment; 5. the desirability of applying a common expiry date for water permits that allocate water from the same resource or land use and discharges that may affect the quality of the same resource; 6. the applicant's compliance with the conditions of any previous resource consent; and 7. the timing of development of FMU sections of this Plan, and whether granting a shorter or longer duration will better enable implementation of the any revised frameworks established in those sections.
	P 41	**Matching monitoring to risk** Consider the magnitude of environmental effects and risk when determining requirements for auditing and supply of monitoring information on resource consents.
	P 42	**Consideration of water permit applications**

PROPOSED WATER & LAND PLAN (2016)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		When considering resource consent applications for water permits: 1. consent will not be granted if a waterbody is fully allocated, or to do so would result in a waterbody becoming over allocated or over allocation being increased; 2. consents replacing an expiring resource consent for an abstraction from an over-allocated waterbody may be granted with a lesser volume and rate or take proportional to the amount of over-allocation and previous use; 3. installation of water measuring devices will be required on all new permits to take and use water, and existing permits in accordance with the Resource Management (Measurement and Reporting of Water Takes) Regulations 2010; 4. where appropriate, minimum level and/or flow cut-offs and seasonal recovery triggers on resource consents for groundwater abstraction will be imposed; 5. conditions will be specified relating to a minimum flow/level, in accordance with Appendix L, to all new or replacement resource consents (except for water permits for Proposed Southland Water and Land Plan Page 39 community water supplies and waterbodies subject to minimum flow and level regimes established under any water conservation order) for: (a) surface water abstraction, damming, diversion and use; and

PROPOSED WATER & LAND PLAN (2016)		
Subject/Topic	**Number (O/P)**	**Objective/Policy**
		(b) groundwater abstraction where there is Riparian, Direct or High degree of hydraulic connection in accordance with Policy 23 “Stream Depletion Effects” and the stream depletion effect exceeds two litres per second.

APPENDIX 8

PROPOSED FARM ENVIRONMENTAL MANAGEMENT PLAN

SCHRADER MAINS LIMITED

FARM ENVIRONMENTAL MANAGEMENT PLAN – JULY 2016

Plan Version	Date	Next Review
Rev A	July 2016	July 2017

Contents

Appendices

A: Property Overview

Contact Person(s):	Hank & Sandra Schrader	Farm Name:	-	Plan Prepared By:	Landpro Limited
Physical Address:	514 Rimu Seaward Downs Road, Waituna	Farm Manager (if different):	N/A	Date:	27 July 201627 July 2016
Email Address:	schrader@woosh.co.nz	Email Address:	-	Date of Next Review:	27 July 2017
Contact Phone:	03 239 5528 or 0274 08 0962	Contact Phone:	-	Milk Supply Number:	N/A
Person Responsible for Implementing Farm Plan:		Hank & Sandra Schrader			

This FEMP sets out the management practices that will be implemented and adopted to actively manage the operation of the property as a dairy farm, so as to ensure that environmental risks are identified and managed appropriately and resource consent conditions complied with. This plan has been prepared in accordance with the requirements of Appendix N Proposed Southland Water and Land Plan.

<u>Objectives of this plan:</u>

- Comply with all legal requirements related to nutrient management, land use and discharge activities.
- Take all practicable steps to maintain or enhance the quality of the property's water resources.
- Take all practicable steps to ensure that there is an adequate supply of soil nutrients to meet plant needs.
- To take all practicable steps to contain nutrients within the property boundaries.
- Take all practicable steps to minimise the risk of nutrient contamination of any areas of significant vegetation and/or wildlife habitat
- Identify and utilise GMP's that will be adopted to achieve the above objectives.

This will be achieved through;

- Identifying and documenting contaminant pathways for the property (based on 'Gleyed' Physiographic Zone information)
- Identify and document environmental risks (nutrients and sediment) for the property
- Identify relevant good management practices (GMP) and where they are required to be implemented to minimise environmental risks
- Keep records to show adherence with good management practices
- Document a water monitoring protocol to ensure that water quality is maintained or improved
- Document the nutrient budgeting protocol to ensure consistency with predicted losses at the time consent was sought
- Ensure compliance with resource consents
- Document clear reporting and compliance procedure to provide certainty

As the person responsible for implementing this plan, I confirm that the information provided is correct:

Name: Hank & Sandra Schrader

Date: 27 July 2016 Signed:..

Legal Description:	Section 7 and Section 49 Block II Oteramika Hundred and Lot 1 DP 12478	(ha)	77.27	Catchment:	Waituna Creek
	Part Section 5-6 Oteramika Hundred	(ha)	33.48	Peak Herd Size:	306 Cows
Total Effective Area (ha):	103 ha	Total Farm Area (ha)	110.75	Stocking Rate:	2.97 cows/ha (effective area)
Cows Wintered On:	90 Cows	Crop Area (ha):	4ha	Crop Type:	Kale
Soil Type:	Woodlands	Area (ha):	92.4 ha		
	Dacre	Area (ha)	17.6 ha		
Physiographic Zone	Gleyed (no variant)	Area (ha)	110.75		

Figure 1: Property Location Plan

Source: LINZ Topo 50 Series

B: Environmental Risk Assessment

The environmental risks for the property have been identified as nutrient (Nitrogen and Phosphorous) and sediment loss from Critical Source Areas via overland flow and artificial drains. There is a low risk of excessive nitrate leaching to groundwater, due to cation exchange and chemical sorption processes within the soil profile.

Critical Source Areas (CSA's) refer to smaller areas within a larger area, where there is disproportionally high loss of pollutants. The dominance of these small areas is dependent on many factors, including soil type, topography, management (such as fertiliser and manure inputs) and transport processes (such as rainfall and artificial drains).

The following sections identify how CSA's will be managed and monitored to minimise environmental risk to receiving water bodies.

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

C: Resource Consents

Note: As at the date of this plan [27 July 2016] resource consents have not been granted to facilitate the conversion of the land to dairy. However this section has been prepared on the basis of the consents which have been sought, and the draft conditions promoted by Schrader Mains Limited, and will be updated upon the granting of consent to reflect actual conditions of consent/expiry dates etc.

Resource consents have been granted to Schrader Mains Limited as set out in Table 1 below. A copy of the resource consents for the property are attached as Appendix B.

Table 1: Summary of Resource Consents held by Schrader Mains Ltd

Consent Number	Consent Type	Description of Activity	Consent Expiry Date
XX	Land Use Consent – Bore Consent	To construct a groundwater bore	1 February 2021
XX	Land Use Consent – Pond Storage	To construct and effluent storage pond	1 February 2021
XX	Water Permit	To abstract groundwater for Stock and Shed Water Purposes	1 February 2031
XX	Land Use Consent – To Establish a Dairy Farm	To convert the land for use as a dairy farm	1 February 2031
XX	Discharge Permit	To discharge agricultural effluent to land from a dairy shed and feedpad/standoff pad	1 February 2031

These resource consents have been granted subject to a suite of conditions which the consent holder is required to comply with at all times during the term of the consent. This FEMP whilst a condition of consent is also written with the express purpose of enabling the consent holder to comply with the terms and conditions of the consent, and to keep the necessary records to demonstrate compliance.

D: Land Management

D.1 Physiographic Zones

This section of the FMP documents the physiographic zone(s) of the property, and identifies the GMPs currently undertaken and opportunities for management practices which will mitigate effects on water quality. The property is wholly located within the Gleyed (no variant) Physiographic Zone.

Table 2: Key transport pathways and contaminants for each physiographic zone

Physiographic Zone	**Key Transport Pathways (✓)**		
	Overland Flow[1]	**Deep Drainage (leaching to groundwater)[2]**	**Artificial Drainage[1]**
Gleyed	✓		✓

[1]Overland flow and artificial drainage transport nitrogen, phosphorous, and microbes and sediment

[2]Deep drainage transports nitrogen

The key transport pathways for the property are identified as nitrogen, phosphorous, microbes and sediment loss from Critical Source Areas via overland flow and artificial drains within the Gleyed Zone.   There is a low risk of excessive nitrate leaching to groundwater.

Given the environmental setting and main transport pathways (i.e. overland flow and artificial drainage within the Gleyed zone), the highest risk periods are in association with sustained, or heavy rainfall, typically between May and the end of July when soils are near field capacity. Contaminant loss during these periods will be avoided by using low rate, deferred effluent irrigation along with stock exclusion from waterways and the use of buffer zones and riparian planting around streams which will reduce nutrient loss. Excessive nutrient loss will be avoided by managing supplements and fertiliser in accordance with a nutrient budget.

D.2 Soils

This section of the FEMP documents the soil types of the property, and identifies what good management practices will be adopted to ensure that the identified soil vulnerabilities are minimised. The property contains both Woodlands and Dacre Soils as shown in Figure 2. Woodlands soils comprise approximately 84% of the property, while Dacre Soils make up the remaining 16% of the property. In terms of the properties of these soils both are considered to be ‘high risk’ in terms of FDE management, and are classified as having the following soil vulnerability factors;

Table 3: Soil Vulnerability Factors

Soil Type	Vulnerability Factor		
	Structural Compaction	**Nutrient Leaching**	**Water Logging**
Dacre Soils	Moderate	Slight	Severe
Woodlands Soils	Moderate	Slight	Moderate

Good Management Practices to be adopted include;

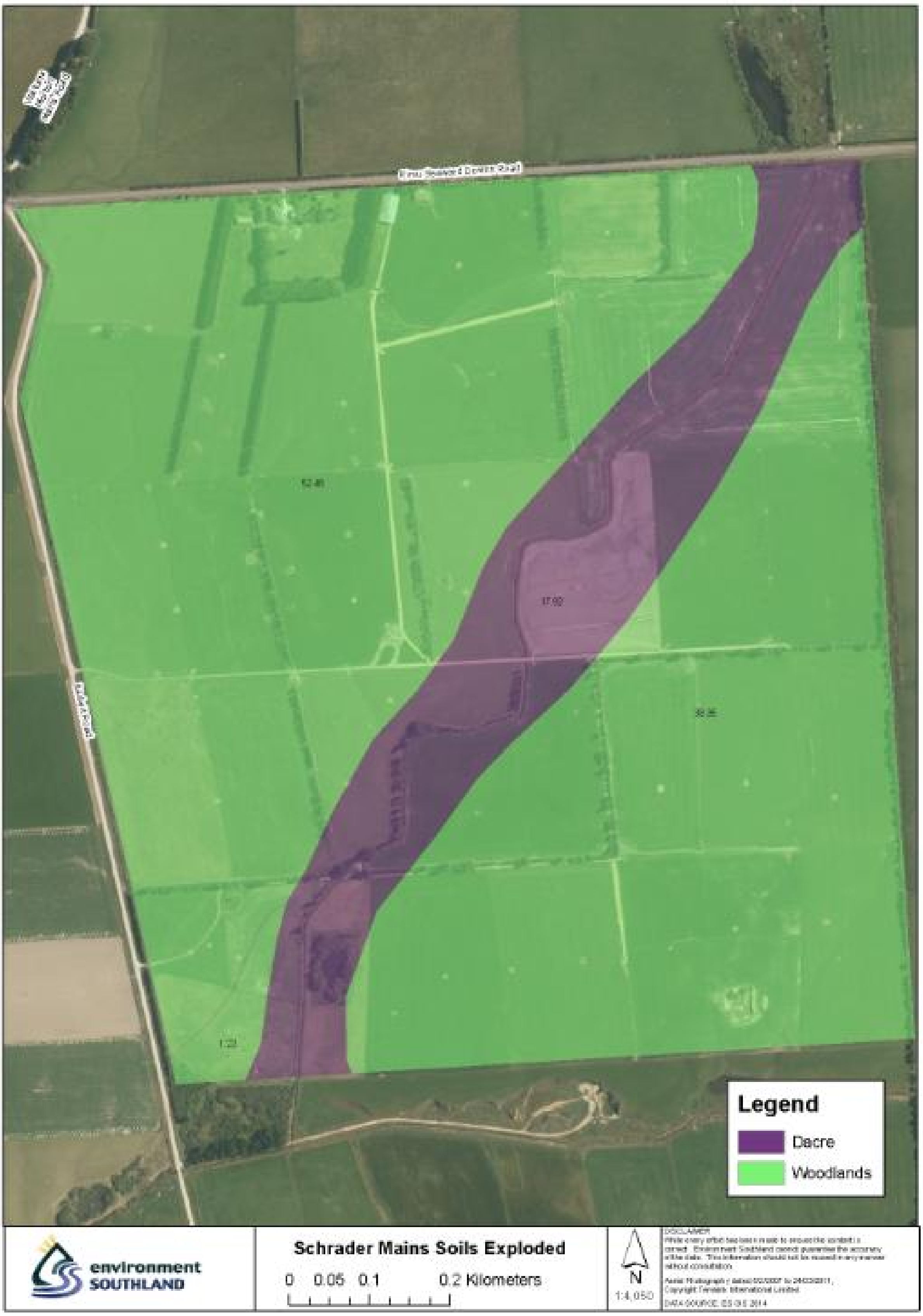
Table 4: Soil Good Management Practices

Good Management Practice	Mitigation Aims	Location	Method
Sediment loss from the farm will be minimised where required with the use of sediment traps and bunds.	• Capture nutrients sediment and	At Critical Source Areas i.e. at the end of swales	Haybales or Sediment Fence.

Good Management Practice	Mitigation Aims	Location	Method
	microbes in wetlands and sediment traps. • Protect soil structure, particularly in gullies and near stream areas.	especially during winter grazing.	
Use of Standoff Pad/Feed Pad to minimise compaction during extensive rainfall events.	• Protect soil structure, particularly in gullies and near stream areas.	Standoff Pad/Feed Pad.	In periods of high rainfall cows will be removed from pasture and stood on the feedpad/standoff pad to minimise damage to pasture and soil structure.
Temporary fencing of Critical Source Areas and swales to minimise compaction of soils and potential for overland flow of sediment to waterways.	• Manage Critical Source Areas.	Critical Source Areas.	Temporary fencing/grazing management
Strategic grazing/wintering	• Reduce the accumulation of surplus N in the soil particularly during autumn and winter.	At Critical Source Areas.	Methods as outlined in *Dairy NZ Wintering in Southland and Otago* will be adopted in selecting appropriate paddocks for establishing crops, providing filtering buffers from overland flow, planning wintering grazing etc.

Good Management Practice	Mitigation Aims	Location	Method
	• Nutrient management. • Protect soil structure, particularly in gullies and near stream areas. • Manage Critical Source Areas.		

Figure 2: Schrader Mains Soil Classification Plan



D.3 Artificial Drainage

Due to the imperfectly drained nature of the property, it is underlain by artificial drainage, primarily in the form of tile drains. These drains are of mixed age, and are located at varying depths from 1 to 1.5 metres throughout the property. Tile drains have been identified as a key environmental risk for this property in respect to manging effects on water quality, and nutrient loading as detailed in Section B FEMP.

The location of tile drains on the property have been identified and are shown on the FEMP Site Plan attached as Appendix A.

Good Management Practices which will be adopted to minimise the effects associated with artificial drainage include;

Table 5: Artificial Drainage Good Management Practices

Good Management Practice	Mitigation Aims	Location	Method
Low rate and deferred effluent irrigation.	• Avoid preferential flow of effluent through drains. • Reduce accumulation of surplus N in the soil, particularly during autumn and winter. • Effluent management.	Effluent disposal area & FDE infrastructure	Deferred storage of effluent is provided to enable application of effluent during optimum periods when there is reduced or no risk of discharge to tile drains from application of effluent. Application of effluent at low rates (as defined in the FDE Section) will also reduce the risk of overland flow of effluent and subsequent discharge to surface water.
Fertilising outside of high risk periods.	• Reduce accumulation of surplus N in the soil,	Whole Farm	Weather forecast will be considered prior to the application of fertiliser and if high

Good Management Practice	Mitigation Aims	Location	Method
	particularly during autumn and winter. • Reduce P use or loss. • Nutrient Management. • Manage Critical Source Areas.		intensity rainfall is forecast to occur application will be deferred.
Ensuring soil P levels are not high.	• Reduce P use or loss. • Nutrient Management. • Manage Critical Source Areas. • Effluent Management	Whole Farm	Annual soil tests will be undertaken to measure Olsen P levels in soils, and monitoring of potential P losses will be undertaken as set out in Section F1 FEMP.
Restricted grazing when soils are wet.	• Protect soil structure, particularly in gullies	Whole Farm	During periods of high intensity rainfall, where ponding and overland flow are or are likely to occur restricted grazing

Good Management Practice	Mitigation Aims	Location	Method
	and near stream areas. • Manage Critical Source Areas. • Reduce accumulation of surplus N in the soil, particularly during autumn and winter.		techniques (as discussed in this FEMP and Dairy Z guidelines) will be implemented. This may include the use of the standoff pad during such events.

Baseline monitoring will be undertaken and once completed, results of monitoring will be utilised to review and assess the effectiveness of land management techniques to minimise nutrient loss by artificial drainage. If monitoring indicates that there is an increase in nutrient loss land management techniques will be amended.

D.4 Critical Source Areas

Critical Source Areas for the property have been identified in conjunction with the Environment Southland Land Sustainability Team, and include;

- Swale areas located around the point of discharge from tile drains;
- Bridge Crossing Approaches;
- Laneways and Races.

Critical Source Areas are shown in the FEMP Site Plan attached as Appendix A. Good Management Practices will be adopted to manage high risk Critical Source Areas as set out in Table 6 below. Reference documents used to identify GMP's include *Environment Southland Fact Sheet*

– *Critical Source Areas* and in *Dairy NZ Wintering in Southland and Otago* and in *Dairy NZ Land Management on Canterbury Dairy Farms – Managing land to reduce sediment and phosphorus loss.*

Table 6: Critical Source Areas Good Management Practices

Good Management Practice	Mitigation Aims	Location	Method
Restricted grazing when soils are wet.	• Protect soil structure, particularly in gullies and near stream areas. • Manage Critical Source Areas. • Reduce accumulation of surplus N in the soil, particularly during autumn and winter. • Reduce P use or loss. • Avoid preferential flow of effluent through drains.	Whole Farm.	During periods of high intensity rainfall, where ponding and overland flow are or are likely to occur restricted grazing techniques (as discussed in this FEMP and Dairy NZ guidelines) will be implemented. This may include the use of the standoff pad during such events.
Minimum or no-till cultivation.	• Protect soil structure, particularly in gullies and near stream areas. • Manage Critical Source Areas.	Crop Paddocks and Re-grassing Areas.	Where appropriate techniques such as direct drilling will be utilised to minimise the potential for discharge to surface water via Critical Source Areas.

Good Management Practice	Mitigation Aims	Location	Method
Avoiding areas of bare land or damaged soils.	• Protect soil structure, particularly in gullies and near stream areas. • Reduce accumulation of surplus N in the soil, particularly during autumn and winter. • Manage Critical Source Areas.	Whole Farm.	Strategic grazing techniques, feedpad/standoff pad and temporary fencing are all methods that will be utilised to avoid areas of bare land or to minimise effects of compaction of soils.
Identification of Tile Drains.	• Manage Critical Source Areas. • Avoid preferential flow of effluent through drains. • Capture contaminants at drainage outflows. • Effluent Management • Capture nutrients sediment and microbes in wetlands and sediment traps.	Whole Farm.	Apply low depths of effluent (i.e. less than 10mm depth) so nutrients can be assimilated by soils within the top soil water deficit.

Good Management Practice	Mitigation Aims	Location	Method
Appropriate construction of Laneways.	• Manage Critical Source Areas.	Laneways.	Tracks and laneways have been sited away from waterways where possible with the camber directing run-off to land to ensure no overland flow of effluent into McMillian Creek. The existing bridge abutments are to be upgraded to ensure effluent is directed off the bridge to land and not able to discharge directly into water.
Identification of culvert crossings and appropriate construction.	• Manage Critical Source Areas. • Riparian Management.	Whole Farm.	There is one major bridge crossing and three culvert crossings as shown on the site plan in Appendix A.
Swale Management.	• Manage Critical Source Areas. • Capture nutrients sediment and microbes in wetlands and sediment traps. • Effluent Management • Capture contaminants at drainage outflow.	Critical Source Areas.	Identify swale areas prior to grazing and cultivation of land and prior to the application of effluent, and retain grass buffers where necessary. Utilise temporary fencing to keep stock off swale areas during periods of sustained heavy rainfall. Utilise the feedpad/standoff pad particularly on the shoulders of the season. Investigate methods for treating

Good Management Practice	Mitigation Aims	Location	Method
	• Avoid preferential flow of effluent through drains.		tile drain outflow i.e. wetlands or other sediment trap options.

D.5 Grazing Management

Grazing Management is an important tool for minimising the effects of grazing on soil and for reducing the potential for the discharge of sediment and other contaminants to water. Grazing Management techniques which will be employed to reduce risks particularly in proximity to artificial drainage areas and CSA's include;

- Pugging damage will be minimised by avoiding high risk areas (Critical Source Areas and artificial drainage) during risky weather events (i.e. snow/rain). This will be achieved through measures such as temporary fencing and use of the feedpad/standoff pad.
- Feeding supplementary feed away from waterways and Critical Source Areas.
- Planning Wintering Grazing Management in accordance with *Dairy NZ – Wintering in Southland and South Otago – A land management guide to good environmental practice.*
- Leaving grass buffer strips when wintering animals on crop.
- Restricted grazing of sloping land (particularly when wintering) from the top of the slope to the bottom of the slope.

Table 7: Grazing Management Good Management Practices (Currently undertaken and proposed to continue to be undertaken)

Good Management Practice	Mitigation Aims	Location/Zone	Method
Sediment loss from the farm will be minimised where required with	• Manage Critical Source Areas.	At Critical Source Areas i.e. at the end of swales especially	Haybales or Sediment Fence. Riparian planting and maintenance of grass buffers will

Good Management Practice	Mitigation Aims	Location/Zone	Method
the use of sediment traps and bunds.	• Capture nutrients sediment and microbes in wetlands and sediment traps. • Riparian Management • Effluent Management • Reduce P use or loss.	during periods of intensive winter grazing.	help reduce sediment in the event of overland flow episodes.
Minimise periods of exposed soil.	• Protect soil structure, particularly in gullies and near stream areas. • Reduce accumulation of surplus N in the soil, particularly during autumn and winter. • Manage Critical Source Areas. • Capture nutrients sediment and microbes in wetlands and sediment traps. • Riparian Management	Cropped paddocks.	Re-sow harvested crop areas as soon as practical to reduce sediment and nutrient loss.

Good Management Practice	Mitigation Aims	Location/Zone	Method
Consider soil conditions in the crop rotation and be ready to adjust rotation if soil condition is unsuitable for cropping (i.e., soil is compacted).	• Protect soil structure, particularly in gullies and near stream areas. • Manage Critical Source Areas. • Capture nutrients sediment and microbes in wetlands and sediment traps.	Whole Farm.	Check over paddocks prior to cropping to assess suitability for cropping (i.e. slope, compaction, distances to nearby waterways).
Reduce soil erosion.	• Manage Critical Source Areas. • Riparian Management • Protect soil structure, particularly in gullies and near stream areas.	Gateways and laneways.	Maintain laneways, and gravel in gateways.

D.6 Intensive Winter Grazing

Intensive winter grazing is an important element of the farm system, as it enables stock to be fed and wintered on the property. Under the proposed conversion not more than 4 hectares will be planted in crop in any given year and up to 90 cows will be wintered on the property between 31 May and 30 July. [Note: Once cropped areas for coming season are identified, these will be marked on the farm map and recorded in the farm diary].

The risks associated with winter grazing are characterised by the physiographic zone; resulting in two key contaminant pathways for the property; Overland Flow and Artificial Drainage. The Good Management Practices to be adopted on the property to manage the effects of winter grazing are set out in Table 8 below;

Table 8: Intensive Winter Grazing Good Management Practices (Currently undertaken and proposed to continue to be undertaken)

Good Management Practice	Mitigation Aims	Location/Zone	Method
Paddock Selection and Setup.	• Manage Critical Source Areas. • Capture nutrients sediment and microbes in wetlands and sediment traps. • Riparian Management • Effluent Management • Reduce P use or loss.	Whole Farm.	When planning which paddocks will be used for intensive winter grazing consider the location of waterways and Critical Source Areas. Provide and maintain pasture buffer strips between crop areas and waterways and swales.
Nutrient Management.	• Nutrient Management • Manage Critical Source Areas	Whole Farm.	Undertake paddock specific soil testing to match nutrients to demand. Use low solubility P fertiliser
Grazing Management.	• Manage Critical Source Areas.	Whole Farm.	Haybales or Sediment Fence. Riparian planting and maintenance of grass buffers will be used to help reduce sediment

Good Management Practice	Mitigation Aims	Location/Zone	Method
	• Capture nutrients sediment and microbes in wetlands and sediment traps. • Riparian Management • Effluent Management • Reduce P use or loss. • Protect soil structure, particularly in gullies and near streams.		in the event of overland flow episodes. Employ strategic grazing techniques such as back fencing, grazing towards Critical Source Areas and utilise standoff pad/feed pad.

D.7 Cultivation

Cultivation is undertaken on the property as part of planting areas of crop (up to 4 hectares under the proposed conversion) and as part of an overall re-grassing program employed on the property. The effects of cultivation activities will be managed through the continued adoption of the following GMP's;

Table 9: Cultivation Good Management Practices (Currently undertaken and proposed to continue to be undertaken)

Good Management Practice	Mitigation Aims	Location/Zone	Method
Paddock Selection and Setup.	• Manage Critical Source Areas.	Whole Farm.	When planning which paddocks will be cultivated consider the location of waterways and Critical Source Areas. Provide and

Good Management Practice	Mitigation Aims	Location/Zone	Method
	• Capture nutrients sediment and microbes in wetlands and sediment traps. • Riparian Management • Effluent Management • Reduce P use or loss.		maintain pasture buffer strips between cultivated areas and waterways and swales.
Buffer Strips.	• Manage Critical Source Areas. • Capture nutrients sediment and microbes in wetlands and sediment traps. • Riparian Management	Whole Farm	Provide buffer strips along water bodies; • 3m slopes 4 degrees or less • 10m on slopes 4 – 16 degrees • 20m on slopes greater than 16 degrees.

D.8 Farm Infrastructure

Farm Infrastructure Areas will be managed so as to minimise the risk of unauthorised discharges to land or water. High Risk farm infrastructure areas include;

- The Cowshed
- The Feedpad/Standoff Pad
- Silage Pits
- Effluent Ponds

- Calf Shed
- Chemical Shed
- Implement Shed & Fuel Depot

Good Management Practices which will be employed to manage high risk farm infrastructure areas are summarised in Table 10 below; A full list of references in respect to Good Management Practices is provided in Section L FEMP.

Table 10: Farm Infrastructure Good Management Practices

Good Management Practice	Mitigation Aims	Location	Method
Cowshed.	• Effluent Management.	Cowshed	At the cowshed, stone traps and sumps will be checked weekly, and clean stormwater will be diverted from the shed roof to minimise the volume of water entering the effluent storage pond.
Feedpad/Standoff Pad.	• Effluent Management. • Manage Critical Source Areas. • Protect soil structure, particularly in gullies and near stream areas.	Feedpad/Standoff Pad	The feedpad/standoff pad will be designed to capture all effluent and divert this to the effluent management system so as to avoid unauthorised discharges to land or water.
Silage Pits.	• Effluent Management. • Manage Critical Source Areas.	Silage Pits.	Silage Pits will be located so as to ensure that there is no discharge of silage pit leachate to land or water. Any

Good Management Practice	Mitigation Aims	Location	Method
			hardstand silage pit areas will be directed to the effluent storage pond.
Effluent Ponds	• Effluent Management.	Effluent Ponds	The effluent pond will be designed and certified by an appropriately qualified person. The effluent pond will also be fenced and checked for leakage during monthly inspections (or at other frequency as directed by the pond design specifications).
Calf Shed	• Effluent Management. • Unintended discharge to the environment.	Calf Shed	Clean out the calf shed on annual basis and dispose of any solids outside of period 1 May to 30 September in any given year. Ensuring that milk lines are secure and that there are no leaking fittings.
Chemical Shed	• Unintended discharge to the environment.	Chemical Shed	Ensure that all chemicals are stored in accordance with HSNO requirements, including separation distances and bunding requirements. Ensure that chemical shed is locked at all times.

Good Management Practice	Mitigation Aims	Location	Method
Implement Shed & Fuel Depot	• Unintended discharge to the environment.	Implement Shed	Ensure that when refuelling machinery that drip pans are used and hoses are returned to bowsers to avoid discharges of fuel to land. Ensure that when maintaining vehicles that waste oil is collected and disposed of.

E: Water Way Management

E.1 Surface Water

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

The key receiving environments from the property are:

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

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

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

E.2 Groundwater

The property is located within the Awarua Groundwater Zone. Generally, groundwater quality within the Awarua Groundwater Zone complies with limits set in the Drinking Water Standards for New Zealand (DWSNZ).

The 2010 State of the Environment (SOE) monitoring report[2] showed that of the 78 bores sampled in the Waihopai groundwater zone, the median nitrate concentration was 0.25 mg/L which is well below the DWSNZ maximum acceptable value of 11.3 mg/L. This indicates groundwater quality in this zone is very good which is interpreted to reflect the relatively large assimilative capacity of groundwater resources in this zone due to denitrification and/or attenuation processes.

Overall, based on the hydrogeological characteristics of the Waituna Catchment there is relatively low risk of nitrate concentrations accumulating in groundwater to levels that exceed the maximum acceptable value (excluding point-source discharges), however as set out in Section I annual Groundwater Monitoring will be undertaken to determine the effects of the activities on groundwater and the potential for accumulation of nitrate.

Groundwater use will also be recorded through the installation of a water meter and data logger as set out in the anticipated conditions of consent.

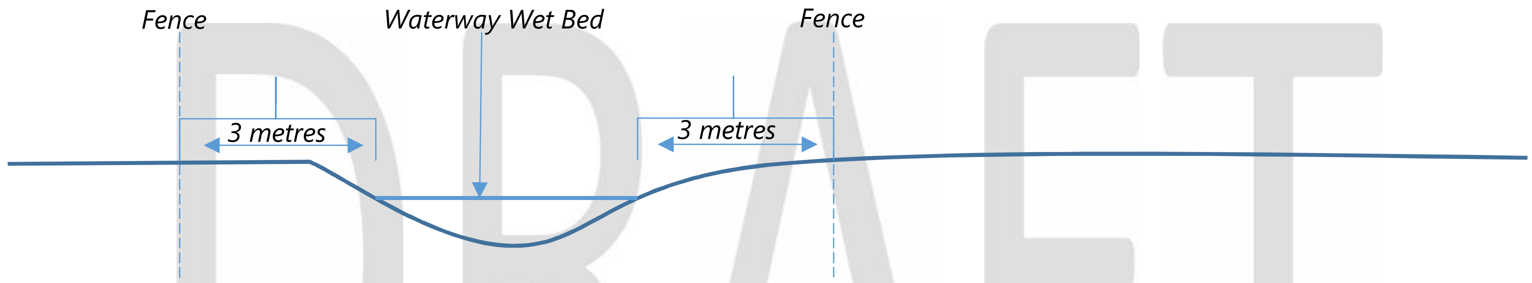
E.3 Fencing of Waterways

The primary waterway (McMillan Creek) which dissects the property is permanently fenced from stock with a minimum 3 meter buffer zone. 3 metres is measured horizontally from the outside edge of the wet bed of the creek, on both sides of the creek. Site inspection by Environment

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

Southland has identified 2 – 3 areas where the fence is closer than 3 metres from the centre line of the bed of the creek. In these locations the fence will be shifted prior to the conversion of the property to ensure that the minimum buffer zone is maintained.

Figure 3: Fencing Buffer Zone Diagram



Where appropriate and as part of good grazing management, temporary fencing will be erected to prevent any point source discharges occurring. This includes fencing off swale areas where they may directly discharge to surface water. Such practices will be adopted as set out elsewhere in this plan, and in the Environment Southland Factsheet on *Critical Source Areas,* and *Dairy NZ Wintering in Southland and South Otago Guide.*

E.4 Riparian Planting

The margins of McMillan Creek have been planted on the western side of the creek. The eastern bank, whilst fenced has not been planted as the creek is subject to regular 'cleaning' which is carried out by Environment Southland, which requires the bank to be free of vegetation which would restrict access to the creek. Accordingly, on the eastern banks of the creek, a grass buffer strip is maintained.

No further riparian planting is able to be undertaken.

E.5 Drain Cleaning

Environment Southland undertake regular clearing of the primary waterway (McMillan Creek) through the property in accordance with Southland Regional Council Flood Control Management Bylaw 2010. During this process the digger operator will clear sediment and material and stockpile this on the banks of the stream. Any drain cleaning works facilitated by Environment Southland are expected to be undertaken in accordance with *Drainage and Channel Maintenance Fact Sheet.*

F: Nutrient Budgeting

F.1 Soil Sampling

Nutrient management is a key component to ensuring good on farm environmental practice. The farm will operate under industry best practice guidelines and in accordance with the Nutrient Budget and Nutrient Management Plan, attached as Appendix E. The Nutrient Management Plan and Budget will be reviewed and updated as required, but on not less than an annual basis. The nutrient budgets have been prepared by a Certified Nutrient Management Advisor. The nutrient budget has been prepared using OVERSEER® 6.2.2 which is the latest version of the model. A copy of Overseer® budget and Nutrient Management Plan are attached as Appendix E.

Regular soil tests will be undertaken to establish the nutrient status of the soils. Soils should be at nutrient levels which avoid any adverse effects on the environment but maintain good pasture production and animal health, by ensuring that the soils are suitable for optimal plant nutrient uptake.

A representative whole fam soil sample at a block level will be undertaken at least once during any 12 month period.

Areas which are receiving FDE will be carefully managed to ensure nitrogen loadings are at acceptable levels and are compliant with conditions imposed by resource consents. The annual effluent nitrogen loading rate shall not exceed 150kg/N/ha. Effluent will be applied utilising low rate application. Effluent management is discussed in Section G of the FEMP.

Levels of potassium will also be monitored to ensure good animal health outcomes, particularly with respect to the effluent block. For more information regarding the nutrients associated with this property please refer to Appendix E of the FEMP for the Nutrient Budget which has been prepared by Miranda Hunter of Roslin Consulting Limited.

F.2 Nutrient Budgets

<u>Assessing Nutrient Losses for consistency with Resource Consent</u>

The resource consent for this dairy operation has been granted on the basis of Nitrogen losses being 29kg/ha/yr and Phosphorus losses of 0.7kg/ha/yr. To ensure that the effects of the dairy farm remain consistent with those proposed in the application the consent holder will periodically assess their actual farming system against the consented farm system in the resource consent.

For the purposes of this FEMP the following terms shall have the following meaning:

1. “Forthcoming Year” means the period from 1 August to 31 July.
2. “Overseer® Benchmark File” is the OVERSEER® input file defined as [?] and attached to and forming part of this Farm Environment Plan.
3. “Milking Season” means the period from 1 August to 30 May.

4. “Nitrogen Loss Calculation” means the amount of nitrogen lost annually from the property over the most recent four year period, including the forthcoming year. The four year period allows for variances in production, climate and farming operation to be taken into account.[3] And reflects the fact that OVERSEER® is a long term average model.

Nitrogen and Phosphorus losses from farm activities to be undertaken in the forthcoming year must be assessed against the farming activities described in the Overseer® Benchmark File.

Process for assessment

A. Using the Overseer® Benchmark File, a report shall be prepared not less than one month prior to the commencement of the Forthcoming Year calculating the losses of nitrogen and phosphorus under the latest version of Overseer®. These losses shall be the ‘Nitrogen Discharge Allowance (“NDA”) for the dairy farming operation under this FEMP.

B. A second report shall be prepared not less than one month prior to the commencement of the Forthcoming Year to determine the Nitrogen Loss Calculation under the latest version of the Overseer® model. This report will be used to ensure that the nitrogen loss calculation does not exceed the NDA.

If the process above indicates that the operation proposed for the Forthcoming Year will give rise to a Nitrogen Loss Calculation that exceeds the NDA, the consent holder will adjust the proposed farming system to ensure that the NDA is not exceeded. Records of the adjustments made to achieve this must be kept and provided to the Council upon request.

The process for assessment must be completed by a Certified Nutrient Management Advisor with the advanced certification.

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[3] Environment Canterbury, Overseer Information Sheet for Farmers, May 2015 www.ecan.govt.nz

Table 11: Good Nutrient Management Practices (currently undertaken and proposed to continue on Farm)

Mitigation	Mitigation Aims	Good Management Practice	Location
Nutrient Management	• Nutrient Management	Prepare a Nutrient Budget as required by Appendix N of the Proposed Southland Water and Land Plan.	Whole farm
		Use proof of placement for fertiliser and farm dairy effluent application.	
		Keep soil Olsen P levels at agronomic optimum; test soils regularly (annually) to check.	Whole farm
		Apply fertiliser up to the edge of the paddock where riparian planting is present and provide a 10m set back from the bed of creeks when applying fertiliser and there is no riparian planting.	Whole farm
		Annual Soil Testing Program	Whole farm

G: Farm Dairy Effluent Management

As at the date of this plan [27 July 2016] the property has not been converted, accordingly there is currently no FDE system operated on the property. The details given below are based on what is proposed to be established as part of the conversion of the property. This plan will be updated at the time of conversion (or as part of any review of the FEMP) to reflect the actual details of the FDE System.

The Farm Dairy Effluent (FDE) section of this plan documents the methods that will be employed in the operation of the FDE System so as to ensure that the discharge of effluent occurs in accordance with anticipated conditions of the consent.

The following reference document will be utilised in the operation of the FDE System "*Dairy NZ Staff Guide to Operating Your Effluent Irrigation System – Low Rate System".* A full list of reference documents is set out in Section K FEMP.

G.1 Effluent System Overview

Total Effluent Disposal Area (ha)	93 ha	Available Storage Volume:	930 Cubic Metres	Maximum Daily Application Depth:	20 mm/daily application
High Risk Soils (ha)	93 ha	Storage Type:	Above Ground Tank	Maximum Pulsed Depth Rate:	10mm/hour
Low Risk Soils (ha	-	Application System:	Larral Smart Hydrant		

G.2 FDE Good Management Practices

All practicable steps will be taken to reduce FDE generation on the property. The following general guidelines as outlined by Dairy NZ will be adopted;

- Minimise water use – the applicant will utilise a green wash system.
- Clean stone trap regularly.
- Maintain and Service all parts of the effluent system.
- Ensure application conditions are acceptable prior to beginning application.

By reducing the amount of effluent and sludge at the source, i.e. the dairy shed; it can be expected that less effluent will require disposal in the long run. Effluent can be minimised as follows;

- Treat the herd gently to avoid upset.

- Reduction of cow stress levels by being quiet and even tempered.
- Reduction of the potential for loud and or unusual noises.
- Reduction of situations cows are not accustomed to.
- Keep use of hoses to a minimum and ensure efficient use of water.
- Repair leaks immediately and maintain storm water drains.
- Recycle water where possible.

G.3 FDE Operational Guide

Prior to the operation of the effluent system, the following steps shall be undertaken;

- Check weather forecasts and avoiding application during or immediately prior to predicted high intensity rainfall events
- Check and record soil moisture levels. Effluent **MUST NOT** be discharged when the soil is at field capacity. Soil Moisture will be tested on farm (via hand held meter) prior to each application of effluent.
- Check wind conditions to ensure that effluent can be discharged without resulting in spray drift and odour beyond the boundary of the property
- Set timer clock on the effluent pump for required duration i.e. One hour
- Check that the effluent pump has come up to optimum operating pressure
- Check all of the nozzles are unblocked
- Check the effluent line for any leaks
- During operation perform regular checks to ensure that the discharge is not resulting in ponding or surface run-off. If surface ponding is occurring, switch the effluent system off, and re-check soil moisture levels
- Record details of the effluent disposal duration, volume and location and keep records for future reference (record these details on the form attached as Appendix D).

G.4 FDE System Monitoring

Following the installation of the FDE system, the system shall be certified by a suitably qualified person that it has been designed and constructed in accordance with the "*Environment Southland Code of Practice for Design and Construction of Agricultural Effluent Ponds, March 2009".*

Within one month of the installation of the FDE system, the application rate of the system will be assessed utilising the *Bucket Method* as set out in the "*Dairy NZ Staff Guide to Operating Your Effluent Irrigation System – Low Rate System"* and records of the assessment kept.

Application Rates shall be assessed annually thereafter in accordance with the methodology specified in *Dairy NZ Staff Guide to Operating Your Effluent Irrigation System – Low Rate System.*

G.5 FDE System Maintenance

Maintenance of the effluent system is essential to ensure that the system is working as intended. Monthly maintenance checks will be undertaken to ensure that all parts involved in the catchment, storage and disposal of effluent are functioning correctly.

The following checks will be undertaken on a regular basis and details recorded:

- Clean stone traps (monthly);
- Check the sump is clear of solid material. If necessary, arrange to clean out the sump;
- Regularly clear the tank of solids when required (expected to be once every two years);
- Check nozzles are clear and in good working order; and
- Check effluent pipe is in good working order and does not have any leaks.

Any matters requiring follow up shall be followed up immediately. A monthly check sheet template is attached as Appendix D.

G.6 FDE System Training

The efficient operation of the effluent system in accordance with the conditions of consent requires staff to be sufficiently trained in the use and operation of the effluent system, including an awareness of the conditions of the consent which control the discharge of effluent.

The Farm Owner will be responsible for ensuring that all staff are trained in the operation and maintenance of the effluent discharge system, and for training new employees. A guide to staff training requirements is detailed in Appendix D, and shall be completed once training has been provided. Effluent training should be revisited or recapped at the beginning of each season to ensure all staff, new and existing, are aware of consent requirements and responsibilities.

Opportunities for further training to improve effluent management will also be identified and undertaken as appropriate, including encouraging attendance at Dairy NZ Effluent Management Workshops/Training and fieldays or similar industry recognised training.

H: Monitoring Programme

Water quality monitoring shall be undertaken to provide an indicative assessment of loss of nutrients to surface water from the property. The purpose of this monitoring is to enable an assessment of the effectiveness of on-farm management practices to ensure that the farm is operated in accordance with the conditions of consent, and in a manner which does not increase the discharge of nutrients (particularly nitrogen and phosphorus). The monitoring program documents methods for monitoring nutrient loads to surface water H.1 to H.6) and methods for monitoring nitrate leaching to shallow groundwater (H.7 to H.12).

As at the date of this plan [27 July 2016] the property has not been converted. The monitoring program as set out below is intended to be implemented in conjunction with the conversion of the land. Where there is a delay in the completion of the conversion, it is intended that a series of baseline water quality sampling will be undertaken such that reflects current landuse providing a benchmark value. These baseline values will be collected in accordance with the parameters set out in H.1 to H.6 below.

H.1 When to Monitor Surface Water

This section sets out the optimum time that samples should be collected. Monitoring data show that the highest N and P concentrations and loads occur under the highest flows. The primary contaminant pathways on the property have been identified as being overland flow and via artificial drains. Therefore, **monitoring shall occur** during high flows, which are defined as periods when;

Soil moisture is at or above 75% of field capacity and there is (or is predicted) more than 10 mm of rainfall over a 24-hour period; or, When flow in the Waituna Creek at Marshall Road is above 5,000 litres per second (mean annual flood level)[4].

Under these conditions, it is likely that overland flow and mole-pipe drain discharge will be occurring. It is noted that soil moisture is typically highest between April and October so this is the period when sampling is most likely to occur.

It is noted by Diffuse Sources and NIWA (2012) that other activities, such as drain clearing, are likely to be major contributors to nutrient and sediment loads to the Waituna Lagoon. The consent holder will document when drain clearing occurs (it is noted that drain clearing on the property is undertaken by Environment Southland).

H.2 Frequency of Monitoring of Surface Water

Monitoring shall take place at least twice over any 12-month period. Monitoring shall also be taken under the current land use in order to establish a benchmark.

H.3 What to Monitor for Surface Water

All water quality monitoring should include the following as a basic site description:

- Site name
- Date

[4] This is Diffuse Sources and NIWA's (2012) definition of a "storm event" at this site

- Time (to the nearest minute, and specify whether in NZST (standard time) or NZDT (daylight savings))
- Weather observations e.g. is it raining, overcast, fine, windy
- Sample water observations e.g. is it clear/turbid, what colour
- Land use on the property in the catchment area being sampled e.g. recent effluent/fertiliser application, no stock, crop type
- It is good practice to take a photo of the water being sampled, and general surrounds. This is particularly useful should there be some anomalous lab results or to document other activities (such as drain clearing) which might affect results.

Tile drain discharge

Flow: time (to the nearest second) how long it takes to fill a container of a known volume. For example, if it takes 20 seconds to fill a 10 litre bucket, the flow is 0.5 litres per second (i.e. volume divided by time). This should be repeated at least twice in order to obtain an average flow for each tile drain sampled.

Water quality parameters (as recommended by Diffuse Sources and NIWA (2012) for characterising nutrient and sediment loads to the Waituna Lagoon):

- Total suspended solids (TSS)
- Nitrate + Nitrite – Nitrogen (NNN)
- Total ammoniacal nitrogen (TAN)
- Dissolved organic nitrogen (DON)
- Total nitrogen (TN)
- Dissolved reactive phosphorus (DRP)
- Total dissolved phosphorus (TDP)
- Total phosphorus (TP)
- *E.coli*

- Electrical conductivity (EC)

Note: TDP and DON allow characterisation of the proportion of particulate versus dissolved/colloidal nutrients and it is not possible to estimate particulate or total dissolved nutrient loads without these parameters.

H.4 Who Shall Monitor Surface Water

Monitoring shall be carried out by a suitability qualified expert or an individual who has been trained by a suitably qualified expert (note: the training does not need to occur under the sampling conditions described above).

If the sampling is to be undertaken by an individual who was been trained by a suitably qualified expert, the expert shall provide documentation of the training to demonstrate competency. Monitoring could also be subject to independent auditing (i.e. by Environment Southland) on an annual basis.

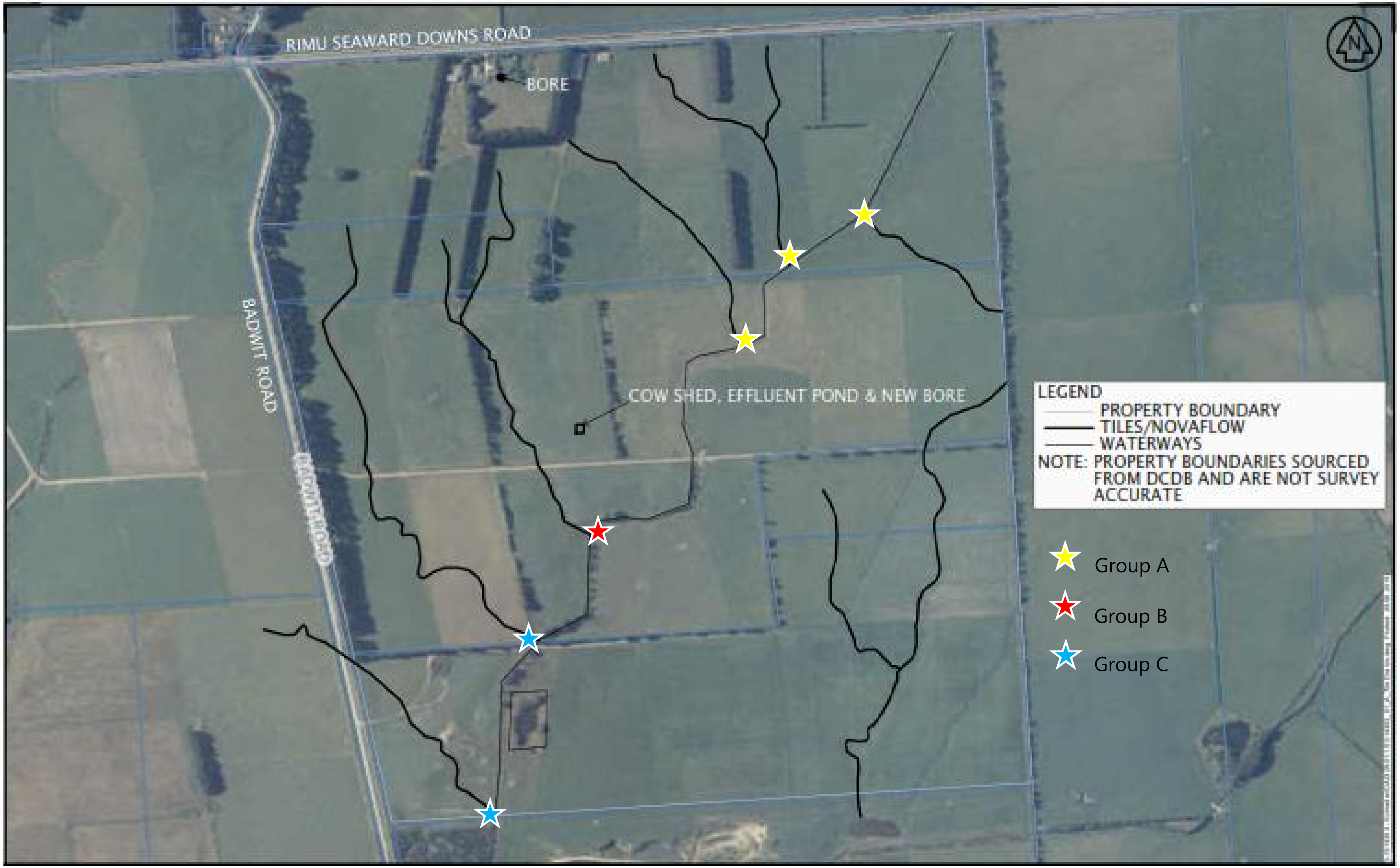
H.5 Where to Monitor Surface Water

Surface water monitoring shall be undertaken at tile drains which are discharging. At least one drain from Groups A, B and C (see map below) shall be monitored on each sampling occasion. The more discoloured discharge from the tile drains should be preferentially sampled as these represent the greatest likelihood of capturing the highest contaminant loss.

Tile Drain Discharge – Group B Location

Sampling to be taken at outfall as shown.

Figure 5: Surface Water Sampling Locations



H.6 Response to Monitoring of Surface Water

The monitoring results from the current land use can be used to provide a benchmark of N and P loads (referred to as the 'benchmark level').

Modelled losses should not exceed 29 kg N/ha/year and 0.6 kg P/ha/year, or equivalent if the Overseer® version changes (referred to as the 'maximum threshold level').

The outputs from the Overseer® modelling (to be done annually to incorporate any changes in the farm operation or soil tests) should also be assessed against the monitoring results to ensure best practices are being applied (referred to as the 'annual level').

If sampling results indicate N or P losses exceed either the benchmark or maximum threshold levels, or if concentrations in tile drain discharge exceeds that measured in the receiving environment, an investigation into the cause must be undertaken by suitably qualified person(s). This may include additional water quality sampling (e.g. upstream and downstream of the property) as appropriate. The results of the investigation must be reported to Environment Southland.

The monitoring results, including an assessment against the annual level, should be incorporated in the annual review of the FEMP.

Note: The levels are difficult to establish without knowing what the maximum flow from the tile drains are. However, set out below is a methodology that could be used to set those limits once the data has been collected.

Tile drain flow (m^3/s) x TN or TP (g/m) concentration= tile drain load ($g/m^2/s$). Multiple this by 3.1536 to get an estimate of kg TN or TP/ha/year.

DON, TAN, NNN, DRP, and TDP can be used to help determine the likely source of TN and TP (e.g. how much is natural inputs) and will inform any investigation (if required).

H.7 When to Monitor Ground Water

Groundwater samples are best monitored in autumn and spring. Surplus nitrogen will accumulate in the soil over summer and early autumn, and will then be flushed through as soil drainage initiates in late autumn. The autumn sample should target this 'first flush' which can be determined from soil moisture and rainfall monitoring. The spring sample should better reflect average nitrate leaching that occurs during the drainage season (i.e. during winter and spring when soils are wet and tends to be when most drainage occurs).

H.8 Frequency of Monitoring of Ground Water

Groundwater monitoring shall be undertaken twice per year.

H.9 What to Monitor for Ground Water

All water quality monitoring should include the following as a basic site description, and records documenting this information shall be kept:

- Site name
- Date
- Time (to the nearest minute, and specify whether in NZST (standard time) or NZDT (daylight savings))
- Weather observations e.g. is it raining, overcast, fine, windy
- Sample water observations e.g. is it clear/turbid, what colour
- Land use around the bore e.g. recent effluent/fertiliser application, no stock, crop type
- It is good practice to take a photo of the bore being sampled, and general surrounds. This is particularly useful should there be some anomalous lab results.

Water quality parameters:

- Nitrate + Nitrite – Nitrogen (NNN)
- Total ammoniacal nitrogen (TAN)
- Dissolved reactive phosphorus (DRP)
- *E.coli*
- Electrical conductivity (EC)
- Chloride (Cl)
- Total iron (Fe)
- Total manganese (Mn)

Fe and Mn should be sampled for the first two sampling rounds to ensure groundwater is not oxygen-reducing. Nitrate tends to denitrify (i.e. convert to gas) in oxygen-reducing water. Therefore, if groundwater is reducing, it is unlikely that nitrate will accumulate to high levels.

H. 10 Who Shall Monitor Ground Water

Monitoring shall be carried out by a suitability qualified expert or an individual who has been trained by a suitably qualified expert (note: the training does not need to occur under the sampling conditions described above).

If the sampling is to be undertaken by an individual who was been trained by a suitably qualified expert, the expert shall provide documentation of the training to demonstrate competency. Monitoring could also be subject to independent auditing (i.e. by Environment Southland) on an annual basis.

H.11 Where to Monitor Ground Water

Groundwater shall be monitored from a shallow groundwater monitoring bore which shall only be used for monitoring purposes. The site of the groundwater monitoring bore shall be agree in writing with Environment Southland's Compliance Manager. Where agreed by Environment Southland an existing bore on the property may be utilised for monitoring purposes, or a new bore shall be located within one of the general areas marked below (in blue).

Figure 6: Groundwater Monitoring Location Plan

H.12 Response to Monitoring of Ground Water

The monitoring results will be incorporated in the annual review of the FEMP. If, over the course of 2 years, nitrate concentrations increase by more than 0.5 mg/L, then a suitably qualified nutrient management advisor should undertake a review of N management. A suitability qualified expert shall also review the frequency of monitoring if an increase is identified.

I: Compliance & Reporting

The conditions of resource consent (Appendix B) shall be complied with at all times. Sections I.1 and I.2 set out the records which are required to be kept which will enable the Consent Holder to demonstrate compliance, as well as detailing the reporting requirements of the consent(s). The Consent Holder will also participate in annual compliance monitoring inspection programs that are to be implemented by Environment Southland.

I.1 Records to be Kept

To demonstrate compliance with the conditions of consent, and to enable an auditable review of the FEMP the following records shall be kept and maintained by Schrader Mains Limited;

- Accurate and auditable records of annual farm inputs, outputs and management practices i.e. Fonterra Farm Diary
- Farm Risk Map
- Nutrient Budget
- Nutrient Management Plan
- Soil Sampling Results
- Water Quality Sampling Results & Records
- Water Abstraction Data Records

- Water Meter Certification
- Effluent Area Map
- Effluent Records i.e. Effluent Application Diary
- Soil Moisture Probe Readings
- Staff Training Records
- Farm Procedures Manual
- Application Depth Test Results
- Monthly Maintenance Check Sheets
- Fertiliser Application Records including rates
- Crop types, locations and yields
- LIC Herd Records (proof of herd composition/age and type of stock carried on property)
- Animal Transfer Cards (proof of transport of herd outside of catchment)

I.2 Reporting

Annual reporting requirements are set out in the conditions of resource consent and include;

- Prior to the first exercise of the Effluent Discharge Consent the Consent Holder shall notify Environment Southland of the operator of the effluent system;
- Prior to the expiry of the Bore Consent the Consent Holder shall provide details of the bore [as set out in Condition 4 Bore Consent] to Environment Southland;
- Within one month of the first exercise of the Water Permit the consent holder shall provide a copy of the installation certificate for the water meter and data logger.

- Upon completion of the construction of the effluent storage pond written confirmation from a suitably qualified person shall be provided to Environment Southland to certify the pond has been constructed in accordance with the appropriate code.
- The Effluent Management Plan Shall be reviewed annually and results of the review reported to Environment Southland by 31 July each year;
- The Farm Environmental Management Plan shall be reviewed annually and results of the review reported to Environment Southland by 31 July each year;
- The Consent Holder shall provide records from the datalogger by 31 July each year.

J: Annual Review & Audit of FEMP

The FEMP shall be reviewed by a suitably qualified person on an at least annual basis. The review shall include (but not be limited to) an assessment of;

Verification of compliance with conditions of consent

Details of the implementation of Good Management Practice and identification of any new Good Management Practices that would be appropriate to employ on the farm to manage risks identified in Section B FEMP.

Overseer® parameter inputs report to confirm that the activity is being carried out in accordance with conditions of consent, and nutrient losses remain consistent with those proposed at the time consent was sought

A property specific environmental risk assessment, including a description of the risks to water quality, which shall be prepared by a suitably qualified person and which identifies any farm specific environmental risks along with measures to mitigate the identified risks.

Review of the data obtained from the monitoring undertaken in accordance with FEMP and any changes made or to be made to farming practice as a consequence of that monitoring data.

A report detailing items above shall be submitted to the consent authority no later than the 31 July each year including an updated version of the FEMP if any amendments have been made.

K: Industry Guidelines

A complete list of the industry guidelines which have been referenced in the development of this FEMP are listed below. The Consent Holder is also referred to the following general sources for guidance in respect to the operation and management of their property.

- Environment Southland www.es.govt.nz
- Dairy NZ www.dairynz.co.nz
- Fonterra www.fonterra.com

Reference Documents/Guidelines;

Dairy NZ – A staff guide to operating your effluent irrigation system – Low Rate System

Dairy NZ – A farmer's guide to managing farm dairy effluent – A good practice guide for land application systems

Dairy NZ – Wintering in Southland and South Otago – A land management guide to good environmental practice

Dairy NZ – Land management on Canterbury Dairy Farms – Managing land to reduce sediment and phosphorous loss

Environment Southland Factsheet – Critical Source Areas

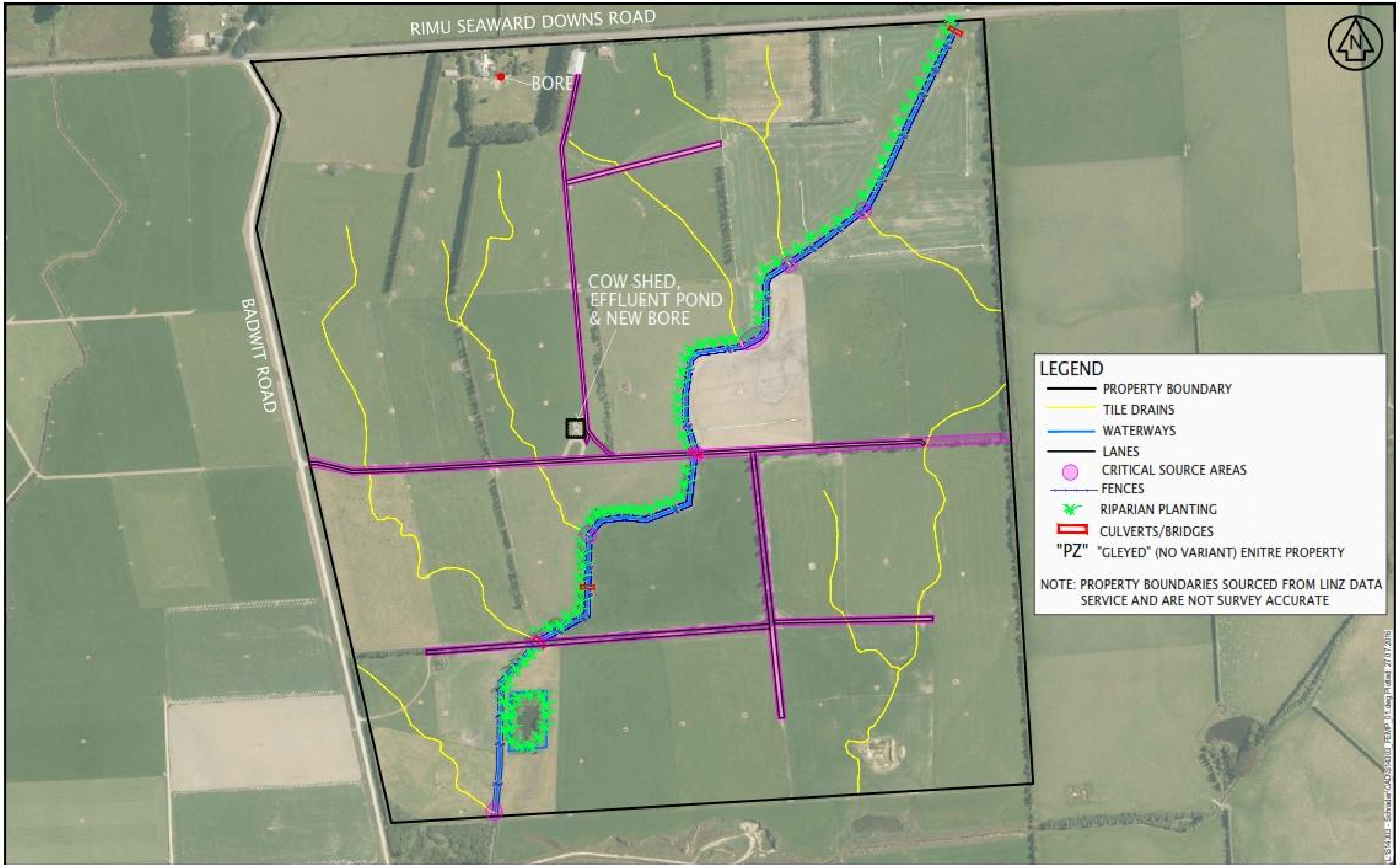
Environment Southland Factsheet – Drainage and Channel Maintenance

Environment Canterbury – Information Sheet for Farmers on OVERSEER®

Sustainable Dairying: Water Accord

APPENDIX A

FEMP SITE PLAN



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NOTES

SCHRADER MAINS LTD
FEMP SITE PLAN

Rev.	Date	Revision Details	By
-	-	-	-

Surveyed	Signed	Date	Job No.	Drawing No.
			S14303	01
Drawn: SLC	Signed	Date: 27.7.16	Scale: 1:2500 @ A1, 1:5000 @ A3	
Designed	Signed	Date	Datum & Level: NZTM 2000	Rev.: -

APPENDIX B

RESOURCE CONSENTS

APPENDIX C

INTENSIVE WINTER GRAZING AREA 2016/17

APPENDIX D

EFFLUENT SYSTEM RECORDS

APPENDIX E

NUTRIENT BUDGETS