Contents

Section 32 Supporting Documents

20 May 2016

Southland Water and Land Regional Plan - Assessment of Plan in meeting Ngāi Tahu aspirations to assist Environment Southland in informing its S32 Analysis

The table below has been prepared by Te Ao Marama Inc,. on behalf of Ngai Tahu ki Murihiku, as an indicative guide to how the draft proposed Southland Water and Land Regional Plan (the "Plan") meets key outcomes and aspirations of Ngāi Tahu. The table provides a 'high level' assessment of the aspirations of Ngai Tahu against the Plan's provisions, and was designed to assist Environment Southland in drafting its Section 32 Report for the Plan. This document is not to be read as, or used as the formal position of Ngāi Tahu, including Papatipu Runanga and their environmental entities, on the Plan. It is a basic analysis of the extent to which the Plan incorporates elements beneficial to Ngāi Tahu rights, interests and values, as well as highlighting areas where costs to the tribe are associated with adverse environmental conditions.

In its assessment, Te Ao Marama Inc has used aspirations Ngai Tahu has previously articulated in the Ngai Tahu Deed of Settlement 1997, and in its strategic and Resource Management Act 1991 recognised documents and tools. The aspirations and legislative provisions in this table are from:

- Ngai Tahu Claims Settlement Act 1998
- Fisheries Act 1996
- Ngai Tahu 2025
- Ngai Tahu Freshwater Policy 1996
- Te Tangi a Tauira – the Cry of the People: Ngāi Tahu ki Murihiku Natural Resource and Environmental Iwi Management Plan 2008

As indicated by Environment Southland the Plan combines two operative regional plans and moves to implement the National Policy Statement for Freshwater Management. In its analysis Te Ao Marama Inc has looked at the Plan in its entirety but noting that there are three groups based on the significance of the change from the operative regional plans. Environment Southland has indicated that the matters that require more significant changes and that have been analysed in more depth are:

- Diffuse nutrient discharges/farming
- Incorporating Ngai Tahu values
- Stock exclusion
- Cultivation
- Effluent systems (commercial/community and domestic)
- Water takes (permitted activity thresholds and schedules)
- Wetlands

The mid-level changes seek are:

- Vertebrate pest control
- Tile drains
- Dust Suppressants
- Minor discharges (cemeteries, solid animal and vegetative wastes, horticultural washwater)

The minor changes are not substantive and are generally technical corrections of omissions, improvements to certainty and clarity, and drafting improvements.

Legend – Contribution of Plan towards meeting Ngāi Tahu Objectives and Outcomes	
(green)	Optimum
(blue)	Good
(yellow)	OK – could go further
(red)	A lot more required
(black)	No contribution

Ngai Tahu 2025 - Outcomes

Outcomes	Specific provisions in Plan that address outcomes				Contribution of Plan towards meeting outcomes	Explanation of assessment
	Objective	Policy	Rule	Other		
The abundance of, access to and use of mahinga kai is increased	5	18, 22, 29 and 44		Glossary Appendix K		Where the Plan provides for maintenance and improvement of water quality, and matters such as the protection of estuaries and riparian habitats, this progresses towards improved abundance of mahinga kai.
Councils have adopted in their everyday practice Ngai Tahu philosophies such as Ki Uta Ki Tai planning.	2, 3, 4, 5, 6, 9, 13 and 15	1, 2, 3, 39A, 44 and 45				The Plan incorporates concepts of Ki uta ki tai and Te Mana o te Wai.
All wahi tapu, mahinga kai and other taonga tuku iho are adequately and appropriately protected according to Ngai Tahu values and interests	5, 9, 13 and 15	1, 2, 3, 20, 22, 24 28 and 29	9, 32, 40, 42 - 44, 49, 51, 53, 55, 57 - 64, 66 - 68, 70, 72, 73 and 75 – 78	Glossary Appendices E, K and M		The Plan provides some protection for wāhi tapu, mahinga kai and other taonga tuku iho although not all objectives and policies are carried through into rules
Te Rūnanga o Ngāi Tahu is actively managing a number of sites, resources and areas either in joint partnership with another agency or as the sole manager. Iwi members are employed in the management of these sites, resources and areas.	4 and 5	1, 2, 20, 24, 28, 40, 44, 45 and 47	57, 58, 59, 63, 64, 67, 68, 72 and 73	Financial Contributions Glossary		The Plan improves upon existing plan provisions, increasing the ability for Ngāi Tahu ki Murihiku to exercise rangatiratanga. The Plan refers to the Charter of Understanding in Policy 1 and recognises nohoanga, mātaitai taiapure and marae.
All waterways are enhanced and restored meeting cultural standards, being void of weeds, having indigenous riparian corridors, with water quality and quantity sufficient to support healthy populations of species of cultural significance.	2, 3, 4, 6, 7, 8, 9, 14, 15, 17 and 18	1 - 25, 27 - 35, 39 - 42, 44, 45 and 47				The Plan incorporates mechanisms that are intended to maintain and improve water quality. However, links between water quality and matching land type with land use activities in high risk areas or high risk activities have not been adequately achieved.
Te Rūnanga o Ngāi Tahu fully participates in the decision-making processes of resource management agencies	4 and 5	1, 2, 20, 24, 28, 40, 44, 45 and 47	57, 58, 59, 63, 64, 67, 68, 72 and 73.	Financial Contributions Glossary		The Plan improves upon existing plan provisions, increasing the ability for Ngāi Tahu ki Murihiku to exercise rangatiratanga

Tikanga is applied in caring for our wähi taonga and the use of well-nurtured and maintained mahinga kai.	Reflected in 1, 2, 3, 4, 5 and 15	Reflected in 1, 2, 3, 44 and 45				The plan recognises and provides opportunities in the management of tribal assets and freshwater quality.
Systems are in place to ensure the ongoing protection of taonga and access to these by all Ngāi Tahu Whānui.	3, 5, 9, 13 and 15	3, 20, 22, 24, 28 and 29	9, 32, 40, 42 - 44, 49, 51, 53, 55 - 64, 66 - 68, 70, 72, 73, 75 - 78	Glossary Appendices E, K and M Financial contributions		The Plan provides some protection for wai and taonga species
Māori property rights are recognised by the Crown and customary management regimes are in place.	4	No specific provisions	No specific provisions	No specific provisions		Recognition of Māori property rights is not provided for in the Resource Management Act 1991 and therefore not addressed in the Plan.
Papatipu Rūnanga have a strong influence in their takiwā.	Reflected in 4 and 5	Reflected in 1, 2, 20, 24, 28, 40, 44, 45 and 47	Reflected in 57, 58, 59, 63, 64, 67, 68, 72 and 73	Reflected in Financial Contributions		The Plan includes provisions for the ability for Ngāi Tahu ki Murihiku to exercise rangatiratanga
Te Rūnanga o Ngāi Tahu is consulted in the development of all government social, environmental and other policy impacting on Ngāi Tahu Whānui.	Reflected in 4 and 5	Reflected in 1, 2, 20, 24, 28, 40, 44, 45 and 47	Reflected in 57, 58, 59, 63, 64, 67, 68, 72 and 73	Reflected in Financial Contributions		The Plan provides for engagement with Ngāi Tahu ki Murihiku.

Ngāi Tahu Freshwater Policy 1996 - Objectives

Objectives	**Specific provisions in Plan that address objectives**				**Contribution of Plan towards meeting objectives**	**Explanation of assessment**
	Objective	**Policy**	**Rule**	**Other**		
To afford total protection to waters that are of particular spiritual significance to Ngāi Tahu	3, 4, 9, and 17	1 - 25, 27 - 35, 39 - 42, 44, 45 and 47				The Plan does not afford total protection for waters of particular spiritual significance to Ngai Tahu. The Plan incorporates mechanisms that are intended to maintain and improve water quality. However, links between water quality and matching land type with land use activities in high risk areas or high risk activities have not been adequately achieved.

Restore, maintain and protect the mauri of freshwater resources	3 and 4	1 - 25, 27 - 35, 39 - 42, 44, 45, 47				The Plan incorporates mechanisms that are intended to maintain and improve water quality. However, links between water quality and matching land type with land use activities in high risk areas or high risk activities have not been adequately achieved.
To maintain vital, healthy mahinga kai populations and habitats capable of sustaining harvesting activities	5 and 15	Policies 18, 22, 29, 44		Glossary Appendix K		Where the Plan provides for maintenance and improvement of water quality, and matters such as the protection of estuaries and riparian habitats, this progresses towards improved abundance of mahinga kai.
To promote collaborative management initiatives that enable the active participation of Ngai Tahu in freshwater management	4 and 5	1, 2, 20, 24, 28, 40, 44, 45 and 47	57, 58, 59, 63, 64, 67, 68, 72 and 73	Financial Contributions Glossary		The Plan improves upon existing plan provisions, increasing the ability for Ngāi Tahu ki Murihiku to exercise rangatiratanga

Te Tangi a Tauira – the Cry of the People Ngāi Tahu ki Murihiku Natural Resource and Environmental Iwi Management Plan 2008 – Outcomes

Outcomes	Specific provisions in Plan that address outcomes				Contribution of Plan towards meeting outcomes	Explanation of assessment
	Objective	Policy	Rule	Other		
That Ngāi Tahu ki Murihiku is involved at a level that allows for effective and proactive management of natural resources, wāhi tapu and wāhi taonga in a manner that upholds the kaupapa of this Plan.	4 and 5	1, 2, 20, 24, 28, 39A, 40, 44, 45 and 47	57, 58, 59, 63, 64, 67, 68, 72 and 73	Financial Contributions section Glossary		The Plan improves upon existing plan provisions, increasing the ability for Ngāi Tahu ki Murihiku to exercise rangatiratanga
That there is mutual understanding of iwi and local authority values and responsibilities with respect to the environment, effective management of resources by councils, and effective performance of kaitiaki by Ngāi Tahu ki Murihiku.	4 and 5	1, 2, 20, 24, 28, 40, 44, 45 and 47	57, 58, 59, 63, 64, 67, 68, 72 and 73	Financial Contributions section Glossary		The Plan improves upon existing plan provisions, increasing the ability for Ngāi Tahu ki Murihiku to exercise rangatiratanga
That the principle of Tino Rangatiratanga is enhanced and partnerships formed and extended.	Reflected in 4 and 5	Reflected in 1, 2, 20, 24, 28, 40, 44, 45 and 47	Reflected in 57, 58, 59, 63, 64, 67, 68, 72 and 73	Reflected in Financial Contributions		The Plan improves upon existing plan provisions, increasing the ability for Ngāi Tahu ki Murihiku to exercise rangatiratanga

That users of this Plan understand the principles of the Treaty of Waitangi and that the interests and values of Ngāi Tahu ki Murihiku are protected and enhanced. This includes the safe guarding of all cultural heritage and significant sites and places.	Reflected in 3, 4, 5, 9, 13, and 15	Reflected in 1, 2, 3, 44 and 45				The Plan being structured around Te Mana o Te Wai and ki uta ki tai show an understanding of the principles of the Treaty of Waitangi and the interests and values of Ngāi Tahu ki Murihiku.
That territorial, regional and central government authorities foster the development of Ngāi Tahu ki Murihiku capacity to contribute to decision making processes, including involvement in long term community strategies across Murihiku.	Reflected in 4 and 5	Reflected in 1, 2, 20, 24, 28, 40, 44, 45 and 47	Reflected in 57, 58, 59, 63, 64, 67, 68, 72 and 73	Reflected in Financial Contributions		The Plan improves upon existing plan provisions, increasing the ability for Ngāi Tahu ki Murihiku to exercise rangatiratanga
That the level of trust and collaboration that is identified between Murihiku councils and Ngāi Tahu ki Murihiku continues as part of normal daily business.	Reflected in 4 and 5	Reflected in 1, 2, 20, 24, 28, 40, 44, 45 and 47	Reflected in 57, 58, 59, 63, 64, 67, 68, 72 and 73	Reflected in Financial Contributions		The Plan improves upon existing plan provisions, increasing the ability for Ngāi Tahu ki Murihiku to exercise rangatiratanga
That it becomes the norm for Ngāi Tahu ki Murihiku values to become embedded in planning documents and management practices used by all agencies working with natural and physical resources and developing environmental policy.	3, 4, 5 and 15	1, 2, 3, 44 and 45				The Plan provides for Ngāi Tahu ki Murihiku values including Te Mana o te Wai and Ki uta ki tai. Through the inclusion of such values, this will assist in ensuring these are applied and used.
To ensure that this Plan is used in a consistent manner in respect to Ngāi Tahu ki Murihiku response to natural resource and environmental management policy development and consent applications.	Reflected in 4 and 5	Reflected in 1, 2, 20, 24, 28, 40, 44, 45 and 47	Reflected in 57, 58, 59, 63, 64, 67, 68, 72 and 73	Reflected in Financial Contributions		The Plan provides for Ngāi Tahu ki Murihiku values including Te Mana o te Wai and Ki uta ki tai. Through the inclusion of such values this will assist in ensuring these are applied and used.
To ensure environmental outcomes accommodate for cultural and traditional spiritual values held by Ngāi Tahu ki Murihiku.	2, 3, 4, 5, 9, 13 and 15	1, 2, 3, 44 and 45				The Plan provides for Ngāi Tahu ki Murihiku values including Te Mana o te Wai and Ki uta ki tai. Through the inclusion of such values this will assist in ensuring these are applied and used.
That integrated management of natural and physical resources is encouraged and that existing relationships with and between local agencies are maintained and enhanced to ensure collaborative goals are set and worked toward.	1, 2, 3, 4, 9 and 13	Referenced in 1, 2, 3, 44 and 45				The Plan provides for integration through provisions relating to Te Mana o te Wai and Ki uta ki tai. The Plan also refers to the Charter of Understanding in Policy 1. Through the inclusion of such values this will assist in ensuring these are applied and used

To ensure the protection, restoration and enhancement of the productivity and life supporting capacity of mahinga kai, indigenous biodiversity, air, water, land, natural habitats and ecosystem, and all other natural resources valued by Ngāi Tahu ki Murihiku.	1, 2, 3, 5 - 9, 13 and 15	1, 2, 3, 44 and 45				The Plan incorporates mechanisms that are intended to maintain and improve water quality. However, links between water quality and matching land type with land use activities in high risk areas or high risk activities have not been adequately achieved.
That Ngāi Tahu ki Murihiku become actively involved in the delivery and awareness of the kaupapa of this Plan with respect to protection and enhancement of the natural environment. This includes the delivery of programmes that promote awareness and provide education regarding the environment to achieve environmental outcomes.	Reflected in 4 and 5	Reflected in 1, 2, 20, 24, 28, 40, 44, 45 and 47	Reflected in 57, 58, 59, 63, 64, 67, 68, 72 and 73	Reflected in Financial Contributions		The Plan includes provisions for the ability for Ngāi Tahu ki Murihiku to exercise rangatiratanga
That Ngāi Tahu ki Murihiku capacity is enhanced to become more involved in "on the ground" monitoring of environmental ecosystems.	Recognised in3	Recognised in 2				The Plan provides for the assessment of water quality and quantity based on Ngāi Tahu indicators of health.
That the planning and delivery of council's regulatory roles in achieving outcomes will take into account and recognise for the potential positive or negative effects that such actions may have on the health and well-being of the Murihiku community.	Recognised in 1, 2, 3, 4, 5, 9 and 13	Recognised in 1, 2, 3, 44 and 45				The Plan recognises and provides for the health and wellbeing of the Murihiku community.
That a sense of belonging and social responsibility with respect to the surrounding environments is encouraged. This includes supporting activities and events that engage communities with their local environments.	Recognised in 1, 2, 3, 4, 5, 9 and 13	Reflected in 1, 2, 20, 24, 28, 40, 44, 45 and 47				The Plan provides for Ngāi Tahu ki Murihiku values including Te Mana o te Wai and Ki uta ki tai.
Ensure that agencies with a statutory role representing our communities recognise Ngāi Tahu ki Murihiku relationships and act in a manner whereby processes and the decisions affecting social well-being are transparent and open.	4 and 5	Reflected in 1, 2, 20, 24, 28, 40, 44, 45 and 47				The Plan provides for Ngāi Tahu ki Murihiku values including Te Mana o te Wai and Ki uta ki tai.

To ensure that the diversity of our communities is represented in forums and elected bodies to ensure awareness and understanding of differing views and values held.	Reflected in4 and 5	Reflected in 1, 2, 20, 24, 28, 40, 44, 45 and 47				The Plan establishes the Freshwater Management Unit process that is intended to provide for Ngāi Tahu and community aspirations and include catchment specific provisions. This implies the need for Environment Southland to engage with Ngāi Tahu and the community to determine these aspirations.
That information presented to the community with respect to aspects of community life including social, economic, environmental and cultural well-being is carried out in a format that is understood by its intended audience, including actions and/or decisions that may result.		1, 2, 3, 44 and 45				The Plan provides for Ngāi Tahu ki Murihiku values including Te Mana o te Wai and Ki uta ki tai.
To ensure that economic development and growth do not have implications for Ngāi Tahu ki Murihiku in exercising kaitiakitanga, or have adverse impacts on the environment and communities.	1, 2, 4, 5 and 13	1, 2, 3, 44 and 45				The Plan seeks to maintain or improve water quality and establishes a process for refinement of provisions through Freshwater Management Units and requiring Good Management Practice.
To ensure that Te Ao Mārama Inc. is supported through succession to maintain partnerships between local authorities and to assist in the understanding and appreciation of Tikanga Māori throughout Murihiku communities.		Reflected in 1, 2, 20, 24, 28, 40, 44, 45 and 47				The Plan provides for Ngāi Tahu ki Murihiku values including Te Mana o te Wai and Ki uta ki tai.

Legislative requirements – Ngāi Tahu Claims Settlement Act 1998 and Fisheries Act 1996

Legislative requirements	**Specific provisions in Plan that address legislative requirements**				**Contribution of Plan towards meeting requirements**	**Explanation of assessment**
	Objective	**Policy**	**Rule**	**Other**		
Protections for, and condition of, Statutory Acknowledgements	5	1		Appendix B		The Plan affords some protection to these areas. All applications that may affect a Statutory Acknowledgement Area are sent to Te Rūnanga o Ngāi Tahu and relevant papatipu rūnanga, in accordance with regulations established following Ngāi Tahu Settlement with the Crown.

Protections for, and condition of, Nohoanga	5	1 and 20	57 – 61 and 63	Glossary		The Plan affords protection through requiring that all applications that may affect a Nohoanga are sent to Te Rūnanga o Ngāi Tahu and relevant papatipu rūnanga.
Protections for, and condition of, Tōpuni	5	1				The Plan affords protection through requiring that all applications that may affect a Tōpuni are sent to Te Rūnanga o Ngāi Tahu and relevant papatipu rūnanga.
Management of habitat for, and condition of, taonga species	5 and 15	3, 22, 28, 29	49, 51, 55 - 63, 66 - 68, 70, 73 and 75 - 77	Appendices E and M		Parts of the Plan provide for taonga species. There are inconsistencies between protections given to trout and those given to taonga species. There are also no general provisions about the nesting/spawning/breeding of these species as well as harvesting times.
Management of habitat for, and condition of, Non-Commercially Harvested Species	5 and 15	Not specifically referenced, but covered by protection measures for taonga species.	Not specifically referenced, but covered by protection measures for taonga species.	Not specifically referenced, but covered by protection measures for taonga species.		Parts of the Plan provide for taonga species. There are inconsistencies between protections given to trout and those given to taonga species. There are also no general provisions about the nesting/spawning/breeding of these species as well as harvesting times.
Protections for, and condition of, mātaitai and taiapure	5	1, 20, 28 and 29	57 – 61 and 63			The Plan affords protection to these areas by providing for them within the Plan and requiring that all applications that may affect a mātaitai or taiapure are sent to the trustees or tāngata tiaki/kaitiaki.
The relationship of Maori and their culture and traditions with their ancestral lands, water, sites, wāhi tapu, and other taonga are recognised and provided for	2 – 5, 13 and 15	1, 2, 3, 44 and 45				The Plan provides for wāhi tapu, mahinga kai and other taonga tuku iho. The objectives and policies are carried through into some rules but not all.

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Cnr North Rd & Price St, Private Bag 90116 Invercargill
New Zealand
Phone 03 211 5115 Fax 03 211 5252
Tollfree (Southland only) 0800 76 88 45
Email service@es.govt.nz
Web site www.es.govt.nz

Memorandum

For Your Information

To: Anita Dawe

CC: Claire Jordan

From: Nick Ward (Freshwater and Marine Science Leader)

Date: 24 February 2016

Subject: ***Used Oil***

Purpose

This memorandum provides an overview of the toxicity and environmental risks associated with used oil.

Toxicity of used oil

Used oil is classed as a Hazardous substance[1,2]. Motor oil picks up a variety of hazardous contaminants when used in engines and transmissions. These toxic contaminants include:

- Lead – persistent human and environmental toxin/carcinogen; children are especially susceptible[3]
- Cadmium – environmental hazard, the International Agency for Research on Cancer has classified cadmium and cadmium compounds as carcinogenic to humans[4].
- Chromium - commonly occurs in two forms. Trivalent chromium (chromium III) is a naturally occurring element that is relatively stable and innocuous, and can be found in plants, animals, and soil. Hexavalent chromium (chromium VI) is far more dangerous for humans, and is usually created by anthropogenic causes. Hexavalent chromium is a toxic human carcinogen that can cause or increase the rates of certain cancers. Both can occur in used oil.
- Arsenic – toxic to animals, some studies have linked it with a broad variety of neurologic, cardiovascular, dermatologic, and carcinogenic effects[5]
- Dioxins - commonly regarded as one of the so called "dirty dozen" - a group of dangerous chemicals known persistent organic pollutants (POPs) there are able to cause reproductive and developmental problems, damage the immune system, interfere with hormones and also cause cancer[6]. Once dioxins enter the body, they last a long time because of their chemical stability and their ability to be absorbed by fat tissue, where they are then stored in the body. Their half-life in the body is estimated to be 7 to 11 years. In the environment, dioxins tend to accumulate in the food chain. The higher an animal is in the food chain, the higher the concentration of dioxins. The developing fetus is most sensitive to dioxin

exposure. Newborn, with rapidly developing organ systems, may also be more vulnerable to certain effects.

- Benzene - Benzene increases the risk of cancer and other illnesses. Benzene is a notorious cause of bone marrow failure. Substantial quantities of epidemiologic, clinical, and laboratory data link benzene to aplastic anemia, acute leukemia, and bone marrow abnormalities[6]. The US Department of Health and Human Services (DHHS) classifies benzene as a human carcinogen.
- Polycyclic Aromatic Hydrocarbons (PAHs) – though this is wide group of chemicals some are known for their carcinogenic and mutagenic properties. There are also a known environmental pollutant, including to fish life[7].
- Polychlorinated Biphenyl (PCBs) - another of the persistent organic pollutants (POPs) group[8]. The International Research Agency on Cancer (IRAC) rendered PCBs as a definite carcinogen to humans.

If used motor oil and the contaminants it contains are disposed of inappropriately and released into the environment, they can harm humans, plants, animals, fish and shellfish. Additionally, oil is a visible pollutant, floating as a scum on the surface which can stop sunlight and oxygen from getting into the water, affecting fish and water plants. It can kill fish, frogs and other animals that breathe from the water's surface.

In fact used oil should be dealt with carefully, in appropriate containers and without mixing with other substances to prevent leakage and discharge to the environment as per guidance from Ministry from Environment[9].

References

1. The Environmental Protection Authority (EPA) 2014 What's in the code of practice for used oil
2. Australian Government - Department of the Environment
3. "Toxic Substances Portal – Lead". Agency for Toxic Substance and Disease Registry.
4. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Volume 58
5. Tseng, Chin-Hsiao; Tai, Tong-Yuan; Chong, Choon-Khim; Tseng, Ching-Ping; Lai, Mei-Shu; Lin, Boniface J.; Chiou, Hung-Yi; Hsueh, Yu-Mei; Hsu, Kuang-Hung; Chen, CJ (2000). "Long-Term Arsenic Exposure and Incidence of Non-Insulin-Dependent Diabetes Mellitus: A Cohort Study in Arseniasis-Hyperendemic Villages in Taiwan". Environmental Health Perspectives 108 (9): 847–51.
6. World Health organisation (WHO) June 2014 Dioxins and their effects on human health. Factsheet No 225
7. Logan T (2007) Perspective on Ecotoxicology of PAHs to Fish. Human and Ecological Risk Assessment: An International Journal. Volume 13, Issue 2
8. Porta, M; Zumeta, E (2002). "Implementing the Stockholm Treaty on Persistent Organic Pollutants". Occupational and Environmental Medicine 10 (59): 651
9. Ministry for the Environment & Occupational Safety and Health Service (2000) Guidelines for the Management and Handling of Used Oil.

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Cnr North Rd & Price St, Private Bag 90116 Invercargill
New Zealand
Phone 03 211 5115 Fax 03 211 5252
Tollfree (Southland only) 0800 76 88 45
Email service@es.govt.nz
Web site www.es.govt.nz

Memorandum
For Your Information

To:	Anita Dawe
CC:	Claire Jordan
From:	Lawrence Kees (Water Resources Scientist) and Brydon Hughes (Consultant Scientist)
Date:	15 February 2016
Subject:	***Thresholds for permitted groundwater and surface water abstraction***

Purpose

This memorandum provides an outline of the rationale for the proposed changes to the rate and volumes of permitted groundwater and surface water abstraction in the proposed Water and Land Plan Change (WAL).

Existing RWP provisions

Rule 23(a) of the RWP establishes the threshold for abstraction of groundwater as a permitted activity at 20 m^3/landholding per day, provided the rate of abstraction does not exceed 2 l/s.

Rule 18(a) established the permitted activity threshold for surface water abstraction at an instantaneous rate of 5 l/s up to a daily volume of 10 m^3/day.

Proposed amendments to RWP provisions

WAL proposes to increase the threshold for permitted abstraction to:

Groundwater
(a) [250 litres per hectare per day][1] up to a maximum of 86 cubic metres per landholding per day; and
(b) a maximum rate of 5 litres per second.

Surface Water
(a) 250 litres per hectare per day up to a maximum of [40][2] cubic metres per landholding per day; and
(b) a maximum rate of less than 2 litres per second.

[1] This has been recommended to be changed to a requirement for a minimum separation distance of 50 metres from any existing lawfully established groundwater take as per comment from Brydon Hughes 16 February 2016.
[2] Added as per comment from Lawrence Kees 16 February 2016

provided the take does not exceed 30 percent of the [naturalised][3] instantaneous flow in the surface water body at the time of take

A maximum of 86 cubic metres of groundwater and surface water combined per landholding per day may be taken as a permitted activity.

Rationale for groundwater permitted activity thresholds

The changes to the permitted activity thresholds are proposed to better reflect the actual potential for localised and cumulative effects to result from small-scale groundwater abstraction. Experience (and improved knowledge of the hydrogeological environment) has shown the groundwater takes of less than 86 m^3/day (equivalent to an average abstraction rate of 1 l/s) are unlikely to result in more than minor effects on the environment in terms of:

- **Well interference effects** – groundwater takes with an average abstraction rate of less than 1 l/s result in minimal drawdown of groundwater levels across the range of hydrogeological environments present in the Southland region. The only situation where such abstraction could potentially be an issue is where pumping bores are immediately adjacent (e.g. immediately adjacent across a property boundary) in areas where aquifer permeability is extremely low. The original proposal to address this issue was the 250 l/s/hectare threshold which would effectively limit the possible density of permitted takes {it is now recommended that this restriction be updated to a minimum separation distance of 50m metres between adjacent groundwater takes.

- **Effects on surface water** – localised and cumulative effects on surface water from groundwater takes <2 L/s are treated as *de minimus* under the existing (and proposed) stream depletion effects policy

- **Effects on groundwater sustainability** – although there are currently a large number of consents for small-scale groundwater abstraction in the Southland region (between 450 to 500), the cumulative volume of groundwater abstraction by takes between 20 m^3/day (the current permitted activity threshold) and 86 m^3/day (the proposed threshold), the cumulative volume of abstraction is limited. While in some areas (particularly those where well yields are low) small takes may account for a significant proportion of existing groundwater allocation (as much as 40% depending on the groundwater zone), analysis of existing consents indicates the cumulative volume of such takes accounts for less than the primary allocation across all groundwater zones

Given the large numbers, consenting and compliance activities associated with small groundwater takes requires significant council resources for limited environmental benefit. In fact virtually all such water permits are issued without the need for technical assessment as associated environmental effects are considered to be no more than minor.

If the groundwater abstraction permitted activity threshold is increased, was use accounting required under the NPS-FM can be achieved in the same manner as for existing permitted takes (both under current RWP provisions as well as RMA S14(3)(b)). Certainly current recording and reporting of water use for small-scale takes (<86 m^3/day) has a high rate of non-compliance and the data collected suffers from a range of data quality and reliability issues.

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[3] Added as per comment from Lawrence Kees 16 February 2016

The proposed increase in the maximum rate for permitted groundwater abstraction (from 2 l/s to 5 l/s) reflects the moderating influence of groundwater storage which ultimately results in the longer-term pumping rate (in m^3/day) being the ultimate determinant of the magnitude of effects resulting from an individual groundwater take. For this reason, short period of higher-rate groundwater abstraction (up to 5 l/s) are considered unlikely to result in adverse environmental effects provided the daily average pumping rate remains below 86 m^3/day (equivalent to a continuous pumping rate of 1 l/s).

Provision has also been added to enable relatively small (up to 10 l/s and 750 m^3/day), non-consumptive groundwater takes under the permitted activity rule provided conditions relating to the discharge of the water back to the original water source are satisfied. This is intended to enable small-scale non-consumptive takes (e.g. gravel processing and alluvial mining) to operate as permitted activities (and therefore not be counted as part of cumulative (consumptive) allocation as they currently are).

Rationale for surface water permitted activity thresholds

In contrast to groundwater, surface water takes have a more immediate effect on the environment as effects of abstraction are immediately manifest on the rate of flow in the surface waterway.

For this reason the maximum rate of permitted surface water abstraction has been reduced from the current 5 l/s to 2 l/s. The proposed daily limit of [40] m3/day provides only for short periods of abstraction at the maximum rate (approximately 5.5 hours continuous abstraction at 2 l/s) to ensure effects on stream flow (and associated ecological values) only occur on an intermittent basis.

The proposed changes to the surface water permitted activity also require that the rate of permitted abstraction do not exceed 30 percent of the naturalised stream flow. This is intended to prevent the situation where the cumulative effects of multiple permitted takes on a small stream result in excessive effects on aquatic ecosystems and habitats.

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Cnr North Rd & Price St, Private Bag 90116 Invercargill New Zealand

Phone 03 211 5115 Fax 03 211 5252

Tollfree (Southland only) 0800 76 88 45

Email service@es.govt.nz

Web site www.es.govt.nz

Memorandum

For Information

To: Anita Dawe, Claire Jordan

From: Lawrence Kees, Water Resources Scientist

Date: 16 February 2016

Subject: ***Use of Q95 versus MALF***

Background

This memorandum sets out the rationale for changing the references to MALF (mean annual low flow) to Q95 in the proposed changes to the surface water quantity provisions of the Regional Water Plan for Southland.

The Regional Water Plan currently uses MALF to derive both allocation thresholds and minimum flows. The proposed shift from MALF to a flow statistic (Q95) allows the effect of abstraction to be assessed against a generated flow duration curve of 'natural' and 'synthetic' flow to assess the impact on catchment/subcatchment hydrology of proposed takes. Employment of a seasonal flow duration statistic allows the applicant and Council to assess the effect of abstraction in a more quantitative way than the arbitrary comparison of hydrographs, which is often employed in irrigation consent applications.

MALF estimates are often made using a number of gaugings that do not produce a significant correlation, and the gaugings are often correlated with sites that have different physiographic controls on hydrology. The benefit of stipulating a flow duration statistic (as opposed to MALF) is that where there are no gaugings in a catchment, the estimation of flow duration curves from approved methodologies that employ appropriate consideration to hydrological inputs and controls, allows a calculation of the minimum flow, and the distribution of the effect of abstraction across a flow regime. Other benefits include the reduction in field work at the time of the consent application (which may reduce the cost of the consent application to the water user) and provision of a consistent basis for the assessment of water allocation.

Staff have developed the capacity to develop a flow duration curve for all streams to the third order in the Oreti catchment, and will be working towards the ability to produce these statistics across the region, thus providing a standard approach to environmental impact assessment. The approach also provides a standard language to define a range of flow cut-offs for consents with a clear indication as to the reliability of supply.

Feedback on the change of approach has been sought from both John Hayes, Cawthron and Matt Hickey (a consultant scientist) who both supported the use of Q95 and both cite academic published literature (Armstrong and Nislow, 2012).

Armstrong, J. D. and Nislow. K.H., 2012. Modelling approaches for relating effects of change in river flow to populations of Atlantic salmon and brown trout. *Fisheries Management and Ecology, 2012* doi: 10.1111/j.1365-2400.2011.00835.x

Technical Comment

To:	Claire Jordan
Fax No:	
From:	Roger Hodson, NPSFM Science Team
Date:	Tuesday, 9 February 2016
File Reference:	A248969
Subject:	***NOF E.coli***

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Comment:

The technical comments below include a discussion on the current understanding of E.coli levels in Southland. There is a particular focus on areas which are not achieving the National Bottom Line for secondary contact recreation set out in the National Policy Statement for Freshwater Management 2014. Where information on the sources of contamination is available it is included along with an expert opinion regarding the importance of different transport pathways.

Overview of Microbial Contamination in Southland

Assessments of microbial contamination (E.coli) against the national objective framework (NOF) compulsory objective of "human health for secondary contact recreation" have illustrated a number of monitoring sites/sub catchments which fail the national bottom line for human health. Figure 1.0 illustrates the assessment of state of environment (SOE) monitoring programs against NOF critera. The time period used for the assessment is a 5 year time period, as presented in the fact sheet "water quality in Southland" of June 2009 – 2014.

The 5 year time period is used in contrast to the suggested annual median in NOF for a number of reasons: it maintains consistency with previous assessments of state in Southland and nationally; includes greater representation of inter annual climate variability and avoids the influence of an extreme annual climate event; and also considerate of the recommendations of McBride (2014) related to the number of samples needed in an assessment period to provide a suitably precise estimate of the median.

E.coil for secondary contact recreation is presented in the top left corner of each site's symbol. Sites which are coloured red in the top left have a median E.coli concentration which is greater than 1000 cfu/100 ml i.e. the "D" band, and sites which have the top left corner coloured orange are in the "C" band have a median value which is between 540 and 1000 cfu/100ml. Sites not achieving the D band are required to be improved, and further more illustrate the failure of existing permitted activities to meet water quality outcomes in these geographical areas. Sites in

for now and your future

the C band are not explicitly considered here, however there is a need to consider a less permissive approach to management in these areas as the current levels of microbial contamination in these areas is very close to D band and relatively small increase in the supply of microbial contaminants could lead to a D band in the future.

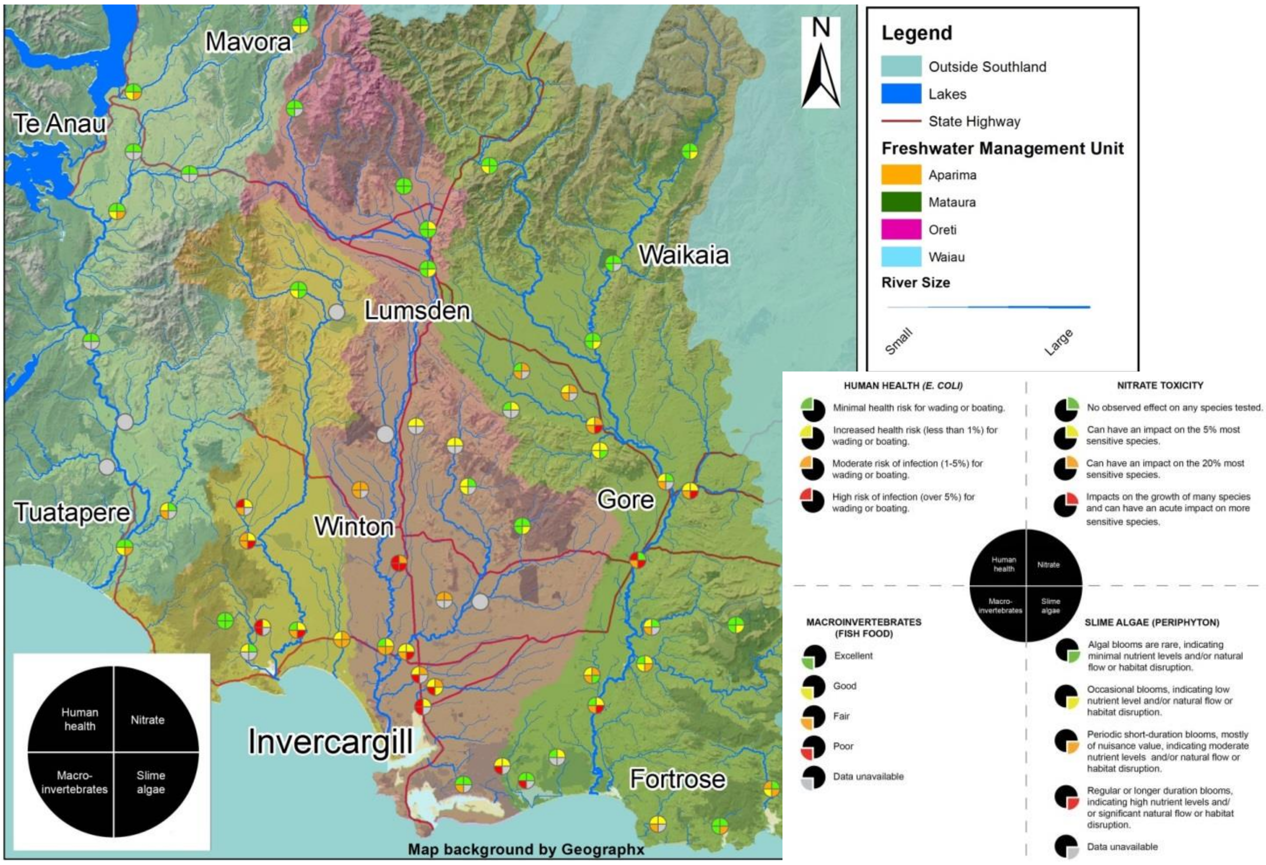


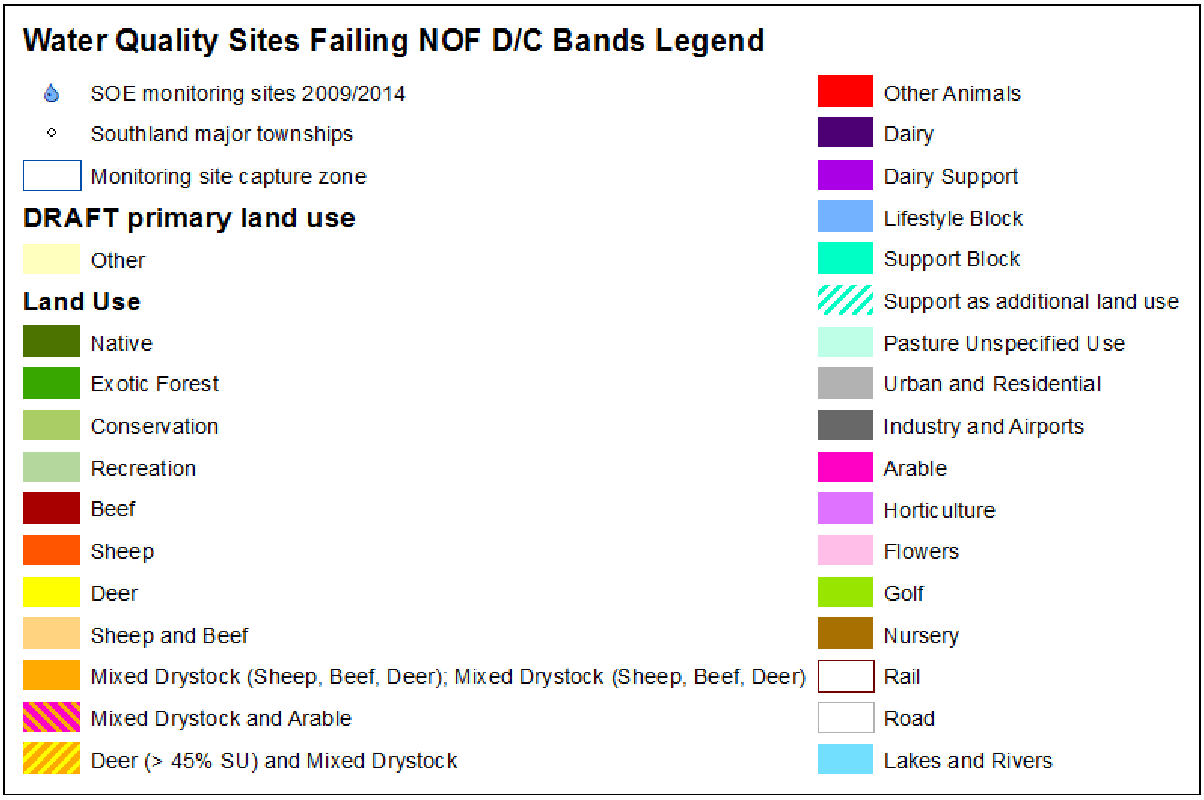
Figure 1.0. July 2009 -2014 state of environment, Human Health - secondary contact recreation (E.coli) is presented in the top left corner of each site symbol

Catchments not achieving the national bottom line – Secondary Contact Recreation

Each of the sites which do not achieve the D band are presented in this section. Sites which are in the D band represent a greater than 5% risk of infection from contact with water during activities which involve occasional immersion and some ingestion of water, such as wading and boating (MFE, 2014). For each site a map, table of supporting catchment information and a qualitative description of sources of contamination and an expert judgement assessment of important pathways is included. All of these locations occur in lowland southland and generally in areas with a high proportion of moderately to high density artificially drained soils and all illustrate a mixture of sources of microbial contamination, however reoccurring sources are from sheep, cows and avian wild fowl.

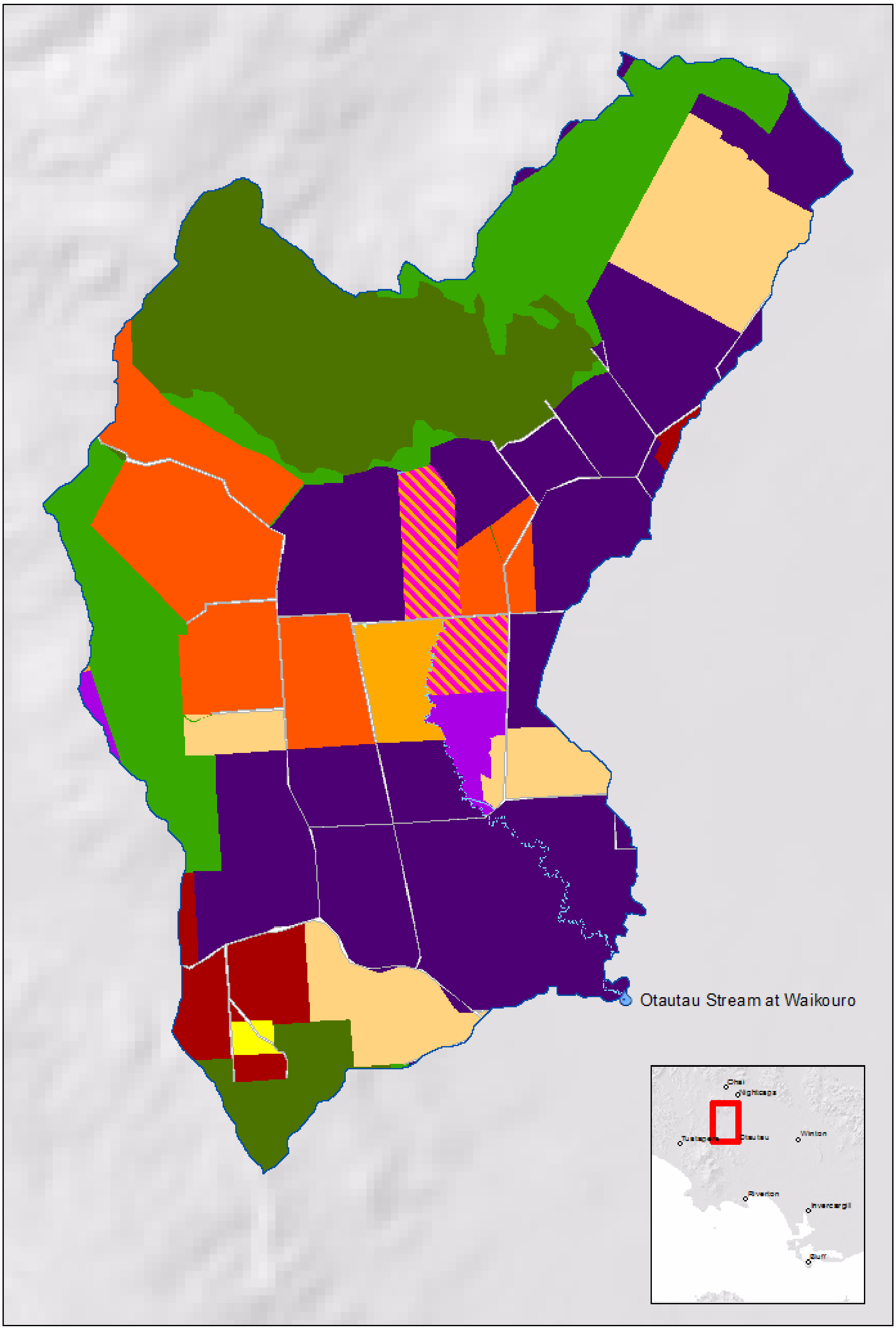
Land use Key

The key in figure 1.0 is a generic key which can be applied to the land use maps for each of the sampling location contributing areas.



Otautau Stream at Waikouro

The Otautau Stream at Waikouro is located to the north west of the township of Otautau. The total catchment land area is c.a. 6900 ha, Land use is dominated by Dairying, and includes substantial areas of indigenous and plantation forestry. Microbial source tacking investigations to date have revealed a mixture of sources including: Human; Ruminants in general and specific positive tests for Cows and Sheep; and wildfowl. It is likely that a number of transport pathways are conveying microbial contamination to the stream. Their relative contribution is likely to vary considerably through time due to the timing of inputs relative to ambient climatic and soil moisture conditions. Given the positive sheep signature it is likely there is deposition of microbial contaminants occurring within the channel zone including on stream banks. The positive human source suggests there are failing on site residential wastewater systems, these are likely to be via sub surface tile drainage or preferential macro pore flow. Almost half of the catchment has a moderate to high density of sub surface drainage and as such present an elevated risk of conveyance of treated wastewaters from farm dairy effluent systems, when application is not well managed on drained soils.


Otautau Stream at Waikouro
Ohai
Nightcaps
Otautau
Winton
Riverton
Invercargill
Bluff

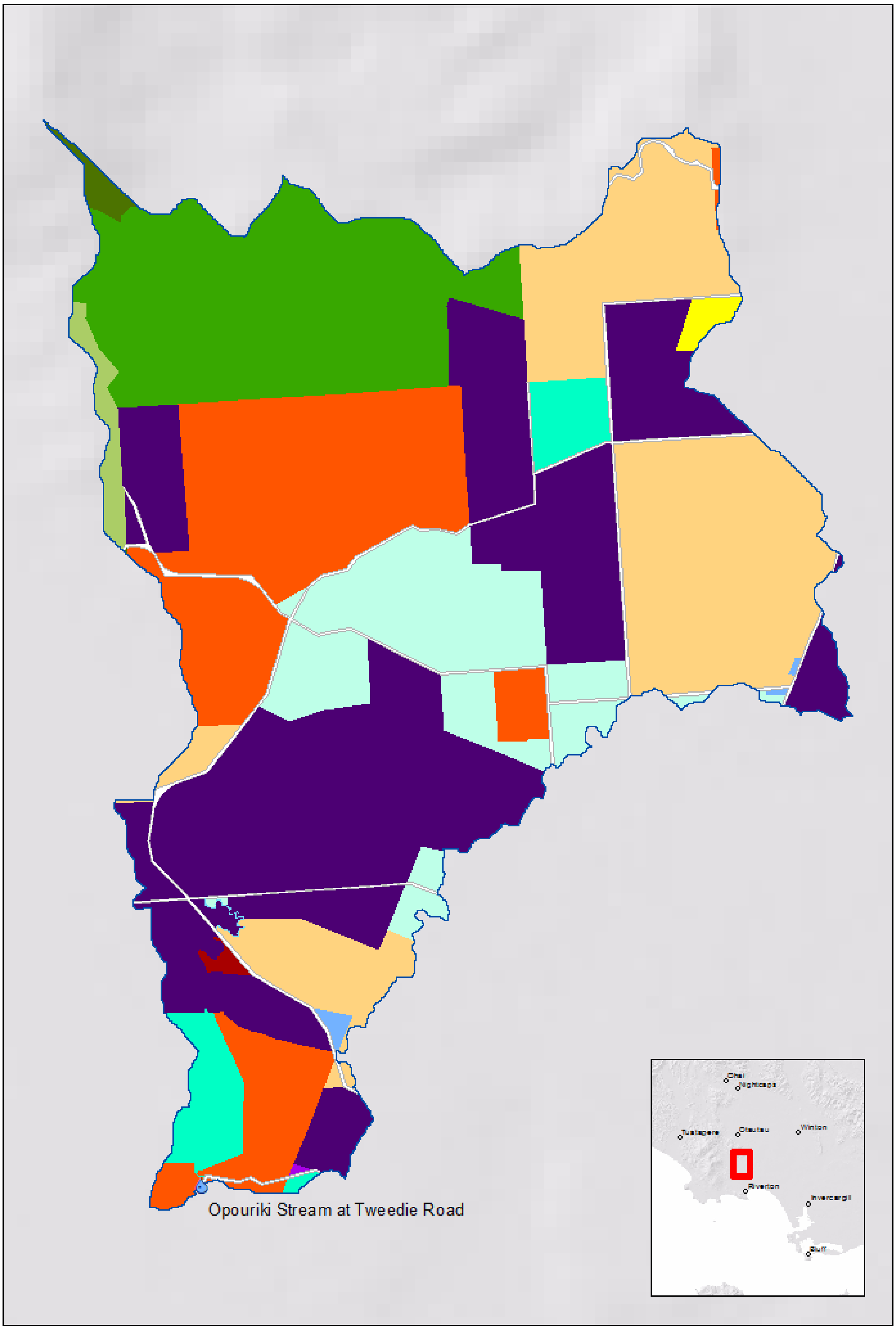
Otautau Stream at Waikouro Land use	**Hectares**	**No of properties**
Beef	229.13	2
Dairy	2315.62	13
Dairy Support	92.59	2
Deer	20.29	1
Forest	1024.74	5
Lakes and Rivers		3
Lifestyle Block	0.16	1
Mixed Drystock (Sheep, Beef, Deer)	122.34	2
Mixed Drystock and Arable	201.49	1
Native	1211.17	5
Pasture Unspecified Use	0.18	1
Road	86.53	1
Sheep	868.22	5
Sheep and Beef	715.46	5
Total	6897.95	47

Otautau Stream at Waikouro Physiographic units	**Hectares**
Gleyed	2534.72
Hill Country	3288.82
Oxidising	882.32
Peat Wetlands	192.09
Riverine	0.01
Total	6897.95

Otautau Stream at Waikouro Artificial subsurface drainage density	**Hectares**
High	1418.80
Low (slope)	697.92
Moderate	1832.07
None (not agricultural)	2816.07
Very high	134.77
Total	6899.63

Opouriki Stream at Tweedie Road

The Opouriki Stream is a tributary of the Pourakino River, in the North west of the Jacobs River Estuary. The catchment area upstream of the sampling site is c.a. 2800 ha. Landuse is dominantly dairying, with considerable areas in forestry, sheep and sheep + beef. Microbial source tracking to date has revealed positive signatures for ruminants both sheep and cows as well as for avian wildfowl. Given the positive sheep signature it is likely there is deposition of microbial contaminants occurring within the channel zone including on stream banks. Direct deposition may also be occurring from other dry stock including sheep and beef. More than half of the catchment has a moderate to high density of subsurface drainage, poor management of farm dairy effluent over artificially drained soils, particularly during very dry and wet periods presents an elevated risk of microbial contamination to the Opouriki Stream.


Opouriki Stream at Tweedie Road
Ohai
Nightcaps
Tuatapere
Otautau
Winton
Riverton
Invercargill
Bluff

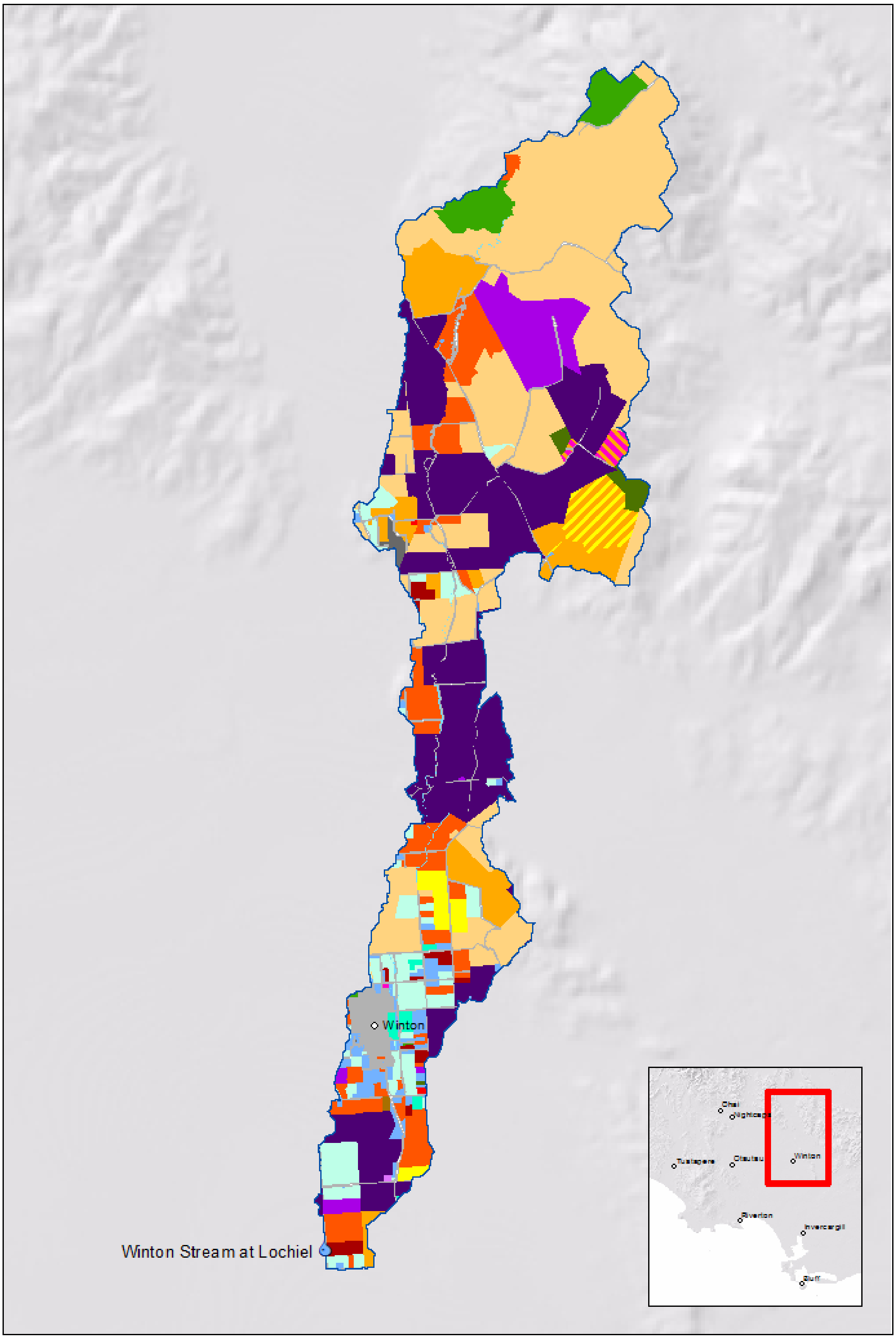
Land use	Hectares	No of properties
Beef	4.84	1
Conservation	27.55	1
Dairy	849.33	9
Dairy Support	0.78	1
Deer	11.74	1
Forest	412.38	1
Lakes and Rivers	1.01	1
Lifestyle Block	5.93	3
Native	11.89	2
Pasture Unspecified Use	278.86	3
Road	55.31	1
Sheep	481.47	5
Sheep and Beef	549.87	4
Support Block	88.87	3
Total	2779.82	36

Physiographic units	Hectares
Gleyed	277.46
Hill Country	1142.82
Oxidising	1359.54
Total	2779.82

Artificial subsurface drainage density	Hectares
High	316.55
Low (slope)	663.59
Moderate	1236.80
None (not agricultural)	562.89
Total	2779.82

Winton Stream at Lochiel

The Winton stream is a tributary of the lower Oreti River, it joins the Oreti south of the township of Winton. The catchment area upstream of the sampling location is c.a. 14000ha. Sheep/beef and dry stock dominate the land use in the catchment, approximately 25% of the catchment is in dairying and a considerable area is used for dairy support. Microbial source tracking has returned positive signatures for ruminants, both sheep and cows as well as avian wildfowl. Given the positive sheep signature it is likely there is deposition of microbial contaminants occurring within the channel zone including on stream banks. Direct deposition may also be occurring from other dry stock including sheep and beef. More than half of the catchment has a high density of subsurface drainage, poor management of farm dairy effluent over artificially drained soils, particularly during very dry and wet periods presents an elevated risk of microbial contamination to the Winton Stream.


Winton
Winton Stream at Lochiel
Ohai
Nightcaps
Tuatapere
Otautau
Winton
Riverton
Invercargill
Bluff

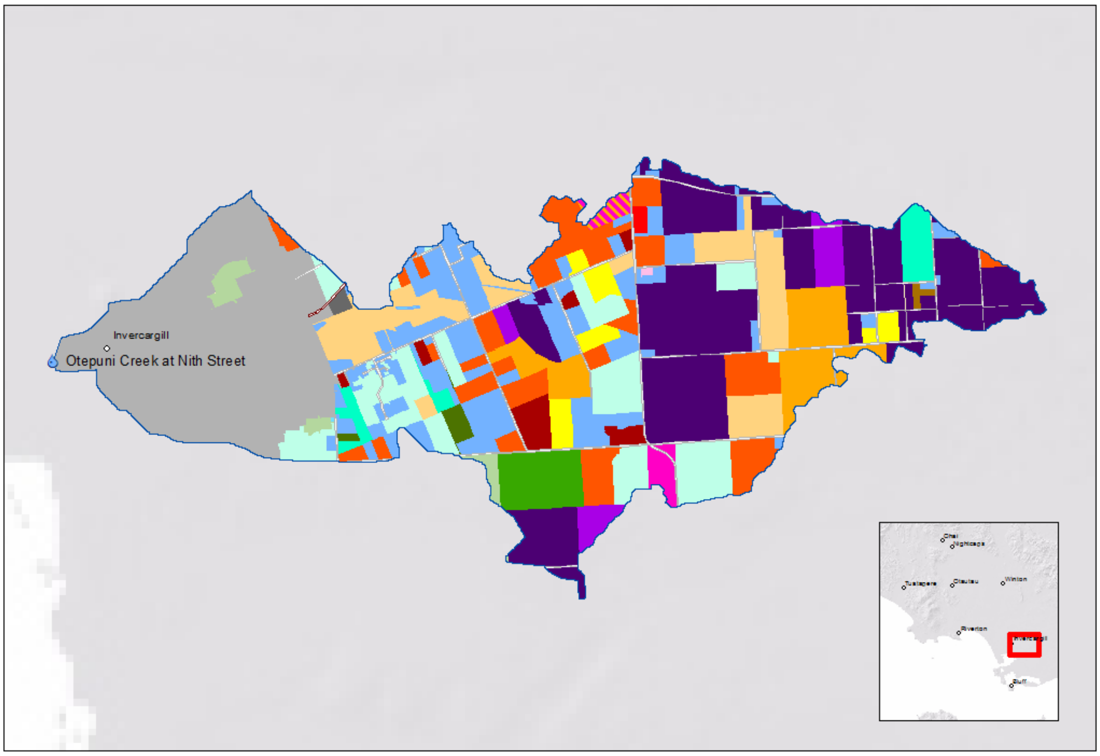
Land use	Hectares	No of properties
(Other - Urban/Not Mapped)	0.08	1
Arable	2.84	1
Beef	143.67	11
Dairy	3390.72	23
Dairy Support	648.60	5
Deer	169.08	2
Deer, Sheep & Beef	320.69	2
Forest	401.52	5
Industry	43.61	3
Lakes and Rivers	25.88	21
Lifestyle Block	323.26	135
Mixed Drystock (Sheep, Beef, Deer)	980.00	5
Mixed Drystock and Arable	76.70	1
Native	104.70	4
Nursery	8.85	1
Other Animals	7.94	2
Pasture Unspecified Use	781.17	43
Residential	216.87	23
Road	294.80	2
Sheep	1311.14	37
Sheep and Beef	4648.47	24
Support Block	72.18	6
Vegetables	4.19	1
Total	13976.95	358

Physiographic units	Hectares
(Other - Urban/Not Mapped)	218.30
Gleyed	6397.87
Hill Country	6972.67
Oxidising	388.10
Total	13976.95

Artificial subsurface drainage density	Hectares
High	6751.16
Low	83.61
Low (slope)	6414.61
Moderate	157.90
None	168.10
None (not agricultural)	374.38
Very low to none	27.18
Total	13976.95

Otepuni Creek at Nith Street

The Otepuni Creek is a tributary of the New River Esturay and includes a large portion of Invercargill City. The catchment area upstream of the sampling location is c.a. 3600 ha. Landuse includes approximately 700 ha of urban areas, a similar amount of dairying and approximately 400 ha of lifestyle properties. Microbial source tracking has illustrated a persistant issue with human sourced microbial contaminants both in a longitudinal survey by Meijer 2012 and in more recent investigations through the human health program. In addition to the Human sources identified to date consistent ruminent sources including both sheep and cows have beed detected along with avian wildfowl and dog. The persistant human sources illustrates an ongoing contribution of human wastewater from Invercargill city sewerage and stormwater infrastructure. Given the positive sheep signature it is likely there is deposition of microbial contaminants occurring within the channel zone including on stream banks. Direct deposition may also be occurring from other dry stock including sheep and beef. Over two thirds of the catchment has a moderate to high subsurface drainage density, with the remainder being the urban area including reticulated surface and sub surface storm water networks.



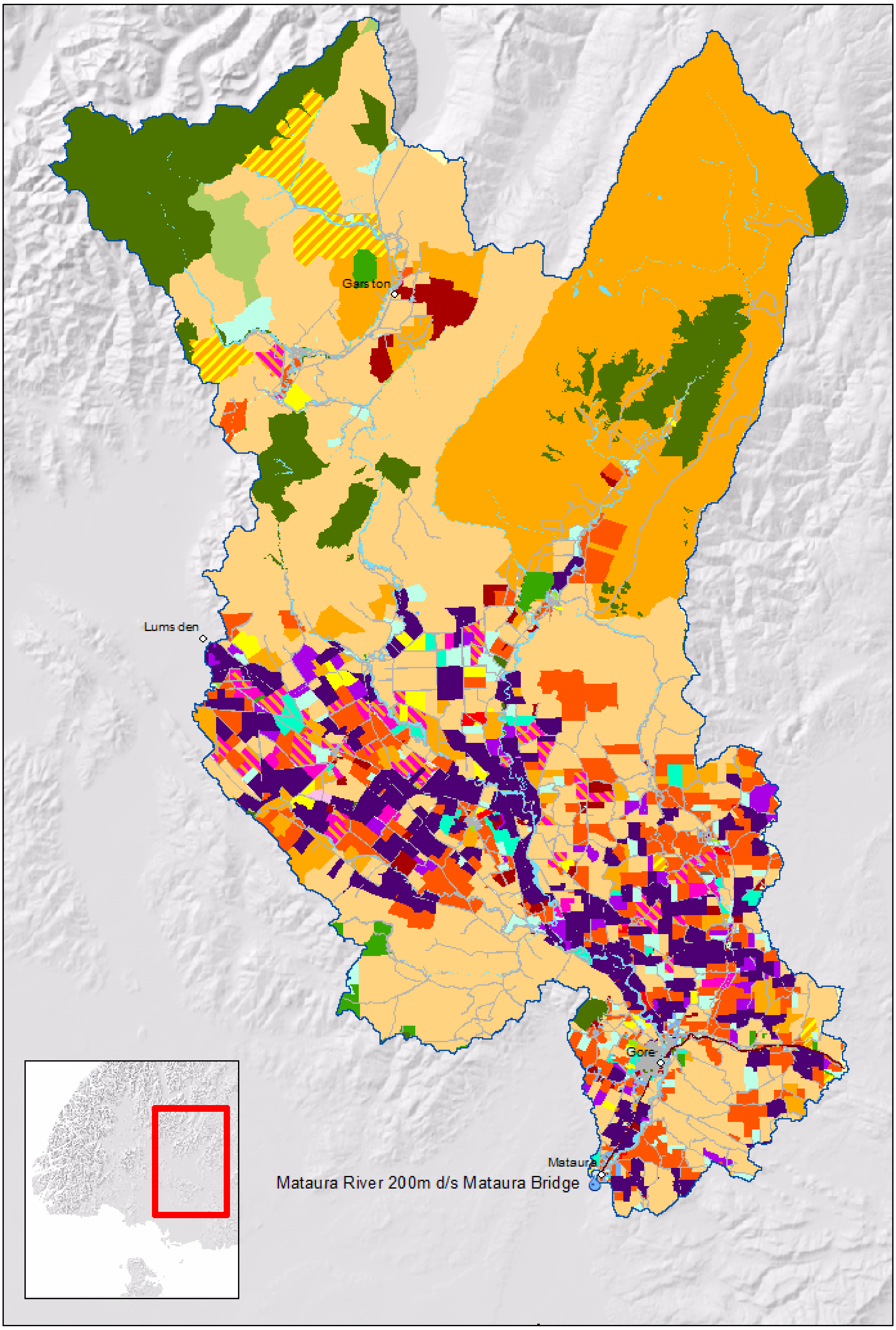
Land use	Hectares	No. of properties
(Other - Urban/Not Mapped)	0.65	1
Arable	24.54	1
Beef	58.51	7
Dairy	775.24	11
Dairy Support	70.35	3
Deer	71.94	4
Flower	1.74	1
Forest	86.50	1
Industry	7.15	1
Lakes and Rivers	0.49	2
Lifestyle Block	414.73	195
Mixed Drystock (Sheep, Beef, Deer)	181.27	2
Mixed Drystock and Arable	16.27	1
Native	17.20	2
Nursery	5.31	1
Other Animals	7.33	1
Pasture Unspecified Use	315.92	17
Rail	1.36	1
Recreation	40.29	3
Residential	772.13	4
Road	84.44	1
Sheep	326.62	32
Sheep and Beef	270.55	6
Support Block	68.94	3
Total	3619.45	301

Physiographic units	Hectares
(Other - Urban/Not Mapped)	796.35
Gleyed	2558.74
Oxidising	178.72
Peat Wetlands	85.64
Total	3619.45

Artificial subsurface drainage density	Hectares
(Other - Urban/Not Mapped)	10.33
High	529.89
Moderate	2252.76
None (not agricultural)	744.50
Very high	81.98
Total	3619.45

Mataura River 200m d/s Mataura Bridge

The Mataura River 200m d/s Mataura Bridge sampling site is on the main stem of the Mataura River immediately downstream of Gore. The next upstream sampling location in Gore has relatively low levels of microbial contamination suggesting a local source rather than an upstream source of contamination. There has been very limited microbial source tracking carried out to date, however the microbial source tracking that has been completed has illustrated Ruminant sources specifically sheep and cows along with an avian source. There is a need to carry out further microbial source tracking in this location, and to specifically test for signatures that persist from any of the point source industrial wastewater discharges in the Mataura township.


Garston
Lumsden
Gore
Mataura
Mataura River 200m d/s Mataura Bridge

Land use	Hectares	No. of properties
(Other - Urban/Not Mapped)	1194.40	1
Arable	2028.34	14
Beef	5331.40	67
Conservation	4004.76	33
Dairy	33400.93	139
Dairy Support	5449.07	49
Deer	3182.33	25
Deer, Sheep & Beef	9090.18	4
Flower	166.83	1
Forest	2817.93	25
Fruit	0.59	1
Golf	109.15	5
Industry	87.08	11
Lakes and Rivers	4930.95	429
Lifestyle Block	1153.00	632
Mixed Drystock (Sheep, Beef, Deer)	96298.19	44
Mixed Drystock and Arable	7300.01	21
Native	40894.55	76
Other Animals	648.65	16
Pasture Unspecified Use	8843.74	175
Rail	121.68	3
Recreation	72.67	11
Residential	851.02	50
Road	5181.45	6
Sheep	33210.70	234
Sheep and Beef	153561.99	247
Support Block	3014.24	31
Vegetables	6.24	2
Total	422952.05	2352

Physiographic units	Hectares
(Other - Urban/Not Mapped)	4270.46
Alpine	94422.19
Gleyed	39305.59
Hill Country	193744.50
Lignite - Marine Terraces	2808.68
Old Mataura	20592.12
Oxidising	41540.32
Peat Wetlands	411.48
Riverine	25856.73
Total	422952.05

Artificial subsurface drainage density	Hectares
(Other - Urban/Not Mapped)	7875.26
High	45934.90
Low	17320.40
Low (slope)	124119.08
Moderate	9895.58
None	17486.48
None (not agricultural)	162550.54
Very high	72.81
Very low to none	38397.19
Total	423652.24

References

McBride, G. (2014), National Objectives Framework for Freshwater: Statistical considerations for assessing progress towards objectives with emphasis on secondary contact recreation values. Prepared for Ministry for the Environment, Wellington. NIWA client Report No: Ham2014-007.

MFE (2014), National Policy Statement for Freshwater Management 2014.

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Memorandum

For Your Information

To:	Anita Dawe
CC:	Claire Jordan
From:	Lawrence Kees (Water Resources Scientist) and Brydon Hughes (Consultant Scientist)
Date:	11 February 2016
Subject:	***Water allocation in Southland***

Purpose

This memorandum provides advice on current allocation levels for water quantity purposes in Southland. In particular, it identifies where resources may be considered to be fully allocated.

Allocation in Southland

The past 15 years have seen a significant increase in the volume of water allocated for consumptive use in Southland, primarily associated with the growing demand for irrigation. With the exception of hydro-electric use in the Waiau catchment, most of the water allocated in Southland is sourced from groundwater, which is often connected to major rivers and streams. Surface water takes and groundwater takes that affect stream flows are restricted during dry periods so that sufficient stream flows are maintained during critical periods. As a result, water is not always available for use when it is required. This limitation on the availability of water is a major constraint on future allocation in most catchments.

Surface Water Allocation

The primary allocation thresholds in the both the Regional Water Plan for Southland 2010 and draft Water and Land Plan Change (WAL) are precautionary and should not be viewed as limits under the National Policy Statement for Freshwater Management (NPSFM), as it is possible that use could occur beyond these thresholds that still allows freshwater objectives to be met. Based on the NPSFM definitions, the surface water resources that could be said to be fully allocated are as follows:

- the Waiau catchment (as a result of the Manapouri Power Scheme) and the Cromel Stream;

In addition, allocation from the Mataura River is also constrained due to the proportional flow allocation outlined in the Water Conservation (Mataura River) Order 1997 (i.e. a fixed percentage of flow is available for allocation, with the volume available for consumptive use varying in response to river flow). In theory additional water can still be allocated from this catchment, however the reliability of supply is not sufficient (at least for irrigation) for run-of-river takes or for groundwater takes that are hydraulically connected to the Mataura River without the use of storage.

Groundwater Allocation

Primary allocation for two confined aquifers in the Oreti Basin (the North Range and Lumsden aquifers) can be considered fully allocated. The main reason for this classification is to ensure storage volumes are maintained (i.e. groundwater levels fully recover on a long-term basis between individual irrigation seasons). Due to the limited hydraulic connection between these aquifers and adjacent groundwater and surface water resources, the primary management consideration is associated with the avoidance of any long-term decline in storage that may adversely affect the reliability of supply for existing groundwater users[1] (rather than effects on adjacent water resource and ecosystems).

North Range Aquifer

The North Range Aquifer can reasonably be considered fully allocated and the proposed allocation limit for the WAL has been established as equal to the current allocation. However, abstraction from this aquifer is managed in terms of minimum level cut-offs and seasonal recovery triggers established in conditions on the three major groundwater takes from this aquifer (and proposed for inclusion in the groundwater appendix). These controls effectively over-ride the cumulative allocation volume to ensure storage in the aquifer remains within a nominated 'operating range' (i.e. it does not fall below a nominated threshold at which point all large-scale abstraction has to cease).

A water user group has recently been established for this aquifer as a part of an agreement between the three large-scale groundwater users. This agreement will provide flexibility for the consent holders (in terms of short-term rates and volumes) provided aquifer storage and water use is managed in accordance within the nominated minimum level cut-offs and seasonal recovery triggers.

Lumsden Aquifer

A similar situation exists in the Lumsden Aquifer to that occurring in the North Range Aquifer in that the proposed primary allocation in the WAL has been established as equal to the current allocation. All consents from this aquifer are subject to minimum level cut-offs which have been proposed for inclusion in the WAL.

However, based on the nominated minimum level triggers it may be possible to allocate additional water from this aquifer system (most likely as supplementary groundwater allocation) while maintaining the existing reliability of supply for existing water users.

Riversdale Aquifer

Questions have been asked about the allocation status of the Riversdale Aquifer, given the Environment Court decision relating to that aquifer. Since the Environment Court decision (South Otago Holdings), the aquifer has been managed as fully allocated due to the potential for cumulative effects on spring-fed streams.

[1] i.e. existing RWP Objective 19, Policy 28 and Policy 30

However, it has been decided not to refer to this aquifer as being fully allocated for three reasons:

(1) there have been some changes in cumulative allocation since the Environment Court decision (mainly associated with reductions in seasonal volumes for replacement consents granted) so the current cumulative allocation is appreciably lower (approximately 25% or >2 million m^3/year) than the total which formed the basis for the Environment Court decision;

(2) there are some changes to the groundwater zone boundary proposed in the WAL. These will alter total allocation granted to existing consents but essentially won't make a major change to overall cumulative allocation;

(3) Proposed changes to the groundwater abstraction permitted activity rule will mean that takes <2 l/s and 86 m^3/day will no longer require consent. Depending on if, and how, this change is implemented, exclusion of takes between the existing permitted activity threshold (20 m^3/day) and 86 m^3/day will decrease cumulative allocation by around 200,000 m^3/year.

Winter Grazing and Dairy Farming

The following memo seeks to describe the susceptibility of particular parts of Southland to dairy grazing and winter grazing practices.

1. Dairy Grazing

Dairy cows grazing pasture excrete between 60-90% of the nitrogen they consume in urine and faeces, and over 70% of the nitrogen excreted is in urine (Haynes & Williams, 1993). This urinary nitrogen is deposited unevenly across the pasture, resulting in small, localised areas that contain a large amount of nitrogen known as urine patches. N losses to the environment occur primarily as leaching below the root zone to groundwater as NO_3^- or as losses to the atmosphere as either N_2O or N_2 gas via denitrification or as NH_3 gas via volatilisation of NH_4^+. N lost to shallow groundwater often ends up in streams during summer low flow recharge and can result in detrimental eutrophication effects. The majority of NO_3^- leaching occurs under a urine patch due to a difference in the loading rate of N from urine (~ 1000 kg $N.ha^{-1}$) (Di & Cameron, 2002; Haynes & Williams, 1993) and the capacity for plants to uptake this N (~ 300 – 700 kg $N.ha^{-1}$) (Moir et al, 2010 & refs within) resulting in an excess of N. In the Southland Region, nitrogen losses from dairy farms are approximately 60% greater than those from intensive sheep/beef/deer pasture farm systems (Ledgard 2014 and refs. within). Phosphorus losses from dairy farms are approximately 25% greater than those from intensive sheep/beef/deer pasture farm systems (Ledgard, 2014 and refs. within). However, phosphorus losses vary considerably with land type and form.

2. Winter Grazing

In-situ grazing of forage crops over the months of May – August has been shown to make a disproportionately large contribution to nutrient losses from the total farm system (De Klein et al. 2010; Monaghan et al. 2013; McDowell & Monaghan 2015; McDowell & Stevens, 2008; McDowell & Houlbrooke, 2008; Shepherd et al. 2012; Smith et al. 2012). Proportions of N and P lost and the mechanism of loss is dependent on the land form and type.

3. Susceptibility across Southland

Nutrient losses from these practices are exacerbated when they occur on parts of the landscape that are susceptible to either nitrogen or phosphorus loss. For example, dairy grazing on shallow stony soils that have no/very little ability to remove nitrogen or store water, resulting in transport of any excess or unused nitrogen below the root zone with drainage. In another example, organic soils, especially newly developed soils are susceptible to phosphorus loss because of the inherent low anion storage capacity of the soil meaning any excess water soluble phosphorus is transported with drainage and lost from the system.

The Physiographic Units provide a mechanism for identifying these areas of high susceptibility. Each of the Physiographic Units that are most susceptible to nutrient loss under dairy grazing and winter grazing are presented below with an explanation of the reasons for this. Particular regard is given not only to the contamination of the direct receiving environment but also to down gradient affects. For example a contaminated aquifer feeding a stream during baseflow may cause the stream to exceed a particular water quality threshold.

- **Old Mataura Physiographic Unit**

The Old Mataura Unit is characterised by highly weathered alluvial gravels of the Luggate and Shotover Formations (Turnbull & Allibone, 2003, Rissmann et al., 2015). The unit is exclusive to the Mataura Catchment and where overlain by well drained shallow stony soils or fragic pallic soils (i.e., Old Mataura Unit) there is little capacity to attenuate N loss. The predominance of well drained shallow stony soils that have little ability to denitrify or hold water (Topoclimate, 2001) means the area is highly susceptible to nitrate leaching to groundwater. The highly weathered nature of the gravels that make up the aquifer results in little/no ability to remove nitrogen and low transmissivity rates, meaning the water moves very slowly and nitrogen concentrations can build to high levels. Commonly these levels exceed the maximum allowable value (MAV) for drinking water (NZDWS, 2008; Rissmann, 2012; Rissmann et al., 2015). Great unsaturated zone lag times (3 – 9 years) (Chanut et al., 2014) also equate to a longer delay in peak nitrate delivery than in equivalent areas (i.e. Oxidised Physiographic Unit). Where ever there is this combination of the Luggate and Shotover formations overlain by well drained shallow stony soils or fragic pallic soils we see elevated groundwater nitrate (Rissmann 2012; Rissmann et al., 2015). Because the unit is dominated by land surface recharge (LSR) there is no flushing of the aquifers by alpine derived water (Rissmann et al., 2015).The median groundwater nitrate-N concentration within the unit is 10.0 mg/L, the highest of any Physiographic Unit (Physiographic User Guide, 2015). Also important to consider with the Old Mataura Unit is its contribution of groundwater to streams during baseflow in the summer months (Liquid Earth, 2010). It is hypothesised that contaminated groundwater from the Balfour area (within Old Mataura) increases the nitrate concentrations in the Waimea Stream considerably under baseflow and that this is contributing to the declining water quality in the Waimea Stream (Moreau and Hodson, 2015; Hodson, 2015) and the overall nitrogen load in the system. The Waimea Stream at Mandeville is one location in Southland that exceeds the national bottom line for periphyton (Hodson, 2015) and is showing increasing trends in surface water nitrate (Moreau and Hodson, 2015).

Summary

- Soils and aquifers do not remove nitrogen
- Due to low aquifer transmissivities nitrate concentrations can build to very high (toxic) levels
- Nitrogen can be rapidly transported below the root zone
- Nitrate concentrations exceed the MAV in many places
- Contribution of contaminated groundwater to surface water during baseflow degrades surface waters. The Waimea Stream is showing significant degradation and is getting worse.
- Lag times are slightly longer than in other equivalent areas (Oxidising Physiographic Unit)
- No/little riverine flushing due to almost exclusive LSR

- **Oxidising Physiographic Unit**

The Oxidising Unit is characterised by areas of soils with an oxic redox state (show little capacity to remove nitrate) underlain by aquifers that also show no little capacity to remove nitrate. Like the Old Mataura Unit these areas are susceptible to nitrate leaching through the soil profile to groundwater and nitrate concentrations become elevated in the underlying aquifers. As with the Old Mataura Unit the Oxidising Unit is dominated by land surface recharge (LSR) and hence receives no flushing by alpine water. The main difference in these units is that the aquifers are younger and less weathered meaning groundwater flows more quickly in these systems and that for equivalent nitrate loadings nitrate concentrations may not reach the same levels those seen in the Old Mataura Unit. Groundwater nitrate hotspots are common under the Oxidising Unit and in some places nitrate concentrations exceed the MAV (Hodson, 2015; NZDWS, 2008; Liquid Earth, 2010; Rissmann 2012; Rissmann et al., 2015). The median groundwater nitrate-N concentration within the unit is 5.7 mg/L, the third highest of any Physiographic Unit (Physiographic User Guide, 2015). In a similar manner to the Old Mataura Unit, aquifers within the Oxidising Unit contribute to baseflow in adjacent streams potentially increasing nitrate concentrations in-stream and overall nitrogen load in the system. The median surface water nitrate-N concentration within the unit is 2.1 mg/L, the second highest of any Physiographic Unit (Physiographic User Guide, 2015).

Summary

- Soils and aquifers do not have ability to remove nitrate
- Groundwater nitrate concentrations are the third highest of any unit and exceeds the MAV for drinking water in some areas.
- Contribution of contaminated groundwater to surface water during baseflow contributes to degradation of surface waters.
- No/little riverine flushing due to almost exclusive LSR

- **Peat Wetlands Physiographic Unit**

The Peat Wetlands Unit is characterised by areas of organic or intergrade soils underlain by peat. Peat areas are particularly prone to phosphorus loss especially is the land has been recently developed (Rissmann et al., 2012; McDowell & Monaghan, 2015). Organic soils have a low anion storage capacity and therefore do not retain phosphorus in the soil profile as well as soils with a higher mineral content (Rissmann et al., 2012; McDowell & Monaghan, 2015). For similar reasons, peats soils are also poor at retaining K and SO_4 and other agronomically applied chemicals including Ca and Mg. Peat wetlands also show elevated *E.coli* presumably due to high void space and consequently less effective filtering/retention of microbes.

Several streams within or hydraulically connected to the Peat Wetlands Unit within the Waituna catchment are showing increasing trends for dissolved reactive phosphorus (DRP). Median groundwater phosphorus concentrations for areas of peat wetland across the southern portion of the Waituna catchment are 50 times higher than those of the northern half of the catchment (Rissmann et al., 2012).

Summary

- Organic soils are poor at retaining phosphorus and other agronomically applied chemicals.
- Peat soils are poor at filtering out microbes equating to high instream *E.Coli* counts.
- Several streams within or that drain the unit are getting worse with regards to DRP.
- Development of land within the Peat Unit for dairy or wintering should be avoided due to the high risk of P and *E.coli* loss.

- **Central Plains Physiographic Unit (Particularly susceptible to losses under dairy grazing)**

The Central Plains Unit is categorised by aquifers that have little or no ability to remove nitrogen overlain by fine textured soils that have a high proportion of mafic derived clay content. Whilst the soils in this Unit have the ability to remove nitrogen the clay content causes them to crack in the dry summer months allowing drainage water carrying nitrogen to be flushed directly into the aquifers (Rissmann et al., 2015). During the winter these soils then expand and the cracks close forcing water to flow through the soil, through the artificial drain network or overland. This means the Central Plains Unit is highly susceptible to nitrate accumulation in groundwater during late summer and autumn when nitrogen that has accumulated in the soil zone over summer is flushed through the system in the first drainage event. Over winter the Unit acts no differently to the Gleyed Physiographic Unit (Rissmann et al., 2015). Ground and surface waters within the Central Plains Unit are showing significant deterioration. The median groundwater nitrate-N concentration within the unit is 6.1 mg/L, this is second only to the Old Mataura Unit (10.0 mg/L) (Physiographic User Guide, 2015). Some samples of groundwater within the Central Plains Unit exceed the MAV for drinking water (NZDWS, 2008; Rissmann 2012; Rissmann et al., 2015). The Central Plains Unit is dominated by land surface recharge so receives little/no flushing by alpine water (Rissmann et al., 2015). The median surface water nitrate-N concentration within the unit is 5.5 mg/L, this is the highest of any Physiographic Unit (Physiographic User Guide, 2015) and is currently showing an increasing trend (Moreau and Hodson, 2015; Hodson, 2015).

Summary

- Aquifers susceptible to nitrate accumulation.
- Soils allow direct transport of nitrate to aquifers in late summer – autumn.
- Groundwater contributes to streams at baseflow, the Waimatuku in particular is showing significant degradation and water quality is getting worse.
- No/little riverine flushing due to almost exclusive LSR.

- **Riverine Physiographic Unit**

The Riverine Physiographic Unit is categorised by recent and fluvial soils overlying oxidised aquifers. These soils are classed as having a severe nutrient leaching risk. Soils and aquifers within the Riverine Unit have no/little ability to remove nitrogen. Nitrogen losses in these areas under wintering can be large (Smith et al., 2012). The Riverine unit is differentiated from the Old Mataura and Oxidised units by a high degree of flushing by river waters, primarily alpine but also bedrock river recharge. Flushing by alpine and bedrock river water provides an ecosystem service by diluting and transporting nutrients in the groundwater. The high degree of river water flushing regulates the concentration of nitrate to values far below the NZ Drinking Water Standard, with nitrate nitrogen concentrations that are below the national bottom line of 6.9 mg/L.

Losses of nitrogen from these areas contribute to the overall load within the catchment. Due to the potentially large magnitude of losses per hectare these areas may contribute a disproportionate amount of nitrogen to the system. In the Oreti, Aparima, Waiau and Mataura the ultimate freshwater receiving environments are the estuaries. Of these the Jacobs River (Aparima) and New River (Oreti) estuaries are showing signs of degradation and decreasing trends in water quality/state of eutrophication (Stevens & Robertson 2012; Stevens & Robertson 2013; Townsend and Lohrer, 2015).

There are significant unknowns around the fate of nitrogen derived from dairy and winter grazing on the Riverine Unit:

- Whether the majority or a significant proportion of the nitrogen lost is flushed through the estuaries to the sea in winter high flow events.
- Whether some/any of this nitrogen is taken up by macrophyte/periphyton growth in the River and in this then a problem in the estuary at a later time?
- Are N losses from dairying and winter grazing on the Riverine Unit a significant contributor to the degradation of the estuaries?
- Nitrogen lost from these areas during drainage events not associated with high flows may be a significant contributor to adverse effects in the downstream ecosystem.

Due to the majority of soils within the Riverine unit being classified as having severe N leaching loss dairying and winter grazing activities on the Riverine Unit will contribute to the load of nitrogen in the catchment. In regards to the catchment, this contribution is likely to be disproportionate to the land area (Smith et al., 2012; Ledgard, 2013. Whether this nitrogen load from winter and dairy grazing on Riverine is having direct significant impacts on the downstream ecosystems is unclear.

Conclusions

The Old Mataura, Oxidising and Peat Wetlands Physiographic Units have been identified as the most susceptible to nutrient loss and water quality degradation resulting from dairy and winter grazing. The Central Plains unit has been identified as being highly susceptible to dairy farming specifically. It should be noted that the Riverine Physiographic Unit is also susceptible to nitrogen loss but due to flushing by alpine water nitrogen does not accumulate in this environment. Nitrogen is transported down catchment and likely contributes a significant load to the downstream ecosystem. The inclusion of this as a unit of high susceptibility can be considered based on the outline provided above.

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OPUS

Environment Southland

Recommendations for Maximum Allowable Seepage from Effluent Ponds

Environment Southland

Recommendations for Maximum Allowable Seepage from Effluent Ponds

Prepared By

Rex Corlett MBA (Tech Mgmt), BSc (Geog), NZCE (Civil), CPEng, FIPENZ
Principal Engineer Rural

Opus International Consultants Ltd
Christchurch Environmental Office
PO Box 1482, Christchurch Mail Centre,
Christchurch 8140
New Zealand
Mobile: 027 451 1238

Peer Reviewed By

David Rider BSc (Geol)
Senior Engineering Geologist/Geo Professional
Farm Dairy Effluent Design
RDAgritech

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1 Introduction

Environment Southland (ES) are currently preparing their Land and Water Plan and have contracted Opus to provide professional advice in the setting of limits on the maximum allowable seepage from Farm Dairy Effluent (FDE) ponds and similar effluent containment structures.

The scope of the agreed work includes:

1) Attend a council meeting on the 18th March to answer councillor questions around the proposed adoption of IPENZ Practice Note 21: Farm Dairy Effluent Pond design and Construction to replace the ES Code of Practice (ESCOP) for the construction of effluent ponds.

2) Make recommendations as to what should be the maximum allowable seepage limits set when using the Pond Drop Test (PDT). Prepare and present a report which sets out the basis of these recommendations.

3) Independent review of this report including its calculations to provide confidence that its content reflects good civil engineering professional practice.

Definitions

Compliance with containment rules is complicated by some industry confusion around the various terms used in storage pond containment performance. Some organisations cite seepage or leakage rates, while others use permeability or hydraulic conductivity. For this report which relates to liquid effluent flow only, the following terms are used.

<u>(1) Seepage Rate and Leakage Rate:</u>
Seepage and leakage rates provide a measure of the flow rate that effluent is able to move through a lining material such as clay. It measures the rate at which fluid exits the lined basal area (i.e. wetted area) into the surrounding environment. The rate is dependent on the thickness of the liner, and depth of liquid above the liner which can be referred to as the pressure or hydraulic head. Generally the greater the head, the greater the seepage or leakage rate.

For this report, if the rate is within allowable limits it is referred to as <u>seepage</u>, whereas if is not then the term <u>leakage</u> is used.

<u>(2) Permeability and Hydraulic Conductivity</u>
These terms have essentially the same meaning and refer to the flow rate of liquid through a material such as soil under a pressure head. This value is usually determined in a civil engineering testing laboratory. If the permeability of a liner soil is known then its seepage rate can be calculated if the thickness of the liner and liquid depth is also known.

<u>(3) Pond Drop Test</u>
In the last year, the industry has adopted significantly improved technology to accurately measure changing FDE pond surface levels over time. Several suppliers have developed their own Pond Drop Test (PDT) claiming a reproducibility of 0.8mm per day. However no standardised test method has yet been developed in NZ. The current version of IPENZ PN21 only provides limited guidance on pond drop testing.

2 Regional Council and Other Codes Comparison

Council or Code Reference	Maximum Allowable Seepage Rate of the Liner (metres/sec)	Maximum Allowable Permeability Rate of the Liner soil (metres/sec) to meet seepage rate	Maximum permeability rate of liner material (mm/day)	Calculated Maximum Seepage Rate (mm/day)	Maximum Seepage Volume (litres/day)	Maximum Seepage Percentage (% of pond volume per day)	Predicted Pond Drop (mm/day)
ESCOP 450 Equiv	3.80E-08	4.95E-09	0.43	3.3	3,174	0.18%	3.50
Waikato RC Equiv	2.15E-08	2.81E-09	0.24	1.9	1,802	0.10%	2.00
ES Recommended	2.15E-08	2.81E-09	0.24	1.9	1,802	0.10%	2.00
ECAN accepted rate - all liners	1.16E-08	1.51E-09	0.13	1.0	968	0.05%	1.08
IPENZ PN21	7.67E-09	1.00E-09	0.09	0.7	641	0.04%	0.71

To provide a basis for comparison between the maximum FDE pond leakage allowable by other NZ regional councils and codes, comparative calculations were undertaken for a typical pond with dimensions of 30m x 30 m x 3m maximum depth containing 1,764,000 litres. The pond has 2:1 (Horiz:Vert ratio) side slopes and a 450mm thick lining.

These results have been summarised alongside in Table 1. The shaded cells show the limit values adopted by the relevant organisations. These come from the stated (or inferred) compliance values for other regional councils or codes.

Table 1: Comparative "Compliance Values" from other Councils or Codes

Based on Table 1 acceptance values from selected councils or codes, the predicted maximum allowable leakage as a total volume loss in litres per day is presented in Figure 1.

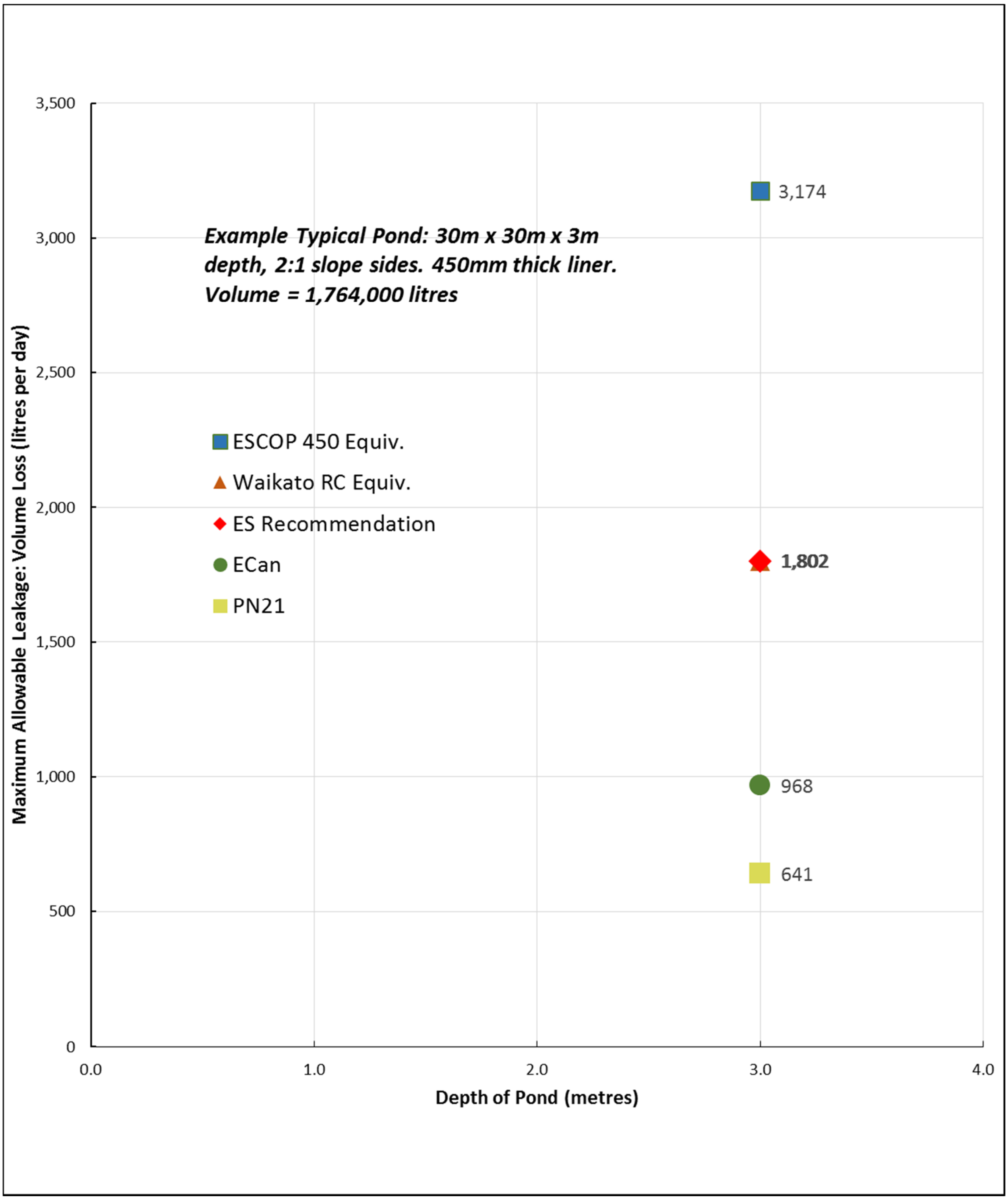

Figure 1: Comparison of Maximum Allowable Leakage between Various Councils and Codes

3 Maximum Allowable Pond Drop Level

Figure 2 below plots the maximum allowable pond level drop for differing pond depths at the acceptance values for the councils and codes selected. It averages the drop of different sized ponds at the given depth.

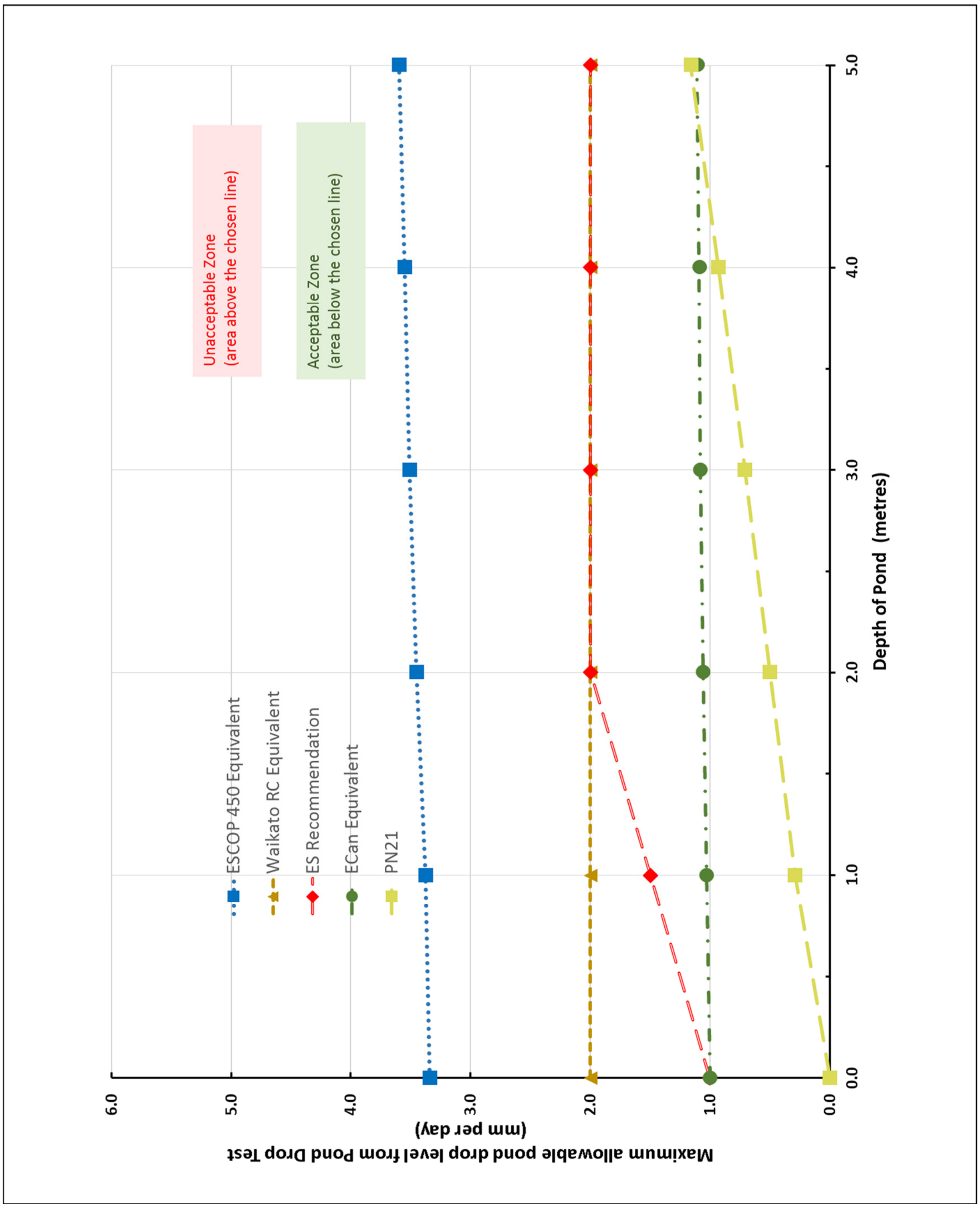

Figure 2: Comparison of Maximum Allowable Pond Drop Levels for Varying Pond Depths, and for Selected Acceptance Values

4 Discussion

Figure 2 illustrates that where there is a maximum liner permeability rate set (e.g. 1 x 10^{-9} for IPENZ 21), pond drop level is sensitive to the maximum depth of the pond. The greater the depth, the greater the risk of a higher seepage rate and hence volume loss. Therefore, for a typical FDE pond, depth is usually a greater indicator of possible leakage than is surface area.

The key questions for Environment Southland to consider for FDE ponds are:

1) **What level of environmental contamination is allowable?**

   Note that this is outside the scope of this report

2) **What maximum volume of pond seepage should be permitted?**

3) **How is seepage loss for FDE ponds best measured?**

To assist in providing technical guidance, commentary is firstly made on the following stated or inferred acceptance values from selected organisations.

IPENZ PN21

IPENZ Practice Note 21 is a Code of Practice, not a standard. It has been produced from an IPENZ-DairyNZ partnership to provide a good-practice industry guidance for designing and constructing FDE ponds. For compacted clay liners it recommends that construction targets a permeability rate of 1 x 10^{-9} m/s. This figure was not intended as a suggested pass/fail value for regional council compliance purposes, but a target which would provide confidence that future FDE ponds could be constructed in accordance with internationally accepted liner permeability standards for gross contaminant confinement.

ES 450 Equivalent

The present ES Code of Practice (ESCOP) allows a minimum liner thickness of 150mm with a seepage rate of 3.8 x 10^{-8} m/s. This would require a soil liner permeability of 1.8 x 10^{-9}. For comparative purposes only, an *ES 450 Equivalent* reference value has been created. This is based on a 450mm thick liner also with a seepage rate of 3.8 x 10^{-8} m/s and a permeability of 5.0 x 10^{-9} m/s.

Waikato RC Equivalent

The Waikato Regional Council have adopted a robust PDT method for compliance purposes. At a pond drop level of about 2mm per day this represents an intervention level by compliance staff.

ECan Equivalent

For resource consent applications Environment Canterbury requires applicants to confirm that seepage rate will not exceed an average rate of 1mm per day. Furthermore, the average seepage rate is to be tested and certified by a Chartered Professional Engineer (CPEng) and the certificate supplied to ECan.

The 1mm per day requirement is seen as quite arduous by the rural industry and has encouraged farmers to move away from compacted clay liners and to use a perceived lower risk synthetic liner instead.

ES Recommendation

ES have requested guidance on what pond drop test value it should set and our recommendation values are illustrated as *ES Recommendation* on the Figure 2 graphs. As previously explained, a single 'across the board' maximum allowable pond drop value is not recommended, but rather a sliding scale based on depth. This approach has been developed into the following Table 2 suitable for inclusion into documents.

Maximum Depth of Pond (m)	*Maximum Allowable Pond Drop (mm per 24 hours)
** Pond must be >75% full (by Volume) during the test*	
<0.5	1.2
0.5 to 1.0	1.4
1.0 to 1.5	1.6
1.5 to 2.0	1.8
>2.0	2.0

Table 2: ES Compliance Recommendation – Maximum Allowable Pond Drop Level

In reaching this recommendation we have been mindful that any set limit should be understandable, measurable, verifiable and enforceable, as well as being in general alignment with good practice codes. Our analysis confirms that leakage rate and therefore leakage volume from a typical FDE pond is very dependent on pond depth, hence our recommendation to not set a single maximum pond drop value for all ponds irrespective of surface area and volume.

The previously adopted ES maximum seepage rate methodology requires knowing the wetted surface area of a pond at the time of PDT testing. This is a major drawback as the lined area under the pond surface is practically very difficult to determine, to verify and adds some uncertainty to the results.

Deep ponds require better permeability material liners than shallow ponds. However the PDT methodology does not discriminate against large shallow ponds which could leak greater volumes than a small deep pond but still be compliant. While not without anomalies, setting an allowable pond level drop for ponds of differing maximum depths is an easier alternative than trying to account for pond surface area.

Current PDT technology is limited to a resolution of 0.8mm which means measure seepage rates below a nominal 9×10^{-9} m/s are not able to be measured. For an IPENZ PN 21 recommended liner thickness of 450mm and with a liner permeability of 1×10^{-9} the PDT is not able to measure the equivalent pond surface level drop. However a PDT that showed a test flat line over the test duration would be a result that council could take confidence in that 'gross' seepage was not occurring. This resolution limitation should not be an issue for compliance testing though as it is where higher permeability values are present that leakage concerns arise. With time and technology, PDT equipment may be available in the future to more accurately measure pond level changes.

The PDT approach is applicable irrespective of the installed liner type and thickness used. Lining systems in use include clay, geomembranes (HDPE, EPDM and GCL) and concrete.

While ES may not wish to take compliance action if leakage just exceeds these recommended maximum PDT values, they will provide a clear limit as to what is expected. Leakage values that grossly exceed these will assist compliance staff in identifying if more immediate and direct actions are required.

4 Other Issues

There are a number of issues that have not been specifically explored as part of this report but will need to be considered by ES if maximum allowable seepage limits are set.

a) **Required Pond Depth for PDT testing**
The greatest value from testing will be achieved when as much of the lined pond area is covered with effluent as possible. Outlet pipes and the interface level between insitu and the overlying fill materials are often where leakage can occur and so the effluent level ideally needs to be above these problematic areas when testing. 75% of the full working volume of the pond should be adopted as the pond is usually higher at this testing level than at 75% of the maximum depth.

There are times in the year that ponds should intentionally be low, e.g. prior to winter. For routine PDT tests these should be coordinated to coincide when ponds will be at higher levels.

b) **How is the maximum pond height determined?**
The maximum pond level height should not include freeboard (typically 500mm).

c) **How is the maximum pond depth determined?**
In many cases the farm owner will not know the maximum pond depth. Even if there were construction plans the actual depths may not be the same as what was designed. Landowners and PDT providers will need to make their own arrangements to ascertain maximum pond depth. This is more easily done when ponds are at the low point in their operating range.

d) **Who can signoff a PDT report?**
Our view is that only an IPENZ assessed Chartered Professional Engineer (CPEng) or Engineering Technician Practitioner (ETPract) should be signing off on the PDT tests. This is to provide professional credibility, especially if it is used as evidence in prosecutions. The quality of a test is not only as good as the skill of the test operator but the competency of the person checking the calculations and reviewing the report before its release. ES needs to have confidence that PDT reports accurately reflect what is being measured as Environment Canterbury do by requiring CPEng sign off.

e) **Standard Test Method?**
Presently there is no test standard for the PDT procedure. I have raised with DairyNZ and IPENZ the possibility of developing such a test and having it included in an updated IPENZ Practice Note 21 Version 3. It is hoped that this will be published later this year after widespread industry consultation and so provide a national standardised test approach. To reflect current good practice, any ES rule needs to allow the latest available test method version to be adopted.

f) **Site Inspection**
A PDT result is not a single check for pond compliance. Further inspection and testing of the pond may be required. A number of FDE ponds have been built below ground water level which may affect PDT results.

Opus International Consultants Ltd
12 Moorhouse Avenue
PO Box 1482, Christchurch Mail Centre,
Christchurch 8140
New Zealand

t: +64 3 363 5400
f: +64 3 365 7858
w: www.opus.co.nz

Preliminary analysis of winter forage crops in Southland

Dr. Lisa Pearson

Introduction

Landcare Research was contracted by Environment Southland to construct a map of livestock forage locations throughout winter of 2014 for the entire Southland region. To better understand the spatial distribution of forage crops in Southland, the current land use and hectares of crop by property area can provide useful information of what farm types graze stock on winter forage. This can also be intersected with the Physiographic Units to assess the number of properties which may be affected by the rules in the regional plan currently being drafted. Using the results from the Landcare Research study and land use information held by Environment Southland (Pearson, 2015) analysis of winter forage distribution across Southland can be assessed.

Limitations

This preliminary assessment has been carried out prior to the review of the Land Use Map and without data correction for spectral errors. The land use map has been created to legal property boundaries and may not represent the true extend of what is farmed.

This assessment is intended to be used as a guide only and a full report titled 'Spatial analysis of winter forage cropping in Southland' is currently in preparation (Pearson and Couldrey, in prep).

Method

To calculate specific areas of winter livestock forage the raster grid cells of the Landcare Research Map (multitemp_classn1.tif) was converted in to a vector format. Two classes were selected from the final output for 'Specifically forage' and 'Likely forage'.

As this is a preliminary investigation the complex methodology to remove spectral errors was not undertaken (Pearson and Couldrey, in prep). Instead a minimum polygon size of 1 ha was applied to remove polygons likely created through spectral interference.

The layer was then intersected with the Draft Land Use Map to identify the land use of properties with winter forage crops (See Appendix 1 for Land Use categories). To further refine and reduce likely error a definition query was used to only assess those land uses which would have winter forage and areas greater than 1ha ("LandUse" IN ('Arable', 'Beef', 'Dairy', 'Dairy Support', 'Deer', 'Deer, Sheep & Beef', 'Lifestyle Block', 'Mixed Drystock (Sheep, Beef, Deer)', 'Mixed Drystock and Arable', 'Other Animals', 'Pasture Unspecified Use', 'Sheep', 'Sheep and Beef', 'Support Block') AND "Shape_Area" >=1).

The resulting layer was dissolved by land use and intersected with the Physiographic Units.

Results and Discussion

There are approximately 3,225 properties in Southland on which greater than 1 ha of forage crop is grown. The amount of crop grown for 2014 is approximately 63,738 ha across all land uses (Table 1). Over 70% of the forage crops are grown on properties that are identified as a combination of sheep and beef. Number of properties provided in Table 1 is calculated from the count of polygons created when fodder areas were intersected with land use and should be used only as an estimate. The methodology developed to asses land use divides some properties into two different categories (ie. Dariy and Dairy Support) even if they are legally the same property. Lakes and Rivers were removed from the assessment, however approximately 440 ha of crops are grown on these areas. Due to the current misalignment with property boundaries near river channels, these areas of crop cannot be attributed back to a land use category or property.

Table 1: Winter forage grown in Southland by land use.

Land Use	Total (ha)	Percentage of crop (%)	No. of properties	Average crop (ha)	Max. crop area (ha)
Sheep and Beef	25,600.4	40.2	803.0	31.9	828.4
Dairy	8,916.1	14.0	744.0	12.0	175.8
Mixed Drystock (Sheep, Beef, Deer)	8,266.6	13.0	192.0	43.1	877.2
Sheep	7,166.1	11.2	514.0	13.9	232.4
Pasture Unspecified Use	3,411.7	5.4	320.0	10.7	96.3
Dairy Support	2,668.2	4.2	172.0	15.5	103.5
Beef	2,165.4	3.4	144.0	15.0	182.2
Mixed Drystock and Arable	1,568.2	2.5	61.0	25.7	89.3
Support Block	1,403.4	2.2	82.0	17.1	117.6
Deer	1,223.4	1.9	87.0	14.1	152.9
Deer, Sheep & Beef	1,001.6	1.6	29.0	34.5	261.1
Arable	200.1	0.3	19.0	10.5	42.0
Lifestyle Block	84.0	0.1	41.0	2.0	7.4
Other Animals	62.5	0.1	17.0	3.7	8.9
Grand Total	63,737.8	100.0	3225.0	19.8	

The average area of fodder grown on Southland properties is approximately 20 ha (Table 1), with the maximum area of 877 ha on a single property. Typically Dairy farms have less fodder crop when compared to other drystock farms as they typically winter cows off the milking platform. 80% of properties in Southland have less than 25 ha of fodder crop (Figure 1, Table 2).

Table 2: Size range of crop on properties

Forage crop size	No. of properties	Percentage of properties (%)	Cumulative (%)
1-5 ha	991	30.7	30.7
5-10 ha	689	21.4	52.1
10-25 ha	934	29.0	81.1
25-50 ha	351	10.9	91.9
50-100 ha	179	5.6	97.5
100-200 ha	53	1.6	99.1
200-300 ha	18	0.6	99.7
300-400 ha	4	0.1	99.8
400-500 ha	2	0.1	99.9
500+ ha	4	0.1	100.0
Grand Total	3225	100.0	100.0

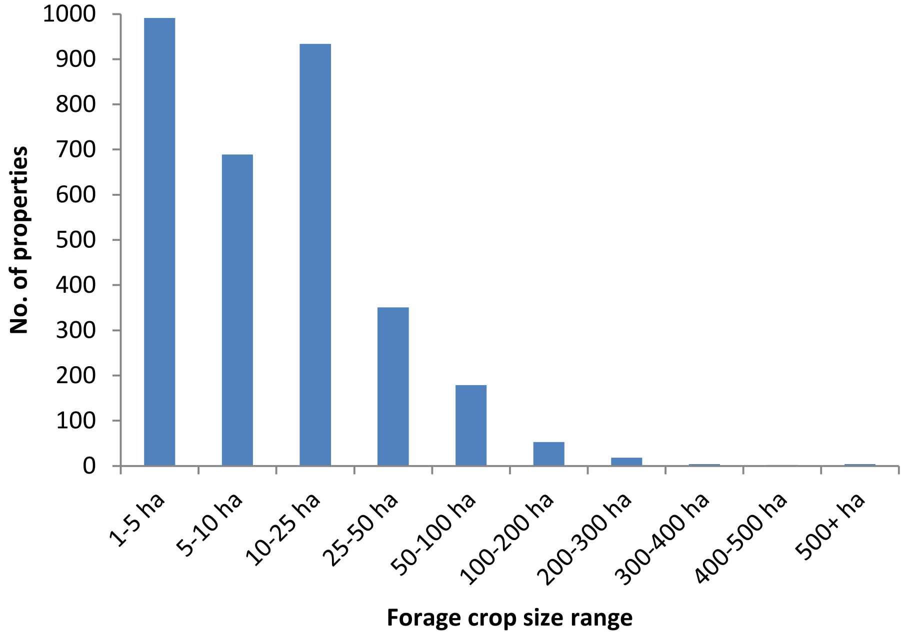

Figure 1: Size range of crop on properties.

The Physiographic Units with the largest amount of forage crops are Hill country, Oxidising and Gleyed (Table 3). See Appendix 2 for comparisons with land use and additional physiographic varients. Number of properties on each physiographic unit is unable to be calculated as many properties have mixed units within the property.

Table 3: Area of crop grown under different physiographic units.

Physiographic Unit	Total of crop (ha)	Percentage (%)
Alpine	53.4	0.1
Central Plains	1,127.2	1.8
Gleyed	12,491.6	19.6
Hill Country	23,501.9	36.9
Lignite - Marine Terraces	2,174.2	3.4
Old Mataura	1,997.2	3.1
Oxidising	14,321.4	22.5
Peat Wetlands	1,949.5	3.1
Riverine	6,105.0	9.6
Grand Total	63,721.4	100

Environmental Impact

The environmental impact of winter crop in Southland is hard to estimate as the stock type grazing the crop is often unknown. However, a few assumptions can be made. Fodder crop on the Dairy milking platform is grown for Dairy cows either for the dry season or for the shoulders of the season before and after cows are wintered off the property. Small amounts of fodder crop on sheep and beef farms are likely supporting their own stock over the winter, while large amounts of crop are also wintering stock from other properties.

How the crop is fed out to stock is also another factor to consider. Lifting crop to feed out on feed pad has a significantly lower nutrient loss than strip grazing animals directly on the crop. Strip grazing on crop significantly reduces soil quality by increasing compaction and decreasing porosity. Soils with poor structure take longer to recover and may require other management practices, such as aeration, to improve soil health. The longer a paddock remains fallow the larger the risk for nutrient and sediment loss.

Summary

Forage crop in Southland is typically grown on most properties, with approximately 70% of crop on drystock farms. Approximately 81% of farms with fodder crop are likely to be growing crops to support their own stock (areas < 50 ha) while the remaining 19% are likely to be grazing other peoples stock. Percentage of crop grown on property should also be used to estimate which properties are likely to be grazing other peoples stock over the winter months. Consultation with industry representatives will also better inform this estimate. Hill country, Oxidising and Gley physiographic Units have the largest amount of crop grown on them.

This assessment is to be used as an estimate only. The input layers are still in a draft form and require further refinement before use. This assessment has not been checked against the Land Cover Database (LCDB4.1, surveyed in 2012) for spectral inconsistencies (ie. scrub categorised as forage crop) or the Digital Elevation Model (DEM) to check for slope errors. This will be added in the final report.

Appendix 1: Land Use Categories

Land use categories are as follows:

- Beef is defined as > 10 beef cows (sheep < 50, deer < 25) on a property
- Deer is specialist deer (deer only) defined as > 25 deer (sheep < 50, beef < 10) on a property
- Sheep is defined as > 50 sheep (beef < 10, deer < 25) on a property
- Sheep and Beef is sheep > 50 and beef > 10 on a property
- Mixed Drystock (Sheep, Beef, Deer) is sheep < 50, beef < 10, deer < 25 on a property
- Deer sheep & beef is (deer (mixed)) where deer numbers are greater than 45 % of stock on property.
- Dairy is milking platform only sources from ES consents database. Does not include dairy < 100 cows.
- Dairy support is dairy as classified by Agribase (inc. Dairy < 100 cows, runoff blocks and winter grazing areas)
- Other animal classification is Agribase classification of other animals, alpacas, bees, dogs, goats, horses, ostriches, pigs and poultry.
- Lifestyle is properties not in the residential zones < 5 ha
- Support block is properties that identify as being graziers.
- Arable is classified by Agribase.
- Pasture unspecified use is properties where not land use information is obtainable.

Note: These categories are subject to change as the recommendations from the Landcare Research review are implemented.

Appendix 2: Piviot tables

Table 4: Number of properties within in each land use by fodder crop size range.

	Sheep and Beef	Dairy	Sheep	Pasture Unspecified Use	Mixed Drystock (Sheep, Beef, Deer)	Dairy Support	Beef	Deer	Support Block	Mixed Drystock and Arable	Lifestyle Block	Deer, Sheep & Beef	Arable	Other Animals	Grand Total
1-5 ha	132	276	174	133	28	46	61	42	22	10	39	5	9	14	**991**
5-10 ha	145	190	131	82	29	40	24	12	14	9	2	3	5	3	**689**
10-25 ha	280	195	145	70	68	56	34	21	32	20		11	2		**934**
25-50 ha	117	65	40	28	28	21	13	8	9	13		6	3		**351**
50-100 ha	81	14	18	7	25	8	11	1	4	9		1			**179**
100-200 ha	30	4	5		6	1	1	3	1			2			**53**
200-300 ha	12		1		4							1			**18**
300-400 ha	3				1										**4**
400-500 ha	2														**2**
500+ ha	1				3										**4**
Grand Total	**803**	**744**	**514**	**320**	**192**	**172**	**144**	**87**	**82**	**61**	**41**	**29**	**19**	**17**	**3225**

Table 5: Area of Fodder crop in hectares by Land Use and Physiographic Unit

	Alpine	Central Plains	Gleyed	Hill Country	Lignite - Marine Terraces	Old Mataura	Oxidising	Peat Wetlands	Riverine	Grand Total
Sheep and Beef	41.1	107.8	3311.8	12564.5	678.6	820.2	4516.5	730.3	2826.0	25596.8
Dairy		460.0	3148.8	1332.6	560.2	185.9	2465.2	338.8	424.5	8915.9
Mixed Drystock (Sheep, Beef, Deer)	12.3	18.2	878.5	4021.0	132.9	97.4	1672.8	354.7	1077.7	8265.5
Sheep		139.2	2024.0	2166.5	323.7	115.7	2001.2	101.2	294.7	7166.1
Pasture Unspecified Use		110.6	736.4	997.7	137.1	153.5	890.3	70.3	314.9	3410.8
Dairy Support		88.5	621.9	681.2	125.5	80.0	636.0	68.9	366.2	2668.2
Beef		31.8	484.5	526.5	51.9	62.9	693.6	141.0	173.1	2165.4
Mixed Drystock and Arable		137.7	652.6	161.3	35.3	128.5	251.3	66.0	135.6	1568.2
Support Block			235.8	233.3	98.3	152.3	561.4	6.9	104.9	1392.8
Deer		1.3	175.5	301.5	5.4	186.3	370.7	41.8	140.9	1223.4
Deer, Sheep & Beef			115.2	495.5	23.9		103.7	27.6	235.8	1001.6
Arable		29.3	60.2			0.0	104.6		5.9	200.1
Lifestyle Block			21.3	16.3	1.6	2.7	35.3	2.1	4.8	84.0
Other Animals		2.7	25.3	4.1		11.8	18.7			62.5
Grand Total	53.4	1127.2	12491.6	23501.9	2174.2	1997.2	14321.4	1949.5	6105.0	63721.4

Table 6: Area of Fodder crop in hectares by Land Use and Physiographic Unit Variant

	Sheep and Beef	Dairy	Mixed Drystock (Sheep, Beef, Deer)	Sheep	Pasture Unspecified Use	Dairy Support	Beef	Mixed Drystock and Arable	Support Block	Deer	Deer, Sheep & Beef	Arable	Lifestyle Block	Other Animals	Grand Total
Alpine - No Variant	41.1		12.3												53.4
Central Plains - No Variant	107.8	460.0	18.2	139.2	110.6	88.5	31.8	137.7		1.3		29.3		2.7	1127.2
Gleyed - No Variant	3164.2	3057.0	820.1	1918.1	711.4	565.3	448.1	641.0	223.1	147.3	104.9	60.2	21.3	23.6	11905.6
Gleyed (o)	147.5	91.8	58.4	105.9	24.9	56.7	36.4	11.6	12.6	28.1	10.3			1.6	586.0
Hill Country - No Variant	3850.6	266.5	995.4	571.4	283.4	278.1	186.3	13.7	22.5	48.4	117.4		2.3	2.2	6637.9
Hill Country (f)	106.8	20.3	88.0	11.4	5.4	19.5			22.0	7.9	2.4				283.7
Hill Country (os)	8143.1	1016.5	2868.8	1420.0	628.0	369.1	324.8	143.2	177.9	221.2	341.6		13.0	0.1	15667.2
Hill Country (r)	463.9	29.3	68.7	163.7	81.0	14.5	15.4	4.4	11.0	24.0	34.1		1.0	1.9	913.1
Lignite - Marine Terraces	678.6	560.2	132.9	323.7	137.1	125.5	51.9	35.3	98.3	5.4	23.9		1.6		2174.2
Old Mataura - No Variant	713.5	121.3	63.2	65.6	116.3	54.8	31.1	113.1	152.3	169.8		0.0	2.7	11.8	1615.5
Old Mataura (b)	106.7	64.6	34.2	50.1	37.1	25.2	31.8	15.4		16.5				0.0	381.7
Oxidising - No Variant	3076.1	1550.8	1471.7	1358.1	583.7	455.5	513.1	234.5	482.1	259.7	85.3	79.3	19.8	8.9	10178.5
Oxidising (b)	878.0	777.6	140.5	484.7	213.5	128.9	170.6	7.8	69.2	58.2	9.2	21.2	15.6	9.8	2984.6
Oxidising (o)	562.4	136.8	60.7	158.4	93.1	51.6	9.9	9.0	10.1	52.8	9.2	4.2			1158.3
Peat Wetlands - No Variant	730.3	338.8	354.7	101.2	70.3	68.9	141.0	66.0	6.9	41.8	27.6		2.1		1949.5
Riverine - No Variant	2377.9	413.6	952.4	288.0	267.5	328.1	169.9	135.1	103.7	140.9	130.5	5.9	2.8		5316.4
Riverine (o)	448.1	10.9	125.2	6.6	47.4	38.1	3.1	0.6	1.2		105.4		2.0		788.6
Grand Total	25596.8	8915.9	8265.5	7166.1	3410.8	2668.2	2165.4	1568.2	1392.8	1223.4	1001.6	200.1	84.0	62.5	63721.4

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Management practices and mitigation options for reducing contaminant losses from land to water

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May 2016

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Management practices and mitigation options for reducing contaminant losses from land to water

Report prepared for Environment Southland

May 2016

R M Monaghan

Table of Contents

1. Background

This document provides a brief description of a range of good agricultural management practices and mitigation measures that are relevant to managing water quality in Southland. This overview has been commissioned by Environment Southland as supporting material that will be used to help underpin policy developments that are being progressed under the Council's Land & Water Plan to be notified in 2016. It draws on a range of generic documents, scientific reports and publications that document the range of potential measures land users can implement to improve water quality outcomes. Section 2 firstly describes general mitigation measures for improving nutrient and effluent management and capturing or attenuating nutrients. Section 3 then provides an overview of mitigation measures that are either targeted at managing critical source areas of contaminant losses (section 3.1) or reducing the accumulation of surplus N in the soil, particularly during autumn and winter (section 3.2).

2. General mitigations

2.1 Nutrient management

2.1.1 Nutrient budgeting

Nutrient budgets account for nutrient flows into and away from farm blocks in fertilizer, feed, animal transfer, animal product and via loss pathways such as leaching, runoff and volatilisation. The planning objective is to ensure that nutrient inputs and outputs are balanced to avoid situations of deficit or surplus. The OVERSEER® nutrient budgeting program (hereafter referred to as Overseer) is a tool that has been developed to assist with such planning decisions.

2.1.2 Reduce use of P fertilizer where Olsen P values are above agronomic optimum

The magnitude of P losses from soil via surface runoff or subsurface flow is generally proportional to soil P concentration. Hence, maintaining a soil test phosphorus (P) concentration in excess of the optimum for pasture production represents an unnecessary source of potential P loss. An optimal soil test P concentration (e.g. Olsen P) can be achieved through regular soil testing and use of nutrient budgeting software, such as Overseer, to guide P inputs. Reducing P inputs and soil test P levels to agronomically-optimum levels will always represent a profitable strategy. The magnitude for P loss mitigation is dependent on how excessive soil Olsen P is. However, soil type also plays a role in P loss and some soil types can lose environmentally-significant quantities of P at Olsen P levels that are less than the agronomic optimum.

2.1.3 Use low solubility P fertilizer forms if runoff risk is high; or fertilize outside risk months (May to September inclusive)

Low water solubility P fertilisers maintain a smaller pool of soluble P in soil solution soon after application than highly water soluble P fertilisers (e.g. superphosphate), thereby minimising the potential for loss should runoff occur. Reactive phosphate rock (RPR) fertiliser has little water soluble P and has been shown to decrease dissolved P losses. However, reactive phosphate rock should not be used where annual rainfall is < 800 mm and soil pH is > 6. Given that only about a third of the applied P in RPR becomes available per annum, a lead-in time is usually required if changing to a fertiliser that has low levels of water soluble P.

2.1.4 Use of Precision Agriculture techniques e.g. GPS guidance and crop sensing

Good design, including the use of novel sensors and automation of crop production, will optimise water and nutrient application according to local plant requirements. Sensors and information usage can also lead to individual animal-based and optimised herd management. By accounting for site-specific growth conditions, water demand and emission risks, precision agriculture can improve local production potentials and increase nitrogen (N) use efficiency.

2.2 Riparian management

2.2.1 Stream fencing

Preventing livestock access to streams decreases stream bank damage (and sediment inputs via bank erosion), bed disturbance of sediments (and entrained *E. coli*, N and P) and stops the direct deposition of excreta into streams.

2.2.2 Improve on-farm infrastructure to keep stock and stock effluent out of waterways

Putting in culverts or bridges at regular stock crossings will prevent animals from fording streams and thus avoid the direct entry of faeces, urine and contaminants entrained in hoof mud. It will also avoid disturbance of the stream bed. Reticulating stock water supplies and planting shade trees away from water will help to reduce animal trafficking through and around stream locations. Reducing runoff from tracks and races using cut-offs and shaping is another particularly important measure that will prevent faecal microorganisms, sediment and P entering streams.

2.2.3 Riparian planting

Planted riparian margins provide a number of ancillary benefits that help to improve the ecological function of waterways. These include the provision of shade to minimise fluctuations in stream temperatures, stabilisation of stream banks, uptake of nutrients from riparian margins, increased biodiversity and aesthetic values.

2.3 Effluent management

2.3.1 Increase land application area to ensure N, P and K returns are not excessive

Because effluent is a particularly rich source of N, P and potassium (K), it makes good economic sense to ensure that inputs of these effluent nutrients are matched to provide the agronomic requirements of pastures on the effluent-treated parts of the farm. The preparation of a nutrient budget will help determine the appropriate area that could be treated with effluent.

2.3.2 Increased effluent pond storage and deferred irrigation

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, surface runoff via an infiltration or drainage impediment, or application to rolling/sloping land. Deferred irrigation, which involves storing FDE in ponds when soil moisture is close to or at field capacity and applying FDE to land at other times, has proven effective at decreasing N, P and *E. coli* losses.

2.3.3 Low rate effluent application

Low rate effluent application systems typically use sprinkler-type delivery nozzles to deliver instantaneous rates of effluent application of 10 mm per hour or less. This is much lower than delivered by a rotating twin gun travelling irrigator, and allows effluent more time to infiltrate the soil, helping to ensure the liquid and nutrients contained in the effluent remain in the root zone, available for plant uptake. Runoff or drainage that may occur will at least have had some degree of filtering by the soil if a low rate application system has been used.

2.3.4 Minimise effluent volumes at source

Reducing wash water volumes (e.g. by scraping the yard first and reducing the amount of rainwater captured in the effluent system) will help to minimise the volumes of effluent that need to be pumped, stored and/or applied to land. As well as saving on electricity and pond construction costs, these measures also help to reduce the water quality risks associated with handling the large volumes of liquid effluents that can be generated and re-distributed around dairy farms.

2.4 Capture nutrients, sediment and microbes in wetlands and sediment traps

2.4.1 Facilitated wetlands

These types of wetlands utilise naturally poorly drained parts of the landscape where seepage flows can more easily be intercepted. Fencing and planting of these areas helps to create a wetland environment where sediment, entrained in flow, can be captured, and N removed by denitrification. The beneficial effects of wetlands can be negated if not fenced to exclude cattle and deer, or leaving buffers when over-sowing or topdressing (or if, for some alpine landscapes, burning).

2.4.2 Constructed wetlands

Modification of landscape features such as depressions and gullies to form wetlands. These types of wetlands have also been designed to capture sediment and N discharging from tile drains. Compared to many natural wetlands, constructed wetlands can be designed to remove contaminants from waterways by: 1) decreasing flow rates and increasing contact with vegetation – thereby encouraging sedimentation; 2) improving contact between inflowing water, sediment and biofilms to encourage contaminant uptake and sorption; and 3) creating anoxic and aerobic zones to encourage bacterial nitrogen processing, particularly denitrification loss to the atmosphere. If constructing a wetland, incorporate appropriate plants (such as red tussock, New Zealand flax, purei (carex secta), raupo, and South Island toetoe) and sediment traps, and consider locating near seepage zones where relevant.

2.4.3 Sediment traps

Sediment traps are engineered structures designed to slow water flows, reduce flow energy, filter sediment and allow grass growth. Examples of such structures include decanting dams, detainment bunds, stock ponds or earth reservoirs constructed at natural outlets of zero-order catchments. In-stream sediment traps are useful for the retention of coarse-sized sediment and associated N and P, but do little to retain N and P bound to fine sediment. As the P sorption capacity of fine particles is much greater than coarse particles (w/w basis), sediment traps can be ineffective at decreasing P loss if the soil is finely textured and/or surface runoff is dominated by fines.

3. Targeted mitigations

3.1 Manage critical source areas (CSAs) – protect soil structure, particularly in gullies and near stream areas

Critical source areas account for the majority of a farm's contaminant losses, but come from a minority of the land area. Identification and targeting of mitigations to critical source areas can greatly increase the cost-effectiveness of mitigations.

3.1.1 Minimise fence-line pacing by deer by creating a visual barrier or separating mobs

This strategy is specifically targeted at red deer who have a tendency to pace and erode fence-lines when stressed, for example, when feed is low or near calving. The strategy involves a combination of tree planting to provide shelter and maintaining sufficient feed to ensure stress is minimised. Placing visual barriers between herds will help to minimise social interaction and thus fence-line pacing that can often occur.

3.1.2 Use minimum or no-til cultivation practices such as direct drilling

Minimum or no-til cultivation practices can help to minimise direct and indirect losses of sediment and nutrients to water. A range of techniques is available, from direct drilling of seed into stubble or pasture, through reduced number of cultivation passes, to more judicious use of conventional ploughs and harrows. These help to reduce the proportion of time that land is bare during the growing cycle. Reduced soil disturbance helps to maintain soil aggregation and water infiltration, which in turn helps to reduce the rapid mineralization of soil N and the generation of surface runoff. The suitability of minimum or no-til practices will depend on a range of other agronomic factors, however, and need to be considered on a case-by-case basis.

3.1.3 Cultivate along contours on sloping ground

Cultivation along contours of cropping land will reduce the speed of runoff water, thereby helping to reduce its erosive power and the amounts of sediment, nutrients and faecal micro-organisms entrained in this flow.

3.1.4 Plant spaced poplars or other poles on steep country

Pole planting (and/or retirement of areas) on highly erodible land will lead to the development of tree roots that help to protect soil on steep slopes from mass-movement erosion.

3.1.5 Match stock management to land use capability

Avoiding grazing heavy stock on steeper, more vulnerable soils, especially when wet, will help to reduce soil treading damage and consequently the amounts of surface runoff that can be generated. This will in turn reduce the quantities of sediment, nutrients and faecal micro-organisms entrained in this flow.

3.1.6 Protecting CSAs on winter forage crops to reduce surface runoff

Winter grazing of a forage crop can often lead to large losses of sediment, P and faecal microorganisms in surface runoff that occurs in gullies and swales. Protection of soils in these areas has been shown to be a particularly cost-effective way to minimise the amount of surface runoff that is generated:

- Graze from the top of the slope toward the CSA (such as a gully or swale) – this uses the crop closest or the CSA as a filter for sediment and dung that might be transported in surface runoff. Ensure the CSA is the last break to be grazed by stock.
- Restrict the time spent grazing in the CSA to 3-4 hrs so animals get their maintenance feed requirements whilst minimising the extent of soil treading damage and thus potential for surface runoff.
- Back fence stock off land that has already been grazed to minimise further soil damage.
- Ideally, avoid cultivating the CSA and leave it in pasture to act as a filter for any surface runoff that may occur.

3.1.7 Protecting CSAs on pastures to reduce surface runoff

Rolling and steep pastoral lands often have clearly identifiable CSAs that are frequently wet and prone to damage by stock trampling. Such trampling will exacerbate the potential for surface runoff, which is often already relatively high due to the occurrence of convergent flows that may arise from seeps and wet gully areas. Direct deposition of animal excreta into these areas also provides a source of contaminants that can be transported in these convergent flows. Protecting these locations from stock damage, even just temporarily during wet periods, is likely to avoid these losses.

3.1.8 Provide deer wallows away from waterways

Red deer will use or create areas for wallowing. The wallows are often directly connected to streams thereby providing a direct conduit for deposited excreta. Disturbance of the stream bed and banks can be a major source of sediment during wallowing. Fencing off existing connected wallows and the creation of a wallow that is not connected to a stream will avoid these problems.

3.1.9 Leave vegetated areas around CSAs and stream margins

A vegetated buffer or filter strip is a fenced-off area containing dense grasses or native plants that runoff water passes through before reaching a water body. These areas act as infiltration or deposition zones that are particularly effective at intercepting particulate material. Their recommended size varies depending on soil and landscape features. It is particularly important that they are located in areas where surface runoff is known to occur or converge.

3.1.10 Plant split grass/clover swards in near-stream areas

Using grass–clover monocultures strategically across a dairy farm may decrease P loss to surface water and improve profitability compared with a mixed pasture. The principle of this technique is to ensure that plants that have a relatively high P demand, such as clover, are located away from near-streams areas. Conversely, grasses that have a lower P demand can be located in near-stream areas (the CSA) and fertilised to maintain a lower soil Olsen P test and thus a smaller reservoir of P that could potentially be transported in overland flow (or subsurface drainage).

3.1.11 Move troughs and gateways away from water flow paths

Areas of compacted soil or gravel have minimal infiltration. Excreta deposited to these areas can therefore be easily transported in surface runoff. To avoid this runoff entering streams, ensure that these hard surface areas are located well away (or "disconnected") from active flow pathways that can deliver water contaminants to streams.

3.2 Reduce the accumulation of surplus N in the soil, particularly during autumn and winter

3.2.1 Reduce inputs of nitrogen, such as fertiliser or N contained in imported feed

Greater N use efficiency can be achieved by the implementation of a number of measures that collectively help to reduce the risk of N losses to water. These include increasing per-animal production, with a commensurate decrease in animal stocking rate (replacement rates particularly) to maintain per hectare production and profitability; using less fertiliser N and some, if prices allow, low N feeds; and maximising the N value of farm dairy effluent by applying it to a greater proportion of the farm. The use of gibberellic acid to boost pasture growth is another option that can allow overall N inputs to the farming system to be reduced accordingly.

3.2.2 Increase the spread of urinary N – change animal type or salt supplementation

Animal type influences N leaching due to inherent differences in the spread of urinary N (the major source of N loss in grazed pastures). Increased urinary spread results in a lower rate of N deposited in urine, greater utilisation by plants and less surplus N that contributes to N losses. Research has shown that N leaching from sheep and deer is approximately half that from beef cows at the same level of feed intake. Potentially, differences also exist between male and female cattle; losses from male cattle being about two-thirds that of female cattle, although there is high uncertainty with this. Similarly, young cattle are assumed to have greater urinary N spread than larger older cattle due to greater animal numbers per unit of feed consumed and thus a greater number of urinations; again, there is limited data on this aspect, however. An alternative way of increasing the spread of urinary N is to supplement animals with salt. Recent research has shown that this increases water intake and urination frequency, resulting in a lower urine N deposition rate and decreased N leaching risk.

3.2.3 Duration-controlled grazing

Research in Southland (and elsewhere) has also shown that restricting autumn grazing rounds to 3-4 hours per break, then excluding the animals (removing them to a pad or barn) can significantly decrease urine deposition to land prior to the on-set of winter drainage. This management system has been shown to decrease nitrate losses in drainage from the milking platform by up to 40%; this does however depend on the extent to which duration-controlled grazing is implemented during autumn months. This principle of duration-controlled grazing as a strategy for reducing N leaching is likely to also apply to grazed winter forage crops, although research quantifying this effect is still in a preliminary stage.

3.2.4 Off-paddock wintering

On-going research in Southland indicates that grazed winter forage crops are a significant source of the nitrate lost in drainage from the dairy farm system.

Strategies that avoid or minimise the deposition of urine to these grazed crops can help to decrease these leaching losses. Stand-off pads (preferably covered) or wintering barns are some of the infrastructure options that could be considered to allow for capture of urinary N that would otherwise be deposited directly in the paddock. Cut-carry fodder crop systems are one example of an off-paddock wintering strategy that might be practical and affordable for some; other approaches that are more commonly used are based around providing ensiled feeds whilst animals are off-paddock during winter.

3.2.5 Re-sow areas of bare or damaged soil as soon as possible

Re-sowing areas of bare or damaged soil as soon as practical will help to minimise periods when exposed soil may be prone to erosion, overland flow or leaching. The rapid establishment of crops or pastures will maximise the opportunity for plants to take up N from the soil, thus reducing the risk of N leaching. This can be particularly important for summer-grazed forage crops that will have much urinary N deposited onto bare soil.

3.2.6 Incorporating low N feeds into diets

Ruminant animals consuming a pasture-based diet typically ingest far more N that they require. Consequently, more than 70% of ingested N is excreted via urine and dung. Because urine is the major source of N lost from grazed pastures in NZ, any strategy that can decrease the amount of urinary N deposited to pasture will help to decrease N leaching losses. The incorporation of low N feeds such as maize or cereals into diets has been shown to decrease urinary N excretion and on-farm N leaching losses. However, it is important to also consider the effects of the production of low-N feed on N losses; when this is done there may only be small whole-system benefits unless N-efficient practices are used to grow the low-N feed crop. Potentially, this strategy will be most beneficial where the low-N feed is a waste by-product from another sector (e.g. vegetable or fruit waste).

3.2.7 Plant catch crops to capture N from grazed winter forages

Preliminary research trials in Canterbury have established that nitrogen (N) leaching from winter forage crop paddocks can be reduced by planting an oat crop immediately after cows harvest the winter forage. The oats crop in this sequence is a “catch crop” that can capture urinary N from the soil, while increasing overall annual crop yield when compared to the standard winter forage crop. Sequence cropping can provide all the feed needed for wintering, whereas kale-only systems require supplements to be brought in to balance the diet. Sequence cropping will only be successful on free-draining soils where machinery can operate soon after kale grazing is completed, where there is irrigation or good rainfall from early December onwards, and where kale is well-utilised during winter grazing so the residues do not interfere with sowing of the oats.

3.2.8 Optimize timing and amounts of irrigation input

The judicious timing of irrigation inputs will minimise the risk of leaching and runoff. Guidance using soil moisture balance calculations or soil moisture sensors will help to ensure irrigation is applied to replace soil moisture deficits, thus minimising applications of surplus water that could transport nutrients beyond the root zone. Regular evaluations of irrigation system performance will help to ensure that water is delivered according to need.

3.2.9 Schedule N applications to meet plant demand using split applications

The principle of scheduling N fertiliser applications to crops and pastures is to synchronise inputs with plant demand, recognising that a range of factors will govern plant requirements. Some important factors are yield potential, the intended use of the crop, moisture and temperature limitations, soil type, paddock history, cultivar and plant establishment. In most situations split applications of N fertiliser will be required to maximise the opportunity for plant N uptake whilst minimising the risk of loss to the wider environment. Due to the potentially wide range of factors to be considered, the use of expert agronomic advice and tools such as crop calculators should be used where appropriate. Detailed guidelines are also provided in Code of Practice Nutrient Management documents prepared by the Fertiliser Association of New Zealand (e.g. NZFMRA 2009).

4. References

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