Ministry for the Environment
Manatū Mō Te Taiao

PO Box 10362, Wellington 6143
Website: www.mfe.govt.nz
Freephone: 0800 499 700

19-D-01602

s 9(2)(a)

Dear s 9(2)(a)

Official information request for documents regarding the Government's Essential Freshwater package

I refer to your Official Information Act 1982 (the Act) request dated 1 August 2019 for:

** All reports, memorandums, papers, documents, advice, correspondence, notes, emails, text messages, and other official information, between the Ministry for the Environment, DairyNZ, Beef+Lamb New Zealand, Federated Farmers and Horticulture New Zealand regarding the Government's Essential Freshwater package, since 1 November 2018.*

** All reports, memorandums, papers, documents, advice, correspondence, notes, emails, text messages, and other official information between the Ministry for the Environment and Regional Councils, regarding the Government's Essential Freshwater package, since 1 April 2019.*

Further to our decision letter of 12 September 2019 please find the third and final tranche of information. This tranche includes the remaining emails and documents relating to your request. Attached is a list of documents being released to you in this tranche of our response.

Some information has been withheld under the following sections of the Act:

9(2)(a)	*protect the privacy of natural persons, including that of deceased natural persons*
18 (d)	*that the information requested is or will soon be publicly available*

Some out of scope information has also been redacted in this response.

In terms of section 9(1) of the Act, I am satisfied that, in the circumstances, the withholding of this information is not outweighed by other considerations that render it desirable to make the information available in the public interest.

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You have the right to seek an investigation and review by the Ombudsman of this decision. Information about how to make a complaint is available at www.ombudsman.parliament.nz or freephone 0800 802 602.

If you wish to discuss this decision with us, please feel free to contact ministerials@mfe.govt.nz.

Yours sincerely

Martin Workman

Director, Water

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No.	Date	Content	Decision	OIA Section/s applied	Reason for withholding	Notes
2018 - 2019 EMAILS and attachments						
1	Thursday 13 December 2018	RE: Essential Freshwater meeting	Released in full			
1.1		Fed Farmers presentation Engagement package	Released in full			
2	Wednesday 20 February 2019	Re: farm environment planning	Released in full			
3	Wednesday 20 March 2019	FW: information on price of vegetable farms and profit per hectare	Released in full			
3.1		Farm Scale economic reports	Released in part			This email attached to item three has seven attachments items 3.1.1 – 3.1.7 Some Out of Scope information has been removed
3.1.1		Nutrient Performance and Financial Analysis of Horticultural Systems on the Waimea Plains	Refused in full	18 (d)	that the information requested is or will soon be publicly available	https://www.hortnz.co.nz/assets/Natural-Resources-Documents/Nutrient-Performance-and-Financial-Analysis-of-Horticultural-Systems-on-the-Waimea-Plains-Final-May-2015.pdf
3.1.2		Hawkes Bay Horticultural Nutrient and Financial Benchmarking Results	Refused in full	18 (d)	that the information requested is or will soon be publicly available	https://www.hortnz.co.nz/assets/Natural-Resources-Documents/Hawkes-Bay-Horticultural-Nutrient-and-Financial-Benchmarking-Results-FINAL.pdf
3.1.3		Ford Farm Scale Economic Impact – Final October 2017	Refused in full	18 (d)	that the information requested is or will soon be publicly available	http://www.horizons.govt.nz/HRC/media/Media/One%20Plan%20Documents/Ford-Farm-Scale-Economic-Impact-Final-October-2017.pdf?ext=.pdf

No.	Date	Content	Decision	OIA Section/s applied	Reason for withholding	Notes
3.1.4		nutrient-performance-and-finacial-analysis-of-lower-wiakato-horticulture	Refused in full	18 (d)	that the information requested is or will soon be publicly available	https://www.hortnz.co.nz/assets/Uploads/nutrient-performance-and-financial-analysis-of-lower-waikato-horticulture.pdf
3.1.5		Stuart Ford EIC PC54-56 11 December 2015.pdf	Released in full			
3.1.6		Appendix-to-Stuart-Ford-evidence-for-Hort-NZ-Economic-Impact-on-Hortic...pdf	Refused in full	18 (d)	that the information requested is or will soon be publicly available	https://www.epa.govt.nz/assets/FileAPI/proposal/NSP000028/Evidence-Submitters-evidence/efdff91fcd/Horticulture-NZ-and-Others-Evidence-Stuart-Ford-Appendix-Economic-Impact-on-Horticultural-Irrigators-in-Hawkes-Bay.pdf
3.1.7		HortNZ_Statement of Evidence_Stuart Ford_Economic assessment on water.pdf	Refused in full	18 (d)	that the information requested is or will soon be publicly available	https://www.google.co.nz/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwiauu6N8oHnAhUolLcAHaaCC84QFjAAegQIAxAC&url=https%3A%2F%2Fcdn.boprc.govt.nz%2Fmedia%2F723852%2Fhortnz-bop-ppc9-eic-stuart-ford.pdf&usg=AOvVaw3bzUdjg1ffiAH7RNLM27of
3.2		Overseer Nutrient Modelling results (002)	Released in full			
3.3		HortNZ Memo DParker FINAL corrected	Released in full			
3.4		14210 - Matthew Norris - The MPI SFF root zone reality project FINAL.pdf	Released in full			
3.5		Deloitte Pukekohe Food Story Final Report.pdf	Refused in full	18 (d)	that the information requested is or will soon be publicly available	https://www.hortnz.co.nz/assets/Deloitte/Summary-report-New-Zealands-food-story-The-Pukekohe-hub.pdf

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No.	Date	Content	Decision	OIA Section/s applied	Reason for withholding	Notes
4	Tuesday 2 April 2019	Essential Freshwater - Impacts on domestic food supply and NZ ability to manage greenhouse gas emissions	Released in full			
4.1		FW information on price of vegetable farms and profit per hectare.eml	Released in full			This is one of two attachments to the email titled document four. Item 4.1 also features attachments, however these attachments are publically available.
4.1.1		Farm scale economic reports	Refused in full	18 (d)	that the information requested is or will soon be publicly available	This email has been released as item 3.1
4.1.2		Overseer Nutrient Modelling results (002)	Refused in full	18 (d)	that the information requested is or will soon be publicly available	This item has been released as item 3.2
4.1.3		HortNZ Memo DParker FINAL corrected	Refused in full	18 (d)	that the information requested is or will soon be publicly available	This item has been released as item 3.3
4.1.4		14210 - Matthew Norris - The MPI SFF root zone reality project FINAL.pdf	Refused in full	18 (d)	that the information requested is or will soon be publicly available	This item has been released as item 3.4
4.1.5		Deloitte Pukekohe Food Story Final Report.pdf	Refused in full	18 (d)	that the information requested is or will soon be publicly available	This item has been released as item 3.5
4.2		RE_Meeting Actions	Out of Scope			This is one of two attachments to the email titled document four.
5	Tuesday 2 April 2019	Regional Sector Water Group Draft Agenda for review	Released in full			

No.	Date	Content	Decision	OIA Section/s applied	Reason for withholding	Notes
5.1		Regional Sector Water Sub agenda	Released in part			Some Out of Scope information has been removed
6	Tuesday 2 April 2019	RE: Request regarding Wanaka Development	Released in part	9(2)(a)	protect the privacy of natural persons, including that of deceased natural person	
7	Thursday 4 April 2019	At-Risk Catchments	Released in full			
8	Thursday 4 April 2019	Essential Freshwater Advisory Network Update #6	Released in part	9(2)(a)	protect the privacy of natural persons, including that of deceased natural person	
9	Friday 5 April 2019	RE: N cap	Released in full			
9.1		Summary of PPC10 Nitrogen Allocation April 2019	Released in full			
10	Thursday 11 April 2019	Sediment working group - data request for turbidity and urban impact testing	Released in part	9(2)(a)	protect the privacy of natural persons, including that of deceased natural person	
10.1		Sediment Working Group notes March 2019	Released in full			
11	Friday 12 April 2019	Continuous turbidity monitoring data request	Released in part	9(2)(a)	protect the privacy of natural persons, including that of deceased natural person	

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No.	Date	Content	Decision	OIA Section/s applied	Reason for withholding	Notes
11.1		Sediment working group - data request for turbidity and urban impact testing	Refused in full	18 (d)	that the information requested is or will soon be publicly available	This is the email released as item 10.
11.2		example df.Rdata	Released in full			
12	Tuesday 16 April 2019	RE: Sediment control/monitoring data for TGM	Released in full			
13	Tuesday 16 July 2019	FW: Request for assistance - Essential Freshwater work	Released in full			
14	Tuesday 16 July 2019	FW: Request for assistance	Released in full			
15	Tuesday 16 July 2019	RE: Request for assistance - Essential Freshwater work	Released in full			
16	Tuesday 16 July 2019	RE: Request for assistance with Essential Freshwater	Released in full			
17	Tuesday 16 July 2019	RE: Request for assistance with Essential Freshwater work	Released in full			
18	Thursday 18 April 2019	Essential Freshwater policy programme at MfE - enforcement aspects - Chris has suggested you may be able to help!	Released in full			
19	Monday 22 July 2019	RE: when is a good time for me to call you?	Released in full			
20	Wednesday 31 July 2019	RE: Request for assistance	Released in full			
21	Thursday 1 August 2019	RE: Neimann, Borck and Pearl Creeks in the Waimea Plains	Released in full			
22	Thursday 1 August 2019	RE: Request for assistance- Waingongoro Rv Taranaki and the EFM programme	Released in full			
23	Monday 5 August 201 9	Follow up question	Released in full			

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No.	Date	Content	Decision	OIA Section/s applied	Reason for withholding	Notes
24	Wednesday 14 August 2019	FW: Request for assistance - in confidence	Released in full			
25	Wednesday 14 August 2019	RE: Economic Impact Assessment of EFW proposals - needing assistance ASAP from Policy SIG please	Released in full			
26	Wednesday 14 August 2019	RE: Request for assistance – in confidence	Released in full			

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ITEM 1

From: Lisa Schollum
To: Roger Bannister
Subject: RE: Essential Freshwater meeting
Date: Thursday, 13 December 2018 10:00:28 AM
Attachments: image001.jpg
image002.jpg
image003.jpg
image004.jpg

Hi Roger

Thanks so much for the presentation slides. Just confirming we have you on the agenda at 11am on Wednesday next week. The meeting is in our office, Level 6, 154 Featherston Street. Please let me know if there's any other info you need.

Thanks again
Lisa

LISA SCHOLLUM
EXECUTIVE ASSISTANT

Federated Farmers of New Zealand
PO Box 715, Wellington 6140
New Zealand

M 021 616 512
D 04 494 9188
www.fedfarm.org.nz

FF Welcome email tag Gallagher- 1811

From: Ewan Kelsall
Sent: Thursday, 13 December 2018 8:55 a.m.
To: 'Roger Bannister' <Roger.Bannister@mfe.govt.nz>
Cc: Lisa Schollum <LSchollum@fedfarm.org.nz>
Subject: RE: Essential Freshwater meeting

Thanks Roger. Appreciate discretion required.

I am away next week but I will leave you in Lisa's competent hands to coordinate.

Cheers

Ewan

From: Roger Bannister <Roger.Bannister@mfe.govt.nz>
Sent: Thursday, 13 December 2018 8:22 a.m.
To: Ewan Kelsall <EKelsall@fedfarm.org.nz>
Subject: RE: Essential Freshwater meeting

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Hi Ewan
Attached are some power point slides that raise the issue and pose some questions we are keen to get feedback on. To emphasise, this is not government policy, we are simply sense-checking some ideas. Comfortable that this be circulated to those attending but would ask for discretion and not go wider at this point

Look forward to next Wednesday

Cheers
Roger

From: Ewan Kelsall <EKelsall@fedfarm.org.nz>
Sent: Tuesday, 4 December 2018 11:47 AM
To: Roger Bannister <Roger.Bannister@mfe.govt.nz>
Subject: RE: Essential Freshwater meeting

A one-pager would be very useful.

I will confirm it in the agenda for the Board meeting now.

Cheers

Ewan

From: Roger Bannister <Roger.Bannister@mfe.govt.nz>
Sent: Tuesday, 4 December 2018 11:45 a.m.
To: Ewan Kelsall <EKelsall@fedfarm.org.nz>
Subject: RE: Essential Freshwater meeting

Hi Ewan
Thanks for coming back – that works well. Can we lock that in? I can provide a preliminary one-pager of things we would like to cover a little closer to the time – along the lines we have already canvased with Chris A in another capacity.

Cheers
Roger

From: Ewan Kelsall <EKelsall@fedfarm.org.nz>
Sent: Tuesday, 4 December 2018 10:21 AM
To: Roger Bannister <Roger.Bannister@mfe.govt.nz>
Cc: Chris Allen <CAllen@fedfarm.org.nz>; Lisa Schollum <LSchollum@fedfarm.org.nz>
Subject: RE: Essential Freshwater meeting

Hi Roger,

Apologies about the delay in coming back to you.

Our National Board are next meeting Wednesday 19 December in Wellington and have

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an hour timeslot available from 11-12.

Would that work for you and your team?

Cheers

Ewan

From: Roger Bannister <Roger.Bannister@mfe.govt.nz>
Sent: Monday, 12 November 2018 10:00 a.m.
To: Ewan Kelsall <EKelsall@fedfarm.org.nz>
Cc: Chris Allen <CAllen@fedfarm.org.nz>; Gavin Forrest <GForrest@fedfarm.org.nz>
Subject: RE: Essential Freshwater meeting

Hi Ewan
We are certainly keen to engage with Federated Farmers and perhaps some of the Board as practicing farmers to discuss the agricultural aspects of Essential Freshwater. We are not in a position to talk about other aspects at the moment but the agricultural activities are the centre of our thinking at present.
Beef and Lamb are holding a workshop on 20 Nov (I'm not sure that is the one you refer to) which will cover some of this work and at which we will be engaged. Therefore, it may not be possible for our team to break out and attend a second session on that day.
Other potential dates are 27-28 Nov or 3-4 Dec. However as the value will be when some of the Board are in Wellington, if you have any dates we will try to work around.

Cheers
Roger

From: Ewan Kelsall <EKelsall@fedfarm.org.nz>
Sent: Friday, 9 November 2018 2:48 PM
To: Roger Bannister <Roger.Bannister@mfe.govt.nz>
Cc: Chris Allen <CAllen@fedfarm.org.nz>; Gavin Forrest <GForrest@fedfarm.org.nz>
Subject: Essential Freshwater meeting

Hi Roger,

Hope all is well with you.

Federated Farmers would like to meet with you and discuss our engagement with the Essential Freshwater programme.

Chris Allen is scheduled to next be in Wellington on Tuesday 20 November for a workshop, any chance you are available to meet later in the afternoon on that date?

If not, can you please suggest a suitable alternative time.

Kind regards

EWAN KELSALL
Senior Policy Advisor, National Water and Environment

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Federated Farmers of New Zealand
Level 6, Wellington Chambers
154 Featherston Street,
PO Box 715, Wellington 6140

P 027 551 1629
www.fedfarm.org.nz

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ITEM 1.1

Essential Freshwater

Improving Management Practices and managing intensification of rural land use

Ministry for the Environment
Manatū Mō Te Taiao

Ministry for Primary Industries
Manatū Ahu Matua

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Wider context

- A range of policy initiatives are underway that could impact on farmers and growers including:
  - Essential Freshwater
  - Zero emissions bill and whether/how agricultural emissions are addressed
  - Potential Biodiversity NPS
  - Potential Versatile Soils NPS
  - Integrated farm planning framework
  - And more…
- We need to consider how these initiatives:
  - Create synergies rather than conflict with each other?
  - Are introduced over time in a way that makes change manageable for farmers and growers?

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Water Taskforce, Kahui Wai Maori, Freshwater Leaders Group, Science and Technical Advisory Group, Regional Council Water Sub-group

Crown/Maori Relationship in Freshwater

Strong foundations

Essential Freshwater

- Stopping further degradation & loss
- Reversing past damage
- Addressing water allocation issues – discharges first

Early work on:

- At-Risk Catchments
- NPS amendments – incl wetlands and sediment
- National Environmental Standard
- Future policy framework

Measurement and monitoring

Supporting implementation

Science, technology & data

Input into cross-Government activity including 3 Waters

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Introduction

- We're in the process of sense testing potential policy options on good management practice.
- We are also talking to FLG, KWM, other groups from the primary sector, Māori agribusiness, environmental NGOs, and councils.
- We will report on the policy options to Ministers in Feb 2019.
- Formal consultation on the freshwater package will take place from May 2019.

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Rural Land Use and Water Quality

- Four key areas
  - Promoting up-take of good management practices;
  - Managing high-risk land use activities;
  - Excluding stock from waterways; and
  - Managing intensification of rural land use.
- Other work streams are addressing situations where significant land use change is needed

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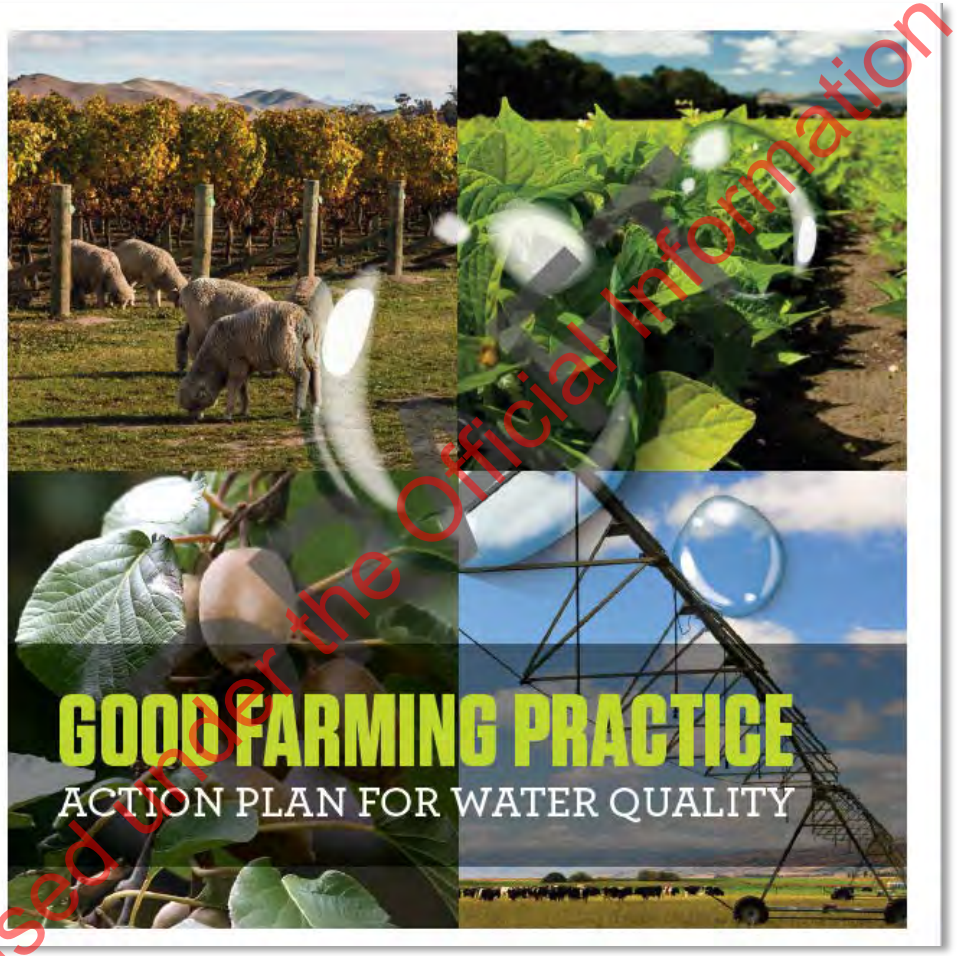
Good Management Practice



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Good Management Practice (GMP)

- Good management practices are an evolving suite of practical measures
- LAWF said that GMP are the minimum – both for the environment and for social licence – but are not the whole answer
- GMP are context specific - need to be tailored to each farm through farm plans
- Ideally farm plans are flexible, adaptive and embed continuous improvement
- The primary sectors, processors and some regional councils are rolling out farm plan-based approaches to GMP

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GMP

- Key questions
  - How could we better support existing initiatives to increase uptake of GMP and Farm Plans? Would this be effective in increasing uptake of GMP on its own? What else is needed?
  - Should farm plans be compulsory? Where? For what activities? Over what timeframe? What barriers would need to be overcome to make this work?
  - Are there any GMPs that could be prescribed in a national regulation? Could existing codes of practice be included in a national regulation? What are they?
  - Are there other options?

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High Risk Land Use Activities

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High-Risk Land-Use Activities

- Some farming activities hit the headlines
  - Intensive grazing especially forage crops
  - Hill country cropping
  - Feedlots (feedpads, sacrifice paddocks)
  - Forestry harvesting

- Economic benefits from these activities but also significant risks to water quality if not well-sited and managed.

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High-Risk Land-Use Activities

- Key questions
  - Are we considering the right set of high-risk land-use activities? What else should we consider?
  - What methods are there for ensuring these activities are well-managed?
  - Should some activities be prohibited in some sites?
  - Which activities (if any) need national regulation – and what would that look like?
  - What should be done about “permanent” high-risk activities that are not in the right site?

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Stock Exclusion

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Stock Exclusion

- Excluding stock from waterways reduces contamination (e-coli, sediment, phosphorus, nitrogen) and improves water quality
- Planting riparian zones improves both uptake of contaminants and biodiversity
- Stock exclusion can be costly (fencing, planting, stock water)
- Industry organisations and regional councils are taking a range of approaches to stock exclusion and riparian planting
- Regulations were drafted in 2017 but were criticised for not being practicable (ability to monitor and defining slope)

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Stock Exclusion

- Key questions
  - Where should stock should be excluded?
  - Should there also be riparian strips?
  - How could central government provide direction on stock exclusion?
  - Would a farm-plan approach work?
  - What is a feasible timeframe for implementing?
  - What practical support would help with stock exclusion and riparian planting?

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Intensification

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Intensification

- Intensification can transform communities, improving incomes, employment and availability of services
- We are focused on intensification that increases discharges, including intensification of an existing land use e.g. increases in stock units carried.
- Many councils already constrain intensification through land-use change rules and/or allocation of nitrogen discharge allowances
- Intensification is forecast to continue in some regions, some of which do not have a rule framework that constrains it.

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Intensification

- Key questions
  - Is there a need for central government measures to constrain intensification?
  - Should constraints apply everywhere or is a risk-based approach to constraining intensification appropriate? Where/when?
  - What are your views on constraining land use change compared with constraining increases in discharges?

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Support systems

- What do we need to set in place to make this work?
- What skills and capability development is needed?
- What roles are there for:
  - Farmers
  - Sector groups
  - Councils
  - Government
- How do we ensure Essential Freshwater initiatives are well-aligned with other policies, including climate change and biodiversity, so that farmers can steer their way through the changes successfully?

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Process and timeframes

- Sense test options (Nov/Dec)
- Ministers consider options and recommendations (Feb 19)
- Cabinet considers the recommendations including for an NES (Mar 19)
- Formal consultation with the NZ public on the freshwater NES (from Apr/May 19)

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Contact details

- John.doorbar@mfe.govt.nz
- Jennie.mcmurran2@mfe.govt.nz
- Irene.parminter@mfe.govt.nz
- Gerard.willis@mfe.govt.nz

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ITEM 2

From: Justine Young
To: Jennie McMurran
Subject: Re: farm environment planning
Date: Wednesday, 20 February 2019 3:32:55 PM

Thanks heaps Jennie much appreciated
I know it's too soon to give anything more specific (although I was hoping) but what you've written is a good confirmation of direction. Between Kay and David burger and others at dairynz we get the picture.
What's interesting is WRC & their pull back from notified farm Environ plan rules & N tracking.
Good to stay in touch
Justine

Get Outlook for iOS

From: Jennie McMurran <jennie.mcmurran2@mfe.govt.nz>
Sent: Wednesday, February 20, 2019 3:05 PM
To: Justine Young
Subject: farm environment planning

Hi Justine

Nice to chat to you yesterday and great to hear that dairy farmers in Taranaki are wanting to be proactive in terms of farm environment planning. My main message it that this is great and to be encouraged.

As I mentioned, we are indeed doing some work around national direction on farm environment planning, as has been signalled in the Essential Freshwater discussion document – see pg 13-14 in this link: http://www.mfe.govt.nz/sites/default/files/media/Fresh%20water/essential-freshwater.pdf

The ambitious high-level objectives on pg 3 are also a useful signal of priority for this work. Minister Parker has talked in some speeches about wanting to reverse decline within 5 years and that water quality is his number one priority.

Public consultation on proposals (which will likely include consideration of a mandatory farm environment plan phased in over time beginning with high priority areas) is expected in the middle of the year. At this stage we are having some targeted discussions with key groups (including the Freshwater Leaders Group and Kahui Wai Maori) to sense test our ideas and help in formulating the policy options so there is nothing formal that I can give you presentation-wise. We have also been talking with regional council groups (and have another session with the policy people in a week or two) and we have also had some discussions with David Burger so it may be useful to chat to him as well. And of course the Good Farming Practice Action Plan also has commitments already to everyone having an FEP
http://www.fedfarm.org.nz/FFPublic/Policy2/National/Good_Farming_Practice-Action_Plan_for_Water_Quality_2018.aspx
Hope this helps!
Kind regards

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Jennie

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ITEM 3

From:	Michelle Sands
To:	Irene Parminter; Jennie.McMurran2@mfe.govt.nz
Cc:	"Roger Bannister"
Subject:	FW: information on price of vegetable farms and profit per hectare
Date:	Wednesday, 20 March 2019 6:34:42 PM
Attachments:	Farm Scale economic reports (3.29 MB).msg Overseer Nutrient Modelling results (002).docx HortNZ Memo_DParker_DOConnor_FINAL_corrected.pdf 14210 - Matthew Norris - The MPI SFF root zone reality project FINAL.pdf Deloitte Pukekohe Food Story Final Report.pdf

Hi Irene, and Jenni,

We haven't spoken for a while about the Ag-Package. Further to the email below, I thought I would provide you both with an update on where we are at with a various regional processes and some feedback I have been receiving from growers:

What is the definition of commercial vegetable growing

HortNZ represents growers of vegetables for human consumption. There are some challenges in defining the activity especially for extensive growing rotations. It's something we need to work through with regional plans, but it's also going to be important for any national rules.

For example, Some grow commercial vegetables exclusively on land that is used for growing vegetables. Others grow commercial vegetables as part of arable rotations on cropping land, and some grow commercial vegetables in pasture rotations on land that is usually used for grazing animals. Different growers might grow different crops at different times of the year on the same piece of land, and farmers might graze animals on that land at times also.

What is Land use change in the context of commercial vegetables

A number of plans which have grand-parenting allocation regimes have rules managing intensification through land use change. One issue for commercial vegetable growing is around leased land and crop rotations. A grower might be growing the same area of the same crop rotation, but moving onto new land that's not been used for vegetables before. In the ECan Hort Plan change, PC1 and TANK we are working towards definitions of land use change for commercial vegetables, which are about area rather than location, so growers can shift growing onto new land without it being defined as land use change.

However even with the land area rather than location definition, there is still an issue with how a grand-parented N load is assigned to land in the first place. This issue is discussed in the memo to Ministers attached. In ECan Hort Plan change at the moment, the proposed approach is a moving land use consent. We are working through this issue in PC1 at the moment, through caucusing , and are looking at land use and discharge consents. When we have made a bit more progress, I will share the planning and legal assessment - in about month.

The other issue is thresholds for land use change. In the proposed TANK V8, there is a land use change threshold that is related to 10% if the farm area, after which the load increase is assessed to determine whether the change has resulted in intensification. I support the load aspect of this rule, but the 10% area threshold creates a lot more flexibility for intensification within large farms rather than small, (and therefore creep in the catchment load limit and potential for adverse water quality effects). I have suggested the intensification area threshold should be same for everyone – because the effects are related to load discharged to the receiving environment, not the amount of land the consent applicant owns.

Is there a threshold at which an arable rotation becomes a commercial vegetable rotation? Or for a Dairy of Beef farm with existing cropping, how much extra cropping could they have before it is a land use change? At present there is a large amount of arable land (500,000 ha - ten times as much as commercial vegetable land). Some arable rotations which are predominately for feeding animals include some commercial vegetables. One thing we think is important as part of a transition to a low emissions economy is for the ag sector to pivot towards more horticulture and fewer animals. If there are fewer animals in NZ in future, an arable grower may wish to increase the vegetables for humans in their rotations and decrease vegetables and

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crops for animals. Increasing vegetables for humans in the rotation, may not lead to more leaching, for example fodder/forage parts of the rotation may have higher leaching than process veggies part of rotations, or the pasture part of a rotation could be increased to offset. I've attached the rootzone reality lysimeter Project report. This project measured short term leaching so it can't be compared to Overseer models directly, but you can see a range of leaching rates under crops for humans and crops for animals. Any policy that favours large farms (eg kg/ha averaged over whole farm) disadvantages growers compared to pastoral farmers.

Most vegetables in NZ are grown for domestic supply and therefore the potential for increases in the growing area for most types of vegetables is related to population growth (and increases in healthy eating we hope, if we all ate 3+ we would need to increase supply). This is particularly true for the vegetables that are in the highest leaching rotations, which grow winter greens for NZers to eat in winter when it's cold and rainy and things don't grow very well in most places, but we still need to eat 3+.

Many growers feel that growing vegetables for domestic supply should not be as restrained as land use activities for export (which is most of the rest of the ag sector including fruit). At the moment policy is forcing the most constraint on rotations growing vegetables for domestic supply, and this is not effects based. Given only 50,000 ha of NZ is in commercial vegetables, current national and regional scale water quality problems are not attributable to vegetables. The effects of vegetables are negligible at the catchment scale, with adverse effects at a local sub-catchment scale in a limited number of places – these are generally small, low energy, lowland systems that are partially urban and sometimes highly modified by flood protection and drainage schemes, eg, Ngakaroa Stream, Whakapipi stream, Karamu stream, Lakes Horowhenua and Waiwiri, etc. We are of the view specific and targeted mitigations are required in these receiving environments, rather than expecting national or regional rules to tackle these specific localised issues.

One of the challenges with differentiating domestic versus export rotations, is that many growers grow domestic and some export crops, e.g. onions for export being part of a domestic potato rotation, and therefore defining rotations on the degree to which they are domestic or export is complex – but could be done approximately as a rolling average. The vegetable crops that have the most potential for expansion as part of a transition to a low emissions economy are those that can be exported. E.g. potatoes, onions, process vegetables. These vegetables can be grown in extensive and arable rotations. (in addition some crops for export can be grown indoors such as tomatoes, cucumbers, capsicums – these are low leaching growing systems)

I think the challenge here, is defining thresholds, that do not disadvantage small farms compared to large farms, that enable a transition to a low emissions economy and promote the health of NZ population while maintaining and improving water quality.

What is the appropriate activity status for commercial vegetables.

In the proposed PC1, land use change to commercial vegetables is non-complying. We are seeking an RDA for new commercial vegetable growing land. The strict activity status for changes to commercial vegetables in the Waikato was related to high leaching rates (kg/ha) for vegetables grown in the Pukekohe/north Waikato area. In some parts of NZ, vegetables are grown in more extensive rotations and in arable rotations. For example in Hawkes Bay where a lot of process veggies are grown, leaching rates are in the order of 5 – 50kg/ha depending on location and are comparable and in some cases lesser than pastoral and orcharding land uses. (Overseer report attached).

Sometimes there is an assumption that the highest leaching occurs because people are undertaking an activity in the "wrong place". We don't think that is the case with vegetable growing. We see the highest leaching occurring in the Pukekohe /north Waikato area. This location has favourable, soil, temperature and rainfall. It is not as dependent on irrigation at the east-coast growing regions, and because of its mild climate, vegetables are grown all year around and so are very important for national domestic food supply. The leaching in the Pukekohe/North Waikato area is high measured as kg/ha, but it still only makes up 3% of the nitrogen load in the Waikato River. This is because it has a very small footprint. That footprint produces a large proportion of NZ's domestic food, (attached Deloitte Pukekohe food story report),

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Vegetable Rotation	Leaching Overseer 6.1 (kg/ha/yr)	Leaching Overseer 6.2.3 (kg/ha/yr)
Extensive: Potato (summer) > Onions > Carrots > Squash > Oats and Rye > Barley (grain) > Oats and Rye	58	114
Intensive: Squash > Broccoli > Oats and Rye > Lettuce (summer) > Mustard > Onions > Oats and Rye > Potato (Winter).	65	174
Market garden: Broccoli > Mustard > Lettuce > Cabbage > Mustard > Spinach > Cauliflower > Cabbage > Mustard.	73	159

HortNZ has supported a consented activity status for new commercial vegetables, and for existing growing in those parts of NZ where the most intensive vegetable rotations are located. We acknowledge vegetable growing is an intense activity with specific good management practices, which differ from pastoral GMPS. We have promoted an NES with independently audited FEPs as an alternative regulatory regime for vegetables.

In the transition period to allocation (hopefully with a carve out for vegetables) if there are national rules, due to the scale of effects of vegetables growing and the health and climate benefits of eating vegetables, we think discretion for consenting commercial vegetables should be limited, with a presumption that provided criteria are met, consent will be granted.

Happy to catch up any time, to discuss these issues or provide further clarification and examples and data where I can.

Michelle Sands
Manager – Natural Resources and Environment | Horticulture New Zealand
P: 04 470 5664 | **M:** 021 610 653

From: Michelle Sands
Sent: Wednesday, 20 March 2019 12:18 p.m.
To: 'Andre Silveira' <Andre.Silveira@mfe.govt.nz>
Cc: Sam King <Sam.King@mfe.govt.nz>; 'Irene Parminter' <Irene.Parminter@mfe.govt.nz>; 'Jennie.McMurran2@mfe.govt.nz' <Jennie.McMurran2@mfe.govt.nz>; 'Stuart Miller' <Stuart.Miller@mpi.govt.nz>; 'frances.skilton@mpi.govt.nz' <frances.skilton@mpi.govt.nz>
Subject: RE: information on price of vegetable farms and profit per hectare

Hi Andre,

I've copied this email to a few people – Sam because I've discussed these matters with him before, Irene and Jennie because it links to the Ag-Package and also Stuart and Frances at MPI who I'm working with on NPS soils – I think they may find this discussion useful for their work too.

I have sent Sam information before on the gross margin of vegetable rotations (previous email attached). The reports attached are Overseer and economic analysis. Some are a few years old, so keep that in mind with the

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economics. With the Overseer keep in mind the different versions of Overseer referred to in the reports. Because Overseer has been less developed for representing vegetables, we have seen some dramatic shifts in leaching estimates with versions, for example, the 2014 Lower Waikato report which includes the Overseer and economic modelling for PC1, was updated for a new version of Overseer in 2017 (not the economics or rotations) and there were large increases in estimated leaching – summarised below.

Vegetable Rotation	**Leaching Overseer 6.1 (kg/ha/yr)**	**Leaching Overseer 6.2.3 (kg/ha/yr)**
Extensive: Potato (summer) > Onions > Carrots > Squash > Oats and Rye > Barley (grain) > Oats and Rye	58	114
Intensive: Squash > Broccoli > Oats and Rye > Lettuce (summer) > Mustard > Onions > Oats and Rye > Potato (Winter).	65	174
Market garden: Broccoli > Mustard > Lettuce > Cabbage > Mustard > Spinach > Cauliflower > Cabbage > Mustard.	73	159

I asked four growers for land costs, these are summarised below. The widest range is the South Auckland area – I think that probably relates to the urban pressure on some blocks, and also because about half of this land is used for extensive rotations and half for intensive.

	Lease irrigation supplied/Ha	**Lease (includes non irrigated)/Ha**	**Buy /Ha**
	$ GST excluded	**$ GST excluded**	**$ GST excluded**
Lincoln /Rolleston	1500 - 2000		80,000 - 125,000
South Auckland (Pukekohe, Bombay, Tuakau,Pukekawa, Patamahoe, Puni,)	1500 - 3200	1200 - 2500	75000, 100,000, 125,000, 170,000, 200,000
Waikato		2500	80000
Hawkes Bay	3000		50000
Canterbury	3000		50000
Horowhenua		2000 - 2500	75000

When analysing the land costs above, its important to keep in mind not all land is growing the same rotation. The rotations in the Lincoln, about half of South Auckland and Horowhenua are most likely to be intensive vegetables, in the Waikato, Hawkes Bay and Canterbury, it's more likely to be extensive. In the Overseer reports the gross margin is calculated for different rotations, and there is some discussion on the proportion of the rotations in some areas, for example in the South Auckland area its about 50% extensive, 45% intensive and 5% market garden. The economic reports reflect a higher GM/Ha for intensive vegetables and market gardens, but lesser land is used for growing.

The thing to keep in mind, is domestic food supply. I've attached a memo I wrote to Minsters Parker and O'Connor just before Christmas. In the appendix it summarises the proportion of each crop that is consumed domestically, and in the attached Overseer reports there are example rotations in different locations, so you

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can see what is grown in what rotation. The modelled rotations are simplified because Overseer has a limited range of vegetables that can be modelled and numerous other constraints, for example with the Levin modelling I'm aware that the largest intensive rotation in that region actually grows more than 20 vegetable crops, but the Overseer modelling represents five. Certain crops like potatoes, carrots, process veggies can grow in extensive rotations with pasture and arable crops, brassicas and leafy greens are grown in intensive rotations (sometimes with potatoes and pasture). In market garden rotations a wide variety of brassicas and greens are grown.

The risk is if policy and economics drive growers out of intensive rotations and into extensive rotations, this is likely to produce a greater proportion of vegetables for export and process, and a lesser proportion of fresh veggies and vegetables for domestic supply. Also, from a water quality perspective while the leaching per ha is higher with the more intensive rotations, from a N load perspective (which is actually what causes water quality effects in receiving environments), because the land area is smaller, the effects of intensive vegetables are not necessarily greater than less productive and more extensive land uses.

When considering the impact on domestic food supply, I think a regulatory approach for vegetables which is different to pastoral farming is warranted. In the memo I wrote to Minsters, I proposed an NES for commercial vegetables, operating within a "carve – out" so catchment limits are not breached. The method proposed is a hybrid with a carve out for vegetables and a natural capital allocation for all land to provide for lease land – I note the carve out for vegetables is also compatible with an underlying trading scheme, particularly one with no initial allocation.

If you need help interpreting this information or more specific analysis I can ask the economist who did this work to provide some thing more specific. Let me know if you need more or different information.

I'm based in Wellington, if you want to meet send me a calendar invite.

Best regards

Michelle Sands
Manager – Natural Resources and Environment | Horticulture New Zealand
P: 04 470 5664 | **M:** 021 610 653

From: Andre Silveira <Andre.Silveira@mfe.govt.nz>
Sent: Thursday, 28 February 2019 4:13 p.m.
To: Michelle Sands <Michelle.Sands@hortnz.co.nz>
Cc: Sam King <Sam.King@mfe.govt.nz>
Subject: RE: information on price of vegetable farms and profit per hectare

Hi Michelle,

Thanks for your time and availability.

Having your colleagues' guidance on a few references and a range of case studies would be very helpful. Particularly if they are from different regions of the country.

Nga mihi
Andre

From: Michelle Sands <Michelle.Sands@hortnz.co.nz>
Sent: Thursday, 28 February 2019 3:44 PM
To: Andre Silveira <Andre.Silveira@mfe.govt.nz>
Subject: Re: information on price of vegetable farms and profit per hectare

Hi Andre,

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I'm in a hearing today, I've passed your email on to vegetable sector colleagues. We don't collect this information, but we might be able to provide some case studies, I'll cone back to you, but please feel feee to give me a call.

Michelle Sands
Manager – Natural Resources and Environment | Horticulture New Zealand
P: 04 470 5664 | M: 021 610 653
A: Level 4, Co-Operative Bank House, 20 Ballance St, Wellington 6011

On Thu, Feb 28, 2019 at 12:04 PM +1300, "Andre Silveira" <Andre.Silveira@mfe.govt.nz> wrote:

> Hi Michelle,
>
> I hope this message finds you well.
> My manager Sam King suggested I check whether you could share information on the price of vegetable farms in the last couple of years.
>
> At the moment we are using trimestral figures from Real Estate Institute NZ from 2017 and 2018, but these only refer to the price
> of farms in the horticultural sector in general.
>
> It would be important to have a more detailed view of the sector.
> Thanks very much in advance.
>
> Kind regards,
> Andre
>
> Andre Silveira (PhD) – Policy Analyst
> Water Taskforce – Ministry for the Environment
> Email: Andre.Silveira@mfe.govt.nz
> Phone: 0224930623
>
> **********
>
> Please Note: The information contained in this e-mail message and any attached files may be confid*ential information, and may also be the subject of legal professional privilege. It is not necessarily the official view of the Ministry for the Environment. If you are not the intended recipient, any use, disclosure or copying of this e-mail is unauthorised. If you have received this e-mail in error, please notify us immediately by reply e-mail and delete the original. Thank you.
>
> **********

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ITEM 3.1

From:	Michelle Sands
To:	Sam.King@mfe.govt.nz; martin.workman@mfe.govt.nz; Bryan.Smith@mfe.govt.nz
Cc:	Mike Chapman
Subject:	Farm Scale economic reports
Date:	Monday, 29 October 2018 6:34:50 PM
Attachments:	image001.png image002.png image003.png Nutrient Performance and Financial Analysis of Horticultural Systems on the Waimea Plains - 30.03.2015.docx Hawkes Bay Horticultural Nutrient and Financial Benchmarking Results - Draft.docx Ford Farm Scale Economic Impact - Final October 2017.pdf nutrient-performance-and-financial-analysis-of-lower-waikato-horticulture.pdf Stuart Ford EIC PC54-56 11 December 2015.pdf Appendix-to-Stuart-Ford-evidence-for-Hort-NZ-Economic-Impact-on-Hortic....pdf HortNZ_Statement of Evidence_Stuart Ford_Economic assessment on water.pdf

Hi all,

It was good to meet with you this afternoon. There were a few follow up actions, and comments from me

Sensitive catchments
Thanks, I've received the invite to the workshop on the 14th and 15th and I will attend.

FEP
We have recently launched the Environmental Management System add on to the NZGAP scheme. This system enables one auditor to assess growers for compliance with their Farm Environment Plan at the same time as auditing for food safety, social practice etc. We are working with MfE on the Good Farm Practice Action Plan. We would like to see the NZGAP EMS audited system accepted by Regional Councils as a national approach for auditing grower FEP's. Our expectation is the NZGAP EMS system could be expanded to audit for implementation of biodiversity and GHG emission good management practices.

NES
We understand the focus of NES is on intensive pastoral farming. However, if the definition of intensification uses nitrogen kg/ha as a proxy for intensification it will capture vegetable growing, unless this activity is excluded. We are of the view that vegetable growing should have different rules and thresholds to pastoral farming.

The regulation of vegetable growing must provide for vegetable rotation, and for new vegetable growing areas to be established to feed a growing population and to replace land lost to urban expansion.

We promote the use of independently audited farm environment plans, (NZGAP EMS) that include risk based FEP and include nutrient and sediment management good management practices.

Water Quality Allocation
Sam suggested we could comment on a draft report in about March 2019. We will be happy to provide comments. I am keen to be involved earlier to test ideas and to help with information and data. I am particularly interested in how the water quality allocation scheme will:

- Value the importance of fresh affordable vegetables for domestic food supply, and
- Support the transition to a low emissions economy

In our view the water quality and quantity allocation for vegetables will need to be treated differently to the pastoral allocation. We also think its important that nitrogen load as well as yield is considered, because it is the load after reasonable mixing that has effects on receiving waters.

To assist with the economic analysis, I've attached a few farm scale economic reports and statements of evidence. If these reports are useful, let me know, and I'm happy to discuss these reports in more detail.

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Water Quantity Allocation
Horticulture has an important role to play in NZ's transition to a low emissions economy. Growing fruit is a very profitable land use with the least water quality effects, and very low greenhouse gas emissions. There are considerable opportunities for under-developed maori land.

The water quality and quantity allocation work will have an influence on whether fruit for export can expand, there are two key issues:

- Crop survival water where surface water is abstracted and water storage is not available
- Increasing water storage. We expect an improvement in water quality if orchards replace dairy.

Out of Scope [redacted]

I look forward to working with you all .

Nga mihi

Michelle Sands
Manager – Natural Resources and Environment | Horticulture New Zealand
P: 04 470 5664 | **M:** 021 610 653
A: Level 4, Co-Operative Bank House, 20 Ballance St, Wellington 6011

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ITEM 3.1.5

BEFORE THE COMMISSIONERS

AT TASMAN

IN THE MATTER	of appeals under clause 14 of the First Schedule of the Resource Management Act 1991 (the Act or the RMA)
AND	
IN THE MATTER	of the Tasman District Plan
AND	
IN THE MATTER	of Proposed Plan Changes 54-56: Waimea Water Management (Security of Supply)

STATEMENT OF EVIDENCE OF STUART JOHN FORD ON BEHALF OF HORTICULTURE NEW ZEALAND

11 DECEMBER 2015

[redacted] ATKINS | HOLM | MAJUREY

Helen Atkins
PO Box 1585
Shortland Street
AUCKLAND 1140

Solicitor on the record Helen Atkins Helen.Atkins@ahmlaw.nz (09) 304 0421

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INTRODUCTION

Qualifications and experience

1. My full name is Stuart John Ford. I am a Director of The AgriBusiness Group and work as an agricultural and resource economist based in Christchurch. I have a Diploma in Agriculture and Bachelor of Agricultural Commerce from Lincoln University and have undertaken post graduate studies in Agricultural and Resource Economics at Massey University.

2. I am a member of the New Zealand Agriculture and Resource Economics Society and the Australian Agriculture and Resource Economics Society. I am also a member of the New Zealand Institute of Primary Industry Management.

3. I have spent over thirty years as a consultant in the primary industries, with the last fifteen years specialising in agricultural and resource economics and business analysis.

4. I have undertaken a wide range of economic impact and cost benefit assessments of proposed statutory planning proposals.

5. I have prepared evidence and presented it to District and Regional Council Hearings Panels as well as the Environment Court and Special Hearing Panels on Conservation Orders.

6. I have been asked by Horticulture New Zealand ("**HortNZ**") to provide this evidence.

7. I have been provided with a copy of the Code of Conduct for Expert Witnesses contained in the Environment Court's Consolidated Practice Note dated 1 December 2014. I have read and agree to comply with that Code. This evidence is within my area of expertise, except where I state that I am relying upon the specified evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

Context and scope of my evidence

8. My evidence is given in support of the relief sought by Hort NZ to Plan Changes 54 to 56 to the Tasman Resource Management Plan which amend the transitional regime pending the Waimea Community Dam ("**the Proposal**").

9. In particular, I have been asked to cover:

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(a) My calculation of the requirement for, and the impact of, not providing sufficient irrigation capability to allow for root stock survival on the Waimea Plains; and

(b) My expert opinion on the economic effects associated with non-affiliated parties benefiting from the Dam.

10. In the evidence that follows I consider the following matters:

(a) The nature of horticultural land in the region;

(b) My analysis of the economic impact on the horticultural sector of the Proposal;

(c) A review of the economic evidence for the Council; and

(d) My conclusions and recommendations.

11. In preparing this evidence I have reviewed the following evidence and materials:

(a) The Proposal;

(b) The Section 42A Officer Report; and

(c) The economic evidence produced by the Council in relation to Plan Changes 45-48 dated 29 May 2015.

Summary of conclusions

12. It is my evidence that the impact of not providing sufficient capital rootstock water would be severe for individual producers as well as the wider economy.

13. In my view, the best method to appropriately manage these effects is to grant priority status to crop survival water in line with the agreement reached at mediation on PC45-48 and attached to the evidence of Mr Keenan.

THE NATURE OF HORTICULTURAL LAND IN THE REGION

14. For PC45-48 I prepared a report[1] for Hort NZ and the Tasman District Council ("**the Council**") which is appended to this evidence, (refer **Appendix 1**) and discussed below. In this report, I rely on a report from Landcare which details that

[1] Ford S (2015): Assessment of the requirement for, and the impact of, not providing sufficient irrigation capability to allow for root stock survival on the Waimea Plains.

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there are approximately 1,257 ha of Pipfruit, 11 ha of Kiwifruit, 634 ha of Vineyards and 15 ha of Hothouses situated within the Waimea Plains.

15. The soils on the Waimea Plains can be classified into either shallow, light soils (Ranzau, Maori) or deep heavy soils (Waimea, Richmond). These two soil classifications differ greatly in terms of their soil moisture holding capacity. The light soils are able to hold 40 mm of soil moisture per 500mm of soil depth while the heavy soils are able to hold 120mm of soil moisture per 500mm of soil depth. The two soil types also have vastly different depths - the light soils are relatively shallow whereas the heavy soils have a much greater depth. The heavy soils are able to hold more water because of their higher soil moisture holding capacity and their much greater depth. The lighter soils have a much lower moisture holding capacity and a much shallower depth of soil that the plants can access it from.

16. Observation of the soil maps of the area indicate an even split between the soils that are classified as light and the soils that are classified as heavy.

17. Therefore, the nature of horticultural operations will differ according to what soil type they are situated on. The lighter soils tend to be more productive than the heavy soils but are heavily reliant on the provision of additional water through irrigation to achieve their potential.

18. Mr Keenan's evidence sets out the importance of the horticultural sector in the economy of the Tasman District.

ECONOMIC IMPACT OF THE PROPOSAL IN REGARDS TO ROOTSTOCK SURVIVAL WATER

19. My PC45-48 report was written in response to a request from Hort NZ and the Council who both contributed to establishing the brief for the work.

20. The purpose of the study was: [2]

> *"to demonstrate why any component of authorised water use for rootstock protection or survival purposes should be assigned a delimited priority during identified stepped*

[2] Ford S (2015): Assessment of the requirement for, and the impact of, not providing sufficient irrigation capability to allow for root stock survival on the Waimea Plains. Page 2

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rationing of all water users in the Waimea Plains Water Management Zones under a drought event."

21. There was a requirement to establish both:

    (a) specific quanta of water required to meet root stock survival defined for each allocation proposed; and

    (b) the economic production risks of non-availability of such water.

22. The information provided in the report was primarily gathered from a survey of 12 growers within the catchment.

23. Below I set out a summary of my results in order to demonstrate the importance of root stock survival water.

24. Details as to the methodology used are included in the report. In my evidence I will concentrate on the results of my work.

The likely requirements for root stock survival water

25. The total requirement for root stock survival water totals 520.4 l / second or 0.520 cumecs of flow from the river as shown in **Table 1** below. It should be noted that this table also contains a calculation of the requirement for Dairy farm water. This was a requirement of the Council.

Table 1: Requirement for Root Stock Survival Water

	Area	Requirement L / ha / day	Requirement L / sec
Pipfruit – Light Soil	628.5	28,000	204
Pipfruit – Heavy Soil	628.5	21,000	153
Kiwifruit	11	28,000	3.6
Vineyards	634	20000	147
Hothouse	15	75000	13
Dairy Farms	263	224	0.68

Calculating the time span from when the water triggers are met until water is required

26. Because of the range of soils and the differences in available soil moisture holding capacity on the plains, I have calculated that, on average, it would be necessary to apply root stock protection water after 20 days of restrictions occurring. This would encompass provision of root stock protection water on the lighter soils after 11 days and on the heavier soils after 30 days.

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Analysis of river flow data

27. River flow data was supplied by the Council.[3] For the Step 3 trigger it entailed daily flow volumes encompassing 55 years from the Wairoa recording site at Irvines. This data was only missing small periods of recording - less than a week - so is considered to be complete.

28. For the Step 4 trigger, the data was much less complete with 10 years of complete records and one year which started in February and met the trigger point at the point of commencement of the record. In an attempt to obtain a more reliable data set the Irvine's data was compared with the Wairoa data to try and establish a relationship between the flow at the higher point and the flow at the lower point. No precise relationship was able to be established between the two flows because of the nature of the river and because there are some consented takes between the two points. Nevertheless it was possible to determine that there was some degree of relationship. In particular, when the Waimea River at the lower trigger point was at 800 l / sec, the average flow at the Wairoa recorder was 1,744 l / sec.

29. I then ran the full data set for the trigger point of 1,744 l / sec over the full data record.

30. In the data set, a year is displayed as an irrigation season - that is from the 1st October to the 30th April, i.e. not a full calendar year.

31. The results of the analysis of the restriction events at the two trigger points are shown in **Table 2** below. The columns depict the total number of years in the record and the number of years in which there were continuous restrictions. This is because these are the events that threaten the survival of the crops. These are shown for both Step 3 and 4 events. The average number of days per year when events occur and the maximum number of days is also shown.

Table 2: Results of analysis of the occurrence of Step 3 and 4.

	Step 3 Total	Step 3 Continuous	Step 4 Total	Step 4 Continuous
Total Number of Years	55	55	55	55

[3] Excel Spreadsheet Provided by Joseph Thomas TDC: AgriBus_WairoaJan15

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Years in which restrictions occur.	42	42	18	18
Average number of days.	18	11	5	4
Maximum number of days.	85	63	50	47

32. Interpretation of the data as shown in the table, and from looking at the full data set of the river flows, tells us that:

(a) The river is quite steep in its recession curve in that when it does trigger the Step 3 recorder it relatively quickly goes on to trigger the next Step (Step 4).

(b) The river does not trigger the steps very often but when it does it stays dry for a long period of time.

(c) Analysis of the full data set of the river flows shows that the number of continuous days of restrictions at Step 4 was greater than 20 for three of the years. There were 26 days of continuous restrictions in 1973, 37 days in 1982 and 47 in the year 2000.

(d) The timing of the restriction events generally started in late January and continued on from there.

(e) There is likely to be an event which would trigger the requirement for Root Stock Survival water every 18 years (3/55).

The impacts of water not being available on an orchard

33. I then modelled the economic impacts of the restrictions on the various types of growing operations.

34. In the Pipfruit model, the impacts that occur are for the drought effect occurring before the picking of the fruit[4] and therefore there is complete loss of income in the first year with only the harvesting expenditure being saved. The Orchard is then replanted with nil production in the first year, 50% production in the second year and full production occurring in the third year.

35. In the Kiwifruit model, the impacts are for the drought effect occurring before the picking of the fruit[5] and therefore there is complete loss of income in the first year with only the

[4] The drought events normally start in January whereas picking of Pipfruit doesn't start till March.

[5] The drought event normally starts in January whereas picking of Kiwifruit doesn't start until April.

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harvesting expenditure being saved. Because of the current situation with PSA[6] in the Kiwifruit industry, replacement plants must be grown within the District. Therefore there is a two year gap before replanting can begin while the replacement plants are regrown. Once replanted there is no production in year 1, 40% of optimum productivity in year 2, 75% in year 3 and full productivity in year 4 after replanting. In other words, full productivity only occurs again 6 years since the drought event.

36. In the Vineyard model, the impacts are for the drought effect occurring before the picking of the fruit[7] and therefore there is complete loss of income in the first year with only the harvesting expenditure being saved. For the first two years after the drought event there is no productivity from the vines. In the third year productivity is at 20% of the optimum, 40% in year four, 70% in year five, 90% in year 6 and then full productivity in year seven following the event.

37. Hothouse productivity continues all year round with the highest productivity being in the summer months. Therefore it is assumed that 50% of production is lost in the year of the drought occurring, there is a further 75% reduction in the following year and a small 10% reduction in the second year after the drought. Because the planting regime is staggered throughout the year to meet the markets requirements for the fruit it is assumed that this planting regime is followed in the recovery year after the event. It takes another full year (i.e. year three) before full production is achieved.

38. The results of the modelling (which was carried out for an 18 year period) are reported as (a) the situation without there being a drought event and (b) the situation in which an event occurs. The net difference between the two is the cost to the Tasman area of not providing for root stock survival water. The figures which follow are calculated for the whole of the 18 years with the event occurring in year two and the recovery taking as long is required after that until the productive unit is back up and running to full production. It then continues at this level until the end of the 18 year period.

---

6 Pseudomonas syringae pv. actinidiae (Psa) is a bacterial disease of kiwifruit vines, first identified on New Zealand kiwifruit orchards in November 2010.

7 The drought event normally starts in January whereas harvesting of the grapes doesn't start until April.

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39. The effects on Gross Revenue are shown in **Table 3** below. It should be noted that the figure reported is the average of the Gross Revenues of the 18 years. That is taken as the total Gross Revenue from each of the systems for the whole of the 18 years divided by the 18 years. In this way it exhibits the average annual impact of the event across the 18 years.

Table 3: Gross Revenue With and Without Root Stock Water ($)

	With Root Stock Water	Without Root Stock Water	Difference
Pipfruit	63,347,772	54,549,470	8,798,302
Kiwifruit	473,000	371,831	101,169
Vineyard	7,100,800	5,246,702	1,854,098
Hothouse	18,750,000	17,343,750	1,406,250
Total	**89,671,572**	**77,511,753**	**12,159,819**

40. As can be seen from **Table 3** the majority of the losses in Gross Revenue occur from the Pipfruit Industry. Over all horticulture, there is a net loss in Gross Revenue of $12 m or 13.5% of the Total.

41. In order to reflect the cost over time the results are also presented as a Net Present Value ("**NPV**") in **Table 4**. The NPV is calculated over the full 18 years of the event discounted at 8% per annum. I note that the year in which the (drought) event is scheduled has the potential to influence the result of an NPV analysis. In this instance I have scheduled it to occur in the second year.

Table 4: Net Present Value With and Without Root Stock Water ($)

	With Root Stock Water	Without Root Stock Water	Difference
Pipfruit	165,597,956	45,982,498	119,615,458
Kiwifruit	1,978,930	1,067,640	911,290
Vineyard	27,451,007	-7,064,349	34,515,357
Hothouse	44,844,480	39,592,720	5,251,760
Total	**239,872,373**	**79,578,509**	**160,293,865**

42. The results of this analysis show that there is considerable loss of NPV. The greatest losses in proportionate terms are suffered by the Kiwifruit and Vineyard models because of the relatively long period before they get back into full production.

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43. The effects on Gross Margin (Gross Revenue – Farm Working Expenses) are shown in **Table 5.** It should be noted that the figure reported is the average of the Gross Margin of the 18 years.

Table 5: Gross Margin With and Without Root Stock Water ($)

	With Root Stock Water	Without Root Stock Water	Difference
Pipfruit	17,669,649	9,409,343	8,260,306
Kiwifruit	211,156	140,656	70,500
Vineyard	2,929,080	461,622	2,467,458
Hothouse	4,785,000	4,426,125	358,875
Total	**25,594,885**	**14,437,747**	**11,157,138**

44. The Gross Margin Analysis shows that there is a 43% drop in the total Gross Margin figure as a result of there not being any root stock survival water.

The impacts on employment

45. Employment impacts have been calculated from indications of employment gained from the grower survey and from previous work carried out in order to ascertain the number of people employed in the 'beyond orchard' part of the production chain. The employment factors expressed here all reflect a Full Time Equivalent ("**FTE**") worker. Many of the jobs offered in the industry are part time in that they only offer employment for from 4 weeks to 20 weeks of the year and during that time they only offer employment when picking is occurring.

46. It should be noted that the figures presented in this section and shown in

47.

48.

49. Table 6 reflect the annual average employment statistics for the whole 18 seasons. That is the total employment figure for the whole 18 years divided by 18 years.

Table 6: Employment With and Without Root Stock Water (FTE).

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	With Root Stock Water	Without Root Stock Water	Difference
Pipfruit	3,921	3,516	405
Kiwifruit	22	18	3
Vineyard	222	179	43
Hothouse	215	199	16
Total	**4,379**	3,912	467

50. The highest impact of the loss of employment is felt in the Pipfruit sector which provides a very high proportion (over 86%) of the Total 467 FTE job losses. These losses equate to 11 % of the FTE jobs that would be in place if there was root stock water available.

RESPONSE TO THE COUNCIL'S S42 REPORT

51. In the staff assessment report, the Council states that:

> *The essence of the Council's position in relation to the Horticulture NZ appeal is:*
>
> *(a) Priority for access to water during low flows and droughts based on economic impact would need to be available for all commercial end uses that met the same criteria, however there is no good resource management reason to make distinction for allocating water, based on value of water to an economic enterprise, even during droughts.*
>
> *(b) The water security in the Waimea Plains is already compromised and a root stock allowance results in worse outcomes for other permit holders.*

52. As part of the discussions held in the mediation on PC 45 – 48 it was maintained by the Council staff that in order for them to consider the necessity to provide for root stock protection water, the loss would have to meet three conditions:

(a) The loss had to be greater than one year's production;

(b) The time to recovery of full production after the event had to be greater than one year; and

(c) The total loss should be significant for the grower and the total wider industry.

53. I believe that this set of criteria which were set by the Council staff very ably meets the first requirement stated in the s42 Report above in being able to make a distinction for

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allocating water, based on value of water to an economic enterprise, even during droughts. I also believe that it could and should be used in evaluation of the economic case for all affected users of the water, not just for the horticultural industry.

54. I believe that in my modelling work carried out for the Council and Horticulture NZ, which I have reported above, I demonstrate that all three of these conditions, which were set by the Council staff, are met by the Pipfruit, Kiwifruit and Vineyard industries.

55. On the other hand, the vegetable growers and Hothouse growers could not meet the requirement that the losses of the crop income should exceed one year. This is despite the fact that in some instances the total loss experienced was very significant for the grower and for the wider economy. That is why the Council agreed to include them in an allowance for the provision of root stock protection water which was signed by the Council as part of the mediation on Plan Change 45 - 48.

56. In regards to the second point raised in the s42A Report, namely that water security in the Waimea Plains is already compromised and a root stock allowance results in worse outcomes for other permit holders, that is exactly my point. The allocation of water is already economically inefficient, and therefore the adoption of the provision of root stock protection water would be a first step towards making the allocation of water economically efficient. This is because, as I have already pointed out, the use of water in horticulture is highly efficient from a number of perspectives. Although it may create marginally worse outcomes for other users of water it would have the impact of creating vastly better outcomes for the Horticultural users of the water. The net effect for the District's economy would be far superior to that which would occur if the proposed regime were to continue in which all users were to suffer an equal level of restrictions to water access.

57. Later on in the s42A report it states that:

> *Horticulture NZ has not provided any general criteria to support a case for assigning priority during droughts based on economic considerations. There is no consistent methodology that would enable it to be applied either in the Waimea Plains or anywhere else in the District.*

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58. I have already pointed out that the Council staff created a very satisfactory set of criteria and I have provided a very detailed analysis of the economic considerations. I am not sure what the Council considers that it requires in addition to the very significant work carried out by Horticulture NZ and shared with the Council. It is almost as if the writer of this s 42A report is not aware of the significant amount of work which was carried out for the earlier Plan Change 45 – 48 which led to agreement by the Council to include provision for root stock protection water in the plan.

59. I maintain that the methodology that I have mentioned here, which was determined by Council staff, is quite satisfactory to be applied in the Waimea Plains or elsewhere in the District. Indeed it was suggested by myself as also being appropriate in consideration of the same issue on the recent hearings on the Plan Change for the Motueka River.

60. In the s42 report it goes on to state:

> *However, there are other water users who can point to capital investment into crops, plant or processes that is at risk through droughts with severe longer term economic consequences. If capital investment is to be a criterion, the size and scale of such an investment and how this might be calculated should be the direction taken to resolve this submission. Any access to such priority should be available for all permit holders.*

61. It is not Horticulture NZ's position that capital investment should be a consideration at all in deriving the methodology to assess whether people should be able to take advantage of the provision for stock protection water. As I have stated, in the preferred methodology to determine access to the stock protection water, it is the scale of the losses either to the individual grower or the wider District economy which should be the measure that is used in determining access, not the significance of the scale of capital investment. This objection is not relevant to the issue which Horticulture NZ is raising.

62. As to the last point, namely that access should be available to all permit holders, Horticulture NZ agrees that access to root stock protection water under the methodology suggested should be available to all permit holders. However, as I have previously discussed, no other industry has asked to be offered the same sort of priority status. Therefore this is not an issue which the Council needs to concern themselves with and is

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not a valid justification for the Council to deny Horticulture NZ's submission.

63. In the s42A report it states that:

> *The Council does not agree that economic considerations should drive resource allocation and has sought advice from an economist on this issue. The advice received confirms that the correct response is not priority end use, but a flexible allocation regime that allows the allocatable portion of water to move between end users according to what use is most economic at any given time - either during a drought or as land use changes.*

64. I agree that economic considerations should not drive resource allocation but in the Tasman District, with an over allocated resource, in which the over allocation needs to be reduced and which diminishes in supply under drought conditions, economics can offer a myriad of potential solutions. In fact, reverting to economic considerations in such an eventuality is the only alternative in order to come up with a solution which is able to provide for the best interests of the citizens in both a financial and an equitable sense.

65. I have not come across the work of the economist which the Council has retained before in New Zealand[8]. I note that the majority of his experience is in academia in Australia. Therefore I am not surprised that his recommendation is that the correct response is to adopt a flexible allocation regime that allows the allocatable portion of water to move between end users according to what use is most economic at any given time.

66. In the Australian situation, you have: water bodies that are very long and cover vast areas of country; a large number and a myriad of potential agricultural users of water from pastoral to arable to horticultural; a significant portion of the allocable water which is stored in Dams for multiple seasons; relatively good knowledge of the amount of water available for the coming season; and the ability to prioritise water use in advance according to the market signals that are available. In that situation, the ability to trade water works particularly well.

[8] Geoffrey Kane, Evidence for Plan Changes 45-48 dated 29 May 2015

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67. In the New Zealand situation we have very different conditions operating: the rivers are relatively short; the available water for abstraction is all run of river; the users of the water are small in number and are all fairly homogenous in their requirements for water; the availability of water is very dependent on current (and often short term) weather conditions; and in times of drought the demand for water for all users is extreme. This is not a situation whereby the ability to trade water is going to add anything to the ability to achieve good economic outcomes.

68. In fact, the Council expert's recommendation is very much a second best alternative in the New Zealand context as a means of achieving economic efficiency from the allocation of water resources during droughts.

69. His advice may achieve efficient use of the resource under the dam scenario, but not under the drought scenario which Hort NZ is proposing that provision for root protection water is allowed.

70. In the section 42A report it states that :

> *The Council considers the Horticulture NZ case for priority does not enable comparable acknowledgement or equitable assessment of any other business such as a significant milk processing plant (that supports the regional dairy industry), or irrigation of highly valuable glasshouse vegetable growing industry. Each of these industries can demonstrate significant economic loss and long term effects of water restrictions.*

71. It seems to me that the Council completely misses the point of what Hort NZ is trying to achieve with the provision of root stock protection water in making this statement. The whole point of the provision of root stock protection water is to try and maintain the integrity of the production systems (the plants) of the affected industries in order for them to be able to survive and produce again in the coming seasons. This is sought not only to protect the owners of the plants from significant costs of replanting and delays until full productivity is regained, but it is also to protect the District economy from the significant costs in terms of both revenue lost and significant employment opportunities foregone in the period when the plants are re-growing.

72. Hort NZ believes that this is a very significant issue in an economy like the Tasman District which has a relatively high

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dependence on the horticultural industry for both revenue and employment. Consideration of the protection of the industry until the dam is commissioned should not be a surprising thing for the industry to expect.

73. I am not sure why the Council feels that it should be constrained because it cannot enable comparable acknowledgement or equitable assessment of any other business. Using the methodology which was suggested as being suitable by the Council in Plan Change 45-48, would quite easily dismiss the claims of such other businesses as a significant milk processing plant.

74. The point is that provision of rootstock protection water is not designed to maintain productivity in the year of the drought, it is designed to keep the plants alive so that they can produce in the following season. If the dairy industry could prove that they needed the supply of water to maintain some part or all of their plant otherwise their ability to process milk the following season is compromised, then there would be a valid argument for some sort of protection for them to be provided. However, I cannot think of a single example of this being the case. Not only is it not possible for it to occur for the local plant, but the dairy industry has multiple options in terms of alternative locations of where it may choose to process the milk.

75. I am not sure why the Council considers that this comparison need to constrain them from making a decision on the issue of root protection water. It is not a comparison which can be validly made.

76. The highly valuable vegetable growing industry (hothouse industry) is an example of a valid comparison. You will note that this was one of the industries which I carried out my analysis on. In running it through the methodology for assessment, we found that although the financial and employment impact was very significant both for the growers and the wider District economy and the time to recovery of full production was greater than a full year, the loss was less than that of a full year's production. So it did not meet the requirement of qualifying for the protection of root stock basically because the root stock is constantly being renewed. This means that there was not a valid argument that it needed to be protected.

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77. I note that the costs to the dairy industry would be only the additional cost of transport to an alternative processing facility, so I doubt that it could truly be classified as significant. In contrast in the case of the hothouse industry they are significant costs. I cannot agree with the Council's contention that the impacts on the dairy industry would be long term, particularly in comparison to the five to seven years which the Pipfruit, Kiwifruit and Vineyard industries would suffer before they were back into full productivity.

78. Therefore, I cannot see how these other industries are held up as valid comparisons to what Horticulture NZ is proposing in terms of root protection water, and moreover I cannot understand the validity of the Councils argument in terms of considering them.

CONCLUSIONS AND RECOMMENDATIONS

79. As set out above, on average it would be necessary to apply root stock protection water after 20 days of restrictions occurring. This would encompass provision on the lighter soils after 11 days and on the heavier soils after 30 days.

80. Capital root stock water would not be required very often (approximately every 18 years) but when the drought event occurs it lasts for quite a long time.

81. A summary of the impacts from the modelling outlined in this evidence is set out in **Table 7** below.

Table 7: Summary Impacts On Orchard ($m)

	With Root Stock Water	Without Root Stock Water	Difference
Gross Revenue	89.7	77.5	8.8
Net present Value	240	79	160
Gross Margin	25.6	14.4	11.2
Employment (FTE's)	4,379	3,912	467

82. Overall there is:

(a) A net loss in Gross Revenue of $12 m or 13.5% of the Total.

(b) Considerable loss of NPV.

(c) 43% drop in the total Gross Margin figure.

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(d) 467 Total FTE job losses which total 11 % of those that would be in place if there was root stock water available.

83. In my view, what Hort NZ is seeking by establishing a priority of water use in favour of horticulture in times of drought is a more efficient allocation of water than the current allocation.

84. I believe that the set of criteria which were set by the Council staff in PC45-48 very ably meets the first concern of the Council staff in the s42A Report regarding being able to make a distinction for allocating water based on value of water to an economic enterprise even during droughts. I believe that it could and should be used in evaluation of the economic case for all affected users of the water not just for the horticultural industry. That is why the Council agreed to include them in an allowance for the provision of root stock protection water which was signed by the Council as part of the mediation on Plan Change 45 - 48.

85. Although it may create marginally worse outcomes for other users of water it would have the impact of creating vastly better outcomes for the Horticultural users of the water. The net effect for the District's economy would be far superior to that which would occur if the proposed regime where to continue whereby all users were to suffer an equal level of restrictions to water access.

86. I believe that in the majority of instances given in the s42A report the staff misinterpret what Hort NZ seeks to achieve and they state invalid reasons why they are reluctant to grant it.

87. The recommendation made by the Council's economist is very much a second best alternative in the New Zealand context as a means of achieving economic efficiency from the allocation of water resources during droughts.

Stuart John Ford
11 December 2015

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"Achieving Outcomes by Building Capability"

The AgriBusiness Group™

Assessment of the requirement for, and the impact of, not providing sufficient irrigation capability to allow for root stock survival on the Waimea Plains

Prepared for: HorticultureNZ
Prepared by: The AgriBusiness Group
January 2015

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Please Read

The information in this report is accurate to the best of the knowledge and belief of the consultants acting on behalf of HorticultureNZ. While the consultant has exercised all reasonable skill and care in the preparation of information in this report neither the consultant nor HorticultureNZ accept any liability in contract, tort or otherwise for any loss, damage, injury or expense, whether direct, indirect or consequential, arising out of the provision of information in this report.

1.0 Executive Summary

This report has been prepared on behalf of Horticulture NZ (HortNZ) in response to the planning regime proposed by the Tasman District Council (TDC) in terms of the proposed rationing of water under a new flow regime in the Waimea River.

The purpose of the study is "*to demonstrate why any component of authorised water use for rootstock protection or survival purposes should be assigned a delimited priority during identified stepped rationing of all water users in the Waimea Plains Water Management Zones under a drought event.*"

There is a requirement to establish both:

- specific quanta of water required to meet root stock survival defined for each allocation proposed and;
- the economic production risks of non-availability of such water.

The information provided in this report was primarily gathered from a survey of 12 growers within the catchment.

The Volume of Water required to maintain the root stock.

The total requirement for root stock survival water totals 520.4 l / second or 0.520 cumecs of flow from the river.

Because of the range of soil available moisture on the plains we have calculated that, on average, we would need to apply root stock protection water after 20 days of restrictions occurring. However this would encompass provision of the water on the lighter soils after 11 days and on the heavier soils after 30 days.

The calculated frequency of events occurring at steps 3 and 4.

Interpretation of the data as shown and from looking at the record tells us that:

- The river is quite steep in its recession curve in that when it does trigger the Step 3 recorder it relatively quickly goes on to trigger the next Step.
- The river does not trigger the steps very often but when it does it stays dry for a long period of time.
- Analysis of the record shows that the number of years when the continuous days of restrictions at Step 4 was greater than 20 was for three years. There were 26 days of continuous restrictions in 1973, 37 days in 1982 and 47 in the year 2000.
- The timing of the events was general starting in late January and continuing on from there.
- In this analysis it was assumed that there was an event which would trigger the requirement for Root Stock Survival water every 18 years (3/55).

The Impacts On Orchard

It should be noted that the models used are calculated to represent the Cash Farm Surplus for each model (Gross Revenue – Farm Working Expenses). This leaves an amount which is available for the additional costs of Debt Servicing, Taxation, Depreciation, Capital Expenditure and a return to the investor.

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It is not possible to represent an average of each of these additional expenditure items because they are very much up to each individual and how they have set up their business. It should be noted that in some cases the resultant Cash Farm Surplus will not be sufficient for the owners to carry on without recourse to further capital introduction either through borrowed capital or attracting new investors. In some instances they will be able to carry on in business without recourse to further capital introduction externally.

The impact of an event occurring has been modelled across a span of 18 years which is the likely occurrence of the event. For the sake of this exercise it is assumed that the second year of the time frame is the year in which the severe drought event occurs. Therefore the figures which follow are calculated for the whole of the 18 years with the event occurring in year two and the recovery taking as long is required after that until the productive unit is back up and running and then continues at this level until the end of the 18 year period. Each of the figures which follow represent the total amount recorded over the 18 years which is divided by the 18 years to give an average impact.

Table 1: Summary Impacts On Orchard ($m)

	With Root Stock Water	Without Root Stock Water	Difference
Gross Revenue	89.7	77.5	8.8
Net present Value	240	79	160
Gross Margin	25.6	14.4	11.2
Employment (FTE's)	4,379	3,912	467

- Overall there is a net loss in Gross Revenue of $12 m or 13.5% of the Total.
- The results of this analysis show that there is considerable loss of NPV.
- The Gross Margin Analysis shows that there is a 43% drop in the total Gross Margin figure as a result of there not being any root stock survival water.
- Overall there were 467 Total FTE job losses which total 11 % of those that would be in place if there was root stock water available.

Alternative Activities that would occur in the Waimea.

All of the people who were asked to contribute to this exercise could not envision what sort of crop that they would grow as an alternative. Many felt that they had chosen to be in the productive sector that they were in and that this was their preference. There was also the fact that they all had a very substantial investment in the production system which they had adopted. They were reluctant to walk away from that investment and adopt a lower return sort of farming operation. They also felt that the relatively low likelihood of a drought occurring would mean that they would most probably risk its occurrence and continue farming in the way that they were.

Therefore in this exercise it has not been possible to envision what the alterative land uses would be therefore the adoption of a replanting of the existing crop has been adopted. It should be noted that this may well be a very conservative estimation of the cost of not providing root stock survival water.

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1 Background and Methodology

1.1 Background

This report has been prepared on behalf of Horticulture NZ (HortNZ) in response to the planning regime proposed by the Tasman District Council (TDC) in terms of the proposed rationing of water under a new flow regime in the Waimea River. This proposed flow regime is to be brought into action in the absence of the proposed Lee Valley Dam. This will be enacted if the TDC decides not to continue with the dam.

At the same time it is proposed that the existing consents to take water within the catchment area will be reassessed to make them in line with their actual needs for irrigation water rather than the existing situation which has them tied to rather generous volumetric entitlements. This will mean that when consents are restricted in the future it will be for a percentage of the actual take allowance rather than a percentage of a rather generous volumetric take. This will mean that the new regime will be considerably more restraining on the take of water than is experienced at present. This exercise of reallocation of the consent volumes to encompass the irrigator's actual needs has yet to be quantified.

HortNZ has real concerns that the flow regime of the river indicates (historically) that from time to time the river runs dry and there is the potential for there to be no takes for relatively long periods. HortNZ believes that there is the real potential for some of the permanent crops grown in the area (Pipfruit, Kiwifruit, Berries and Grapes in particular) to suffer loss of the crop. The death of their permanent crops would mean that the growers would suffer extreme hardship.

That is why in their submissions on the Proposed Plan they asked for a similar form of relief to that enacted in other jurisdictions (Hawkes Bay for example) whereby an allowance of sufficient water would be made available to keep the crop alive but not to maintain its productivity. They call this allowance; Root Stock Survival Water.

1.2 Methodology

The following methodology is in response to a work brief dated the 29th September.

The purpose of the study is "*to demonstrate why any component of authorised water use for rootstock protection or survival purposes should be assigned a delimited priority during identified stepped rationing of all water users in the Waimea Plains Water Management Zones under a drought event.*"

There is a requirement to establish both:

- Specific quanta of water required to meet root stock survival defined for each allocation proposed and;
- The economic production risks of non-availability of such water.

Hydrological Information Required

An assessment of the existing volumetric and flow rate quanta required in the Waimea to:

- Maintain existing indoor vegetable production, or production at 70%, expressed in litres per second per hectare and in cubic metres per day / ha and per month / ha across the summer months of production.

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- Keep alive commercial vegetable crops without providing for growth in the crop across the summer months.
- Maintain rootstock survival for permanent crops, berry crops and viticulture.
- Provide for dairy shed washdown and milk cooling water.

Economic Information Required

- An overall comparison of the differing economic values provided per hectare of production activities including an assessment of employment, cash cycling and gross margin / similar for pastoral, commercial vegetable cropping, viticulture, indoor cropping, permanent fruit crops and berryfruit production.
- An assessment of the likely difference in the effect of water non-availability at step 4 compared with step 3 on the continuity of such businesses.
- Some indication of the likely alternative activities that would develop in the Waimea catchment.
- An assessment of the annual effect on employment, revenue to be provided etc. in the Tasman region over the long term.

1.2.1 Methodology

The following methodology was carried out in order to produce this report.

Determine frequency of events.

The frequency of a restriction event occurring at step 3 and step 4 was calculated from Tasman District Councils available river flow records.

Gain financial information from growers.

A survey of growers was carried out which covered commercial vegetable cropping, viticulture, indoor cropping, pipfruit and berry fruit production which entailed interviewing 12 growers in total.

The information that was gathered in the interview included;

- The rate of take required to maintain indoor vegetable production, keep alive commercial vegetable crops and maintain root stock survival for permanent crops,
- Gross margin information,
- Capital development costs including the costs of replanting any stock lost in a drought event,
- Te time frame till full production was reached in order to calculate the lost opportunity of production during the time out of production and
- The employment impacts on both permanent and seasonal labour.

Compile information on losses experienced in the processing sector.

Information on the losses suffered in the processing sector in terms of employment was taken from previous studies of the impact of restrictions on labour availability. Impacts of the total lost revenue was gained by interviewing a few of the major processing companies (4 interviews).

Calculate the requirement for the volume of water required to maintain the root stock.

The amount required to maintain the operations of the individual growers was ascertained at the interview stage. The individual information gathered from the growers was then rated up by the land

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use mix as described in the Landcare[1] report. From this exercise the total volumetric requirement to maintain the root stock was calculated. This figure was then compared against the flow statistics in order to evaluate the likely impact of it occurring at step 3 and step 4 and some discussion was generated as to when it was best implemented.

An assessment of the likely alternative activities was compiled.

Information on the likely alternative activities was gained at the individual interview stage. This entailed an assessment by the land owner of what they would do as an alternative cropping regime if the drought event occurred and if they decided not to continue with their current operation. This was expressed in terms of revenue and employment impacts of the alternative land use option. This was rated up to calculate the total impact on the Tasman region's economy.

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[1] Landcare 2013: Assessing Water Quality Risks and Responses with Increased Irrigation in the Waimea Basin.

2 The Volume of Water required to maintain the Root Stock

The majority of information in this section of the report is taken from the Agfirst[2] report which is appended as Appendix 1. In this report Agfirst estimate the likely requirements to allow for root stock survival for Apple trees on the Waimea Plain.

2.1 The Likely Requirements for Root Stock Survival Water.

Pipfruit

In the report Agfirst point out that the soils on the Waimea Plains can be classified into either shallow, light soils (Ranzau, Maori) or deep heavy soils (Waimea, Richmond). These two classifications of the soils differ greatly in terms of their soil moisture holding capacity. The light soils are able to hold 40 mm of soil moisture per 500mm of soil depth while the heavy soils are able to hold 120mm of soil moisture per 500mm of soil depth. The two soil types have vastly different depths of the soils where the light soils are relatively shallow whereas the heavy soils have a much greater depth of soil. Therefore the two different soil types have much different water holding capacity with the heavy soils being able to provide for much more water because of their higher soil moisture holding capacity and their much greater depth while the lighter soils have a much lower moisture holding capacity and a much lower depth of soil that the plants can access it from.

Observation of the soil maps of the area indicate that the soil types are evenly split between the soils that are classified as light and the soils that are classified as heavy. Observation of the land uses displayed in the Landcare report indicate that the Pipfruit industry is again pretty evenly split between the two soil types.

They also point out that the climatic data from NIWA records show that the daily Evaporation (the rate that moisture is lost to the atmosphere) is as shown in Table 2.

Table 2: Daily Evaporation data (mm / day). (Nelson Airport)

	Dec	Jan	Feb	March
Average	4.6	4.8	3.9	2.7
Maximum	4.8	4.9	4.6	3.4
Minimum	4.2	4.6	3.4	2.0

The amount of daily water allowance required to maintain root stock survival in the pipfruit industry has been arrived at after a combination of interviews with local experts and apple growers and the combined opinion of the Agfirst team in Nelson who have over 70 years of experience including over 26 years monitoring soil moisture status of apple trees using Neutron probes.

Their estimation of the likely requirements are shown in Table 3.

[2] Agfirst (2014): Rootstock Survival for Apple trees on the Waimea Plains, Tasman. Report prepared for Hort NZ.

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Table 3: Rootstock Survival Recommendation for Apple Trees (mm / day).

	December	January	February	March
Light Soils	2.8	2.8	2.8	2.4
Heavy Soils	2.1	2.1	2.1	1.7

Kiwifruit

Interviewing the growers did not shed much light on the likely requirements for root stock water on Kiwifruit. In the end it was decided that the amount which was calculated by Agfirst for Pipfruit would be sufficient for the Kiwifruit plantations as well.

Vineyards

Feedback from the vineyard growers was that the nature of water demand for the vines meant that demand is not as high as for the pipfruit industry. Therefore we agreed that 2.0 mm / day would be sufficient to allow for root stock survival in the vineyards.

Hothouse.

The hot house that was interviewed was completely hydroponic so there was the requirement for their normal amount of water to be made available. They had two types of plants that were grown, the first is Tomatoes which are planted at 20,000 plants / ha and the second is Capsicums which are planted at 56,000 plants / ha. They both required 3 l / plant /day.

Dairy Farming

In order to continue their operation Dairy Farms would require additional water to the stock drinking water which they have free access to. This water is for the washing down of the dairy shed and the cooling of the milk. If it were to be considered in the same light as the root stock survival water it would not be deemed to be necessary as it is provided to allow the continuance of production of the dairy operation. For the Horticultural crops considered in this report no water has been provided to continue production, the water calculated here is to keep the crops alive so that they can produce again in the next season. If the same consideration was made to dairy farming there would be no justification for making an allowance for this level of activity because the dairy cows can be kept alive on their drinking water alone.

Nevertheless it has been requested to provide an estimate of the total amount required for this activity. We know that in other exercises the amount of 70 l / head / day has been allowed to provide for shed wash down and milk cooling water. If we assume that there are 3.2 cows per ha this would require 224 l / day.

Therefore the total requirement for root stock survival water is as shown in Table 4.

Table 4: Requirement for Root Stock Survival Water

	Area	Requirement	Requirement

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		L / ha / day	L / sec
Pipfruit – Light Soil	628.5	28,000	204
Pipfruit – Heavy Soil	628.5	21,000	153
Kiwifruit	11	28,000	3.6
Vineyards	634	20000	147
Hothouse	15	75000	13
Dairy Farms	263	224	0.68

The total requirement for root stock survival water totals 520.4 l / second or 0.520 cumecs of flow from the river.

2.2 Calculating the Time Span from when the water Triggers are Met until the Water is required.

Because the likelihood of an event happening has had to be manufactured and there is no indication of when total irrigation will be required to cease it is difficult to accurately calculate how long it will take until the provision of root stock survival water will be required. This is partly complicated by the relatively steep recession curve that is apparent in the Waimea River. This makes us believe that when an event will happen the periods between the triggering of step 3, step 4 and the notice for all irrigation to cease will be relatively short.

If we assume that the wilting point will begin when there is 50% of the soil available water still available and that when an event occurs the Evapotranspiration factors are at their highest and that it takes on average 11 days to go from step 3 to step 4 then on the light soils it would take approximately 10 days to reach the trigger point but on the heavier soils it would take approximately another 15 days until there would be demand for root stock survival water.

This would allow us to assume that, on average, we would need to apply root stock protection water after 20 days of restrictions occurring. However this would encompass provision of the water on the lighter soils after 11 days and on the heavier soils after 25 days.

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3 The calculated frequency of events occurring at steps 3 and 4.

3.1 The Rationing Steps Proposed

The following rationing steps have been taken from Table 1c Minimum flows and triggers for rationing Waimea Zones: No Lees Valley Community Dam which is sourced from Section 31- Rules for Water Takes Damming or Diversion 02-08-2014.

The proposed rationing steps are as follows;

Step 3: 2,300 l / sec in the Wairoa at Irvines, all consents go to 50% of consented take.

Step 4: 800 l / sec in the Waimea River at the TDC Nursery Recorder, all consents got to 70% of the consented take.

At this point it is unclear at what trigger level that consented takes will be required to cease takes altogether. It is proposed to be triggered by a combination of the potential for salt water intrusion to groundwater takes and maintaining a minimum flow in the river. Both of these trigger points have not as yet been determined by the TDC and it is proposed to leave it up to their discretion.

3.2 Analysis of River Flow Data

Data was supplied by the TDC[3] of their river flow data. For the step 3 trigger it entailed daily flow volumes encompassing 55 years from the Wairoa recording site at Irvines. This data was only missing small periods of record (less than a week) so is considered to be complete.

For the Step 4 trigger the data was much less complete with 10 years of complete records and one year which started in February and met the trigger point at the point of commencement of the record. In order to attempt to get a more reliable data set the Irvine's data was compared with the Wairoa data to try and establish a relationship between the flow at the higher point and the flow at the lower point. We are aware of the fact that no firm relationship has been able to be developed between the two flows because of the nature of the river and the fact that there are some consented takes between the two points. Nevertheless we established that there was some degree of relationship and determined that the average of the events was that when the Waimea at the lower trigger point was at 800 l / sec the average flow at the Wairoa recorder was 1,744 l / sec.

We then ran the full data set for the trigger point of 1,744 l / sec over the full data record. In the data set a year is displayed as an irrigation season that is from the 1st October to the 30th April, note this is not for a calendar year.

The results of the analysis of the restriction events at the two trigger points are shown in Table 5. The columns depict the total number of years in the record and analysis of the continuous events because these are the events that threaten the survival of the crops. These are shown for both Step 3 and 4 events. The average number of days per year when events occur and the maximum number of days is also shown.

[3] Excel Spreadsheet Provided by Joseph Thomas TDC: AgriBus_WairoaJan15

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It should be noted that there is no cessation in the record of Step 3 and the instigation of Step 4 in the data as presented.

Table 5: Results of analysis of the occurrence of Step 3 and 4.

	Step 3 Total	Step 3 Continuous	Step 4 Total	Step 4 Continuous
Total Number of Years	55	55	55	55
Years in which restrictions occur.	42	42	18	18
Average number of days.	18	11	5	4
Maximum number of days.	85	63	50	47

Interpretation of the data as shown and from looking at the record tells us that:

- The river is quite steep in its recession curve in that when it does trigger the Step 3 recorder it relatively quickly goes on to trigger the next Step.
- The river does not trigger the steps very often but when it does it stays dry for a long period of time.
- Analysis of the record shows that the number of years when the continuous days of restrictions at Step 4 was greater than 20 was for three years. There were 26 days of continuous restrictions in 1973, 37 days in 1982 and 47 in the year 200.
- The timing of the events was general starting in late January and continuing on from there.
- In this analysis it was assumed that there was an event which would trigger the requirement for Root Stock Survival water every 18 years (3/55).

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4 The on orchard impacts of the water not being available for financial performance.

In assessing the viability of determining the costs and benefits of each of the crop types specified in the brief we came up with the following conclusions as to the impacts.

Indoor vegetable production information that was provided to us was all for completely hydroponic production. Therefore this sector is completely reliant on the supply of water continuing all year round. Therefore the option of maintaining production at 70% of optimum would automatically mean that productivity would be limited to 70 % of the current production. For a hydroponic production system to suffer the sort of water restriction which is likely to occur in this situation would mean that production would fail completely and then once water was available again it would have to be staggered in terms of planting so it would take an additional 18 months for full productivity to be restored.

The option of keeping alive commercial vegetable crops without providing for growth is effectively a policy of writing the current crops off. No crop that we are aware of can be kept alive without trying to race to seed so the option of keeping them alive until there is enough water for them to grow again is not a viable option. Therefore there is no provision for this policy in our calculations.

Maintaining sufficient root stock survival water is encompassed in our calculations but there is no allowance for the maintenance of productivity.

Sufficient dairy shed was down and milk cooling water has been calculated for but there is no impact on productivity allowed for in our calculations.

Models Used

The models used to calculate the impacts are based on the MPI Orchard Monitoring Models in their format and an example is included as Appendix 2. For each of the Pipfruit, Kiwifruit and Vineyard models the models were set up as set out by MPI and were then further adapted to reflect more average conditions and operating expenditure experienced in the Tasman District. This was aided by the feedback from the growers.

The indoor vegetable model was constructed based on the feedback received from the growers.

It should be noted that the models used are calculated to represent the Gross Margin for each model (Gross Revenue – Direct Orchard Working Expenses). This leaves an amount which is available for the additional costs of Business Overhead Expenses (which includes items such as Rates, Insurance, Accounting, Administration etc) Debt Servicing, Taxation, Depreciation, Capital Expenditure and a return to the investor. In this way we did not consider the impact of these additional items on the individual's ability to continue to carry on producing. It should be noted that in some cases the resultant Cash Farm Surplus will not be sufficient for the owners to carry on without recourse to further capital introduction either through borrowed capital or attracting new investors. In some instances they will be able to carry on in business without recourse to further capital introduction externally.

It is not possible to represent an average of each of these additional expenditure items because they are very much up to each individual and how they have set up their business. It should be

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noted that in some cases the resultant Cash Farm Surplus will not be sufficient for the owners to carry on without recourse to further capital introduction either through borrowed capital or attracting new investors. In some instances they will be able to carry on in business without recourse to further capital introduction externally.

4.1 The Impacts of Water not being available on Orchard.

The impact of an event occurring has been modelled across a span of 18 years which is the likely occurrence of the event. For the sake of this exercise it is assumed that the second year of the time frame is the year in which the severe drought event occurs. Because of the timing of the event most of the expenditure has already been spent in that year therefore the only losses are the loss of the revenue from the crop and the cost of harvesting and further packing the crop. In all cases it is assumed that the grower either is vertically integrated into the further processing industry or pays the cost of that exercise.

The areas of the crops grown as listed in the Landcare report areas shown in Table 6.

Table 6: Areas of Crops Grown on the Waimea Plain (ha).

	Area
Pipfruit	1257
Kiwifruit	11
Vineyard	634
Hothouse	15
Total	**1917**

Pipfruit Impacts

The impacts that occur on the Pipfruit Model is for the drought effect occurring before the picking of the fruit and therefore there is complete loss of income in the first year with only the harvesting expenditure being saved. The Orchard is then replanted with nil production in the first year, 50% production I the second year and full production occurring in the third year.

Kiwifruit Impacts.

The impacts that occur on the Kiwifruit Model is for the drought effect occurring before the picking of the fruit and therefore there is complete loss of income in the first year with only the harvesting expenditure being saved. Because of the current situation with PSA in the Kiwifruit industry replacement plants must be grown within the District. Therefore there is a two year gap before replanting can begin while the replacement plants are regrown. Once replanted there is no production in year 1, 40% of optimum productivity in year 2, 75% in year 3 and full productivity in year 4 after replanting (note that this is 6 years since the drought event).

Vineyard Impacts.

The impacts that occur on the Vineyard Model is for the drought effect occurring before the picking of the fruit and therefore there is complete loss of income in the first year with only the harvesting expenditure being saved. For the first two years after the drought event there is not productivity from the vines. In the third year productivity is at 20% of the optimum, 40% in year four, 70% in year 5, 90% in year 6 and then full productivity in year seven.

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Indoor Vegetables

Productivity within the hothouse continues all year round with the highest productivity being in the summer months. Therefore we have assumed that 50% of production is lost in the year of the drought occurring, there is a further 75% reduction in the following year and a small 10% reduction in the following year. Because the planting regime is staggered throughout the year to meet the markets requirments for the fruit it is assumed that this planting regime is followed in the recovery year after the event. It takes another full year before full production is achieved.

4.2 Results of the modelling.

The results of the modelling which was carried out for an 18 year period are reported as the situation without there being a drought event and the situation in which an event occurs. The net difference between the two reports the cost to the TDC area of not providing for root stock survival water. Therefore the figures which follow are calculated for the whole of the 18 years with the event occurring in year two and the recovery taking as long is required after that until the productive unit is back up and running and then continues at this level until the end of the 18 year period.

Gross Revenue

The Gross Revenue affects are shown in Table 7. It should be noted that the figure reported is the average of the Gross Revenues of the 18 years,that is taken as the total Gross Revenue from each of the systems for the whole of the 18 years divided by the 18 years. In this way it exhibits the average impact of the event across the 18 years.

Table 7: Gross Revenue With and Without Root Stock Water

	With Root Stock Water	Without Root Stock Water	Difference
Pipfruit	63,347,772	54,549,470	8,798,302
Kiwifruit	473,000	371,831	101,169
Vineyard	7,100,800	5,246,702	1,854,098
Hothouse	18,750,000	17,343,750	1,406,250
Total	**89,671,572**	**77,511,753**	**12,159,819**

As can be seen from Table 7 the majority of the losses in Gross Revenue occur from the Pipfruit Industry. Overall there is a net loss in Gross Revenue of $12 m or 13.5% of the Total.

Net Present Value

In order to reflect the cost of time that is expressed in the way that this has been modelled the results are also presented as a Net Present Value in Table 8. The NPV is calculated over the full 18 years of the event which is discounted at 8% per anuum. There is the potential to influence the result of an NPV analysis according to when you schedule the event as occurring. In this instance I have scheduled it to occur in the second season.

Table 8: Net Present Value With and Without Root Stock Water

	With Root Stock Water	Without Root Stock Water	Difference

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Pipfruit	165,597,956	45,982,498	119,615,458
Kiwifruit	1,978,930	1,067,640	911,290
Vineyard	27,451,007	-7,064,349	34,515,357
Hothouse	44,844,480	39,592,720	5,251,760
Total	**239,872,373**	**79,578,509**	**160,293,865**

The results of this analysis show that there is considerable loss of NPV. The greatest losses in proportionate terms are suffered by the Kiwifruit and Vineyard models because of the relatively long period before the get back into full production.

Gross Margin

The Gross Margin (Gross Revenue – Farm Workng Expenses) affects are shown in Table 9. It should be noted that the figure reported is the average of the Gross Margin of the 18 years.

Table 9: Gross Margin With and Without Root Stock Water

	With Root Stock Water	Without Root Stock Water	Difference
Pipfruit	17,669,649	9,409,343	8,260,306
Kiwifruit	211,156	140,656	70,500
Vineyard	2,929,080	461,622	2,467,458
Hothouse	4,785,000	4,426,125	358,875
Total	25,594,885	14,437,747	11,157,138

The Gross Margin Analysis shows that there is a 43% drop in the total Gross Margin figure as a result of there not being any root stock survival water.

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5 The impacts of the water not being available on employment.

Employment impacts have been calculated from indications of employment gained from the grower survey and from previous work carried out in order to ascertain the number of people employed in the beyond orchard part of the chain. The employment factors expressed here all reflect a Full Time Equivalent worker. Many of the jobs offered in the industry are part time in that they only offer employment for from 4 weeks to 20 weeks of the year.

It should be noted that the figures presented in this section and shown in Table 10 reflect the annual average employment statistics for the whole 18 seasons. That is the total employment figure for the whole 18 years divided by 18 years.

Table 10: Employment With and Without Root Stock Water (FTE).

	With Root Stock Water	Without Root Stock Water	Difference
Pipfruit	3,921	3,516	405
Kiwifruit	22	18	3
Vineyard	222	179	43
Hothouse	215	199	16
Total	**4,379**	3,912	467

The highest impact of the loss of employment is felt in the Pipfruit sector which provides a very high proportion of the 467 Total FTE job losses which total 11 % of those that would be in place if there was root stock water available.

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6 An assessment of the likely alternative activities that would develop in the Waimea.

All of the people who were asked to contribute to this exercise could not envision what sort of crop that they would grow as an alternative. Many felt that they had chosen to be in the productive sector that they were in and that this was their preference. There was also the fact that they all had a very substantial investment in the production system which they had adopted. They were reluctant to walk away from that investment and adopt a lower return sort of farming operation. They also felt that the relatively low likelihood of a drought occurring would mean that they would most probably risk its occurrence and continue farming in the way that they were.

Some were wealthy enough to be able to afford the sort of losses that a drought would impose on them while others would be financially ruined by such an event. They all felt that if a change was forced on them they would have to walk away from a substantial investment in superstructure. They all felt that if this were the case then it would be someone else that would be carrying out the farming operation.

Therefore in this exercise it has not been possible to envision what the alterative land uses would be therefore the adoption of a replanting of the existing crop has been adopted. It should be noted that this may well be a very conservative estimation of the cost of not providing root stock survival water.

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Appendix 1: Rootstock Survival for Apple trees on the Waimea Plains, Tasman.

Horticultural New Zealand
The Terrace PO Box 10232
Wellington 6143 New Zealand

26th November 2014

Angela Halliday, Advisor, Natural Resources and Environment

Dear Angela

Rootstock Survival for Apple trees on the Waimea Plains, Tasman.

Background.

Tasman District Council requires a rationale to demonstrate why any component of authorised water use for rootstock protection or survival purposes should be assigned a delimited priority during identified stepped rationing of all water users in the Waimea Plains Water Management Zones under a drought event.

The hydrological dynamics and rationing constraints for the Waimea River mean there is a need to consider the limits that should be imposed on any priority take and use regime during any drought given the extreme shortage of water in the catchment.

In the situation of water take and use demand during a drought-induced flow recession, and the staged rationing response in the Tasman Resource Management Plan where there is no water augmentation via a dam, any priority regime for any purpose needs to be established in relation to:

- specific quanta defined for each allocation proposed
- economic production risks of non-availability

This would need to be determined with reference to the rationing step or steps. This information is needed before any Plan coding at policy or rule levels can be assessed.

Hydrological rationale

HortNZ have engaged Agfirst Consultants Nelson Ltd to provide an expert opinion on the volumetric and flow rate quanta required in the Waimea to maintain rootstock survival for pipfruit during a drought given an extreme shortage of water in the catchment.

Pipfruit

Rooting depth, growth stage, crop co-efficient, soil and climate data need to be taken into account when determining the crop water requirement. A healthy root system is essential as it facilitates the uptake of water and nutrients. A healthy pipfruit tree is deep rooting. Rooting depth has been measured up to 2m. This represents a relatively large volume of soil within which the plant can explore for water.

Agfirst Consultants Nelson Ltd
171 High Street
P.O. Box 33 Motueka
Phone: (03) 528 0330

Fax: (03) 528 0331

Pipfruit go through two critical growth periods each with its own demand for water.

1. Cell division phase - Bud-burst – 6 weeks post fruit set.

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2. Cell expansion phase - Fruits enlarge through to harvest, shoot growth, leaves mature and then shoots terminate. Root growth in spring and again post-harvest as the tree replenishes reserves prior to dormancy.

Fig 1. Relative growth patterns of a Pipfruit tree (Peterson & Stevens, 1994, Tree Fruit Nutrition).

Crop coefficient.

A crop coefficient relates crop water use at a particular development stage to the amount of evapotranspiration (ET) calculated from weather data. Crop co-efficient vary between growth stages which reflects the changing characteristics and therefore water demand of the pipfruit crop over the growing season.

Table 1. Apple crop co-efficient during the growing season - Lincoln Environmental Report No. 4487/1, Feb 2003.

APPLES	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Co-efficient	0.5	0.7	0.9	1.0	1.0	0.9	0.4	0.4

Soils.

Soil moisture holding capacity is one of the key determinants of irrigation water demand. Soils differ in their ability to store water, depending on their texture. Sandy soils hold the least because they have large pore spaces between the sandy particles. Clay soils have much smaller pore spaces, giving them a greater water holding capacity. Soils on the Waimea plains are a combination of textures. The soil types can be classified into either shallow, light soils or deep, heavy soils as follows:

Table 2. Soil moisture holding capacity by soil type on the Waimea Plains – Lincoln Environmental Report No. 4487/1, Feb 2003.

Soil type	Class	Soil moisture holding capacity (per 500 mm of soil)
Ranzau stony clay loam (Rz) Ranzau gravelly silt loam (Rzg) Maori gravelly sandy loam (M)	Shallow, light	40mm
Waimea silt loam & sandy loam (Y) Waimea clay loam (Ym) Richmond clay loam (Rm) Richmond peaty clay loam (RmP) Richmond silt loam (Rs)	Deep, heavy	120mm

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It is a combination of the depth of soil and the water holding capacity per unit depth of soil. The trees on the two different soil types require the same volume of total water, but the amount of added water needed varies, as the deeper soils have a much larger reservoir of water to draw from. Trees planted on the heavier soils (Figure 3, Waimea clay loam) are able to access more water at depths which encouraged deeper rooting, whereas trees planted on the shallower, light soils (Figure 2, Ranzau gravelly silt loam) have most of the water held near the surface, and the percentage of stones increases with depth, thus discouraging the root system from further growth.

Fig 2. Soil moisture content on Ranzau gravelly silt loam Fig 3. Soil moisture content on Waimea clay loam.

Figures 2 & 3 show soil moisture content down the soil profile (150 – 850mm) from two different soil types on the Waimea Plains; Fig 2, Ranzau gravelly silt loam (shallow, light soil texture) and Fig 3, Waimea clay loam (deep, heavy soil texture). The readings have been taken using a Neutron probe. The blue line is the full point of the soil, which is the point at which all soil pores are occupied by water. The red line is

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the trigger point at which irrigation water should be applied so as to avoid stress to the tree which may impact on production. Note: trigger point is not the wilting point. The larger the area between the trigger point and full point the larger the capacity the soil has to hold water i.e. more clay content, deeper, heavier soils. Note that at 450 – 850mm there is significantly different soil moisture content of the two soil types whereas; the Ranzau gravelly silt loam (Fig 2) has a full point of 20% soil moisture content (VSM) while the Waimea clay loam has a full point of between 31 – 37% soil moisture content for the same depth range.

Climate data.

Daily climate data was based on climatic records from 1972 – 2013 recorded at Nelson Airport.

Table 3. Daily Evaporation (Penman ET) (mm/day) – NIWA – Nelson airport.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Average	3.2	3.9	4.6	4.8	3.9	2.7	1.7	0.7
Range	2.3 – 3.4	3.4 – 4.2	4.2 – 4.8	4.6 – 4.9	3.4 – 4.6	2.0 – 3.4	0.8 – 2.0	0.07 – 0.8

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Expert opinion.

Local experts were interviewed in the preparation of this report. Cumulatively they have over 70 years of experience with apple growers on the Waimea Plains. The experts are Craig Hornblow, Director, Agfirst Consultants Nelson Ltd, Steve Spark, Director, Agfirst Consultants Nelson Ltd & John Bealing, Retired Director, Agfirst Consultants Nelson Ltd. Agfirst Consultants Nelson Ltd have been using Neutron probes to monitor soil moisture status on apple orchards on the Waimea Plains for over 26 years. In addition to these independent specialists, a cross-section of apple growers on the Waimea Plains have been interviewed for their opinion on root stock survival.

Conclusion

Table 4 is the recommended minimum amounts of water required to maintain rootstock survival of apple trees during the growing season grown on the Waimea Plains, Tasman. Under drought conditions or when extreme dry conditions prevail then the risk to rootstock survival has been classified at **critical, high, med or low** depending on the time of year.

Critical: The four months of November – February is considered the riskiest period for rootstock survival so therefore a higher minimum about of water is required to ensure rootstock survival. This is a critical period as it sets the tree up for the following season. If during this period critical biochemical processes do not occur within the tree due to lack of water then the survival of the tree is in jeopardy. It is therefore considered a critical period. ET rates are also at the highest so the risk to water stress is heightened.

High: The next risky period is on the shoulders of the critical period; October and March. Slightly less minimum amount of water is required during these periods to ensure survival.

Med – Low: The tail of growing season is the least risky to survival and so the minimum water requirement is the lowest. ET is tapers off dramatically as winter approaches.

The amount of water required will also vary depending on the soil type. Apple trees grown in heavier, deep soils are likely to have a larger root system to explore a greater volume of soil for water in soils with a larger water holding capacity, so therefore the apple trees grown in these soils will require slightly less amounts of applied water to ensure survival. Conversely apple trees grown in light, shallow soils are likely to have a smaller root system exploring a smaller volume of soil for water in soils with already a much lower water holding capacity, so the apple trees grown in these soils will require a greater quantity of water to ensure survival.

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It should also be noted that the critical period whereby the survival amount of water will need to be applied will be reached much sooner with trees grown in the lighter soils than that of trees grown in the heavy soil types as the drought proceeds.

If you have any questions about this report please contact Dean Rainham, AgFirst Consultants Nelson Limited on 027 839 9613.

Yours sincerely

Dean Rainham (BHortSc(hons))
Horticultural Consultant

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Table 4. ROOTSTOCK SURVIVAL RECOMMENDATION FOR APPLE TREES GROWN ON THE WAIMEA PLAINS, TASMAN.

Crop	Oct	Nov	Dec	Jan	Feb	March	Apr	May
APPLES	High	Critical	Critical	Critical	Critical	High	Med	Low

RISK CLASSIFICATION	*Shallow, light soil types		*Deep, heavy soil types	
Critical	20mm/week	2.8mm/day	15mm/week	2.1mm/day
High	17mm/week	2.4mm/day	12mm/week	1.7mm/day
Medium	14mm/week	2.0mm/day	9mm/week	1.3mm/day
Low	10mm/week	1.4mm/day	5mm/week	0.7mm/day

***Shallow, light soil types**

Ranzau stony clay loam

Ranzau gravely silt loam

Maori gravelly sandy loam

loam

Richmond peat clay loam Richmond silt loam

***Heavier, deep soil types**

Waimea silt & sandy loams

Waimea clay loam
Richmond clay

HortNZ - Apple rootstock survival, Waimea Plains – 26Nov14

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Appendix 2: Example of Gross Margin Information Gathered.

	Grade	**Yield**	**Price ($)**
Income			
Variable Costs			
Seed			
Cultivation			
Fertiliser			
Agri Chem			
Irrigation			
Harvesting			
Land Lease			
Grading			
Packing			
Freight			
Commision			
Levy			

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Waikato Horticulture Overseer Nutrient Modelling

1 Background

This report briefly summarises the Overseer (6.2.3) nutrient budget results for three cropping rotations that are representative of horticulture in the Waikato region. This work was carried out to provide Jacobs some N leaching results that they can use in their GIS modelling to represent the leaching losses experienced over time in the Waikato Region.

2 Methodology

The Overseer nutrient budgets were created using data collected from 13 growers of horticulture crops within the Waikato Basin, with the majority of crops grown in the Pukekohe growing area and based on consultation with an expert panel of growers. This data was collected in 2013, for a previous report by The AgriBusiness Group.

Based on the data and consultation with a panel of growers, three representative rotations and three mitigation techniques for vegetable growing in the Pukekohe growing region were developed.

Three representative rotations were modelled:

- Rotation one was designed to represent the more extensive rotation of major large-scale crops such as potatoes, onions and carrots which make up approximately 50% of the land in horticulture production in Lower Waikato.
- Rotation 2 represents the more intensive rotation with the inclusion of more green crops such as broccoli and summer lettuce, which make up approximately 45% of the land in horticulture production.
- Rotation 3 represents a traditional market garden rotation, which are significantly more intensive and make up approximately 5% of land in horticulture production in Lower Waikato.

These rotations are outlined in the following sections.

The Overseer files were created using Overseer version 6.2.3. All files were created using the relevant Overseer Best Practice Data Input Standards. The files were also created to be consistent with Proposed Plan Change 1 (Schedule B – Nitrogen Reference Point), in particular:

- June is the final crop month, as required for commercial vegetable production.
- The nutrient budgets capture the entire enterprise, to truly represent nitrogen losses from farm at the catchment level, in which house sections were included.
- Location- The Waikato region was used, to ensure consistency with climate settings.
- Block climate data- The Climate Station tool was used. The GPS coordinate -37.325559 , 174.992809 was used for Rotation 1 – Extensive, and -37.238964 ,174.902172 was used for Rotation 2 – Intensive and Rotation 3 – Market Garden.
- Soil description- Soil order is used in order to follow the requirements of Environment Waikato in order to ensure consistency between areas of the region that have S-Map

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data and those that don't. A Granular soil was selected, to represent the Patumahoe Loam soils that are present in the Waikato horticulture area.

3 Results

3.1 Rotation 1- Extensive

Rotation one was designed to represent the more extensive rotation of growing the major large-scale crops. It is estimated that this rotation represents approximately half the area grown in the Lower Waikato.

The rotation is as follows:
Potato (summer) > Onions > Carrots > Squash > Oats and Rye > Barley (grain) > Oats and Rye

The rotation was split into four 30 ha Overseer blocks (refer to **Appendix 1**). A house section (0.4 ha) was also included in the Overseer budget.

Across the property, an average of **114 kg N / ha / yr** was lost to water (**Table 1**). Nitrogen losses varied between cropping blocks. It is difficult to analyse the nitrogen leaching contribution from each individual crop, as this is largely dependent on the available nitrogen from the previous crops.

Table 1: Nitrogen loss report for Rotation 1- Extensive

Block name[1]	N lost to water kg N/ha/yr	N in drainage * ppm	N surplus kg N/ha/yr	Added N ** kg N/ha/yr
Oats/rye - pot - onion	153	**17.5**	248	425
Onion - carrot	203	**25.9**	216	278
Carrot - squash - oats/rye	94	**12.7**	4	160
Barley - oats/rye	8	1.2	21	87
House	38	N/A		
Other sources				
Whole farm	**114**			

** N concentration due to leaching in drainage water at the bottom of the root zone. Maximum recommended level for drinking water is 11.3 ppm (note that this is not an environmental water quality standard).*

*** Fertiliser, organic and effluent inputs*

[1] The Overseer blocks are named by the Crops on the block in the Reporting Year. Note that the crops are included in the block name if they are only in some of the Reporting Year. For example, only the last two months of the potato crop are in the Reporting Year in the first block of Rotation 1, yet it is named.

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3.2 Rotation 2- Intensive

Rotation 2 represents a much more intensive crop mix but it was somewhat limited by the range of crops available. It is estimated that this rotation represents approximately 45% of the area grown in the Lower Waikato.

The rotation is as follows:
Squash > Broccoli > Oats and Rye > Lettuce (summer) > Mustard > Onions > Oats and Rye > Potato (Winter).

The rotation was split into four 18 ha Overseer blocks (refer to **Appendix 2**). A house section (0.4 ha) was also included in the Overseer budget.

An average of **174 kg N / ha / yr** was lost to water (**Table 2**).

Table 2: Nitrogen loss report for Rotation 2- Intensive

Block name	N lost to water kg N/ha/yr	N in drainage ppm	N surplus kg N/ha/yr	Added N kg N/ha/yr
Potato - squash - broccoli	174	18.6	148	317
Broccoli - oats/rye - lettuce - mustard	115	15.0	34	86
Onion - cabbage	173	21.6	448	511
Cabbage - oats/rye - potato	237	30.1	-22	272
House	38	N/A		
Other sources				
Whole farm	**174**			

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3.3 Rotation 3- Traditional Market Garden

The traditional market garden rotation was much more intensive and was designed to represent the sort of rotation grown in market gardens and was somewhat limited by the range of crops available. It is estimated that this rotation represents approximately 5% of the area grown in the Lower Waikato. The rotation is as follows:

Broccoli > Mustard > Lettuce > Cabbage > Mustard > Spinach > Cauliflower > Cabbage > Mustard.

The rotation was split into four 0.5 ha Overseer blocks (refer to **Appendix 3**). A house section (0.1 ha) was also included in the Overseer budget.

An average of **159 kg N / ha / yr** was lost to water (**Table 3**).

Table 3: Nitrogen loss report for Rotation 3- Traditional Market Garden

Block name	N lost to water kg N/ha/yr	N in drainage ppm	N surplus kg N/ha/yr	Added N kg N/ha/yr
Oats/rye - broccoli - oats/rye	37	74	7.3	122
Oats/rye - lettuce - cabbage	90	180	19.7	324
Cabbage - oats/rye - spinach	89	179	24.2	146
Cauliflower - cabbage - oats/rye	108	216	24.9	165
Oats/rye - broccoli - oats/rye	37	74	7.3	122
House	9	93	N/A	
Whole farm	**159**			

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4 Appendices

Appendix 1: Rotation 1 Extensive - Cropping rotation at the block level

Block 1: Oats/rye - potato - onion

Year 1												Reporting Year											
Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Barley (spring)								Oats and rye					Fallow	Potato (long)							Fallow		Onions

Block 2: Onion - carrot

Year 1												Reporting Year											
Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Crop	Fallow	Potato (long)							Fallow			Onions							Fallow			Carrots	

Block 3: Carrot - squash - oats/rye

Year 1												Reporting Year											
Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Onions							Fallow					Carrots				Squash					Oats and rye		

Block 4: Barley - oats/rye

Year 1												Reporting Year											
Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Crop				Squash					Oats and rye			Barley (spring)								Oats and rye			

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Appendix 2: Rotation 2 Intensive - Cropping rotation at the block level

Block 1: Potato - squash - broccoli

Year 1												Reporting Year											
Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Crop		Oats & Rye					Fallow			Potato (medium)					Squash						Broccoli (winter/spring)		

Block 2: Broccoli - oats/rye - lettuce - mustard

Year 1												Reporting Year											
Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Crop			Squash						Broccoli (winter/spring)				Oats & Rye			Lettuce				Mustard			Fallow

Block 3: Onion - cabbage

Year 1												Reporting Year											
Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Crop	Oats & Rye			Lettuce				Mustard			Fallow	Onions							Fallow	Cabbage (winter)			

Block 4: Cabbage - oats/rye - pot

Year 1												Reporting Year											
Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Onions							Fallow	Cabbage (winter)						Oats & Rye					Fallow			Potato (medium)	

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Appendix 3: Rotation 3 Traditional Market Garden - Cropping rotation at the block level

Block 1: Oats/rye - broccoli - oats/rye

Year 1												Reporting Year											
Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Fallow		Cauliflower			Cabbage (summer)			Oats & Rye						Fallow	Broccoli (winter/spring)						Oats & Rye		

Block 2: Oats/rye - lettuce - cabbage

Year 1												Reporting Year											
Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Crop			Broccoli (summer)						Oats & Rye					Lettuce								Cabbage (winter)	

Block 3: Cabbage - oats/rye - spinach

Year 1												Reporting Year											
Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Crop		Lettuce								Cabbage (winter)				Oats & Rye						Spinach			

Block 4: Cauliflower - cabbage - oats/rye

Year 1												Reporting Year											
Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Crop		Oats & Rye						Spinach				Fallow		Cauliflower			Cabbage (summer)			Oats and rye			

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ITEM 3.3

Memorandum

Date: 19 December 2018 (Corrected 21 January 2018)

Subject: Regulation for Commercial Vegetables

To Minister David Parker and Minister Damien O'Connor

From: Michelle Sands, Horticulture New Zealand

Copies Mike Chapman and Horticulture New Zealand Board.

1. Commercial Vegetables.

We recommend a national regulatory approach for commercial vegetables. The aim is to secure domestic food supply and to manage the effects of growing commercial vegetables.

There are three aspects to the proposed approach:

- National Policy Statement for Soils, that provides greater protection for versatile soils.
- Recognition of nationally important uses in the National Policy Statement for Freshwater Management, that includes domestic food supply.
- National Environmental Standard for commercial vegetable operations, that sets nationally consistent regulation.

1.1 Value of vegetables to New Zealand

The majority of commercial vegetables grown in New Zealand are for domestic supply, 75% by value, (data provided in Appendix A). Commercial vegetable production has high input costs, occupying the most expensive rural land on the urban fringe. The vegetable sector has 1,318 levy paying members who employ an estimated 4,000 or more workers across the sector. The food produced per hectare is high, with an estimated 1.5 million tonnes of vegetables produced from 50,000 hectares of land. The profit made from vegetables is relatively low, given the relatively small size of farms. Profit is extremely variable due to crop type, yield, location, weather and 'price on the day'. (Seymour, J. Vegetable NZ, 2018, pers comm., 12 December)

Diet makes an important contribution to health and wellbeing. Dietary risk factors include having a low intake of fruit and vegetables, a high intake of salt, sugar and red meat, and low fibre consumption. Together, dietary risk factors account for 8.6 percent of all health loss, (Ministry of Health, 2018).

In 2016/17 half of children and under half of adults met the recommended vegetable and fruit consumption guidelines. Those from the most deprived neighborhoods are less likely to meet the recommended intake of fruit and vegetables. (Ministry of Health). In 2017/18, one third of adults and over 10% of children are obese, (Ministry of Health).

Positive health outcomes for New Zealanders, are dependent on a reliable supply of fresh, affordable vegetables. If we cannot grow vegetables in New Zealand, retailers will import vegetables to meet domestic demand. Given our isolation, we will be more reliant on frozen, processed and air-freighted vegetables.

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1.2 Vegetable rotations

Growing the same crop in the same location, results in poor crop performance. This is because depletion of the soil nutrients will occur over time. The growth of some crops is suppressed by self-emitted metabolites if they are not grown in rotations with other crops.

Some rotations include legumes, which fix atmospheric nitrogen to be used by following crops in the rotation. Some crops with deep strong roots are useful for opening channels deeper in the subsoil than the harvested crop might penetrate. A pasture phase can improve soil structure by adding organic matter to the soil.

Rotating crops breaks pest and disease cycles by removing host material for a period and reducing pest populations. Some crops and their residues can act as soil bio-fumigants. In NZ there are certain sorghum and brassica species used in this way. (Davis, S, 2018, pers comm., 21 June)

An example of a crop rotation in Pukekohe is provided as an animation, in the attached file named: Roation_EWxample.mp4. (Jacobs, 2018).

1.3 Leased land

In New Zealand we grow approximately 500,000 tonnes of potatoes per year on 10,000 hectares of land. But potatoes cannot return to the same land for 5 years, so they need 50,000 hectares of land over a 5-year rotation. (Claridge, C. Potatoes NZ, 2018, pers comm., 10 December).

Growers don't own all the land they grow on. The viability of vegetable growing is dependent on regulations that treat leaseholders and landowners fairly.

As we transition to a low-emissions economy, we have an opportunity to reduce methane emissions through land use diversification. To achieve diversification quickly, allocation systems that work for leased land will be vital.

2. National Policy

2.1 National Policy Statement for Versatile Soils

Versatile soils are a natural asset, the management of which is essential for:

- meeting the nutritional demands of our existing domestic population, and for
- meeting the needs of future generations who will be operating in a low emissions economy with a different climate. In the future, the value of our best soils as a resource for food production both for NZ and export is likely to increase.

2.2 National Policy Statement for Freshwater Management 2014

We generally support the direction set by the National Policy Statement for Freshwater Management, (NPSFM).

Allocation for domestic food supply

We are of the view that there are some uses of water that should be recognised as nationally important.

In our view, domestic food supply should be recognised as a nationally important use. Domestic food supply of meat, milk and fruit is a consequence of export production. This is not the case for commercial vegetables, where domestic supply is the primary market.

In order to provide for domestic food supply, the existing area of commercial vegetable growing needs to be maintained. The complexity of crop rotations means it is not practical to separate rotations that are exclusively for domestic markets, from those that grow crops for export as well as domestic.

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Therefore, we recommend grand-parenting the nitrogen load for existing commercial vegetable rotations. The allocation of nitrogen for new areas of commercial vegetable growing would then be subject to the same allocation as other primary production uses. This recognises that any expansion in commercial vegetable growing area is likely to be driven by export markets, with some expansion also expected to provide for population growth.

3. National Environmental Standard for Commercial Vegetables

We propose national regulation due to the difficulty that has arisen as various Regional Councils have sought to regulate for commercial vegetable production.

Growers supplying our domestic markets are direct competitors with one another. For this reason, growers support nationally consistent environmental standards to create a level playing field across all regions.

We propose that a National Environmental Standard (NES) for commercial vegetables would preclude the development of rules or resource consents that are more stringent than the NES.

3.1 Nitrogen and Overseer

Nitrogen limits have been used for managing water quality across a range of contaminants. This method works best for dairy. On dairy farms as nitrogen losses increase sediment, phosphorus and *E. coli* losses also increase. It has limitations for sheep and beef that have relatively low nitrogen losses, but high sediment losses from hill country. This method also does not work well for horticulture, which has relatively high nitrogen and very low *E. coli* losses. This is illustrated by the water quality modelling undertaken by NIWA to support Plan Change 1 in the Waikato. The graphs, provided in Appendix B illustrates the cumulative land area and load contribution of various contaminants at the mouth of the Waikato River.

Overseer is a tool that works reasonably well for pastoral farms, but has many limitations for representing cropping systems (Parliamentary Commissioner for the Environment, 2018). Some of these limitations relate to technical issues that the software owner could resolve over time, these issues include:

- calibration
- water balance
- representation of a limited number of crops.

A more serious limitation of Overseer for representing cropping, is its spatial and temporal resolution. It is fundamentally incompatible with representing complex crop rotations without using numerous 'work-arounds'. (Khaembah & Brown , November 2016).

Given the limitations of Overseer as an on-farm tool for growers and the uncertainty over its estimates of long-term average nutrient discharges from vegetable rotations, we are of the view that it would be more effective to regulate for crop area and good management practice, than use on-farm Overseer budgets in regulation.

We recognise the limit setting concept within the NPSFM is dependent on the estimation of the non-point source loads associated with the full variety of land uses.

Our recommendation is that proxy rotations that represent the long-term average crop rotations are used for limit setting. Proxy rotations can be developed in Overseer or an equivalent model such as APSIM.

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3.2 Methods of allocating water quality limits

A grand-parented allocation approach provides for existing investment. It provides most flexibility to activities with higher leaching.

The natural capital allocation method allocates to land based on its productive capability. To date, the natural capital allocation regimes, have assumed that low intensity animal production is the default land use for New Zealand. An alternative plant-centric approach to natural capital would also be possible. This would generate a different initial allocation pattern, with more nitrogen allocated to land suitable for cropping and less to hill country suitable for native or plantation forestry.

Identifying nationally important uses in the NPSFM presents an opportunity to allocate to these uses with the approach that best provides for that use.

Our proposed approach is a hybrid, with a grand-parented allocation for existing commercial vegetable growing and pastoral natural capital allocation for the remaining land.

Discharge or land use consent

Most plans regulate limits under the Resource Management Act using a land use control (Section 9), either instead of or in addition to, a discharge control (Section 15).

Land use and subdivision consents are attached to the land. When land is sold, the consent transfers to the new owner.

The problem with the allocation of a nitrogen limit to land for commercial vegetables is that it does not provide for crop rotation. Crops may rotate onto land that was not used for cropping before. The land may not have been allocated enough nitrogen (via grand-parenting or natural capital) to provide for cropping on the land. If cropping on the land exceeds a nitrogen intensity threshold, a consent may be required. This consent could be required even though the grower is still undertaking the same activity, for example the same crop area, the same crop rotation, in the same catchment.

If a consent is required to rotate onto new land, the activity managed by the consent would be that being undertaken by the leaseholder. But the landowner would own the consent, and would keep the consent at the end of the lease. This might present an opportunity for the landowner to intensify the land into an activity which is not vegetables. The vegetable grower may be faced with re-consenting their existing operation at the end of each lease.

This approach potentially allows for a creep in the catchment limit or a reduction in the area in vegetables over time.

The impact of allocating nitrogen to land and its impact on rotations is recognised in Canterbury. Environment Canterbury are working on a horticulture plan change, to address this issue. In the Waikato Region, in response to Plan Change 1, some landowners are stipulating landowner ownership of the nitrogen allocation associated with the leaseholder's activity, as a condition of the lease.

Water quality catchment limits are load limits, that relate to a combination of non-point and point source discharges. The allocation of these limits are discharges, and our view could be managed as discharge consents under section 15.

Section 137 provides for discharge permits to be transferred to another person. If the nitrogen allocation associated with commercial vegetable growing was allocated as a discharge consent to the grower, the grower could take the nitrogen allocation associated with their activity with them at the end of their lease. However, this approach has the potential to leave the landowner without an allocation to undertake a later activity.

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Our proposal is a hybrid between a land use consent and a discharge consent. We are seeking a fair approach for leaseholders and landowners. We propose that a pastoral natural capital approach is used to allocate to land with a land use consent. The extra nitrogen required to grow commercial vegetables crops, is allocated with a discharge consent, that can be moved within an FMU and transferred to other commercial vegetable growers.

3.3 Accounting framework

The accounting framework for the commercial vegetable allocation could occur at the national level or the Freshwater Management Unit level.

Freshwater Management Unit accounting

If the limit is managed at the FMU level, the process would be as follows:

1. Regional councils develop freshwater values, objectives and establish limits in a manner consistent with the NPSFM.

2. Nitrogen is used as a water quality proxy, but plans provide for methods to manage limits across all contaminants.

3. In each FMU, a nitrogen load limit (calculated using Overseer, APSIM or equivalent) is established. The limit is consistent with achieving instream objectives for those attributes influenced by nitrogen.

4. The existing commercial vegetable growing load (calculated using Overseer, APSIM or equivalent for the existing proxy rotations) is identified.

5. The grand-parented commercial vegetable load limit and area is subtracted from the catchment load limit and catchment area.

6. The remaining catchment limit is allocated to land using land use capability and the 'pastoral' natural capital approach.

7. The land area that is grand-parented for commercial vegetables, is allocated the equivalent 'pastoral' natural capital limit, based on its land use capability.

8. The additional grand-parented load, is available to be allocated to commercial vegetable growers under the NES as a discharge consent limit, if the consent criteria are met.

National accounting

A national nitrogen limit for commercial vegetable growing would be needed to manage the limit at the national level. The commercial vegetable limit would represent the extra nitrogen load that is required to grow vegetables compared with pastoral land use.

The area in New Zealand in commercial vegetable production is approximately 50,000 hectares. If we assumed that on average 30 kg/ha more was required to grow vegetables than pasture (this is predicted to be a conservative estimate), the nominal allocation for commercial vegetables would be 1,500,000 kg. In context, there is approximately 9,000,000 hectares of sheep and beef land and approximately 2,000,000 hectares of dairy land. (Statistics New Zealand, 2017). The commercial vegetable nitrogen limit would be very small compared to the nitrogen limit committed to pastoral farming. This national limit would only be accessible through a consent, regulated by the NES for commercial vegetables.

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The national limit approach does not need each of the regional councils to have completed the limit setting process. When objectives and limits are set for each FMU, the limit required to provide for commercial vegetable growing would be accommodated within the catchment limit in the same way as it would be if the accounting was managed at the FMU.

3.4 Transfer and trading

The NES allocates a discharge consent which is expressed as a cropping area and proxy discharge load. The discharge is non-point and can occur anywhere within the FMU to allow for rotations, provided the NES criteria are met.

The discharge consent could be transferred to another commercial vegetable grower in the FMU.

The NES approach is not dependent on a catchment scale nitrogen trading scheme, or catchment collectives. However, for new commercial vegetable areas or existing commercial vegetable areas in catchments that don't meet water quality objectives, then trading or catchment collectives, would improve the ability of growers to meet the consent criteria.

3.5 Audited Farm Environment Plans - NZGAP

New Zealand Good Agricultural Practice (NZGAP) provides assurance for the safe and sustainable production of fruit and vegetables in New Zealand. NZGAP was established in 1999 and has maintained its position as a credible assurance scheme in New Zealand for addressing regulatory compliance and enabling market access both domestically and internationally.

The NZGAP Environmental Management System (EMS) add-on has been developed to enable growers to meet regional council requirements for Farm Environment Plans (FEP) and provide ongoing compliance with Good Management Practice standards alongside the usual NZGAP assessment. The EMS assurance framework replicates what is already in place for the core NZGAP programme and the standard is based on credible environmental quality assurance systems such as GLOBALG.A.P. and ISO 14001, while also addressing local regulatory environmental requirements., (NZGAP, 2018a), (NZGAP, 2018b), (NZGAP, 2018c), (NZGAP, 2018d).

These implementation guidelines support growers to meet the requirements by listing each of the checklist questions (compliance control points) with accompanying compliance criteria and relevant guidance material. The guidance utilises references from New Zealand legislation, Industry Guidelines and Codes of Practice where growers can find relevant information for the management area.

We are negotiating acceptance of NZGAP as an independently audited Farm Environment Plan System in Environment Canterbury and Waikato Reginal Council. We are expecting NZGAP to be officially agreed to by Environment Canterbury in January 2019. (NZGAP, 2018e).

3.6 Activity status and consent criteria

This section summarises the activity status and proposed assessment criteria for existing and new outdoor commercial vegetable growing operations.

Existing Commercial Vegetable Growing - Controlled Activity

For existing outdoor commercial vegetable growers the consent is a discharge consent associated with a grand-parented maximum crop area. The consent can be moved within the FMU during the lifetime of the consent and/or transferred to another commercial vegetable grower within the FMU.

The consent is subject to the following criteria:

- The area of commercial vegetables is no larger than the maximum crop area in the benchmark period, adjusted for any traded areas.

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- A proxy rotation that represents the grand-parented rotation is nominated.
- The grower is a member of the NZGAP EMS and has an audited FEP that documents the area of crops grown on a 5-yearly rolling average and demonstrates the ongoing implementation of good management practice in a manner consistent with the EMS and industry Codes of Practice including:
    - Code of Practice for Nutrient Management. (Horticulture New Zealand, 2014)
    - Erosion and Sediment Control Guidelines. (Horticulture New Zealand, 2014)
    - Vegetable Washwater Discharge Code of Practice. (Horticulture New Zealand, 2017)
    - Soil and Drainage Management Guide. (Horticulture New Zealand, 2017)
- The operation can be located anywhere within the FMU, but if it is located within a sub-catchment where receiving waters (4th order and above and lakes) meet the catchment objectives, for nitrogen, sediment and phosphorus, the grower is required to meet good management practice and to undertake extra mitigations where the EMS risk assessment process directs.
- If the operation is located within a sub-catchment where receiving waters (4th order and above and lakes) do not meet the catchment objectives, for nitrogen and/ or sediment and/or phosphorus, the grower is required to meet good management practice and to undertake extra mitigations where the EMS risk assessment process directs, and to undertake further reductions across all contaminants.
- The FEP will identify over the life of the consent what actions will be implemented to contribute to achieving catchment objectives across all contaminants, with actions prioritised using a risk based assessment.
- Off-set mitigation can only occur within the sub-catchment, and could include offset between contaminants, to reflect catchment values.

New Commercial Vegetable Growing - Restricted Discretionary Activity

For new outdoor commercial vegetable growing areas the consent is granted as a discharge consent associated with a maximum crop area, and can be moved within the FMU during the lifetime of the consent and/or transferred to another commercial vegetable grower within the FMU subject to the following restricted discretionary activity criteria:

- A maximum crop area and proxy rotation that represents the rotation is nominated.
- The Grower is a member of the NZGAP environmental management system and has an audited farm environment plan that documents the area of crops grown on a 5-yearly rolling average and demonstrates the ongoing implementation of good management practice in a manner consistent with EMS and industry codes of practice including:
    - Code of Practice for Nutrient Management. (Horticulture New Zealand, 2014)
    - Erosion and Sediment Control Guidelines. (Horticulture New Zealand, 2014)
    - Vegetable Washwater Discharge Code of Practice. (Horticulture New Zealand, 2017)
    - Soil and Drainage Management Guide. (Horticulture New Zealand, 2017)
- Assessment of the FEP demonstrates across nitrogen, sediment, *E.coli* , and phosphorus through a combination of good management practice, extra mitigations and offset, the commercial vegetable operation will have an equivalent or lesser impact on water quality objectives compared with the existing land use.
- The FEP will identify over the life of the consent what actions will be implemented to contribute to achieving catchment objectives across all contaminants, with actions prioritised using a risk based assessment.
- Off-set mitigation can only occur within the sub-catchment, and can include offset between contaminants, to reflect catchment values.
- A commitment to progressive revegetation of slopes greater than 20 degrees on the property or site.
- A progressive riparian planting programme over the life of the consent.

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Environmental impact of the proposed approach

Our expectation is that establishing a National Environmental Standard that requires all commercial vegetable growers to meet good management practice, will aid in the implementation of good management practice and result in lesser water quality impacts in those catchments where water quality needs to be maintained.

In those catchments where water quality objectives are not met, the proposed approach requires good management practice and extra mitigation, and provides flexibility for growers to move to other parts of the FMU that have lesser water quality constraints. Our expectation is that this will reduce the impact of commercial vegetable growing in those catchments where water quality improvements are needed.

The restricted discretionary activity provides a consenting pathway for new commercial vegetable growing areas if the applicant can demonstrate the activity will have the same or lesser impact than the existing activity. While on average vegetable cropping does have higher nitrogen leaching than pastoral land uses, there is a lot of cropping that occurs within pastoral farms. In New Zealand there is an estimated 700,000 ha of crops grown to feed animals. (Ministry Primary Industry, 2016). Cropping land is amongst the land most suitable for growing vegetables for human consumption. Sustainable Farming Fund research, Root Zone Reality, has demonstrated with lysimeter data, that in some instances high leaching loads are measured beneath crops grown to feed animals. (Norris, et al., 2018a).

We have also created an animation that demonstrates how catchment offsetting could achieve neutral or positive water quality outcomes with an increase in commercial vegetables. This analysis has been undertaken using the NIWA data used to support Waikato Regional Council's the Plan Change One. (Semadeni-Davies,, 2015). (This analysis is attached in the following spatial storybook: https://jeg.maps.arcgis.com/apps/MapJournal/index.html?appid=51d34a2df58a4aa9b0cfab0de59254c5 Username & password: HealthyRivers & Horticulture1718. (Jacobs, 2018))

Our expectation is that some land can be converted to commercial vegetable growing and have a neutral or positive impact on water quality values.

The NZGAP Environmental Managements System has been designed to reflect water management, however we intend that future updates of the Environmental Management System will include the ability to audit farm environment plans for improvements to biodiversity and reductions in greenhouse gas emissions.

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Appendix A Outdoor Fresh and Processed Commercial Vegetable Data. (Plant and Food)

Vegetable	Growers number 2018	Area planted hectares 2018	Crop volume tonnes 2018	Domestic sales value $ million, fob 2018	Export sales value $ million, fob July 2017 - June 2018	Domestic/Export sales value Percentage* 2018
Asparagus	40	521	1500	7	2	81%
Beans						
fresh	5	300	3000	6	0	100%
processed	25	900	21700	4	39	10%
Beetroot						
fresh	20	120	6000	4	0	100%
processed	8	260	21500	3	25	11%
Brassicas	125	3632	115700	80	2	97%
Broccoli	75	2082	24700	35	0	100%
Cabbage	75	804	58000	25	0	100%
Cauliflower	20	546	33000	20	0	100%
Capsicums	22	85	21000	25	22	53%
Carrots	54	1851	135900	56	0	100%
fresh	20	800	88000	40	8	83%
processed	34	600	65900	16	2	87%
Cucumbers	51	50	1770		20	0%
Garlic	10	210	1200	7	5	58%
Kumara	48	1141	24000	55	0	100%
Lettuce				42	1	99%
outdoor	140	1532		17	0	100%
Onions	92	5227	191639	30	93	24%
Peas						
fresh	20		2000		0	
processed	120	4075	44000	25	74	25%
Potatoes		9450		852	129	87%
Pumpkin	30	1158	38000	13	0	100%
Shallots	4		1200	3	0	88%
Silverbeet/Spinach	10	2028	3500	12	0	100%
Squash	24	6642	88179	3	59	5%
Sweetcorn						
fresh	63		22000	11	0	99%
processed	116		76800	17	42	28%
Tomatoes	129	770	95400	132	0	100%
outdoor; processed	6	408	53000	9	4	66%
Total		45192	1238588	1549	527	75%

*Percentages calculated from unrounded sales values

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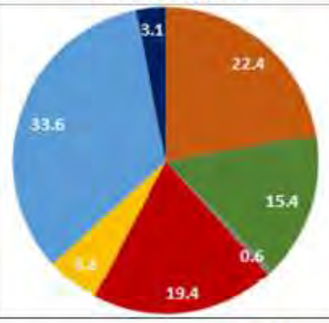
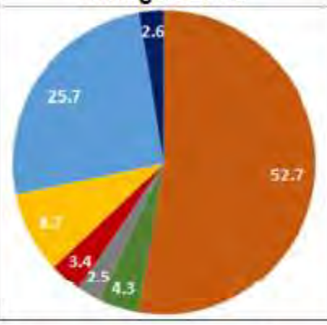
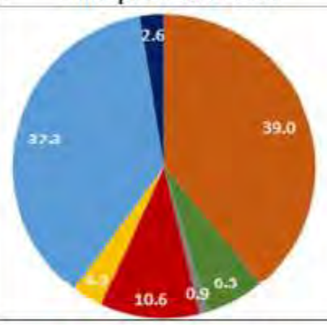
Appendix B: Proportion of land use type and unattenuated cumulative loads of nitrogen, phosphorus and sediment and attenuated *E.coli* loads (excluding point-sources) in selected sub-catchments along the Waikato River (Jacobs, 2017)**,** (Semadeni-Davies,, 2015)

Units: Percentage

Sub-Catchment	Landuse Area	Nitrogen Load	Phosphorous Load	E. Coli Load	Sediment Yield
Waikato at Port Waikato					

Dairy Forestry Horticulture Maize Miscellaneous Native Forest & Scrub Other Animal Sheep and Beef - Hill and High Sheep and Beef - Intensive Urban Dairy support

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ITEM 3.4

Plant & Food RESEARCH
RANGAHAU AHUMĀRA KAI

PFR SPTS No. 14210

The MPI SFF root zone reality project (401484) and the HortNZ northern fluxmeters project (HortNZ RI 1009) – summary of year 1 and year 2 activity

Norris M, Johnstone P, Green S, van der Klei G, van den Dijssel C, Thomas S, Wright P, Clark G

January 2017

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Confidential report for:

Foundation for Arable Research (ref X14-08); Horticulture New Zealand; Environment Canterbury; Horizons Regional Council; Hawke's Bay Regional Council; Environment Waikato; Auckland Regional Council; Ravensdown Cooperative Ltd

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PUBLICATION DATA

Norris M, Johnstone P, Green S, van der Klei G, van den Dijssel C, Thomas S, Wright P, Clark G. January 2017. The MPI SFF root zone reality project (401484) and the HortNZ northern fluxmeters project (HortNZ RI 1009) – summary of year 1 and year 2 activity. A Plant & Food Research report prepared for: Foundation for Arable Research (ref X14-08); Horticulture New Zealand; Environment Canterbury; Horizons Regional Council; Hawke's Bay Regional Council; Environment Waikato; Auckland Regional Council; Ravensdown Cooperative Ltd. Milestone No. 71207. Contract No. 31134. Job code: P/411100/01, P/411107/01. SPTS No. 14210.

Report approved by:

Sarah Bromley
Business Support Manager, Sustainable Production Portfolio
January 2017

Warrick Nelson
Operations Manager, Sustainable Production
January 2017

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THE NEW ZEALAND INSTITUTE FOR PLANT & FOOD RESEARCH LIMITED (2017)

EXECUTIVE SUMMARY

The MPI SFF root zone reality project (401484) and the HortNZ northern fluxmeters project (HortNZ RI 1009) – summary of year 1 and year 2 activity

Norris M[1], Johnstone P[1], Green S[2], van der Klei G[1], van den Dijssel C[2], Thomas S[1], Wright P[1], Clark G[4]
Plant & Food Research: [1]Hawke's Bay, [2]Palmerston North, [3]Lincoln, [4]Pukekohe

January 2017

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In July 2014 two projects were commissioned to establish a network of passive-wick tension fluxmeters in commercial cropping farms in Canterbury, Manawatu, Hawke's Bay and Matamata/Pukekohe. The fluxmeter network is being used to measure nutrient concentrations of nitrogen (N) and phosphorus (P) in drainage water under good management practices.

This report summarises activity for the period between fluxmeter installation (August 2014 to May 2015) and 30 October 2016.

The experimental design across the network includes four monitor regions, three sites per region and 12 fluxmeters per site. The fluxmeters were installed to collect drainage at a depth of 1 m, selected to represent a depth below which nutrient uptake across most crop species is likely to be minimal. Sites provide a range of cropping systems, soil types, climatic conditions and management practices relevant to each region.

A range of soil, plant and leachate measurements are being collected from the sites on an ongoing basis and key results are summarised below. Respective soil fertility ranges considered as 'low', 'moderate' or 'high' are listed as follows: for mineral N, 0–50, 50–150 and > 150 kg N/ha, for anaerobically mineralisable nitrogen (AMN), 0–100, 100–200 and > 200 kg N/ha and for Olsen P, 0–20, 20–50 and > 50 mg P/L.

Site 1 — Canterbury

Site 1 is located on a Mayfield silt loam. Fluxmeters were installed in August 2014 into an established ryegrass seed crop. The crop was harvested for seed in January 2015 and subsequently grazed in July 2015. Spring wheat was sown in August 2015 and harvested in March 2016 and the site sown with barley (the current crop) in April 2016.

Rainfall for the Year 1 monitoring period (1 October 2014 to 30 September 2015) totalled 416 mm, 44% below the long-term average for the area (748 mm). The amount of irrigation applied over this period totalled 268 mm. There were six drainage samplings with a total drainage volume of 101 mm. Most (89%) drainage was collected between July and September 2015. Mineral N and total P losses in drainage were 43 kg N/ha and 0.15 kg P/ha respectively.

Rainfall for the Year 2 monitoring period (1 October 2015 to 30 September 2016) totalled 536 mm, 28% below the long-term average for the area. The amount of irrigation applied over this period totalled 207 mm. There were nine drainage samplings with a total drainage volume of 74 mm. About half (52%) of the drainage was collected between early June and mid-August 2016. Mineral N and total P losses in drainage were 44 kg N/ha and < 0.05 kg P/ha respectively. Residual soil mineral N concentrations (0–100 cm depth) at the most recent sampling occasion

in April 2015 were high (239 kg N/ha) while Olsen P concentrations (0–20 cm depth) were low (12 mg/L).

Site 2 — Canterbury

Site 2 is located near Methven on a mixed cropping and livestock grazing enterprise. Soil type is a Barrhill silt loam. Since installation of the fluxmeters in September 2014 there have been three crops including barley planted in October 2014, white clover planted in March 2015 and a second barley crop planted in September 2016. The second barley crop was sown to provide early cover for a carrot crop which is due to be planted in mid-October.

Rainfall for the Year 1 monitoring period (1 October 2014 to 30 September 2015) totalled 565 mm, 24% below the long-term average for the area (748 mm). The amount of irrigation applied over this period totalled 145 mm. There were three drainage samplings with a total drainage volume of 13 mm. All drainage was collected between July and September 2015. Mineral N and total P losses in drainage totalled 3 kg N/ha and 0.09 kg P/ha respectively.

Rainfall for the Year 2 monitoring period (1 October 2015 to 30 September 2016) totalled 484 mm, 35% below the long-term average for the area. The amount of irrigation applied over this period totalled 60 mm. There was only one sampling event (November 2015) with a total drainage volume of only 1 mm. Due to low drainage volumes, mineral N and total P losses were very low (< 0.5 kg N/ha and < 0.05 kg P/ha). Residual mineral N concentrations (0–100 cm depth) at the most recent sampling occasion in August 2016 were high (244 kg N/ha) while Olsen P concentrations (0–20 cm depth) were low (16 mg/L).

Site 3 — Canterbury

Site 3 is located near Southbridge on a mixed cropping and livestock grazing farm. Soil type is a Templeton silt loam. Fluxmeters were installed in September 2014 into an established ryegrass seed crop. The ryegrass seed crop was harvested in January 2015 and the site rotationally grazed until early November 2015 before being sown with process beans in December 2015. The beans were harvested in March 2016 and the site subsequently sown with forage oats (the current crop).

Rainfall for the Year 1 monitoring period (1 October 2014 to 30 September 2015) totalled 547 mm, 11% below the long-term average for the region (616 mm). The amount of irrigation applied over this period totalled 450 mm. There were two drainage samplings with a total drainage volume of 8 mm. All drainage was collected between August and September 2015. Due to low drainage volumes, mineral N and tot P losses were low (1 kg N/ha and < 0.05 kg P/ha).

Rainfall for the Year 2 monitoring period (1 October 2015 to 30 September 2016) totalled 442 mm, 28% below the long-term average for the area. The amount of irrigation applied over this period totalled 270 mm. There were four drainage samplings with a total drainage volume of 39 mm. Over half (63%) of the drainage was collected in February 2016. Mineral N and total P losses in drainage totalled 4 kg N/ha and 0.07 kg P/ha respectively. Residual soil mineral N concentrations (0–100 cm depth) at the most recent sampling occasion in April 2016 were high (321 kg N/ha) while Olsen P concentrations (0–20 cm depth) were moderate (25 mg/L).

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Site 4 — Manawatu

Site 4 is located near Levin on an intensive vegetable cropping enterprise. Soil type is a Shannon silt loam. Since installation of the fluxmeters in October 2014 there have been five crop sequences including lettuce planted in October 2014, two spinach cycles planted in February and May 2015, lettuce planted in January 2016 and cabbage planted in March 2016. Zucchini is due to be planted in mid-October.

Rainfall for the Year 1 monitoring period (1 October 2014 to 30 September 2015) totalled 1046 mm, 5% higher than the long-term average for the area (995 mm). The amount of irrigation applied over this period totalled 22 mm. There were eight drainage samplings with a total drainage volume of 339 mm. Most (81%) of the drainage was collected between April and September 2015. Mineral N and total P losses in drainage totalled 212 kg N/ha and 0.56 kg P/ha respectively.

Rainfall for the Year 2 monitoring period (1 October 2015 to 30 September 2016) totalled 1018 mm, 1% higher than the long-term average for the area. The amount of irrigation applied over this period totalled 40 mm. There were eight drainage samplings with a total drainage volume of 339 mm, the same total volume as was collected over the Year 1 period. Most (72%) of the drainage was collected over the winter to early spring period (June to September). Mineral N and total P losses in drainage totalled 118 kg N/ha and 0.27 kg P/ha respectively. Residual soil mineral N (0–100 cm depth) and Olsen P concentrations (0–20 cm) at the most recent sampling occasion in March 2016 were high (154 kg N/ha and 122 mg/L respectively).

Site 5 — Manawatu

Site 5 is located near Bulls on a mixed cropping and livestock grazing enterprise. Soil type is a Pukepuke sandy loam. Since installation of the fluxmeters in September 2014 there have been three crops including maize sown in October 2014, an oats cover crop sown in August 2015 and a fodder beet crop sown in November 2015. The site is currently fallow and due to be planted with forage oats in mid-October 2016.

Rainfall for the Year 1 monitoring period (1 October 2014 to 30 September 2015) totalled 1189 mm, 27% higher than the long-term average for the area (934 mm). The amount of irrigation applied over this period totalled 368 mm. There were seven drainage samplings with a total drainage volume of 611 mm. Most (78%) of the drainage was collected between April and September 2015. Mineral N and total P losses in drainage totalled 226 kg N/ha and 0.49 kg P/ha respectively.

Rainfall for the Year 2 monitoring period (1 October 2015 to 30 September 2016) totalled 933 mm, comparable to the long-term average for the area. The amount of irrigation applied over this period totalled 410 mm. There were ten drainage samplings with a total drainage volume of 411 mm. Drainage was collected at regular intervals during the monitoring period. Mineral N and total P losses in drainage totalled 75 kg N/ha and 0.20 kg P/ha respectively. Residual soil mineral N (0–100 cm depth) concentrations at the most recent sampling occasion in September 2016 were low (44 kg N/ha) while Olsen P concentrations (0–20 cm depth) were moderate (32 mg/L).

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Site 6 — Manawatu

Site 6 is located near Ohakune on a mixed cropping enterprise. Soil type is an Ohakune brown loam. Fluxmeters were installed in April 2015 and the site sown with winter wheat in May 2015. Following harvest of the wheat crop in February 2016, the site remained fallow until June 2016 when a second wheat crop was planted (the current crop).

Rainfall for the Year 1 monitoring period (1 October 2014 to 30 September 2015) totalled 1401 mm, 8% higher than the long-term average for the area (1300 mm). No irrigation was applied over this period. There were three drainage samplings with a total drainage volume of 196 mm. All drainage was collected between June and September 2015. Mineral N and total P losses in drainage have totalled 37 kg N/ha and 0.21 kg P/ha respectively.

Rainfall for the Year 2 monitoring period (1 October 2015 to 30 September 2016) totalled 1222 mm, 6% less than the long-term average for the area. No irrigation was applied over this period. There were six drainage samplings with a total drainage volume of 228 mm. Most (90%) of the drainage was captured between mid-June and mid-September 2016. Mineral N and total P losses in drainage totalled 16 kg N/ha and 0.06 kg P/ha respectively. Residual soil mineral N concentrations (0–100 cm depth) at the most recent sampling occasion in June 2016 were high (167 kg N/ha) while Olsen P concentrations (0–20 cm depth) were moderate (26 mg/L).

Site 7 — Hawke's Bay

Site 7 is located near Otane on a mixed cropping and livestock grazing enterprise. Soil type is a Waimakariri silt loam. Since installation of the fluxmeters in September 2014 there have been four crop sequences including a carrot crop sown in September 2014, an Italian ryegrass crop sown in February 2015, a pea crop sown in October 2015 and an Italian ryegrass crop sown in January 2016. The most recent Italian rye grass crop was sprayed off in mid-September 2016 in preparation for sowing of a pea crop in October.

Rainfall for the Year 1 monitoring period (1 October 2014 to 30 September 2015) totalled 661 mm, 14% below the long-term average for the area (765 mm). The amount of irrigation applied over this period totalled 88 mm. There were three drainage samplings with a total drainage volume of 20 mm. Most (90%) of the drainage was collected between November and December 2014. Mineral N and total P losses in drainage totalled 2 kg N/ha and 0.07 kg P/ha respectively.

Rainfall for the Year 2 monitoring period (1 October 2015 to 30 September 2016) totalled 573 mm, 25% below the long-term average for the area. The amount of irrigation applied over this period totalled 140 mm. There were five drainage samplings with a total drainage volume of 21 mm. Most (93%) of the drainage was captured between mid-June and mid-September 2016. All drainage was collected between October and November 2015. Mineral N and total P losses in drainage totalled 2 kg N/ha and 0.06 kg P/ha respectively. Residual soil mineral N concentrations (0–100 cm depth) at the most recent sampling occasion in September 2016 were low (41 kg N/ha) while Olsen P concentrations (0–20 cm depth) were moderate (29 mg/L).

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Site 8 — Hawke's Bay

Site 8 is located near Hastings on a mixed cropping and livestock grazing enterprise. Soil type is a Waimakariri silt loam. Since installation of the fluxmeters in October 2014 there have been four crop sequences including a sweetcorn crop sown in December 2014, an Italian ryegrass crop sown in March 2015, a tomato crop sown in October 2015 and an Italian ryegrass crop sown in March 2016. The most recent Italian rye grass crop was sprayed off in mid-September 2016 in preparation for sowing of a sweetcorn crop in October.

Rainfall for the Year 1 monitoring period (1 October 2014 to 30 September 2015) totalled 651 mm, 8% below the long-term average for the area (711 mm). The amount of irrigation applied over this period totalled 76 mm. There was only one drainage sampling in this period (September 2015) with a total drainage volume of 0.3 mm. Due to low drainage volumes, mineral N and total P losses in drainage were very low (< 0.5 kg N/ha and < 0.05 kg P/ha respectively).

Rainfall for the Year 2 monitoring period (1 October 2015 to 30 September 2016) totalled 596 mm, 16% below the long-term average for the area. The amount of irrigation applied over this period totalled 150 mm. There was no drainage recorded over this period and consequently no drainage losses of mineral N or total P. Residual soil mineral N concentrations (0–100 cm depth) at the most recent sampling occasion in October 2016 were low (34 kg N/ha) while Olsen P concentrations (0–20 cm depth) were moderate (40 mg/L).

Site 9 — Hawke's Bay

Site 9 is located near Takapau on a mixed cropping and livestock grazing enterprise. Soil type is a Takapau silt loam. Fluxmeters were installed in September 2014 and the site subsequently sown with peas and then beans. The site remained fallow until August 2015 before being planted with barley which was harvested in January 2016. Italian ryegrass (the current crop) was sown in March 2016 for winter grazing.

Rainfall for the Year 1 monitoring period (1 October 2014 to 30 September 2015) totalled 1035 mm, 7% below the long-term average for the area (1112 mm). The amount of irrigation applied over this period totalled 103 mm. There were eight drainage samplings with a total drainage volume of 62 mm. Most (90%) of the drainage was collected between June and September 2015. Mineral N and total P losses in drainage totalled 7 kg N/ha and < 0.05 kg P/ha respectively.

Rainfall for the Year 2 monitoring period (1 October 2015 to 30 September 2016) totalled 989 mm, 11% below the long-term average for the area. The amount of irrigation applied over this period totalled 150 mm. There were six drainage samplings with a total drainage volume of 66 mm. Over half (65%) of the drainage was collected between mid-August and mid-September 2016. Mineral N and total P losses in drainage totalled 17 kg N/ha and 0.06 kg P/ha respectively. Residual soil mineral N (0–60 cm depth) and Olsen P concentrations (0–20 cm depth) at the most recent sampling occasion in January 2016 were low (58 kg N/ha and 17 mg/L respectively).

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Site 10 — Matamata/Pukekohe

Site 10 is located near Matamata on a mixed cropping and livestock grazing enterprise. Soil type is a Waihou silt loam. Fluxmeters were installed in May 2015 and the site subsequently sown with Italian ryegrass which was sprayed off in September 2015. Potatoes were sown in October 2015 and harvested in March 2016. Onions (the current crop) were planted early July 2016.

Rainfall for the Year 1 monitoring period (1 October 2014 to 30 September 2015) totalled 1043 mm, 8% below the long-term average for the area (1131 mm). The amount of irrigation applied over this period totalled 80 mm. There were four drainage samplings with a total drainage volume of 150 mm. All drainage was collected between July and September 2015. Mineral N and total P losses in drainage totalled 30 kg N/ha and 0.06 kg P/ha respectively.

Rainfall for the Year 2 monitoring period (1 October 2015 to 30 September 2016) totalled 1050 mm, 7% below the long-term average for the area. The amount of irrigation applied over this period totalled 120 mm. There were six drainage samplings with a total drainage volume of 112 mm. Most (75%) of the drainage was collected between mid-July and mid-September 2016. Mineral N and total P losses in drainage totalled 12 kg N/ha and < 0.05 kg P/ha respectively. Soil mineral N concentrations (0–100 cm depth) at the most recent sampling occasion in July 2016 were high (346 kg N/ha) while Olsen P concentrations (0–20 cm depth) were moderate (41 mg/L).

Site 11 — Matamata/Pukekohe

Site 11 is located near Pukekohe on an intensive vegetable cropping enterprise. Soil type is a Patumahoe clay loam. Fluxmeters were installed in March 2015 and the site subsequently sown with potatoes in June 2015. The site remained fallow following harvest of the potato crop in November 2015 before being planted with onions (the current crop) in June 2016.

Rainfall for the Year 1 monitoring period (1 October 2014 to 30 September 2015) totalled 1166 mm, 1% less than the long-term average for the area (1183 mm) while rainfall for the Year 2 monitoring period (1 October 2015 to 30 September 2016) totalled 1273 mm, 8% higher than the long-term average for the area. There was no irrigation applied in either year.

Due to periodic flooding of the fluxmeter units in both years an alternative approach is being considered to estimate losses using a combination of measured N and P concentrations and modelled drainage volumes (as is the common approach for measuring losses using devices like suction cups). To ensure a high level of confidence in the predictions, additional soil physical measurements are being collected from the site. These will be used in the soil water balance model to predict drainage volumes. An onsite rain gauge will also be installed to accurately quantify inputs from rainfall and irrigation.

Residual soil mineral N concentrations (0–100 cm depth) at the most recent sampling occasion in July 2016 were moderate (145 kg N/ha) while Olsen P concentrations (0–20 cm depth) were high (148 mg/L).

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Site 12 — Matamata/Pukekohe

Site 12 is located near Tuakau on a mixed cropping and livestock grazing enterprise. Soil type is a Patumahoe clay loam. Fluxmeters were installed in April 2015 and the site remained fallow until potatoes were sown in November 2015. The potato crop was harvested in April 2016 and the site has been fallow since.

Rainfall for the Year 1 (1 October 2014 to 30 September 2015) and Year 2 (1 October 2015 to 30 September 2016) monitoring periods totalled 1166 mm and 1273 mm respectively, comparable or slightly higher than the long-term average for the area (1183 mm). During the first year of monitoring, drainage volumes captured in the fluxmeters were considerably higher than those predicted by the soil water balance. The experimental site was subsequently re-established in June 2016 in an area of the field less prone to flooding of the fluxmeter units. Since reinstallation there has been one drainage sample collected in December 2016. While drainage volumes were similar to those predicted by the soil water balance, further sample collection over the coming months is required to confirm the success of the reinstall.

Soil mineral N (0–100 cm depth) and Olsen P concentrations (0–20 cm depth) at the most recent sampling occasion in August 2016 were high (153 kg N/ha and 118 mg/L).

Summary

Across the 12 sites cumulative mineral N losses for the Year 1 monitoring period (1 October 2014 to 30 September 2015) ranged from 0 to 226 kg N/ha. Mineral N losses for the Year 2 monitoring period (1 October 2015 to 30 September 2016) ranged from 0 to 118 kg N/ha (Figure i). High net losses were associated with high drainage volumes and mineral N concentrations (predominantly nitrate-N) in drainage water. In most cases drainage losses occurred during the late autumn, winter and/or early spring months when rainfall and soil moisture levels were highest. At a number of sites soil mineral N concentrations were high even though drainage losses were low. This represents a high risk of loss.

Cumulative P losses in the respective Year 1 and Year 2 monitoring periods ranged from 0 to 0.56 kg P/ha and from 0 to 0.27 kg P/ha (Figure i). These represented fairly small net losses, of which the majority (50–95%) was in the dissolved reactive form (DRP) in the drainage water. At some sites soil Olsen P concentrations were very high, well above recommended sufficiency concentrations for crops.

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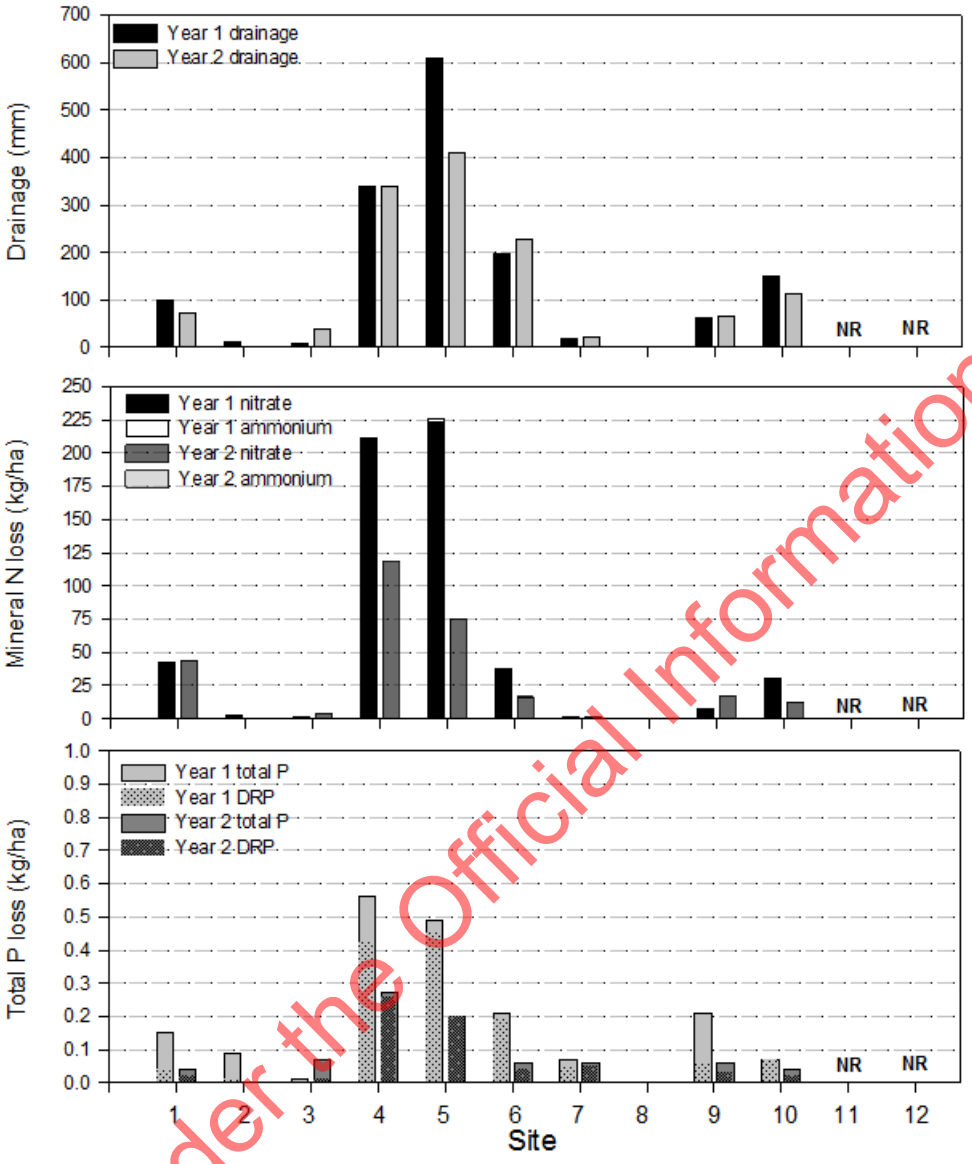

Figure i. Summary of drainage volumes and mineral N and total P losses in drainage across the 12 fluxmeter sites for the Year 1 (1 October 2014 to 30 September 2015) and Year 2 (1 October 2015 to 30 September 2016) monitoring periods. No results (NR) were obtained at Sites 11 and 12 due to flooding of the fluxmeter units.

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For further information please contact:

Paul Johnstone
Plant & Food Research Hawke's Bay
Private Bag 1401
Havelock North 4157
NEW ZEALAND
Tel: +64 6 975 8880
DDI: +64-6-975 8899
Fax: +64 6 975 8881
Email: paul.johnstone@plantandfood.co.nz

1 INTRODUCTION

Regional authorities around New Zealand are developing plans to improve freshwater quality while enabling sustainable intensification of agriculture. A common theme is the requirement that farmers should, as a minimum, be applying agricultural good management practice (GMP; Lambie, 2015). However, there is relatively little information available regarding the measured inter-annual nitrogen (N) and phosphorus (P) losses from the root zone of commercial cropping paddocks under GMP.

In July 2014 two new projects funded by the Ministry for Primary Industries (Sustainable Farming Fund), the Foundation for Arable Research, Horticulture NZ, Environment Canterbury, Horizons Regional Council, Hawke's Bay Regional Council, Waikato Regional Council, Auckland Regional Council and Ravensdown commenced to create a network of tension fluxmeters in commercial cropping farms in Canterbury, Manawatu, Hawke's Bay, Matamata and Pukekohe, and use these to measure losses of N and P in leachate water.

Results from this work will provide farmers and regional authorities with measurements of leaching losses from cropping farms across sites and seasons, and will be the basis for ongoing extension efforts to ensure GMPs are widely accepted and adopted by farmers. Data will also be available for future efforts to improve predictive models that can either be used to manage crops or inform policy development.

This report summarises activity from the network between 1 October 2014 and 30 September 2016. Not all sites have been operating for this entire period.

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2 METHODS

2.1 Overview

In this project we have created a network of tension fluxmeters installed on contrasting commercial cropping farms in Canterbury, Manawatu, Hawke's Bay, Matamata and Pukekohe. Results from this work will provide farmers and regional authorities with robust measurements of nutrient leaching losses from cropping farms across sites and seasons under good management practices.

2.2 Tension fluxmeters

Leachate losses can be measured in a number of ways and each method has associated strengths and potential weaknesses. In this project nutrient concentrations in drainage water are being quantified using passive-wick tension fluxmeters. Tension fluxmeters have been used across a wide variety of land uses (e.g. pipfruit, kiwifruit, grapes, potatoes, leafy greens) in New Zealand for the past decade.

The design of fluxmeters is simple. The unit itself is made of cylindrical PVC piping which has a convergence zone where drainage water is intercepted as it moves down the soil profile. The units are 120 cm long and the convergence zone 20 cm wide (Figure 1). In the convergence zone fine sand is packed on top of diatomaceous earth to filter drainage water before it enters the storage tank (to reduce sediment transfer). A passive wick ensures that water only enters the storage tank when soil moisture is at or above field capacity, preventing preferential flow in to the tank. The maximum storage volume in each tank is 14 L. Attached to each fluxmeter are two small gauge plastic tubes to remove drainage water under suction during sampling events. Once installed, the units are designed to remain in the soil for an extended period.

The strengths of the fluxmeter units are that they provide a measure of losses under commercial practice, and that they are installed below the root zone so can be left in place for an extended period and capture a complete record of drainage events. The potential weaknesses that need to be managed include spatial variability (related to the narrow convergence zone), installation processes which disturb the soil profile and specific technical limitations (e.g. high water tables flood the units, installation is difficult in stony soils, artificial drainage above the units can result in erroneous results). Many of these issues are common across different methods for measuring leaching losses.

A summary of the design and functionality of fluxmeter units is provided by Gee et al. (2009) and Meissner et al. (2010).

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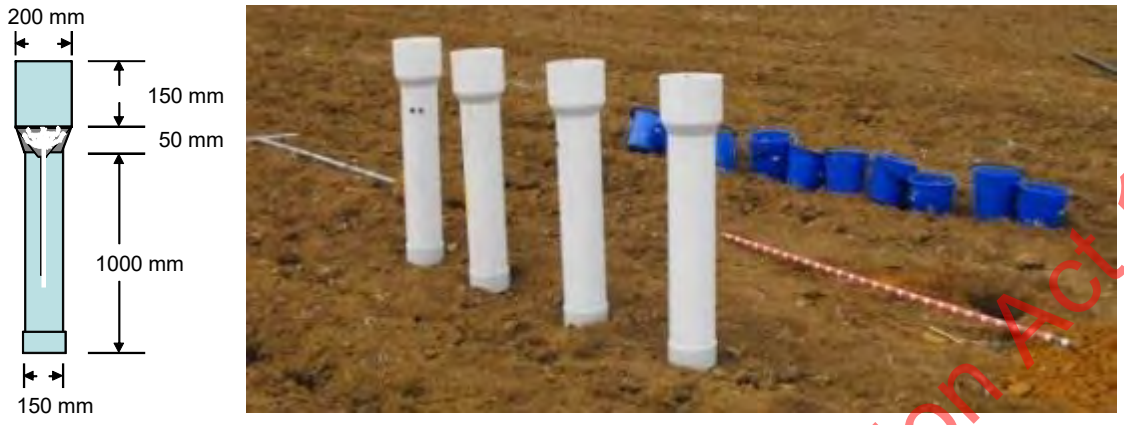

Figure 1. Basic passive wick tension fluxmeter design installed at all sites. The units are installed below the soil surface, and intercept drainage water and hold it in a storage tank until sampling. Diatomaceous earth and fine sand are packed into the convergence zone to filter drainage water. The maximum storage volume is about 14 L.

2.3 Experimental design

The basic experimental design across the fluxmeter network includes four monitor regions, three sites per region and 12 fluxmeters per site. The top of the fluxmeters were installed to a depth of 1 m, selected to represent a depth below which nutrient uptake across most crop species is minimal.

The four monitor regions are Canterbury, Manawatu, Hawke's Bay and Matamata/Pukekohe[1], representing a number of significant cropping areas in New Zealand. All sites are located on commercial properties that were identified by the project partners as providing a range of cropping systems, soil types, climatic conditions and management practices relevant to each region.

In all cases site inspections were conducted before installation to review the project aims and approach with collaborating growers, identify suitable rotations and candidate sites on their farms, and assess any technical limitations at these sites (e.g. high water table, stony soils, artificial drainage). Collaborating growers were already applying a range of GMP's at the start of the project.

The layout of fluxmeters at a given site was in clusters of four units (Figure 2). Tubing from the individual fluxmeters within a cluster was trenched back to a central measurement hub. Within a cluster the approximate distance between fluxmeters was about 4 m; between clusters the approximate distance was 25 to 40 m.

The same experimental approach was used at all sites.

[1]The Canterbury, Manawatu and Hawke's Bay sites are part of the SFF Root Zone Reality Project (SFF 401484) and the Matamata/Pukekohe sites are part of an extension project (HortNZ RI 1009). Because the same approach has been adopted at all sites and the strength of the network is in the range of conditions it covers all sites have been reported together.

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Figure 2. Example layout of fluxmeter units within a field. Clusters of four units were installed within a 4 m radius and tubing was trenched back to a central sampling hub (H). The distance between clusters depended on site features and ranged from 25 to 40 m.

2.4 Installation process

Installation of fluxmeters at each site typically occurred during the changeover of crops to minimise disruption to the farmer. Soil moisture conditions were carefully considered before installation to minimise potential repacking effects associated with excessively wet or dry soil.

The fluxmeter clusters were installed in representative and comparatively uniform areas of the site to minimise potential variability in results (the intent was to record an average site value under GMP, not extremes). This was assessed by topography, test holes and, where available, site-specific soil maps (e.g. S-map, EM profiles). Grower knowledge of their site was also used to cross-check the locations.

Fluxmeters were installed according to an established procedure. This included augering holes (diameter 200 mm) to a depth of 2.2 m. As the soil was removed it was placed in to ordered buckets in approximately 10 cm sampling intervals for subsequent repacking (Figure 3a). The top of the fluxmeter unit was designed to sit at 1 m below the surface, so soil from below 1 m was discarded.

Fluxmeters were carefully lowered into the holes and the profiles repacked with the stratified soil layers (Figure 3b). Repacking included compacting the soil firmly to mimic conditions prior to disturbance. Based on previous experience, 'settling effects' can last anywhere from 3 to 12 months, depending on the soil type and soil moisture conditions during repacking. Checks for resettling are conducted by comparing estimates of predicted drainage (using a validated soil water balance model) against actual drainage measurements. At most sites cultivation occurred soon after the fluxmeters were installed, meaning that disturbance of the soil profile (at least in the topsoil) was inevitable.

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Tubing from individual fluxmeters was trenched back to a central hub (four fluxmeters per hub) at approximately 60 cm depth (below the depth of the deepest cultivation implement). The collection hubs were designed to minimise potential compaction effects over the fluxmeter units themselves (Figure 3c).

Figure 3. Example of the installation process showing (a) preparation of the holes for installation and soil being hand-augered into buckets according to depth, (b) lowering of the fluxmeters into holes, and (c) tubing coming from the individual fluxmeters back to central hub sampling points.

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2.5 Measurements

A range of soil, plant and leachate measurements are being collected from the network sites.

2.5.1 Soil sampling

Soil samples are being collected at the start of each new crop sequence to quantify indicators of soil fertility. On each sampling occasion four samples are composited for each fluxmeter cluster across a range of sampling depths (0–20, 20–40, 40–60, 60–80 and 80–100 cm).

Samples from the 0–20 cm depth are being analysed for basic soil fertility indicators (pH, Olsen phosphorus [Olsen P], exchangeable cations and cation exchange capacity [CEC]) and soil nitrogen (N) characteristics (ammonium N, nitrate N, anaerobically mineralisable N (AMN), total N and total carbon [C]), whereas the deeper samples are only being analysed for N characteristics and total C.

For the purposes of this summary only mineral N (0–100 cm), AMN (0–100 cm) and Olsen P (0–20 cm) concentrations are reported and as site averages. Range values considered as 'low', 'moderate' or 'high' are listed in Table 1.

Table 1. Range values for mineral N, AMN and Olsen P considered as 'low', 'moderate' or 'high'.

Analyte	Low range	Moderate range	High range
Mineral N (kg N/ha, 0–100 cm)	0–50	50–150	> 150
AMN (kg N/ha, 0–100 cm)	0–100	100–200	> 200
Olsen P (mg/L, 0–20 cm)	0–20	20–50	> 50

2.5.2 Crop sampling

Crop samples are collected on two or three occasions during each crop sequence to quantify biomass productivity and N uptake. The number of sampling occasions reflects the duration of crop growth (typically two harvests for crops in the ground for < 5 months, and three harvests for crops in the ground for > 5 months).

On each occasion four samples are collected from each fluxmeter cluster. The size of the sample is specific to each crop (see Appendix 1 for a list of harvest protocols). In most cases, the final harvest is timed to coincide with the commercial harvest of each crop. Final harvest samples are also separated into two components: the plant material that is removed from the site during harvesting, and the plant material that is returned to the soil as residue. This information is important for considering nutrient cycling dynamics. In most cases, only the above-ground biomass is sampled; the exception is where below-ground biomass forms part of the marketable biomass (e.g. potato tubers, carrot roots).

In all cases, total fresh biomass is recorded and samples oven-dried to determine dry matter percentage (DM%); this is subsequently used to estimate total dry biomass of either the whole plant or marketable plant.

Samples are subsequently ground and analysed for total N concentration (one composite sample per fluxmeter cluster) and N uptake calculated.

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2.5.3 Leachate sampling

Leachate samples are routinely collected from the fluxmeter units. The timing of sampling varies by site and season, reflecting irrigation practices, rainfall and key soil physical properties that influence drainage. A simple water balance model is used to assist in drainage predictions.

On each sampling occasion leachate is collected from individual fluxmeter units. The maximum number of samples on any sampling occasion is 12 (i.e. one per fluxmeter, assuming all units have captured drainage). Sampling involves using a suction pump to remove drainage water from the buried fluxmeters. The volume of drainage is then recorded and three 40 mL plastic tubes retained from each fluxmeter for further analyses (one for inorganic N and dissolved reactive phosphorus (DRP), one for Total P and one spare). Samples for inorganic N and DRP analysis are pre-filtered in the field using Axiva™ syringe filters (0.45 micron). The remaining samples are not filtered. Following collection the samples are frozen until further analysis.

2.6 Analyses

All analyses are performed by an IANZ-accredited laboratory following standard analytical procedures. In brief, soil indicators are measured according to the following procedures; pH, by electrode following extraction in distilled water (1:2.5 ratio); Olsen P by colourimetry following 0.5 M bicarbonate extraction, exchangeable cations by atomic emission spectroscopy (MP-AES) following 1.0 M ammonium acetate extraction (1:20 v/v ratio), nitrate-N by Cd reduction and NED colourimetry and ammonium-N by Berthelot colourimetry, both following extraction in 1.7 M KCl, AMN determined colourimetrically following a 7-day anaerobic assay, and total N and total C by Dumas combustion. CEC is calculated as the sum of exchangeable cations and the extractable acidity and mineral N as the sum of nitrate and ammonium N. Plant tissue N is measured by Dumas combustion. Leachate samples are measured according to the following procedures: nitrate-N by Cd reduction and NED colourimetry, ammonium N by Berthelot colourimetry, Total P by molybdate reduction following persulphate oxidation and DRP by molybdate reduction following 0.45 µm filtration.

2.7 Supplementary data

Weather data for each site (daily and long-term) is collated from the National Institute of Water and Atmospheric Research's (NIWA) climate database using observations from the nearest climate station. For some sites, a combination of stations is used to provide the required data. Observations included daily air temperature (minimum, mean and maximum), solar radiation, rainfall, vapour pressure, wind run and mean sea level (MSL) pressure (Appendix 2).

2.8 Data management

Statistical corrections have been applied to site estimates of drainage volume and nutrient concentrations to balance for the spatial arrangement of the fluxmeters in clusters and associated issues with non-overlapping data. Checks have also been performed on measured drainage volumes using a water balance model that accounts for daily rainfall, irrigation, crop water use and soil hydraulic properties. Where measured drainage volumes are greatly different from those estimated by the water balance, the leachate volumes and associated laboratory analyses have been omitted from this report. The number of samples comprising site averages for a given sampling occasion is noted in the individual sections below.

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3 RESULTS

Results have been collated by each individual site and reflect the period 1 October 2014 to 30 September 2015 (Year 1) and the period 1 October 2015 to 30 September 2016 (Year 2). Fluxmeter installation dates varied across sites, reflecting the range of rotations and specific soil conditions at each site. All Canterbury sites were installed by September 2014, Manawatu sites by April 2015, Hawke's Bay sites by October 2014 and Matamata/Pukekohe sites by May 2015.

The key content summarised for each site can be broadly grouped according to the following categories: background site and crop management practices, weather summaries, soil fertility indicators, soil water balances and N and P leachate losses.

Data that were collected but not included in this report included detailed soil fertility and crop biomass measurements. These data are being collected for future model validations.

3.1 Site 1 — Canterbury

3.1.1 Background site and crop management history

Site 1 is located near Methven on a mixed cropping and livestock grazing enterprise. Soil type is a Mayfield silt loam. Fluxmeters were installed at the site in August 2014 into an established ryegrass seed crop sown in March 2013. Key site characteristics are described in Table 2.

Table 2. Summary of key farm and site characteristics, Site 1 — Canterbury.

Location	Methven
Farming system	Mixed cropping, winter livestock grazing
Topography	Flat
Soil type	Mayfield silt loam
Key soil characteristics[1]	Soil order: Typic argillic pallic Texture: Silt loam Topsoil bulk density: 1.22 g/cm^3 Subsoil bulk density: 1.53 g/cm^3 Drainage class: Moderate N leaching vulnerability: Medium
Previous land use history	Converted from dryland cropping in 2004 to irrigated cropping and livestock grazing.
Fluxmeter installation date	26 August 2014
Irrigation infrastructure	Centre pivot

[1] A full description of the Mayfield silt loam is available online at https://smap.landcareresearch.co.nz/home. Listed characteristics are taken from S-MAP factsheets and are not based on measured site values.

Since installation of the fluxmeters there have been four crops including ryegrass seed, ryegrass pasture, spring wheat and barley (Table 3). The established ryegrass crop (harvested for seed in January 2015 and subsequently grazed in July 2015) was sprayed off in August 2015 in preparation for spring wheat. Following conventional cultivation, spring wheat was sown on 21 August 2015. The wheat crop was harvested in March 2016 and the site sown with barley (the current crop) in April 2016. Respective N and P inputs have totalled 266 kg N/ha and 0 kg P/ha (ryegrass seed), 216 kg N/ha and 0 kg P/ha (ryegrass pasture), 306 kg N/ha and 15 kg P/ha (spring wheat) and 256 kg N/ha and 21 kg P/ha (barley) (Table 3).

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Table 3. Summary of crop management practices since fluxmeter installation (26 August 2014), Site 1 — Canterbury.

Crop management practices	Sequence 1 — Ryegrass seed	Sequence 2 — Ryegrass pasture	Sequence 3 — Spring wheat	Sequence 4 — Barley
Variety	'Barrier'	'Barrier'	'Discovery'	'Pudura'
Planting population	12 kg seed/ha	Same crop	112 kg/ha	92 kg/ha
Planting date	March 2013	March 2013	21 August 2015	16 April 2016
Harvest date[1]	26 January 2015	12 August 2015[2]	10 March 2016	Current crop
Cultivation practices	Minimum tillage	None	Ploughed	Grubber followed by maxi-till
Fertiliser practices (product)[3]	150 kg/ha Ammo36 (S) 405 kg/ha Urea (S)[4] 125 kg/ha Ammonium Sulphate (S)	50 kg/ha KCl (S) 470 kg/ha Urea (S)[5]	65 kg/ha Urea (B) 273 kg/ha 30% Potash Sulphur Super (S) 601 kg/ha Urea (S)[6]	300 kg/ha Sulphur Super (B) 60 kg/ha Potassium Chloride (S) 129 kg/ha Ammo 31 (S) 470 kg/ha Urea (S)[7]
Summed N and P (elemental)	N = 266 kg/ha P = 0 kg/ha	N = 216 kg/ha P = 0 kg/ha	N = 306 kg/ha P = 15 kg/ha	N = 256 kg/ha P = 21 kg/ha
Stock type	Lambs	Dairy cows (in calf)	-	-
Stock density	25 lambs/ha	17 cows/ha	-	-
Additional stock information	Grazed from early September to early October 2014	Grazed in July 2015	-	-

[1]Commercial harvest date. [2]Reflects the date the ryegrass was sprayed off.[3]B = base application, P = planting application, S= side dressing application(s); note – details on base and planting applications were not available for sequence 1. [4]Split over three applications between October and November 2014. [5]Split over four applications between January and May 2015. [6]Split over six applications between August and December 2015. [7]Split over three applications between September and November 2016.

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3.1.2 General weather conditions

Year 1 (1 October 2014 to 30 September 2015)

Rainfall for the Year 1 period totalled 416 mm (Figure 4a), 44% below the long-term average for the region (748 mm). The mid-summer to autumn period (January to May 2015) was very dry with only 79 mm rainfall recorded, 75% less than the long-term average for this period (322 mm).

Mean air temperature for the 12 month period was 10.3°C, cooler than the long-term average (11.2°C) (Figure 4b) while solar radiation totalled 4930 MJ/m^2, comparable to the long-term average of 4764 MJ/m^2 (Figure 4c).

Year 2 (1 October 2015 to 30 September 2016)

Rainfall for the Year 2 period totalled 536 mm, 28% less than the long-term average for the region (Figure 4a). The winter to early spring period (June to September) was particularly dry with 138 mm rainfall recorded, 41% less than the long-term average for this period (234 mm).

Mean air temperature over the 12 month period averaged 11.1°C while solar radiation totalled 475 MJ/m^2, both comparable to the long-term averages for the area (Figures 4b and c).

3.1.3 Soil nitrogen and phosphorus fertility levels

Soil samples for N and P fertility analyses were taken during installation of the fluxmeters in September 2014, 2 weeks after sowing of the spring wheat crop in September 2015 and 5 days after sowing of the barley crop in April 2016.

Mineral N (0–100 cm)

Samples taken in September 2014 had moderate concentrations of mineral N (98 kg N/ha), while concentrations for samples taken in September 2015 and April 2016 were high (287 and 239 kg N/ha respectively) (Figure 5a). For all sampling occasions the predominant form of mineral N was nitrate-N (51–90%), although ammonium-N concentrations were elevated in the September 2014 samples. For samples taken in September 2015, high mineral N concentrations were consistent with urine deposition during the 2015 winter grazing period in conjunction with previous N fertiliser applications (Table 3).

AMN (0–100 cm)

AMN concentrations were high for the September 2014 and September 2015 samples (257 – 266 kg N/ha) and reflected high levels of potentially mineralisable N (Figure 5a). High AMN concentrations were consistent for samples taken under long-term pasture or shortly after conversion to cropping. In contrast, AMN concentrations were considerably lower for the April 2016 samples (89 kg N/ha) and likely reflected the mineralisation of organic N forms during the previous crops.

Olsen P (0–20 cm)

Olsen P concentrations (0–20 cm depth) were low for all sampling occasions (12 to 14 mg/L respectively) and below normal concentrations suggested for ryegrass seed, spring wheat and barley production (20–30 mg/L) (Figure 5b).

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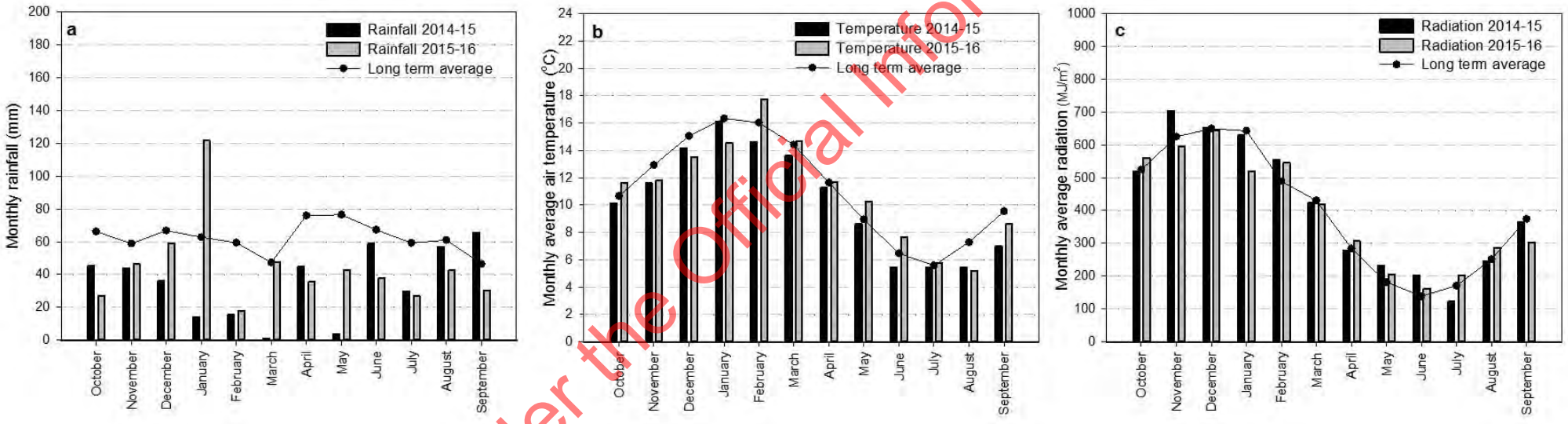

Figure 4. Monthly (a) rainfall (mm), (b) average air temperature (°C) and average solar radiation (MJ/m^2) for 1 October 2014 to 30 September 2016 at Methven (NIWA Station 37920). Long-term climate data (2001–14) are presented for the Winchmore station (NIWA Station 4764).

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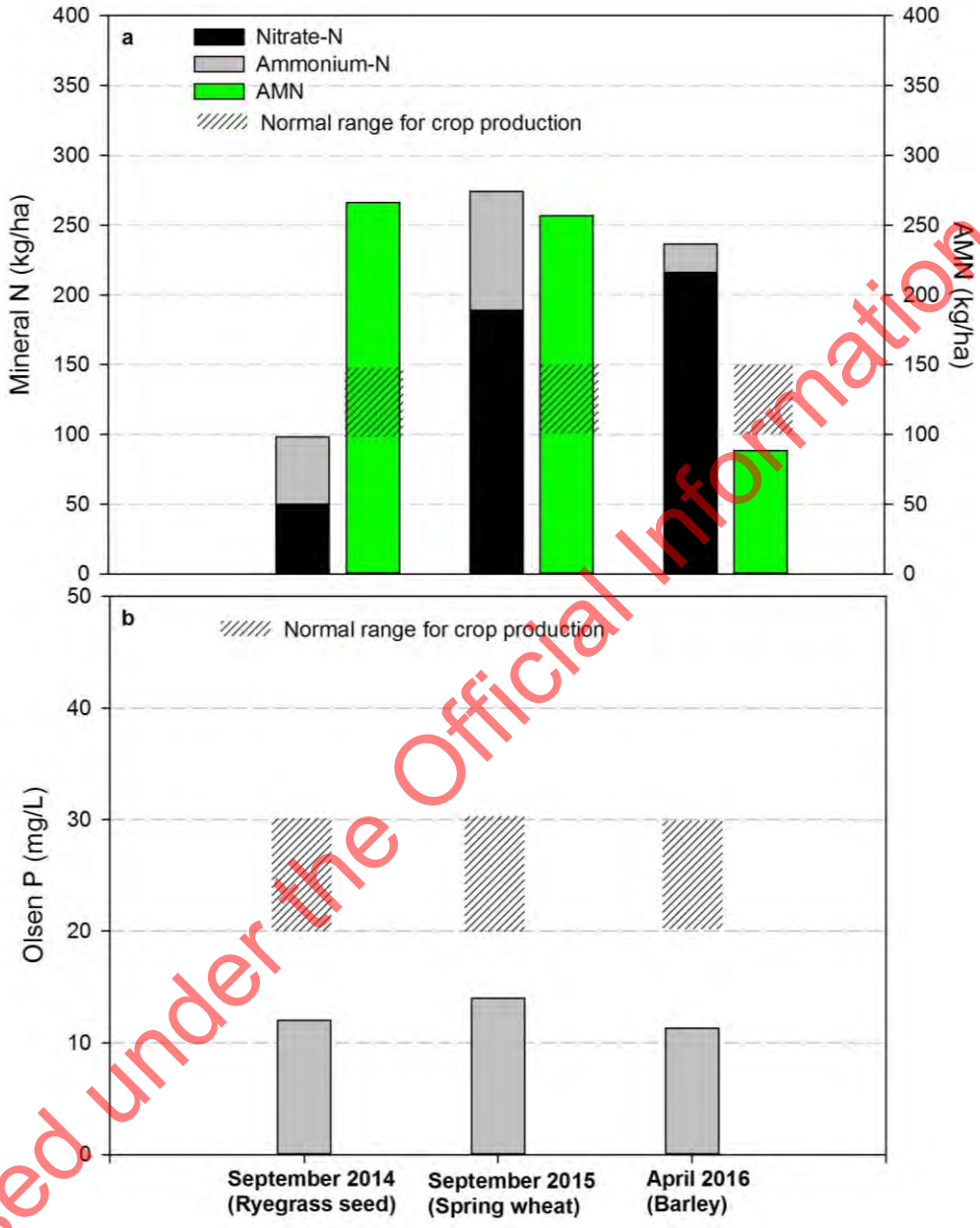

Figure 5. Soil mineral N and AMN (0–100 cm depth) (a) and Olsen P (0–20 cm depth) (b) at Site 1 — Canterbury for samples taken in September 2014, September 2015 and April 2016. Normal ranges suggested for crop production are provided by Hill Laboratories (http://www.hill-laboratories.com/page/pageid/2145845703/Crop_Guides)

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3.1.4 Soil water balance

Year 1 (1 October 2014 to 30 September 2015)

The soil water balance for Site 1 is shown in Figure 6. Rainfall and irrigation for the Year 1 period totalled 416 mm and 268 mm respectively. There was only one rainfall event over 50 mm which occurred in mid-June 2015 (56 mm over 2 days). The range in individual irrigation application volumes was 4–35 mm.

For all depths, there was a decreasing trend in modelled soil water contents between October 2014 and June 2015, consistent with a very dry mid-summer to autumn period. Modelled soil water contents then increased over the mid-winter to sprig period in response to more frequent rainfall events. Most drainage was collected over this period (July to September 2015).

Year 2 (1 October 2015 to 30 September 2016)

Rainfall and irrigation for the Year 2 period totalled 536 mm and 207 mm respectively. The largest rainfall event was in late January (44 mm recorded over 2 days) while the range in individual irrigation application volumes was 5–20 mm (Figure 6).

In contrast to the Year 1 monitoring period, there was an increasing trend in modelled soil water contents over the monitoring period, likely reflecting a degree soil moisture recharge following the previous dry year. For the 0–30 cm depth, modelled soil water contents increased to high levels (>80 mm) over the summer period (December to February), reflecting frequent irrigation events. In general, levels remained above 60 mm for the duration of the monitoring period. Modelled soil water contents for the 30–60 and 60–90 cm depths decreased slightly over the mid-spring to summer period (October to February) before increasing to comparably high levels (> 60 mm) for the duration of the late autumn to early spring period (May to September). Drainage was collected on a consistent basis between mid-November 2015 and late August 2016.

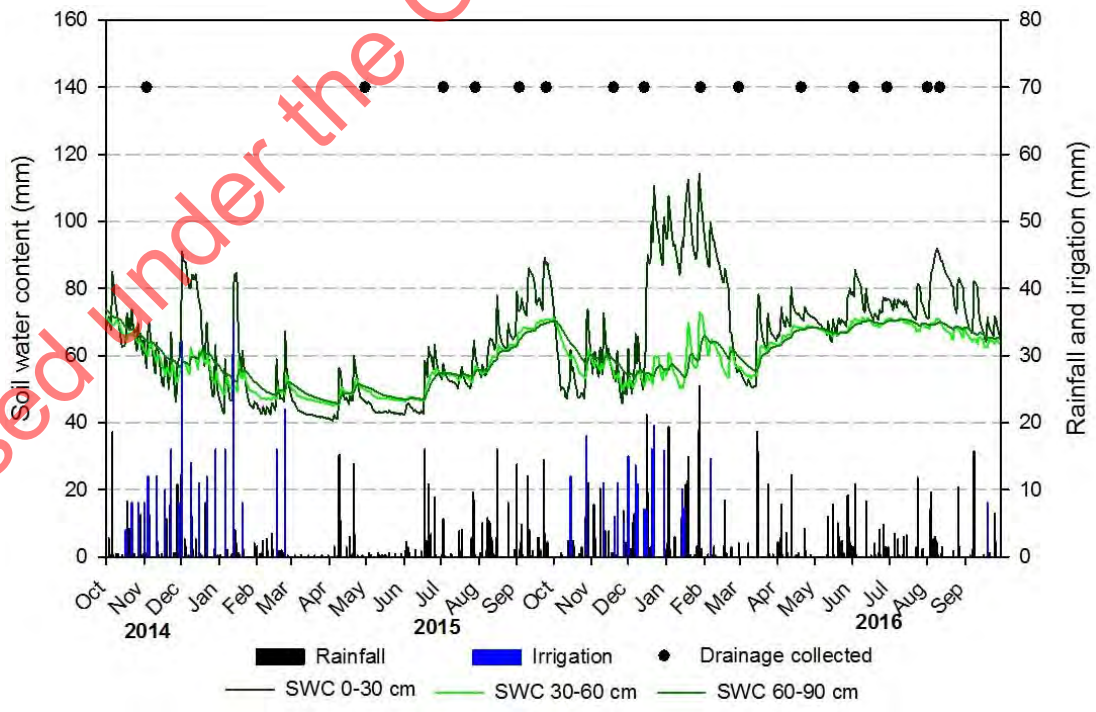

Figure 6. Summary of daily rainfall, irrigation and modelled soil water content (0–30 cm, 30–60 cm and 60–90 cm) for the period 1 October 2014 to 30 September 2016, Site 1 — Canterbury. Fluxmeter units were installed on 26 August 2014.

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3.1.5 Losses of N and P in drainage water

Year 1 (1 October 2014 to 30 September 2015)

Drainage samples were collected on six occasions in the first year following installation of the fluxmeters (Figure 7b). Total drainage volume was 101 mm.

Nitrate-N and ammonium-N concentrations in drainage for this period averaged 26.2 mg/L and 3.1 mg/L respectively (Figure 7b). Nitrate-N concentrations tended to increase over this period and peaked at 36.6 mg/L in late July 2015, while ammonium-N concentrations remained low for the duration of this period. Measured mineral N losses from the system totalled 43 kg N/ha (Figure 7c) with the majority of N lost as nitrate-N (42 kg N/ha). Losses were elevated for the period July to September (39 kg N/ha), consistent with increased drainage volumes and elevated nitrate-N concentrations.

Total P and DRP concentrations averaged 0.39 mg/L and 0.25 mg/L respectively (Figure 8b). Overall, net P losses were low, totalling 0.15 kg P/ha with DRP loss accounting for 0.04 kg P/ha. The observed decline in the concentration difference between total P and DRP over the monitoring period suggests a net decrease in the transfer of dissolved organic P and/or sediment bounds P forms (> 0.45 µm). This most likely reflects a soil 'settling effect' following installation of the fluxmeter units.

Year 2 to date (1 October 2015 to 30 September 2016)

Drainage samples were collected on nine occasions in the second year following installation of the fluxmeters (Figure 7b). Total drainage volume was 74 mm.

Nitrate-N and ammonium-N concentrations in drainage for this period averaged 43.4 mg/L and 0.4 mg/L respectively (Figure 7b). Nitrate-N concentrations trended upwards over this period peaking at 63.0 mg/L in mid-August 2016. Measured mineral N losses from the system totalled 44 kg N/ha (Figure 7c) with N lost almost entirely as nitrate-N. Losses were comparable to those observed in Year 1 (42 kg N/ha).

Total P and DRP concentrations averaged 0.07 mg/L and 0.06 mg/L respectively (Figure 8b). Measured P losses from the system over this period were minimal (< 0.05 kg P/ha; Figure 8c).

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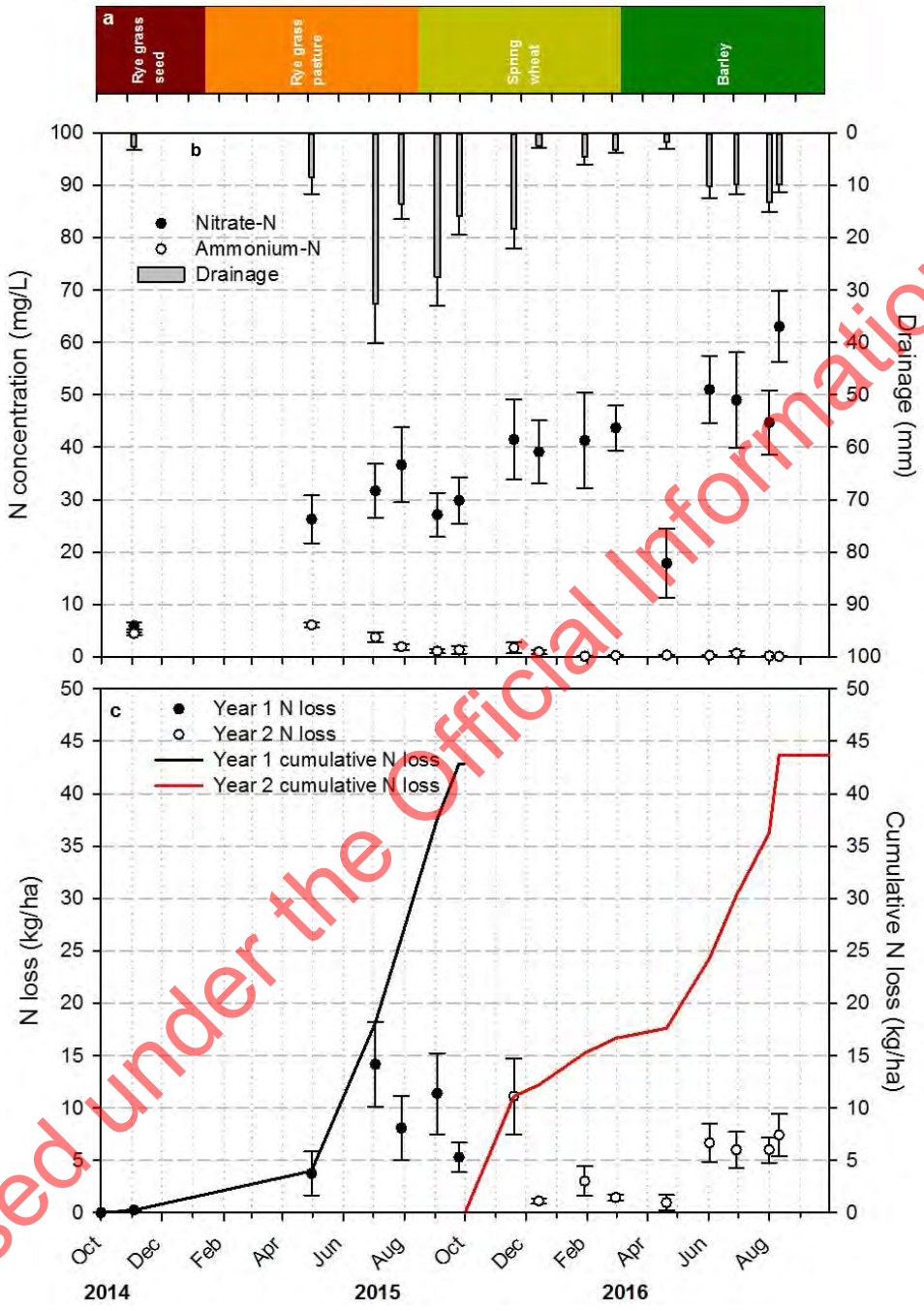

Figure 7. Summary of crop sequence (a), measured drainage and inorganic N concentrations (nitrate-N and ammonium-N) in drainage (b) and measured system losses of inorganic N in drainage for Year 1 (1 October 2014 to 30 September 2015) and for Year 2 (1 October 2015 to 30 September 2016) (c) Site 1 — Canterbury. Mean drainage is calculated from the volume of leachate collected at each sampling event, corrected for the surface area of the fluxmeters. Bars around each point represent the standard error of the mean. Lower limit of detections: nitrate-N: 0.02 mg/L; ammonium-N: 0.01 mg/L. Fluxmeters were installed on 26 August 2014.

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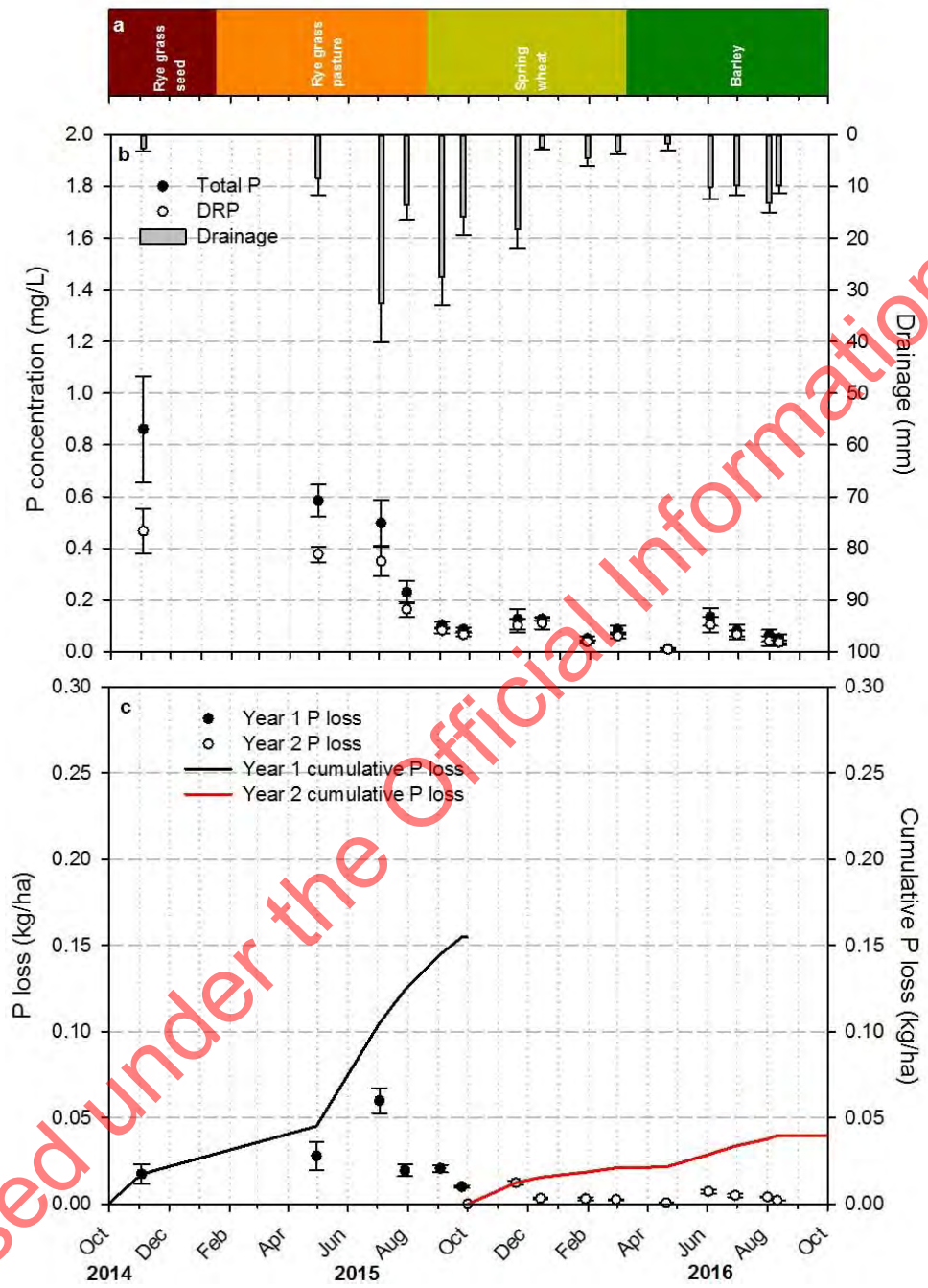

Figure 8. Summary of crop sequence (a), measured drainage and P concentrations (total P and DRP) in drainage (b) and measured system losses of total P in drainage for Year 1 (1 October 2014 to 30 September 2015) and for Year 2 (1 October 2015 to 30 September 2016) (c) Site 1 — Canterbury. Mean drainage is calculated from the volume of leachate collected at each sampling event, corrected for the surface area of the fluxmeters. Bars around each point represent the standard error of the mean. Lower limit of detections: Total P: 0.02 mg/L; DRP: 0.001 mg/L. Fluxmeters were installed on 26 August 2014.

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3.2 Site 2 – Canterbury

3.2.1 Background site and crop management history

Site 2 is located near Methven on a mixed cropping and livestock grazing enterprise. Soil type is a Barrhill silt loam. Fluxmeters were installed at the site in September 2014 following a ryegrass crop. Key site characteristics are described in Table 4.

Table 4. Summary of key farm and site characteristics, Site 2 — Canterbury.

Location	Methven
Farming system	Mixed cropping, livestock grazing
Topography	Flat
Soil type	Barrhill silt loam
Key soil characteristics[1]	Soil order: Typic immature pallic Texture: Silt loam Topsoil bulk density: 1.22 g/cm^3 Subsoil bulk density: 1.42 g/cm^3 Drainage class: Well drained N leaching vulnerability: Medium
Previous land use history	Mixed cropping and livestock grazing for more than 10 years.
Fluxmeter installation date	22 September 2014
Irrigation infrastructure	Gun

[1]A full description of the Barhill silt loam is available online at https://smap.landcareresearch.co.nz/home. Listed characteristics are taken from S-MAP factsheets and are not based on measured site values.

Since installation of the fluxmeters there have been three crops including two crops of barley and one crop of white clover (Table 5). The first barley crop was sown in October 2014 and harvested in February 2015. The site was subsequently sown with white clover in March 2015 and harvested for seed in February 2016. The clover crop was retained over the autumn and winter period for grazing by lambs before being terminated in mid-August 2016. Carrots (the current crop) were planted in late September 2016. Respective N and P inputs have totalled 154 kg N/ha and 18 kg P/ha (barley) and 22 kg N/ha and 32 kg P/ha (carrots). No fertiliser was applied to the clover crop (Table 5).

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Table 5. Summary of crop management practices since fluxmeter installation (22 September 2014), Site 2 — Canterbury.

Crop management practices	Sequence 1 — Barley	Sequence 2— White clover (seed)	Sequence 3 — White clover (grazing)	Sequence 4— Carrots
Variety	'Summit'	Information not available	Information not available	'Carson'
Planting population	120 kg/ha	3 kg/ha	3 kg/ha	40 kg/ha
Planting date	16 October 2014	20 March 2015	20 March 2015	30 September 2016
Harvest date[1]	1 March 2015	10 February 2016	15 August 2016[2]	Current crop
Cultivation practices	Ploughed, grubbed twice and drilled	Heavy rolled, direct drilled	-	Shallow grubbed x2, ploughed, grubbed, and rolled followed by power harrow.
Fertiliser practices (product)[3]	150 kg/ha Urea (B) 8 kg/ha 50:50 mix of CropMaster15/Carrot Brew (B) 150 kg/ha Urea (S)[4]	No fertiliser applied	4000 kg/ha lime (S) 1000 kg/ha dolomite (S)	125 kg/ha DAP (B) 225 kg/ha potassium sulphate (B) 100 kg/ha serpentine super (B) 20 kg/ha borate 46 (B) 12 kg/ha zinc sulphate (B) 8 kg/ha copper sulphate (B)
Summed N and P (elemental)	N = 154 kg/ha P = 18 kg/ha	N = 0 kg/ha P = 0 kg/ha	N = 0 kg/ha P = 0 kg/ha	N = 22 kg/ha P = 32 kg/ha
Stock type	No stock	Lambs	Lambs	-
Stock density	-	46 lambs/ha	Average 22 lambs/ha	-
Additional stock information	-	600 lambs grazed for 3 days in May to remove barley regrowth 600 lambs grazed for 7 days in November	200 lambs in mid-April for 51 days, additional 250 lambs added mid-May for 21 days 250 lambs grazed for 20 days from late July	-

[1]Commercial harvest date. [2]Reflects the date the clover crop was terminated. [3]B = base application, P = planting application, S= side dressing application(s). [4]Applied as a single application in late November 2014.

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3.2.2 General weather conditions

Year 1 (1 October 2014 to 30 September 2015)

Rainfall for the Year 1 period totalled 565 mm, 24% below the long-term average for the region (748 mm) (Figure 9a). The late spring to summer period (October 2014 to February 2015) was particularly dry with only 135 mm recorded, 57% less than the long-term average of 314 mm.

Mean air temperature for the 12 month period was 10.7°C, cooler than the long-term average (11.2°C) (Figure 9b) while solar radiation totalled 5110 MJ/m^2, slightly higher than the long-term average of 4764 MJ/m^2 (Figure 9c).

Year 2 (1 October 2015 to 30 September 2016)

Rainfall and mean air temperature for the Year 2 period totalled 484 mm, 35% below the long-term average for the region (Figure 9a). The winter and early spring period (June to September 2016) was particularly dry with only 125 mm recorded, 47% less than the long-term average for this period (234 mm).

Mean air temperature for the 12 month period was 11.6°C, warmer than the long-term average (Figure 9b) while solar radiation totalled 5039 MJ/m^2, slightly higher than the long-term average (Figure 9c)

3.2.3 Soil nitrogen and phosphorus fertility levels

Soil samples for N and P fertility analyses were taken shortly after installation of the fluxmeters in September 2014, 3 weeks following sowing of white clover in April 2015 and 5 weeks before sowing of the barley crop in August 2016.

Mineral N (0–100 cm)

Mineral concentrations were low for samples taken in September 2014 (61 kg N/ha), moderate for samples taken in April 2015 (134 kg N/ha) and high for samples taken in August 2016 (229 kg N/ha) (Figure 10a). Samples taken in September 2014 and August 2016 had elevated concentrations of ammonium-N (49 to 74% of mineral N), whereas nitrate-N was the predominant form of mineral N (84%) for samples taken in April 2015. The high mineral N concentrations for the August 2016 samples were consistent with the previous crop type (N fixing legume) and management practice (grazed by lambs for the preceding months) (Table 5).

AMN (0–100 cm)

AMN concentrations increased from moderate in the September 2014 and April 2015 samples (156–183 kg N/ha) to high for the August 2016 samples (244 kg N/ha). For all sampling occasions, AMN concentrations were above normal concentrations suggested for barley and white clover production (100–150 kg N/ha).

Olsen P (0–20 cm)

Olsen P concentrations remained consistently low across all sampling occasions (15–16 mg/L) and below normal concentrations suggested for barley and white clover production (20–30 mg/L) (Figure 10b).

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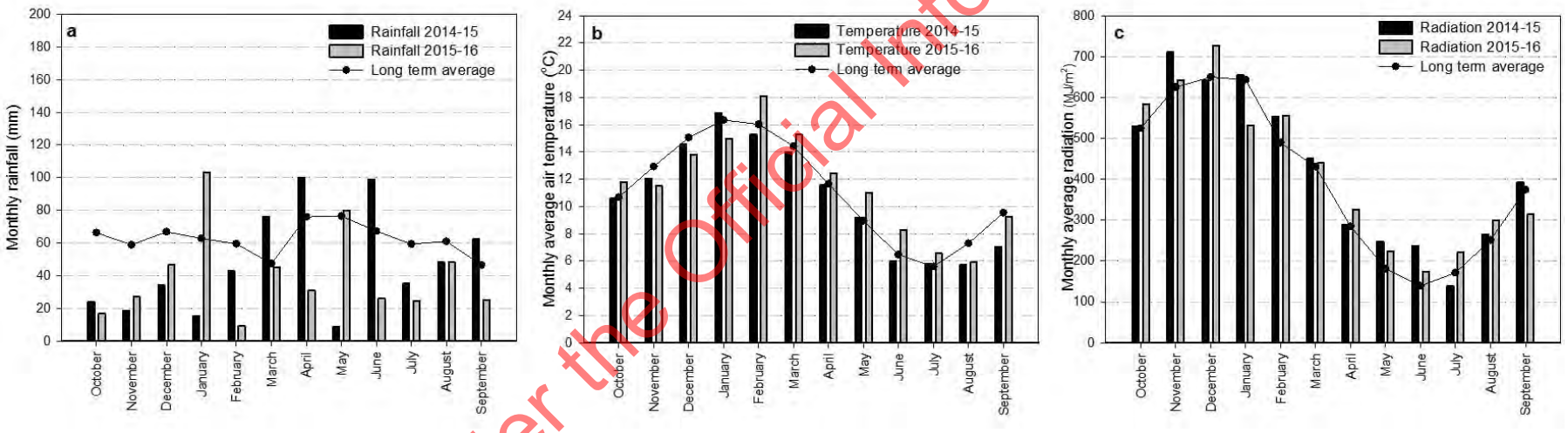

Figure 9. Monthly (a) rainfall (mm), (b) average air temperature (°C) and average solar radiation (MJ/m^2) for 1 October 2014 to 30 September 2016 at Methven (NIWA Station 37920). Long-term climate data (2001–14) are presented for the Winchmore station (NIWA Station 4764).

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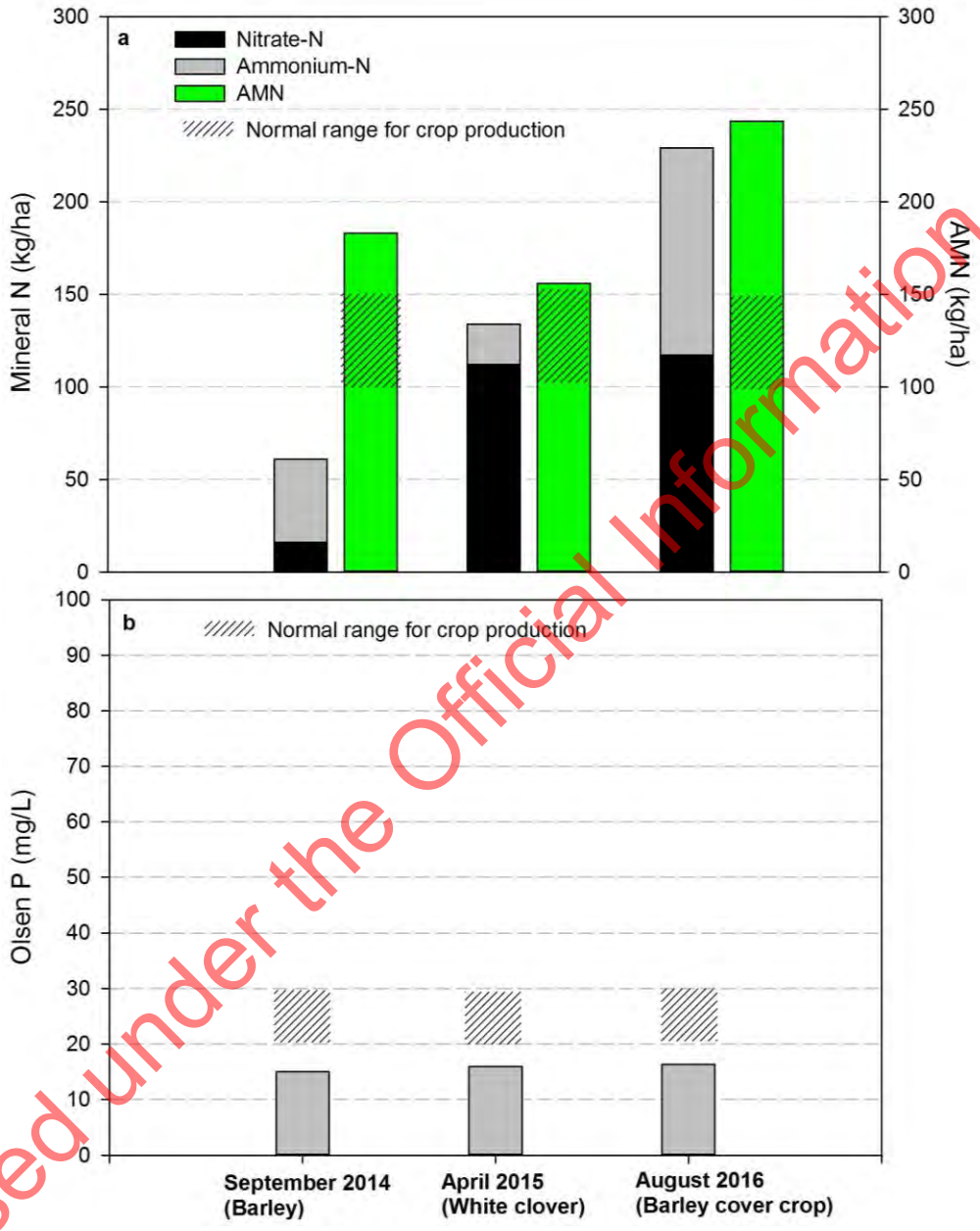

Figure 10. Soil mineral N and AMN (0–100 cm depth) (a) and Olsen P (0–20 cm depth) (b) at Site 2 — Canterbury for samples taken in September 2014, April 2015 and August 2016. Normal ranges suggested for crop production are provided by Hill Laboratories (http://www.hill-laboratories.com/page/pageid/2145845703/Crop_Guides).

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3.2.4 Soil water balance

Year 1 (1 October 2014 to 30 September 2015)

The soil water balance for Site 2 is shown in Figure 11. Rainfall and irrigation for the Year 1 period totalled 647 mm and 145 mm respectively. There was one rainfall event over 50 mm that occurred in late June 2015 (75 mm over 1 day). The range in individual irrigation application volumes was 35–40 mm.

Modelled soil water contents for the 30–60 cm and 60–90 cm depths tended to increase from mid-January 2015 and remained elevated (> 100 mm) from mid-June 2015. Fluxmeter drainage samples were collected from late July 2015.

Year 2 (1 October 2015 to 30 September 2016)

Rainfall and irrigation for the Year 2 period totalled 484 mm and 60 mm respectively. The largest rainfall events occurred in late January and mid-March when 38 mm and 36 mm were recorded in a single day respectively (Figure 11). All irrigation was applied in a single application in mid-February.

Modelled soil water contents decreased at all depths from October onwards and remained at comparably low levels (< 50 mm) for the 30–60 and 60–90 cm depths for the duration of the summer period (December to February). They increased slightly over the winter and early spring period (June to September). The only drainage sample was collected in mid-November 2015.

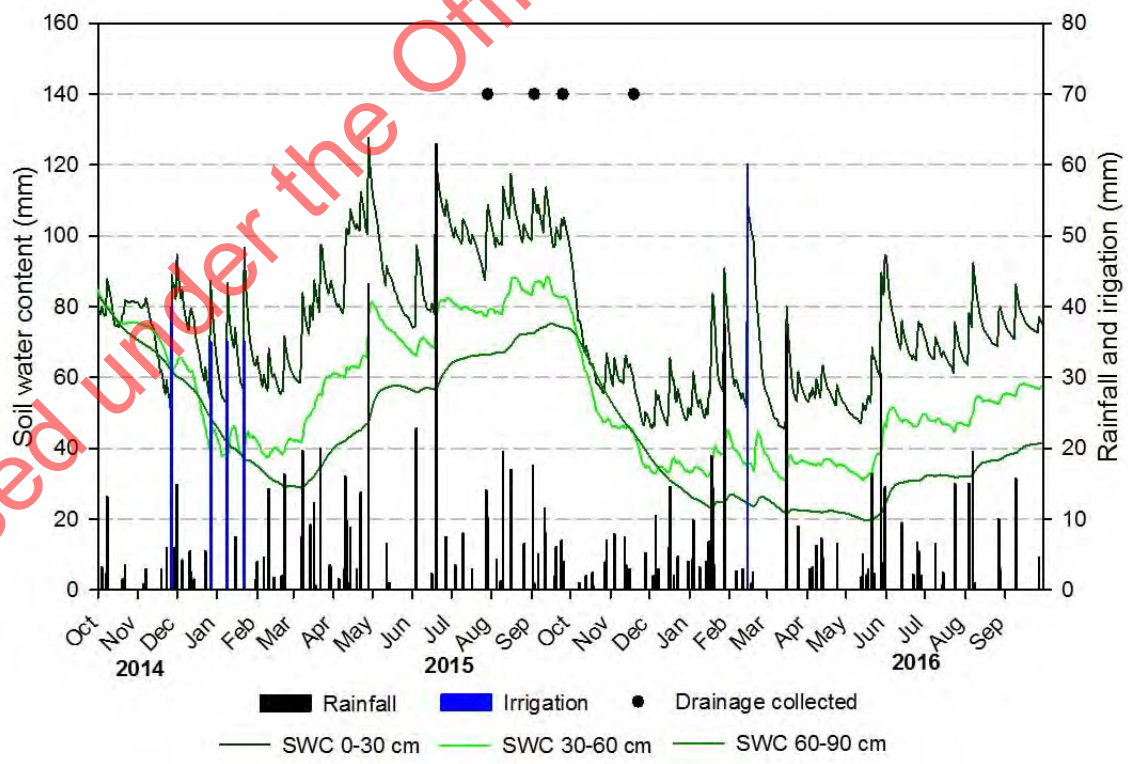

Figure 11. Summary of daily rainfall, irrigation and modelled soil water content (0–30 cm, 30–60 cm and 60–90 cm) from 1 October 2014, Site 2 — Canterbury. Fluxmeter units were installed on 22 September 2014.

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3.2.5 Losses of N and P in drainage water

Year 1 (1 October 2014 to 30 September 2015)

Drainage samples were collected on three occasions in the first year following installation of the fluxmeters (Figure 12b). Total drainage volume was 13 mm.

Nitrate-N and ammonium-N concentrations in drainage for this period averaged 22.3 mg/L and 9.3 mg/L respectively (Figure 12b). Due to low drainage volumes, measured mineral N losses were low totalling 2.6 kg N/ha (Figure 12c) with the majority of mineral N lost as nitrate-N (2.0 kg N/ha).

Total P and DRP concentrations averaged 0.96 mg/L and 0.69 mg/L respectively (Figure 13b). Measured P losses from the system over this period were minimal (< 0.1 kg P/ha; Figure 13c).

Year 2 (1 October 2015 to 30 September 2016)

Drainage samples were collected on one occasion in the second year following installation of the fluxmeters (Figure 12b). Total drainage volume of 1 mm.

Respective nitrate-N and ammonium-N concentrations in this sample were 18.6 and 4.1 mg/L (Figure 12b). Due to low drainage volumes, there was sufficient sample for only DRP analyses. DRP in drainage for this event averaged 0.26 mg/L (Figure 13b). Due to low drainage volumes, measured mineral N and DRP losses were very low (< 0.5 kg N/ha and < 0.1 kg P/ha; Figures 12c and 13c respectively).

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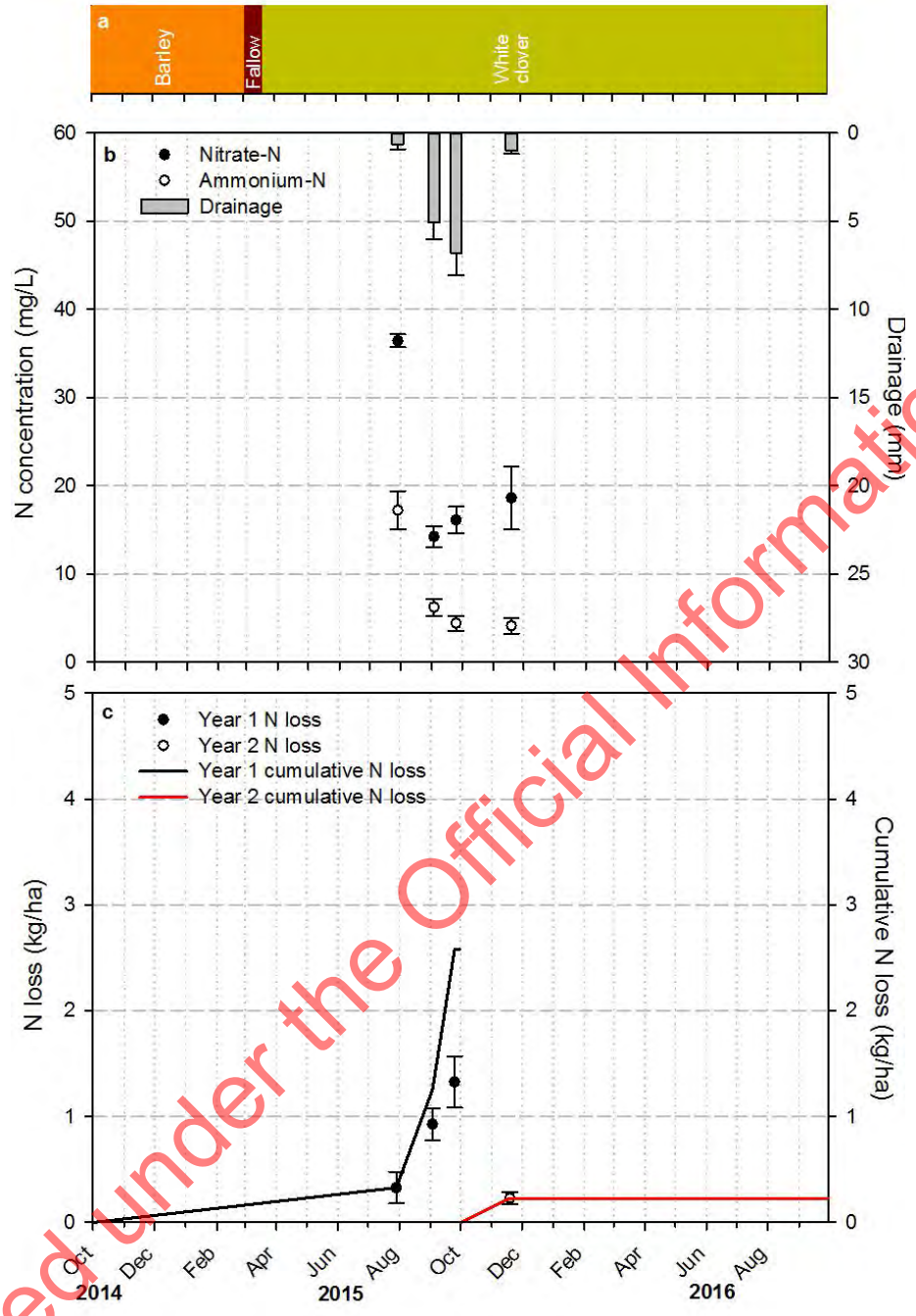

Figure 12. Summary of crop sequence (a), measured drainage and inorganic N concentrations (nitrate-N and ammonium-N) in drainage (b) and measured system losses of inorganic N in drainage for Year 1 (1 October 2014 to 30 September 2015) and for Year 2 (1 October 2015 to 30 September 2016) (c) Site 2 — Canterbury. Mean drainage is calculated from the volume of leachate collected at each sampling event, corrected for the surface area of the fluxmeters. Bars around each point represent the standard error of the mean. Lower limit of detections: nitrate-N: 0.02 mg/L; ammonium-N: 0.01 mg/L. Fluxmeters were installed on 22 September 2014.

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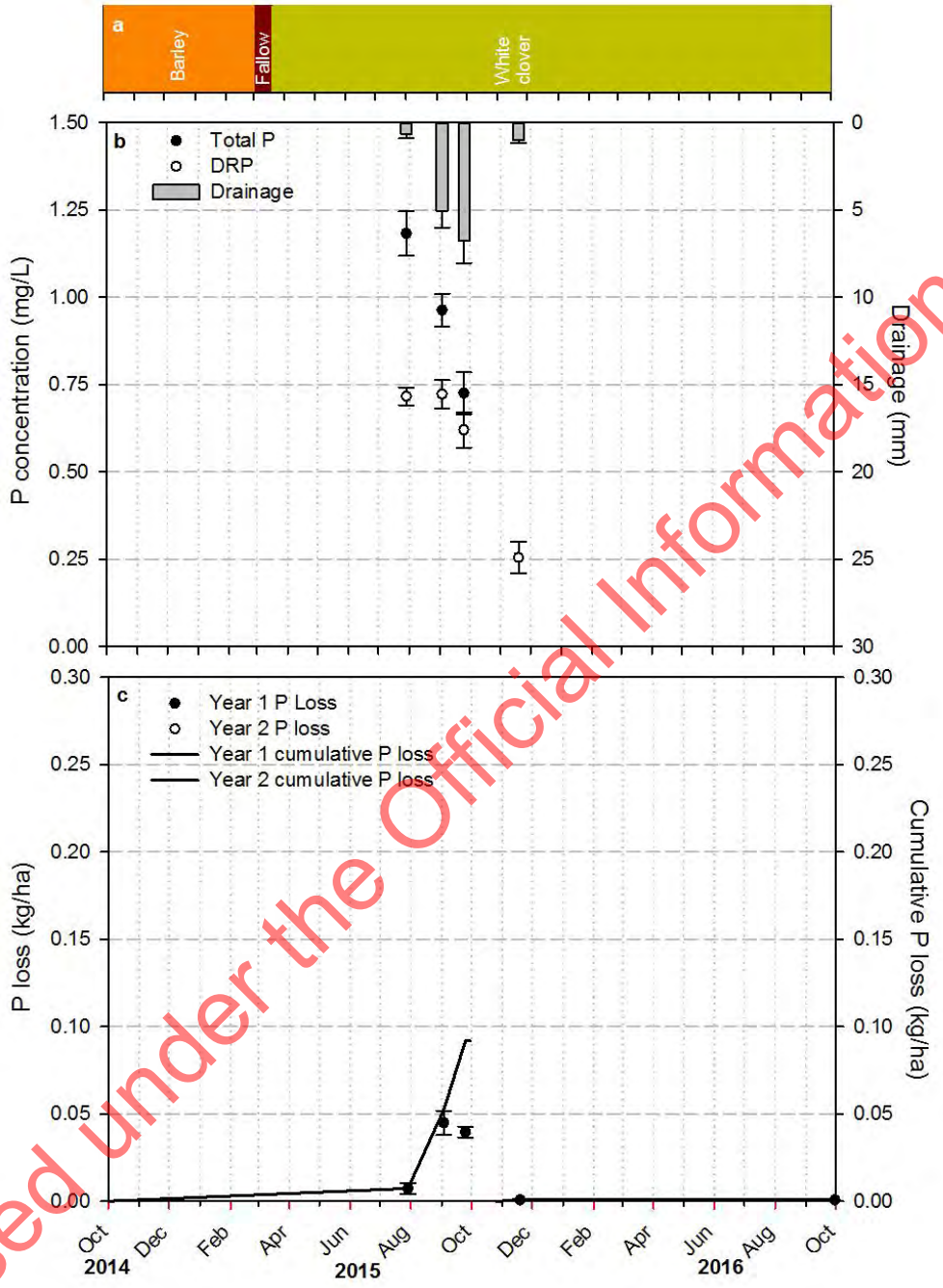

Figure 13. Summary of crop sequence (a), measured drainage and P concentrations (total P and DRP) in drainage (b) and measured system losses of total P in drainage for Year 1 (1 October 2014 to 30 September 2015) and for Year 2 (1 October 2015 to 30 September (c) Site 2 — Canterbury. Mean drainage is calculated from the volume of leachate collected at each sampling event, corrected for the surface area of the fluxmeters. Bars around each point represent the standard error of the mean. Lower limit of detections: Total P: 0.02 mg/L; DRP: 0.001 mg/L. Fluxmeters were installed on 22 September 2014.

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3.3 Site 3 — Canterbury

3.3.1 Background site and crop management history

Site 3 is located near Southbridge on a mixed cropping and livestock grazing enterprise. Soil type is a Templeton loam. Fluxmeters were installed at the site in September 2014 into an established ryegrass seed crop sown in March 2014. Key site characteristics are described in Table 6.

Table 6. Summary of key farm and site characteristics, Site 3 — Canterbury.

Location	Southbridge
Farming system	Mixed cropping, livestock grazing
Topography	Flat
Soil type	Templeton loam
Key soil characteristics[1]	Soil order: Typic immature pallic Texture: Loam over clay Topsoil bulk density: 1.22 g/cm^3 Subsoil bulk density: 1.42 g/cm^3 Drainage class: Moderately well drained N leaching vulnerability: Low
Previous land use history	Arable cropping for past 5 years
Fluxmeter installation date	24 September 2014
Irrigation infrastructure	Roto-Rainer

[1]A full description of the Templeton loam is available online at https://smap.landcareresearch.co.nz/home. Listed characteristics are taken from S-MAP factsheets and are not based on measured site values.

Since installation of the fluxmeters there have been four crops including ryegrass seed, ryegrass pasture, process beans, forage oats and kale (the current crop) (Table 7). The ryegrass seed crop was harvested in January 2015 and the site was rotationally grazed by ewes and lambs until early November 2015. The site was planted to process beans in December 2015 and harvested in March 2016. Forage oats was then planted in late March for winter grazing. Grazing was completed in early September and the site subsequently planted with kale (the current crop) in late September. Respective N and P inputs have totalled 152 kg N/ha and 0 kg P/ha (ryegrass seed), 28 kg N/ha and 0 kg P/ha (ryegrass pasture), 104 kg N/ha and 30 kg P/ha (process beans), 28 kg N/ha and 0 kg P/ha (forage oats) and 46 kg N/ha and 0 kg P/ha (kale) (Table 7).

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Table 7. Summary of crop management practices since fluxmeter installation (24 September 2014), Site 3 — Canterbury.

Crop management practices	Sequence 1 — Ryegrass seed	Sequence 2 — Ryegrass grazing	Sequence 3 — Beans	Sequence 4 — Forage oats	Sequence 5 — Kale
Variety	'Perun'	'Perun'	'Stanley'	White forage oats	Food processing variety
Planting population	15 kg seed/ha	15 kg seed/ha	374,000 seeds/ha	80 kg seed/ha	2.3 kg/ha
Planting date	27 March 2014	27 March 2014	26 December 2015	26 March 2016	20 September 2016
Harvest date[1]	23 January 2015[3]	30 October 2015[4]	18 March 2016	3 September 2016	Current crop
Cultivation practices	Not available	None	Grubber followed by press	Direct drill	Grubbed x3, rolled, grubbed & rolled
Fertiliser practices (product)[2]	180 kg/ha Urea (S) 150 kg/ha Urea (S)	60 kg/ha Urea (S)	300 kg/ha Crop 20 (B) 100 kg/ha Urea (B)	60 kg/ha Urea (S)	100 kg/ha Urea (S)
Summed N and P (elemental)	N = 152 kg/ha P = 0 kg/ha	N = 28 kg/ha P = 0 kg/ha	N = 77 kg/ha P = 30 kg/ha	N = 28 kg/ha P = 0 kg/ha	N=46 kg/ha P= 0 kg/ha
Stock type	Sheep	Sheep	-	Sheep	-
Stock density	123 sheep/ha	72 sheep/ha	-	124 hoggets/ha	-
Additional stock information	Site grazed by ewes and lambs in October	Site grazed by ewes in February and March Site grazed by store lambs in July and August Site grazed by ewes and spring lambs in September Site grazed by ewes and lambs in November	-	Sheep were break fed from late July to early September and over the fluxmeter units for 12 days from early August	-

[1]Commercial harvest date. [2]B = base application, P = planting application, S= side dressing application(s). [3]The site was grazed rotationally following harvest of the seed. [4]Reflects the date the ryegrass was sprayed off.

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3.3.2 General weather conditions

Year 1 (1 October 2014 to 30 September 2015)

Rainfall for the Year 1 period was 547 mm, 11% below the long-term average for the region (616 mm) (Figure 14a). Rainfall for the winter and early spring period (June to September 2015) was 238 mm, comparable with the long-term average (235 mm). Mean air temperature for the 12 month period was 11.0°C, comparable than the long-term average (11.2°C) (Figure 14b) while solar radiation totalled 5140 MJ/m^2, also comparable with the long-term average of 4986 MJ/m^2 (Figure 14c)

Year 2 (1 October 2015 to 30 September 2016)

Rainfall and mean air temperature for the Year 2 period was 442 mm, 28% below the long-term average for the region (616 mm) (Figure 14a). The winter and early spring period (June to September) was particularly dry with only 114 mm rainfall recorded, 46% less than the long-term average for this period (213 mm). Mean air temperature for the 12 month period was 11.6°C, slightly warmer than the long-term average (Figure 14b) while solar radiation totalled 5141 MJ/m^2, comparable with the long-term average (Figure 14c).

3.3.3 Soil nitrogen and phosphorus levels

Soil samples for N and P fertility analyses were taken during installation of the fluxmeters in September 2014, in January 2016 (3 weeks following sowing of the bean crop) and in April 2016 (1 week after sowing of the forage oats crop).

Mineral N (0–100 cm)

Samples taken in September 2014 had low concentrations of mineral N (36 kg N/ha) while concentrations for samples taken in January and April 2016 were high (469 and 321 kg N/ha respectively) (Figure 15a). The very high concentrations observed for the January 2016 samples were consistent with the application of fertiliser N at planting (samples were taken after this application) in conjunction with recently mineralised N from the previous ryegrass crop (the site had been under pasture for the previous 2 years). For all sampling occasions, nitrate-N was the predominant form of mineral N (74–97%).

AMN (0–100 cm)

AMN concentrations were moderate to high for all sampling occasions (169–225 kg N/ha) and reflected elevated levels of potential mineralisable N (Figure 15a). Concentrations were consistent for samples taken following conversion of long-term pasture to cropping (Table 7).

Olsen P (0–20 cm)

Olsen P concentrations were low for the September 2014 samples (18 mg/L) and moderate for those taken in January and April 2016 (25–30 mg/L). These concentrations were slightly below the normal concentrations suggested for ryegrass (20–30 mg/L) and bean production (35–75 mg/L) but within the optimum range for forage oats production (Figure 15b).

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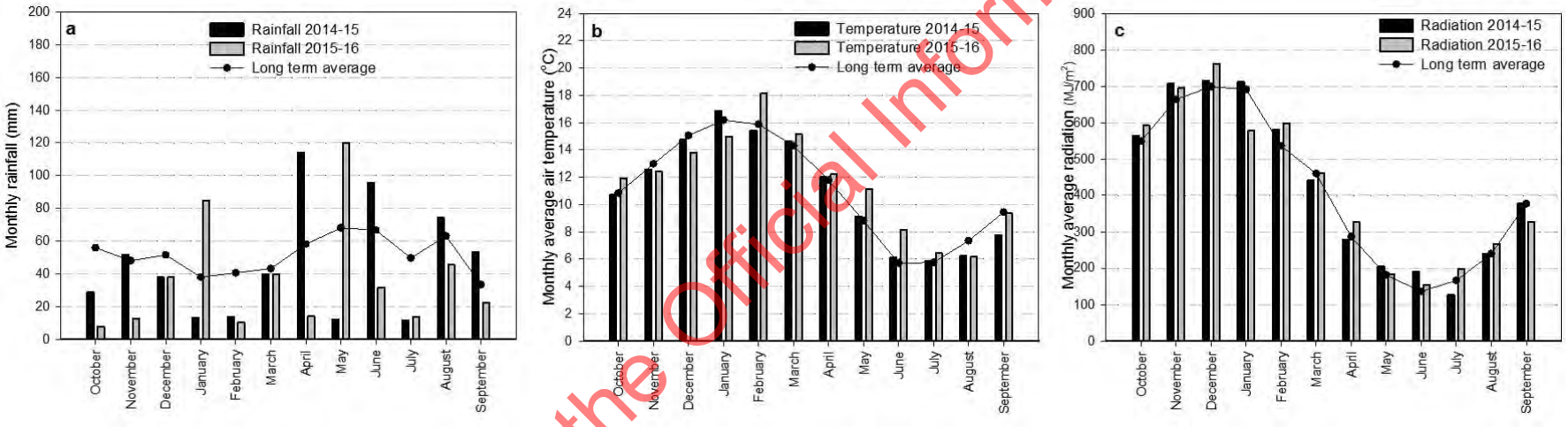

Figure 14. Monthly (a) rainfall (mm), (b) average air temperature (°C) and average solar radiation (MJ/m^2) for 1 October 2014 to 30 September 2016 at Leeston (rainfall; NIWA Station 39066), Chertsey (temperature; NIWA Station 39661) and Lincoln (radiation; NIWA Station 17603). Long-term climate data are presented for the Lincoln (rainfall and radiation, 2001–14) and Ashburton stations (temperature, 2006–14, NIWA Station 26170).

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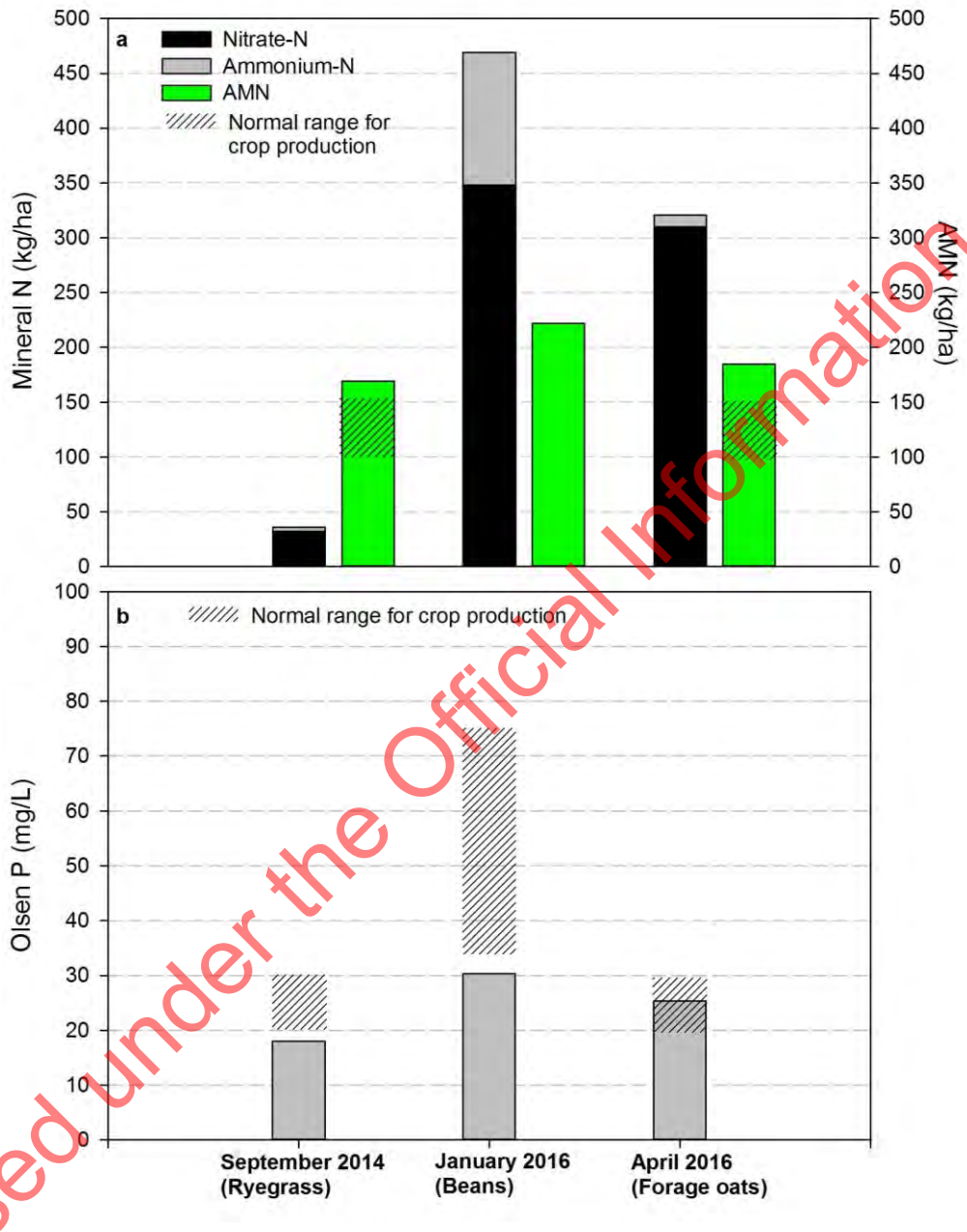

Figure 15. Soil mineral N and AMN (0–100 cm depth) (a) and Olsen P (0–20 cm depth) (b) at Site 3 — Canterbury for samples taken in September 2014, January 2016 and April 2016. Normal ranges suggested for crop production are provided by Hill Laboratories (http://www.hill-laboratories.com/page/pageid/2145845703/Crop_Guides).

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3.3.4 Soil water balance

Year 1 (1 October 2014 to 30 September 2015)

The soil water balance for Site 3 is shown in Figure 16. Rainfall and irrigation for Year 1 totalled 547 mm and 450 mm respectively. There was only one rainfall event over 50 mm which occurred in late April 2015 (57 mm over 3 days). Irrigation was applied at 50 mm per application between late October 2014 and mid-February 2015.

Modelled soil water contents at all depths tended to increase from April 2015 and remained at elevated contents from mid-August 2015 onwards. Fluxmeter drainage samples were collected during this period.

Year 2 (1 October 2015 to 30 September 2016)

Rainfall and irrigation for the Year 2 period totalled 442 mm and 270 mm respectively. The largest rainfall event was in late May 2016 (70 mm recorded over 4 days) (Figure 16). There were six irrigation applications of 45 mm between early December 2015 and mid-March 2016.

Modelled soil water contents decreased at all depths from October onwards before increasing to elevated levels in late December in response to a period of consistent rainfall and large irrigation volumes. Four drainage samples were collected over the Year 2 period, one in January, one in February and two in June.

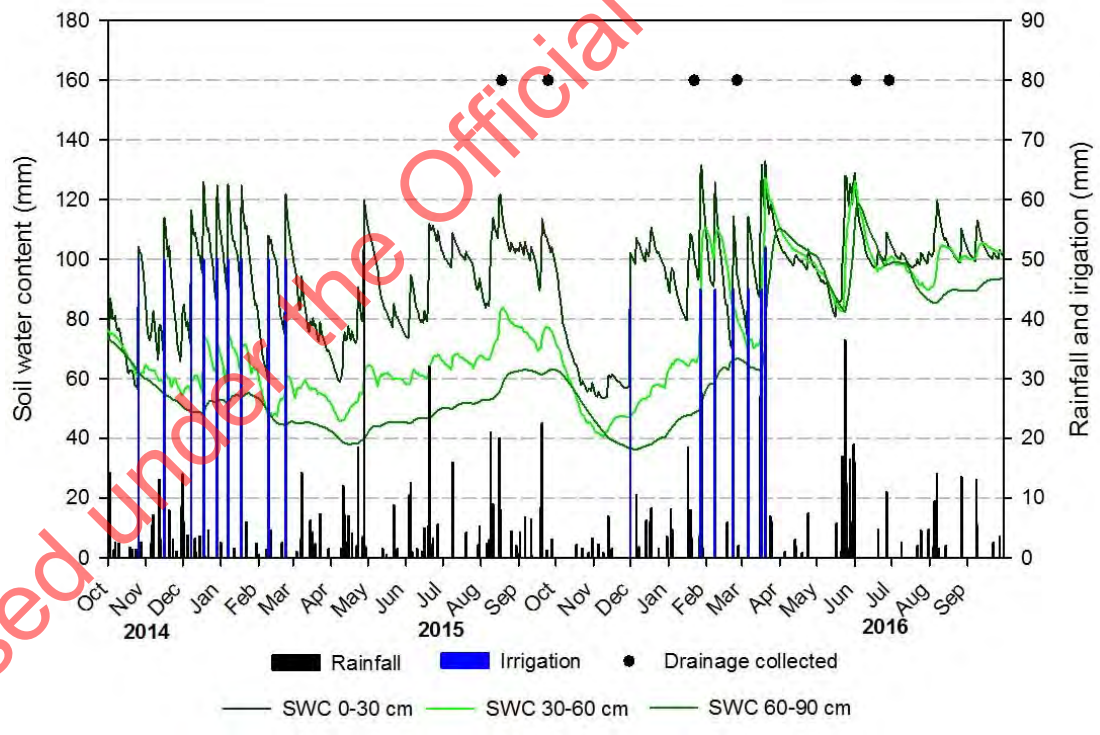

Figure 16. Summary of daily rainfall, irrigation, modelled soil water content (0–30 cm, 30–60 cm and 60–90 cm) and predicted drainage from 1 July 2014, Site 3 — Canterbury. Fluxmeter units were installed on 24 September 2014.

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3.3.5 Losses of N and P in drainage water

Year 1 (1 October 2014 to 30 September 2015)

Drainage samples were collected on two occasions in the first year following installation of the fluxmeters (Figure 17b). Total drainage volume was 8 mm.

Nitrate-N and ammonium-N concentrations in drainage for this period averaged 7.8 mg/L and 1.0 mg/L respectively (Figure 17b). Due to low N concentrations and low drainage volumes, measured mineral N losses from the system were minimal totalling 0.9 kg N/ha (Figure 17c) with the majority of this N lost as nitrate-N (0.8 kg N/ha).

Total P and DRP concentrations averaged 0.22 mg/L and 0.15 mg/L respectively (Figure 18b). Measured P losses from the system over this period were minimal (< 0.1 kg P/ha; Figure 18c).

Year 2 (1 October 2015 to 30 September 2016)

Drainage samples were collected on four occasions in the second year following installation of the fluxmeters. Total drainage volume was 39 mm.

Nitrate-N and ammonium-N concentrations in drainage for this period averaged 10.5 mg/L and 0.5 mg/L respectively (Figure 17b). Nitrate-N concentrations were highest in the June 2016 samples (17.6 mg/L). Despite higher drainage volumes and nitrate-N concentrations than in Year 1, measured mineral losses remained low (3.9 kg N/ha; Figure 17c).

Total P and DRP concentrations averaged 0.20 mg/L and 0.17 mg/L respectively (Figure 18b). Measured P losses from the system over this period were minimal (0.07 kg P/ha; Figure 18c).

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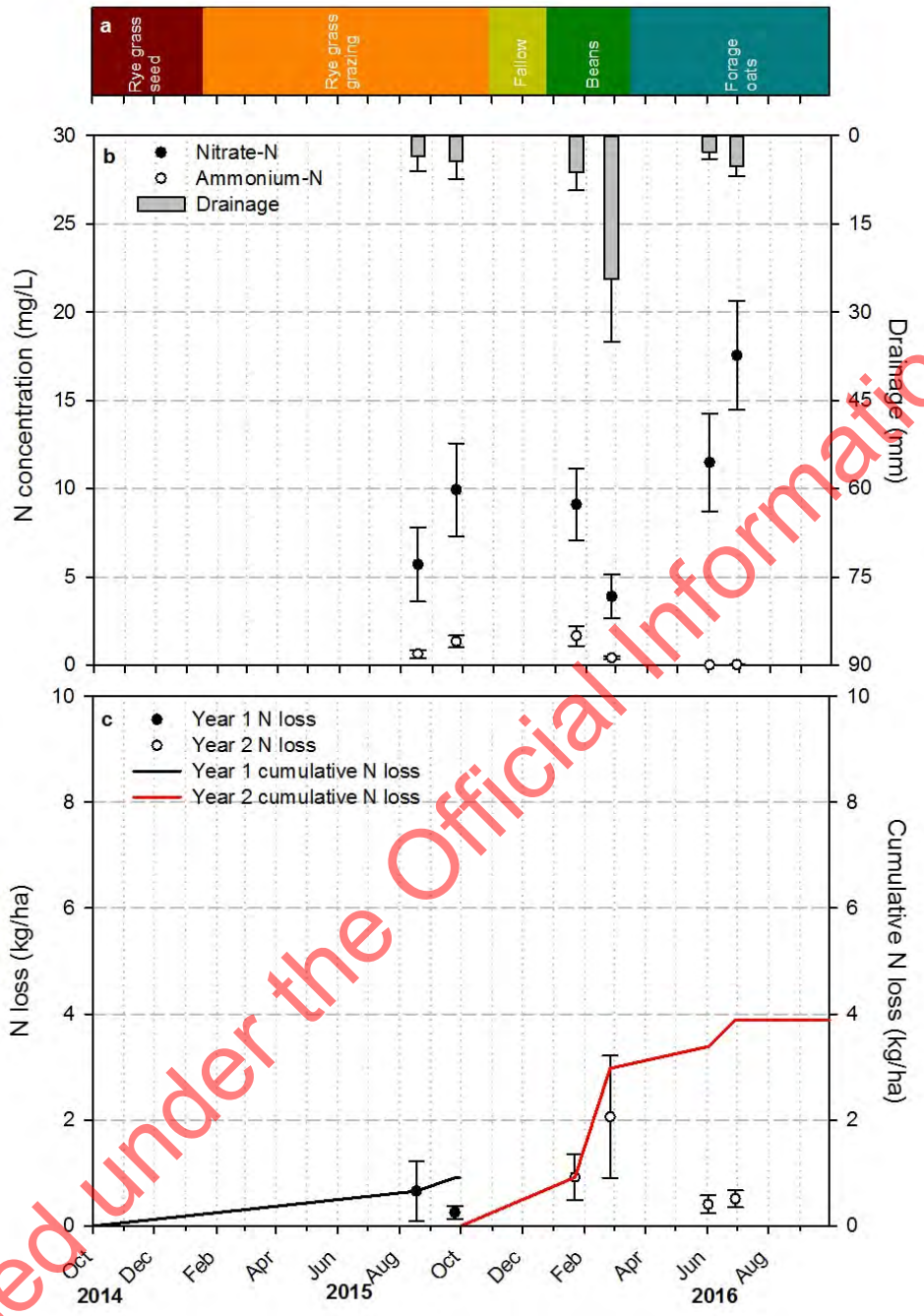

Figure 17. Summary of crop sequence (a), measured drainage and inorganic N concentrations (nitrate-N and ammonium-N) in drainage (b) and measured system losses of inorganic N in drainage for Year 1 (1 October 2014 to 30 September 2015) and for Year 2 (1 October 2015 to 30 September 2016) (c) Site 3 — Canterbury. Mean drainage is calculated from the volume of leachate collected at each sampling event, corrected for the surface area of the fluxmeters. Bars around each point represent the standard error of the mean. Lower limit of detections: nitrate-N: 0.02 mg/L; ammonium-N: 0.01 mg/L. Fluxmeters were installed on 24 September 2014.

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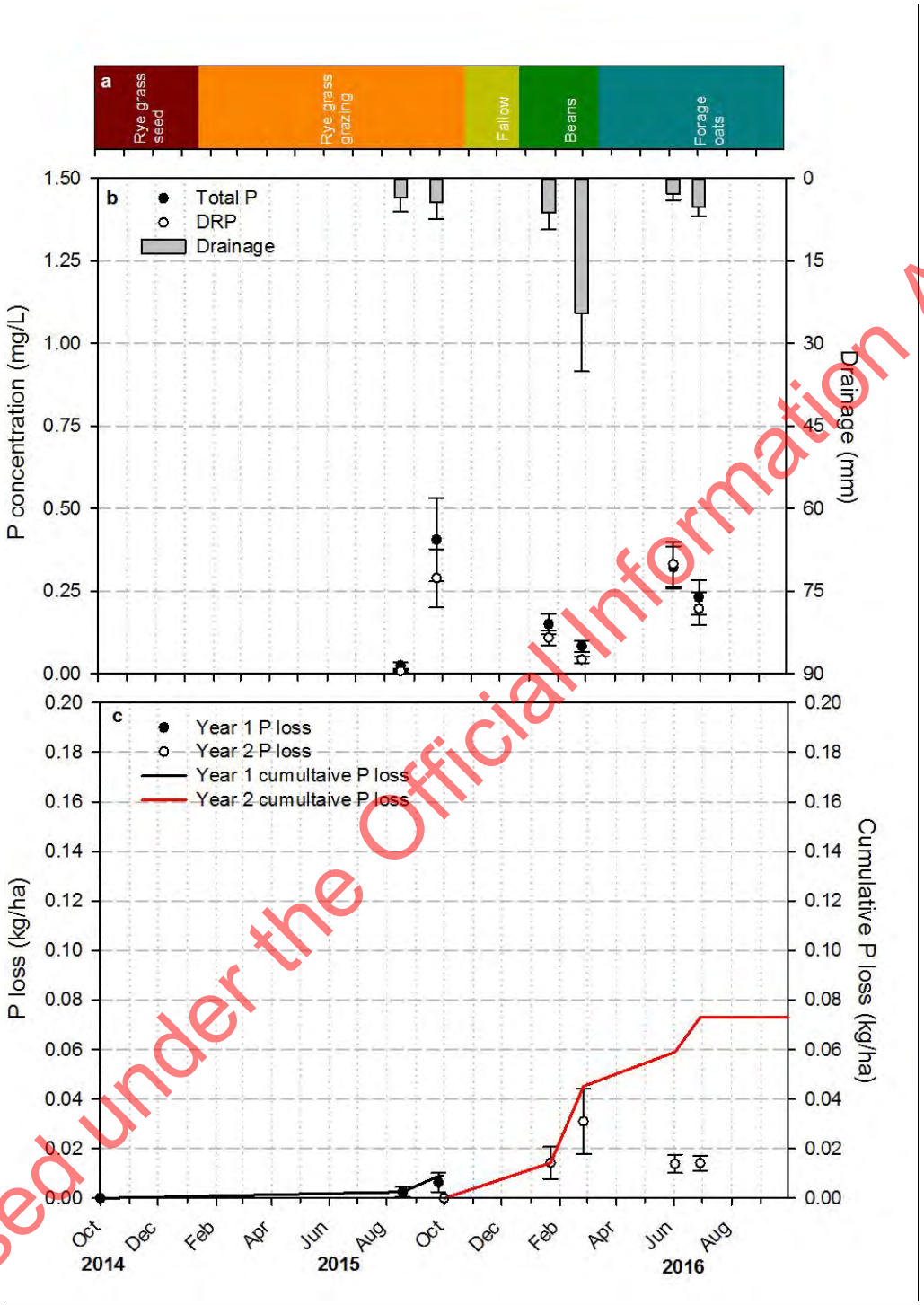

Figure 18. Summary of crop sequence (a), measured drainage and P concentrations (total P and DRP) in drainage (b) and measured system losses of total P in drainage for Year 1 (1 October 2014 to 30 September 2015) and for Year 2 (1 October 2015 to 30 September 2016) (c) Site 3 — Canterbury. Mean drainage is calculated from the volume of leachate collected at each sampling event, corrected for the surface area of the fluxmeters. Bars around each point represent the standard error of the mean. Lower limit of detections: Total P: 0.02 mg/L; DRP: 0.001 mg/L. Fluxmeters were installed on 24 September 2014.

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3.4 Site 4 — Manawatu

3.4.1 Background site and crop management history

Site 4 is located near Levin on an intensive vegetable cropping enterprise. Soil type is a Shannon silt loam. Fluxmeters were installed at the site in October 2014. Key site characteristics are described in Table 8.

Table 8. Summary of key farm and site characteristics, Site 4 — Manawatu.

Location	Levin
Farming system	Intensive vegetable production
Topography	Flat
Soil type	Shannon silt loam
Key soil characteristics[1]	Soil order: Mottled argillic pallic Texture: Silty loam Topsoil bulk density: 1.22 g/cm^3 Subsoil bulk density: 1.42 g/cm^3 Drainage class: Moderate over slow N leaching vulnerability: Low
Previous land use history	Intensive vegetable production for past 7 years.
Fluxmeter installation date	20 October 2014
Irrigation infrastructure	Lateral

[1]A full description of the Shannon silt loam is available online at https://smap.landcareresearch.co.nz/home. Listed characteristics are taken from S-MAP factsheets and are not based on measured site values.

Since installation of the fluxmeters there have been six crops grown. The first crop (lettuce 2014) was planted in October 2014 and harvested 2 months later in December. Spinach was subsequently planted in February 2015 (harvested in April), May 2015 (harvested in September 2015) and July 2015 (harvested in September 2015). Following harvest of the third spinach crop, the site remained fallow until December before being planted to lettuce (lettuce 2015) which was harvested in February 2016. A cabbage crop was planted in March 2016 and harvested in July 2016. The site is currently fallow and is due to be planted to zucchinis in October 2016. Respective N and P inputs have totalled 200 kg N/ha and 208 kg P/ha (lettuce 2014), 81 kg N/ha and 0 kg P/ha (spinach 1), 101 kg N/ha and 16 kg P/ha (spinach 2), 62 kg N/ha and 26 kg P/ha (spinach 3), 91 kg N/ha and 40 kg P/ha (lettuce 2015) and 191 kg N/ha and 46 kg P/ha (cabbage) (Table 9).

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Table 9. Summary of crop management practices since fluxmeter installation (20 October 2014), Site 4 — Manawatu.

Crop management practices	Sequence 1 — Lettuce	Sequence 2 — Spinach	Sequence 3 — Spinach	Sequence 4 — Spinach	Sequence 5 — Lettuce	Sequence 6 — Cabbage
Variety	'Casino'	'Twilight'	'Blackglove'	'Manatee'	'Casino'	'Hyb 228'
Planting population	43,500 plants/ha	650,000 plants/ha	650,000 plants/ha	650,000 plants/ha	43,860 plants/ha	32,890 plants/ha
Planting date	23 October 2014	18 February 2015[1]	27 May 2015[1]	2 July 2015[2]	30 December 2015	9 March 2016
Harvest date[3]	24 December 2014	1 April 2015	10 September 2015	28 September 2015	11 February 2016[4]	21 July 2016
Cultivation practices	Chisel plough and power harrow	Chisel plough and power harrow followed by bed moulding	Rotary hoe	Rotary hoe	Chisel plough and power harrow followed by bed moulding	Chisel plough and power harrow followed by bed moulding
Fertiliser practices (product)[5]	2.2 t/ha Aglime (B) 2 t/ha SSP (B) 560 kg/ha CropStart (S) 490 kg/ha CAN (S)[6]	300 kg/ha CAN (S)	313 kg/ha CropStart (S) 234 kg/ha CAN (S)	519 kg/ha CropStart (S)	760 kg/ha Nitrophoska (B)	387 kg/ha Nitrophoska (B) 153 kg/ha Kieserite (B) 517 kg/ha Rustica blue (S) 309 kg/ha CAN (S)
Summed N and P (elemental)	N = 200 kg/ha P = 208 kg/ha	N = 81 kg/ha P = 0 kg/ha	N = 101 kg/ha P = 16 kg/ha	N = 62 kg/ha P = 26 kg/ha	N = 91 kg/ha P = 40 kg/ha	N = 191 kg/ha P = 46 kg/ha
Stock type	No stock	No stock	No stock	No stock	No stock	No stock
Stock density	-	-	-		-	-
Additional stock information	-	-	-		-	-

[1]Crop was only established over half the experimental area. [2]Crop was established over the second half of the experimental area. [3]Commercial harvest date. [4]40% of the crop was selectively harvested on this date with remainder harvested on 17 February 2016. [5]B = base application, P = planting application, S= side dressing application(s). [6]Split over two applications between November and December 2014.

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3.4.2 General weather conditions

Year 1 (1 October 2014 to 30 September 2015)

Rainfall and mean air temperature for the Year 1 period was 1046 mm and 13.1°C. This was comparable with the long-term average for the region (995 mm and 13.2°C respectively) (Figure 19a and b). The mid-autumn to early winter period (1 April to 30 June 2015) was particularly wet, with close to twice the amount of rainfall (489 mm) compared with the long-term average for the same period (256 mm).

Solar radiation for the 12 month period totalled 5030 MJ/m^2, comparable to the long-term average of 4949 MJ/m^2 (Figure 19c).

Year 2 (1 October 2015 to 30 September 2016)

Rainfall for the Year 2 period totalled 1018 mm, comparable to the long-term average for the region (Figure 19a) while air temperature averaged 14.0°C, warmer than the long-term average (Figure 19b). Solar radiation totalled 4994 MJ/m^2, comparable to the long-term average (Figure 19c).

3.4.3 Soil nitrogen and phosphorus fertility levels

Soil samples for N and P fertility analyses were taken during installation of the fluxmeters in September 2014, and in May 2015, October 2015 and March 2016 prior to planting of respective spinach, lettuce and cabbage crops.

Mineral N (0–100 cm)

Samples taken in September 2014 had low concentrations of mineral N (36 kg N/ha), whereas concentrations for samples taken in May and October 2015 and March 2016 were high (327, 162 and 154 kg N/ha respectively) (Figure 20a). For all sampling occasions the predominant form of mineral N was nitrate-N (66–81%). High concentrations of mineral N in the May and October 2015 and March 2016 samples reflect the application of N fertilisers to the previous lettuce and spinach crops (Table 9) which were above expected removal rates.

AMN (0–100 cm)

AMN concentrations were low to moderate across the four sampling dates (65–109 kg/ha; Figure 20a). Concentrations were within normal ranges suggested for lettuce, spinach and cabbage production (100–150 kg N/ha) (September 2014, May 2015 and March 2016 samples) but below normal levels for the October 2015 samples.

Olsen P (0–20 cm)

Olsen P concentrations were high for both all sampling occasions (111–149 mg/L) and well above normal concentrations suggested for lettuce and spinach (35–90 mg/L) and cabbage production (35–70 mg/L) (Figure 20b).

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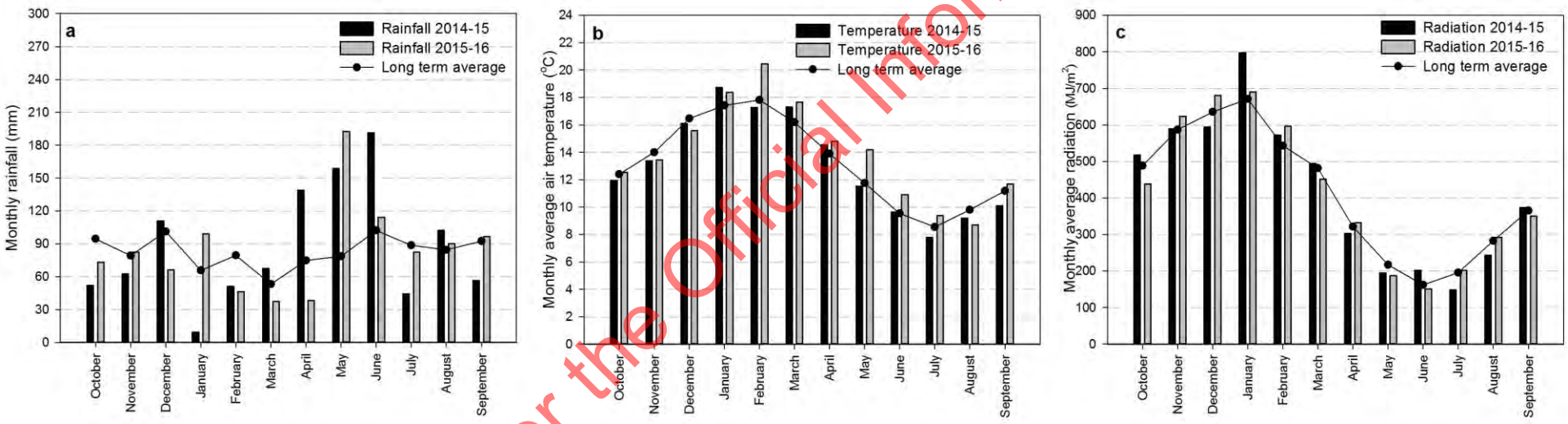

Figure 19. Monthly (a) rainfall (mm), (b) average air temperature (°C) and average solar radiation (MJ/m^2) for 1 October 2014 to 30 September 2016 at Levin (NIWA Station 3275). Long-term climate data (2001–14) are presented for the Levin station.

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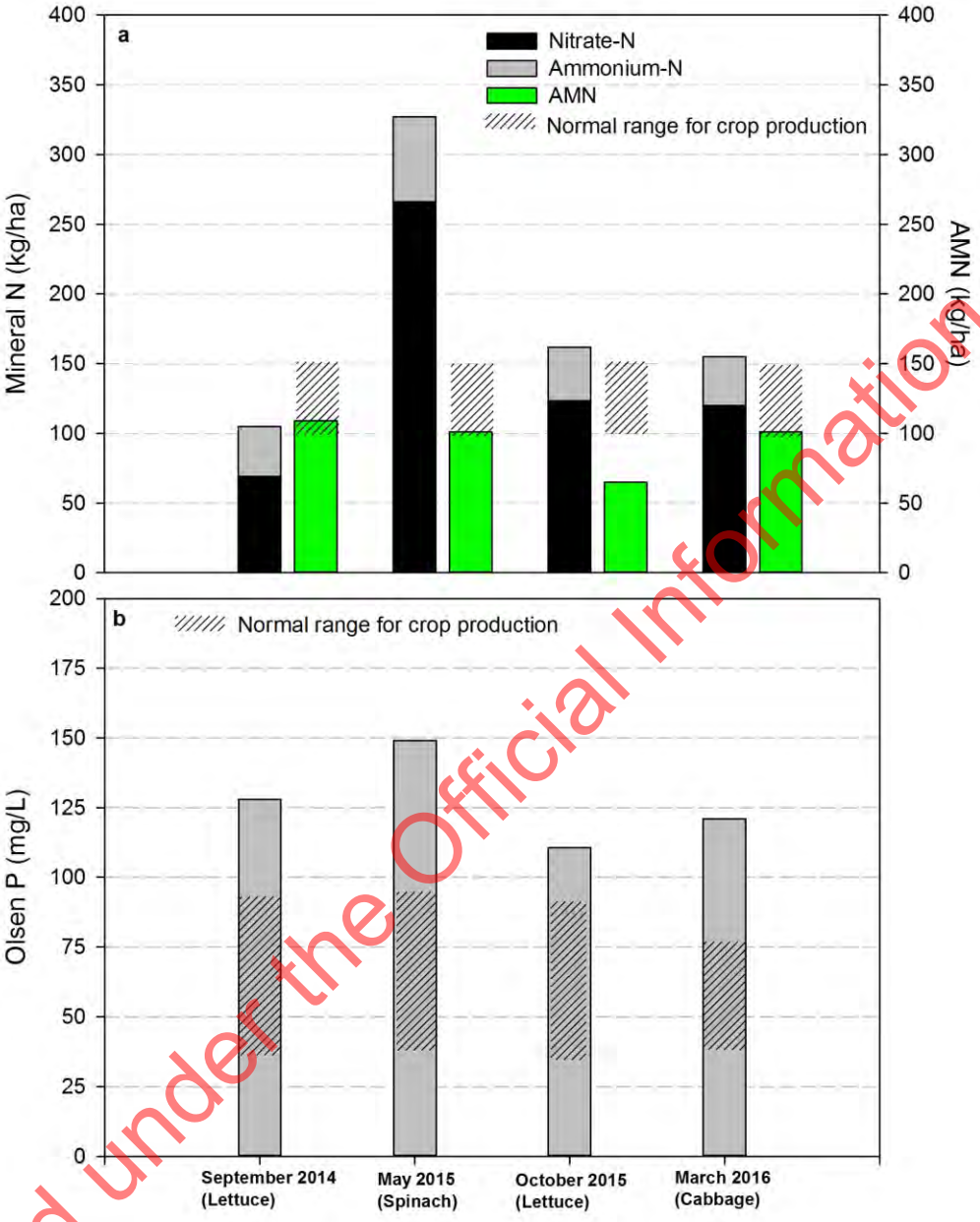

Figure 20. Soil mineral N and AMN (0–100 cm depth) (a) and Olsen P (0–20 cm depth) (b) at Site 4 — Manawatu for samples taken in September 2014, May 2015, October 2015 and March 2016. Normal ranges suggested for crop production are provided by Hill Laboratories (http://www.hill-laboratories.com/page/pageid/2145845703/Crop_Guides).

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3.4.4 Soil water balance

Year 1 (1 October 2014 to 30 September 2015)

The soil water balance for Site 4 is shown in Figure 21. Rainfall and irrigation for the Year 1 period totalled 1046 mm and 22 mm respectively. The mid-autumn through to early winter period was particularly wet and there were a number of significant rainfall events including 93 mm over 6 days in early April, 111 mm over 5 days in mid-May and 97 mm over 2 days in mid-June. The range in individual irrigation application volumes was 5 to 6 mm.

Modelled soil water contents for all depths remained elevated for the duration of the monitoring period (> 110 mm). This was consistent with the collection of drainage samples, which occurred on a regular basis throughout the year.

Year 2 (1 October 2015 to 30 September 2016)

Rainfall and irrigation for the Year 2 period totalled 1018 mm and 40 mm respectively. The wettest period occurred between mid to late May when 116 mm was recorded over a 9 day period (Figure 21). There were two irrigation applications of 20 mm between late January and early February 2016.

As in Year 1, modelled soil water contents for all depths tended to decrease between December and February although on the whole remained elevated for the duration of the monitoring period (> 110 mm). Drainage samples were collected on a regular basis throughout the year (eight in total).

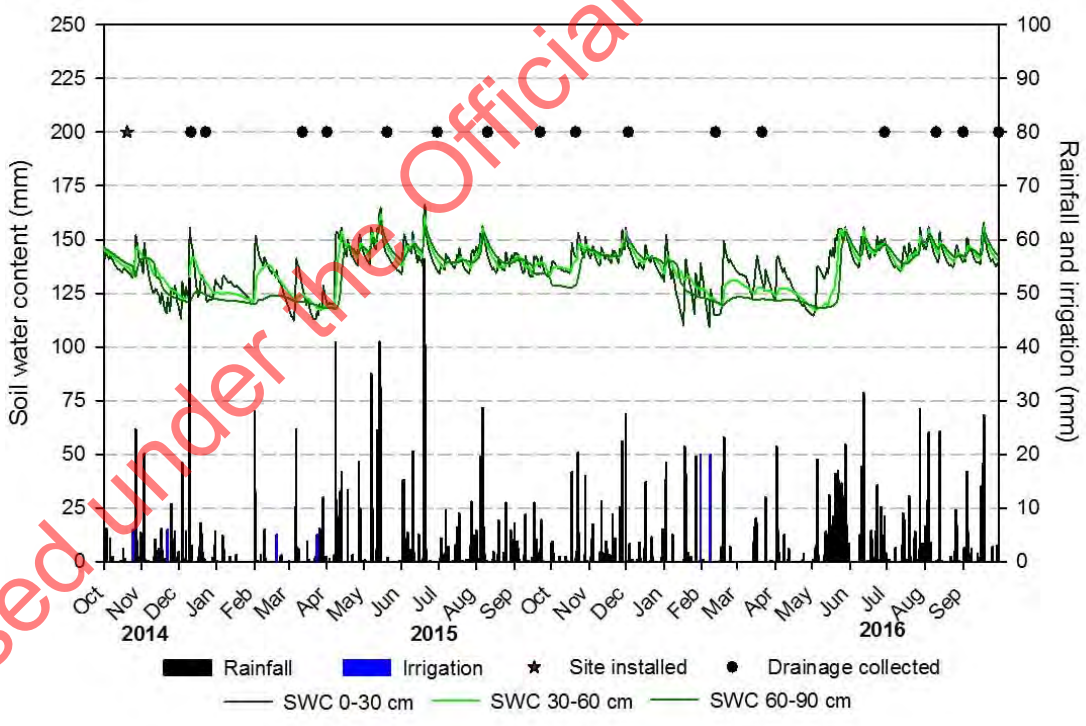

Figure 21. Summary of daily rainfall, irrigation and modelled soil water content (0–30 cm, 30–60 cm and 60–90 cm) from 1 October 2014, Site 4 — Manawatu.

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3.4.5 Losses of N and P in drainage water

Year 1 (1 October 2014 to 30 September 2015)

Drainage samples were collected on eight occasions in the first year following installation of the fluxmeters. Total drainage volume was 339 mm.

Nitrate-N and ammonium-N concentrations in drainage for this period averaged 50.0 mg/L and 1.5 mg/L respectively (Figure 22b). Nitrate-N concentrations tended to increase over time and peaked at 75.0 mg/L in late June 2015, while ammonium-N concentrations remained comparatively low (< 4.6 mg/L). Measured mineral N losses from the system totalled 212 kg N/ha (Figure 22c) with the majority of N lost as nitrate-N (210 kg N/ha). The high N losses observed between May and September 2015 reflected the combination of high nitrate-N concentrations in drainage and increased drainage volumes.

Total P and DRP concentrations averaged 0.29 mg/L and 0.21 mg/L respectively (Figure 23b). Measured P losses from the system were low, totalling 0.56 kg P/ha with DRP loss accounting for 0.42 kg P/ha (Figure 23c). The observed decline in the concentration difference between total P and DRP over the monitoring period suggests a net decrease in the transfer of dissolved organic P and/or sediment bounds P forms (> 0.45 µm). This most likely reflects a soil 'settling effect' following installation of the fluxmeter units.

Year 2 (1 October 2015 to 30 September 2016)

Drainage samples were collected on eight occasions in the second year following installation of the fluxmeters. Total drainage volume was 339 mm, the same as in Year 1.

Nitrate-N and ammonium-N concentrations in drainage for this period averaged 37.7 mg/L and 0.02 mg/L respectively (Figure 22b). Nitrate concentrations decreased from 56.1 mg/L in early December 2015 to 19.9 mg/L in late September 2016. Measured mineral N losses from the system totalled 118 kg N/ha (Figure 22c) with N lost almost entirely as nitrate-N.

Total P and DRP concentrations averaged 0.14 mg/L and 0.07 mg/L respectively (Figure 23b). Measured P losses from the system were low (0.27 kg P/ha; Figure 23c).

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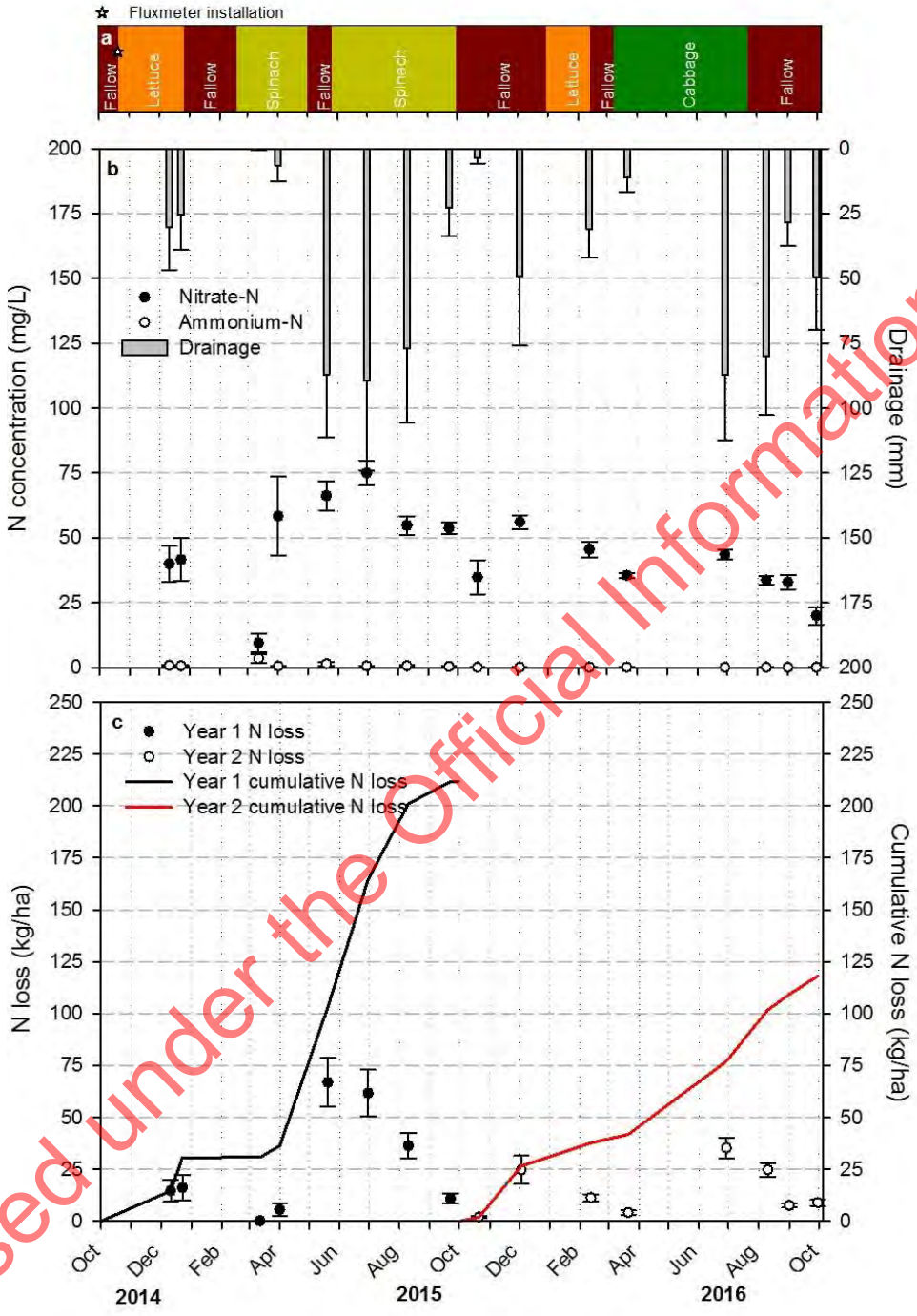

Figure 22. Summary of crop sequence (a), measured drainage and inorganic N concentrations (nitrate-N and ammonium-N) in drainage (b) and measured system losses of inorganic N in drainage for Year 1 (1 October 2014 to 30 September 2015) and for Year 2 (1 October 2015 to 30 September 2016) (c) Site 4 — Manawatu. Mean drainage is calculated from the volume of leachate collected at each sampling event, corrected for the surface area of the fluxmeters. Bars around each point represent the standard error of the mean. Lower limit of detections: nitrate-N: 0.02 mg/L; ammonium-N: 0.01 mg/L.

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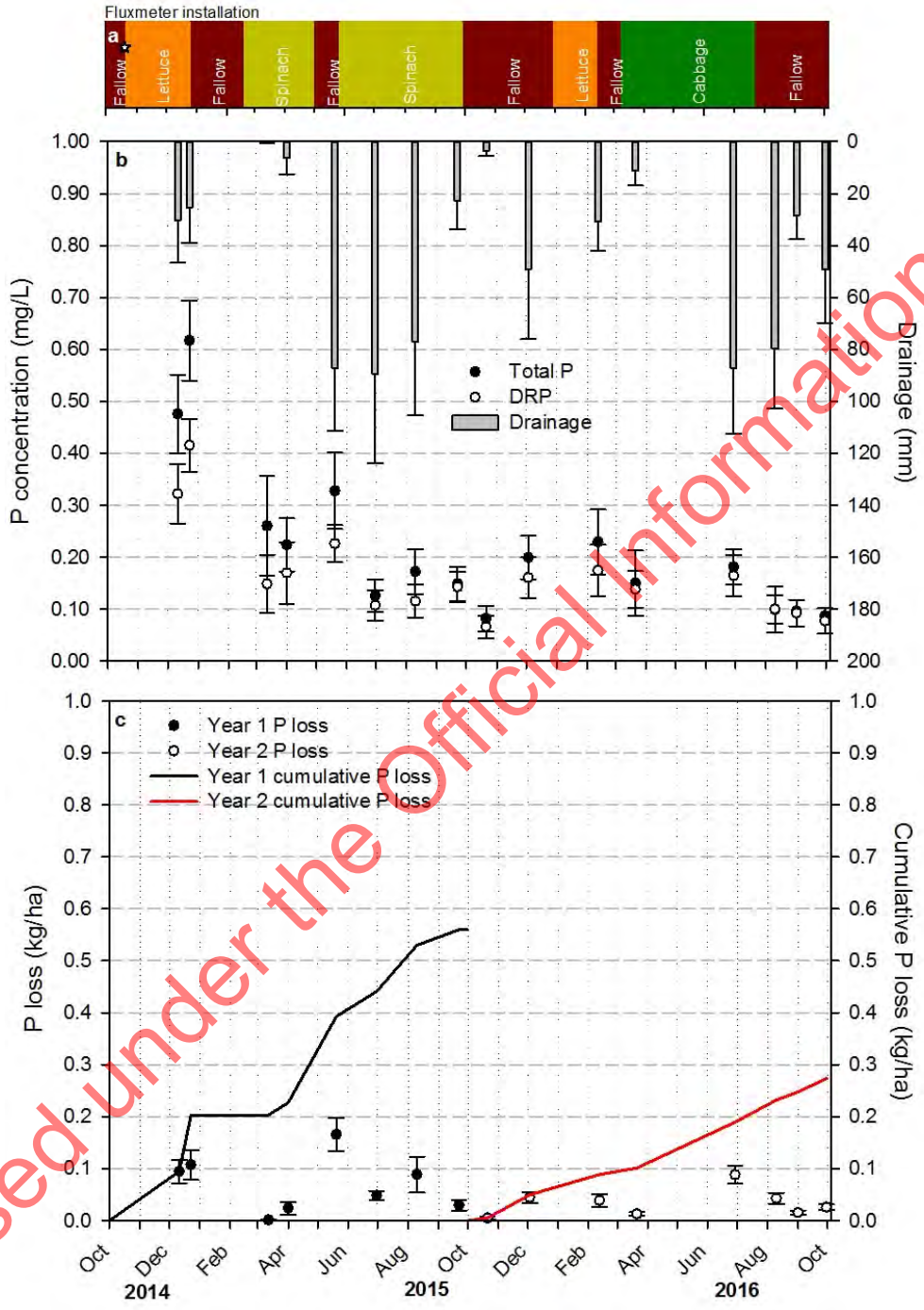

Figure 23. Summary of crop sequence (a), measured drainage and P concentrations (total P and DRP) in drainage (b) and measured system losses of total P in drainage for Year 1 (1 October 2014 to 30 September 2015) and for Year 2 (1 October 2015 to 30 September 2016) (c) Site 4 — Manawatu. Mean drainage is calculated from the volume of leachate collected at each sampling event, corrected for the surface area of the fluxmeters. Bars around each point represent the standard error of the mean. Lower limit of detections: Total P: 0.02 mg/L; DRP: 0.001 mg/L. Fluxmeters were installed on 24 September 2014.

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3.5 Site 5 – Manawatu

3.5.1 Background site and crop management history

Site 5 is located near Bulls on a mixed cropping and livestock grazing enterprise. Soil type is a Pukepuke sandy loam. Fluxmeters were installed at the site in September 2014. Key site characteristics are described in Table 10.

Table 10. Summary of key farm and site characteristics, Site 5 — Manawatu.

Location	Bulls
Farming system	Mixed cropping, livestock grazing
Topography	Flat
Soil type	Pukepuke sandy loam
Key soil characteristics[1]	Soil order: Typic sandy gley Texture: Sandy loam Topsoil bulk density: 1.18 g/cm^3 Subsoil bulk density: 1.38 g/cm^3 Drainage class: Poorly drained N leaching vulnerability: Very low
Previous land use history	Converted from pine plantation to mixed cropping and livestock grazing in 2009.
Fluxmeter installation date	29 September 2014
Irrigation infrastructure	Centre pivot

[1]A full description of the Pukepuke sandy loam is available online at https://smap.landcareresearch.co.nz/home. Listed characteristics are taken from S-MAP factsheets and are not based on measured site values.

Since installation of the fluxmeters there have been three crops including maize, an oats cover crop and fodder beet (Table 11). The site was sown to maize in October 2014, harvested for grain in May 2015 and then left fallow for the winter before being sown to oats in late August 2015. The oats crop was planted to reduce wind erosion before establishment of a fodder beet crop in November 2015. The fodder beet was progressively harvested between mid-June and late July for use as winter feed. The site was subsequently planted to forage oats (the current crop) in late September 2016. Respective N and P inputs have totalled 189 kg N/ha and 42 kg P/ha (maize), 158 kg N/ha and 40 kg P/ha (fodder beet) and 158 kg N/ha and 40 kg P/ha (forage oats) (Table 11). No fertiliser was applied to the oat cover crop.

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Table 11. Summary of crop management practices since fluxmeter installation (29 September 2014), Site 5 — Manawatu.

Crop management practices	Sequence 1 — Maize	Sequence 2 — Oats cover crop	Sequence 3—— Fodder beet	Sequence 4 — Forage oats
Variety	P8805	'Milton'	'Enermax'	'Milton'
Planting population	95,000 plants/ha	80 kg/ha	100,000 plants/ha	130 kg seed/ha
Planting date	28 October 2014	15 August 2015	3 November 2015	27 September 2016
Harvest date[1]	1 May 2015	25 October 2015[2]	15 July 2016[3]	Current crop
Cultivation practices	Turbo chisel followed by turbo till and power harrow	Turbo chisel followed by disking and then planting	Ripped followed by rotary hoe (20 cm strips)	Turbo chisel followed by disking and then planting
Fertiliser practices (product)[4]	130 kg/ha SSP (B) 60 kg/ha KCl (B) 300 kg/ha Nitrophoska (P) 330 kg/ha Urea (S)	None	100 kg/ha DAP (P) 219 kg/ha Super10 (P) 103 kg/ha Sustain-N (P) 100 kg/ha KCl (P) 200 kg/ha MOP (P) 100 kg/ha Sustain-N (S) 80 kg/ha Urea (S) 250 kg/ha MOP (S)[5] 50 kg/ha ammonium sulphate (S)	1250 kg/ha chicken manure (B) 250 kg/ha Yara Mila (B) 170 kg/ha Super 10 (B) 130 kg/ha Coated urea (B) 70 kg/ha MOP (B) 53 kg/ha Zinc zulphate (B)
Summed N and P (elemental)	N = 189 kg/ha P = 42 kg/ha	N = 0 kg/ha P = 0 kg/ha	N = 158 kg/ha P = 40 kg/ha	N = 123 kg/ha P = 40 kg/ha
Stock type	No stock	No stock	Yearling cattle	No stock
Stock density	-	-	1 cow/ha	-
Additional stock information	-	-	Cows in field from early August to mid-September	-

[1]Commercial harvest date. [2]Reflects the date the oats cover crop was sprayed off. [3]Crop was progressively harvested between early June and mid-July 2016. [4]B = base application, P = planting application, S= side dressing application(s). [5]Split over two applications between January and February.

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3.5.2 General weather conditions

Year 1 (1 October 2014 to 30 September 2015)

Rainfall for the Year 1 period was 1189 mm, 27% higher than the long-term average for the region (934 mm) (Figure 24a). The mid-autumn to early winter period (1 April to 30 June 2015) was particularly wet with close to three times the amount of rainfall (612 mm) compared to the long-term average for the same period (228 mm).

Average air temperature for the 12 month period was 13.3°C, comparable to the long-term average (13.4°C) (Figure 24b) while solar radiation totalled 5330 MJ/m^2, close to the long-term average of 5113 MJ/m^2 (Figure 24c).

Year 2 (1 October 2015 to 30 September 2016)

Rainfall for the Year 2 period totalled 933 mm, comparable to the long-term average for the region (Figure 24a). Rainfall was distributed relatively evenly over the year except for the month of May where more than three times the amount of rainfall was recorded (213 mm) compared to the long-term average for the same period (66 mm). Average air temperature over the 12 month period was 14.1°C, warmer than the long-term average (13.4°C; Figure 24b) while solar radiation totalled 5199 MJ/m^2 comparable to the long-term average for the region (5113 MJ/m^2; Figure 24c).

3.5.3 Soil nitrogen and phosphorus fertility levels

Soil samples for N and P analyses were taken following installation of the fluxmeters in September 2014, prior to planting of respective fodder beet and forage oats crops in November 2015 and September 2016.

Mineral N (0–100 cm)

Samples taken in September 2014 and September 2016 had low concentrations of mineral N (35–44 kg N/ha) with an increased proportion of mineral N present in the ammonium-N form (41–52%). In contrast, mineral concentrations were moderate for samples taken in October 2015 (126 kg N/ha) with a greater proportion present as nitrate-N (70%).

AMN (0–100 cm)

AMN concentrations were moderate (134–156 kg N/ha) for all sampling occasions and within or slightly above the normal concentrations suggested for maize, fodder beet and oats production (100–150 kg N/ha) (Figure 25a).

Olsen P (0–20 cm)

Olsen P concentrations were moderate (25–32 mg/L) and within, or close to, the normal concentrations suggested for maize (15–30 mg/L), fodder beet (20–30 mg/L) and oats (20–30 mg/L) (Figure 25b).

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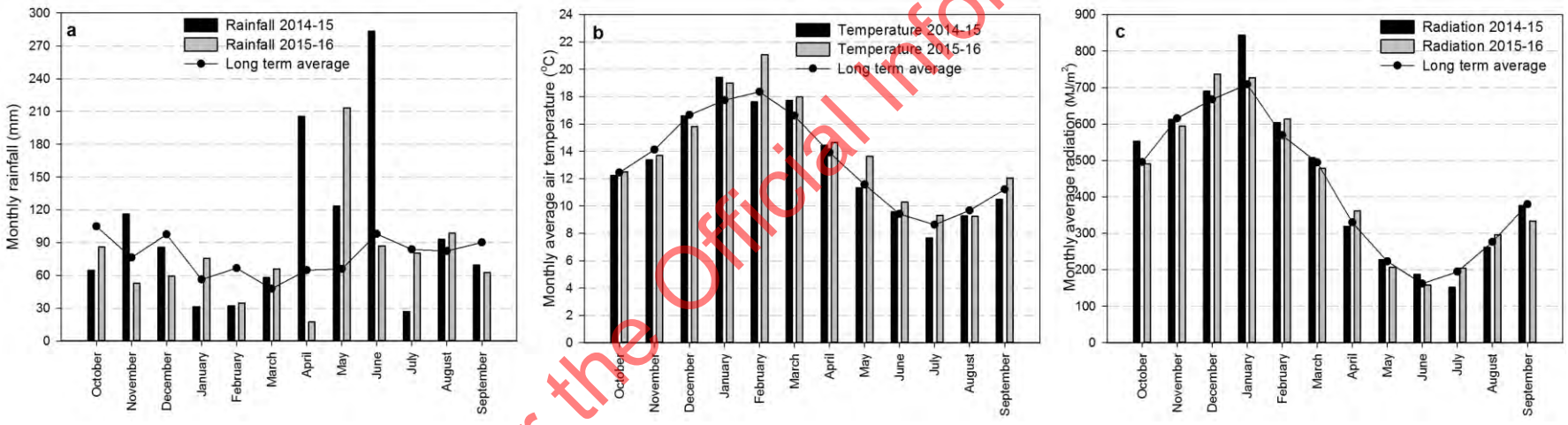

Figure 24. Monthly (a) rainfall (mm), (b) average air temperature (°C) and average solar radiation (MJ/m^2) for 1 October 2014 to 30 September 2016 at Palmerston North (NIWA Station 3243). Long-term climate data (2001–14) are presented for the Palmerston North station.

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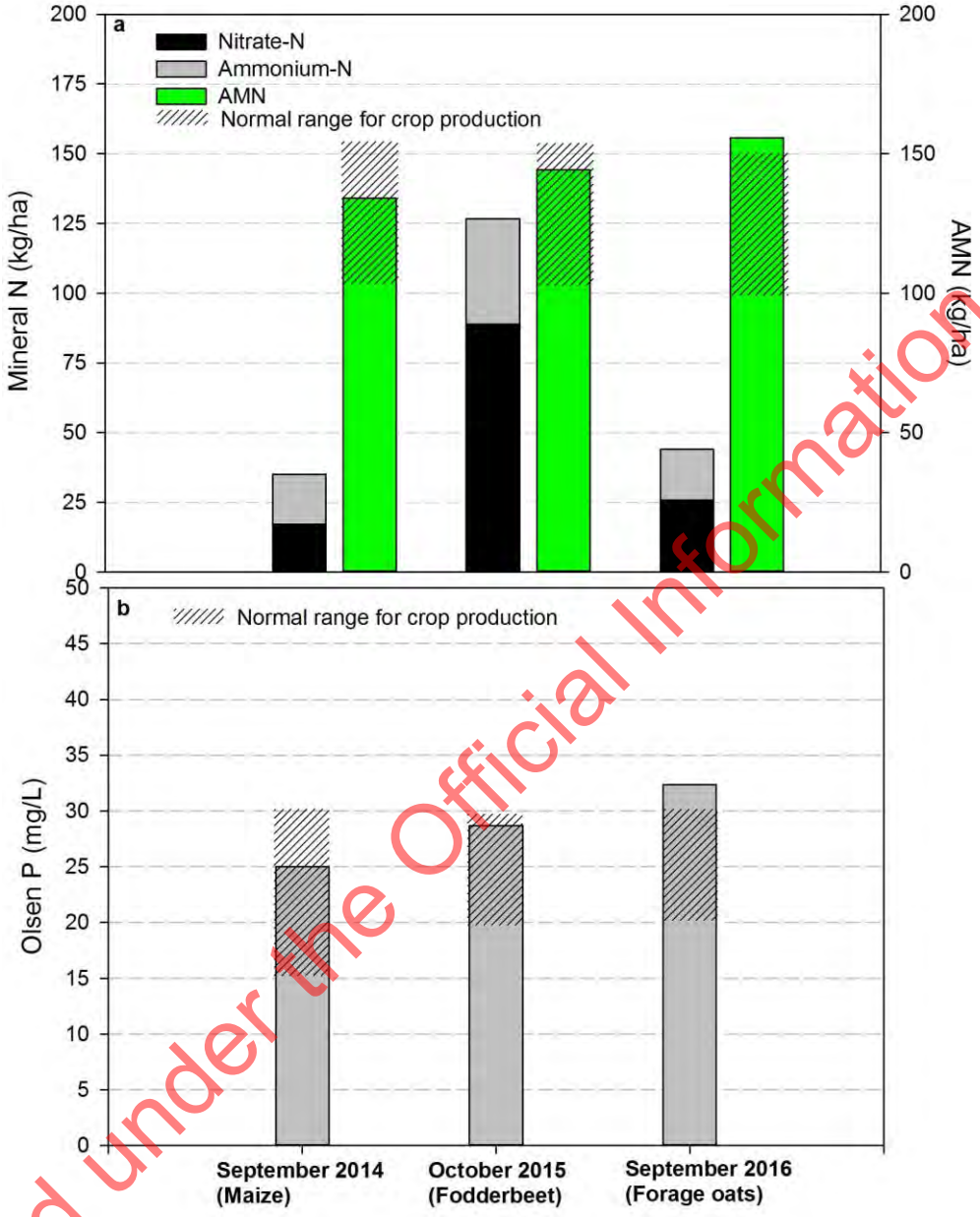

Figure 25. Soil mineral N and AMN (0–100 cm depth) (a) and Olsen P (0–20 cm depth) (b) at Site 5 — Manawatu for samples taken in September 2014, October 2015 and September 2016. Normal ranges suggested for crop production are provided by Hill Laboratories (http://www.hill-laboratories.com/page/pageid/2145845703/Crop_Guides).

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3.5.4 Soil water balance

Year 1 (1 October 2014 to 30 September 2015)

The soil water balance for Site 5 is shown in Figure 26. Rainfall and irrigation for the Year 1 period totalled 1189 mm and 368 mm respectively. The mid-autumn through to early winter period (April to August 2015) was particularly wet and there were a number of significant rainfall events including 153 mm over 7 days in early April, 96 mm over 5 days in mid-May and 163 mm over 2 days in mid-June. The range in individual irrigation application volumes was 5 to 7.5 mm.

Modelled soil water contents for all depths remained elevated for the duration of the monitoring period (> 110 mm). This was consistent with drainage sample collection which occurred on a regular basis throughout the year (seven in total).

Year 2 (1 October 2015 to 30 September 2016)

Rainfall and irrigation for the Year 2 period totalled 933 mm and 410 mm respectively. Rainfall occurred on a consistent basis through this period, however the late-autumn through to early spring period (May to September 2015) was particularly wet and there were a number of significant rainfall events including 54 mm in 1 day in early May, 91 mm over 8 days in late May and 46 mm over 2 days in late August. Irrigation was applied on a daily basis between late December and mid-March at 5 mm per application.

As in Year 1, modelled soil water contents remained elevated for the duration of the monitoring period (> 100 mm) and were consistent with regular rainfall and irrigation inputs. Drainage samples (ten in total) were collected on a regular basis throughout the year.

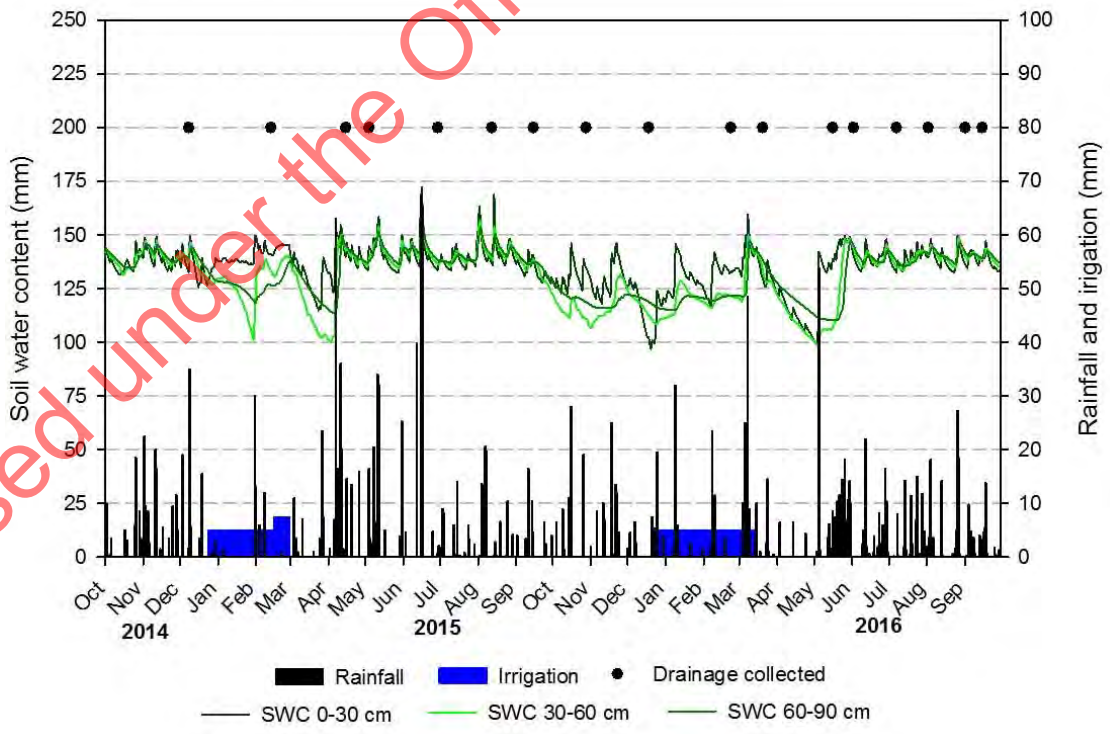

Figure 26. Summary of daily rainfall, irrigation and modelled soil water content (0–30 cm, 30–60 cm and 60–90 cm) from 1 October 2014, Site 5 — Manawatu. Fluxmeter units were installed on 29 September 2014.

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3.5.5 Losses of N and P in drainage water

Year 1 (1 October 2014 to 30 September 2015)

Drainage samples were collected on seven occasions in the first year following installation of the fluxmeters. Total drainage volume was 611 mm (Figure 27b).

Nitrate-N and ammonium-N concentrations in drainage for this period averaged 33.7 mg/L and 1.0 mg/L respectively (Figure 27b). Nitrate-N concentrations peaked at 80.1 mg/L in mid-February 2015 before decreasing steadily over the autumn to spring period while ammonium-N concentrations remained low for the duration of Year 1 (< 1.2 mg/L). Measured mineral N losses from the system totalled 226 kg N/ha (Figure 27c) with the majority of N lost as nitrate-N (223 kg N/ha). Increased mineral N losses between May and September 2015 reflected the combination of elevated nitrate-N concentrations in drainage and high drainage volumes.

Total P and DRP concentrations averaged 0.14 mg/L and 0.12 mg/L respectively (Figure 28b). Measured P losses from the system were low, totalling 0.49 kg P/ha with DRP loss accounting for 0.45 kg P/ha (Figure 28c).

Year 2 (1 October 2015 to 30 September 2016)

Drainage samples were collected on ten occasions in the second year following installation of the fluxmeters. Total drainage volume was 411 mm (Figure 27b).

Nitrate-N and ammonium-N concentrations in drainage for this period averaged 27.6 mg/L and 0.02 mg/L respectively (Figure 27b). Measured mineral N losses from the system totalled 75 kg N/ha (Figure 27c) with N lost almost entirely as nitrate-N. While still relatively high, mineral N losses were considerably lower than those observed over the Year 1 monitoring period (226 kg N/ha). As in Year 1, drainage nitrate-N concentrations peaked in mid-February (70.1 mg/l) before decreasing over the winter through to spring period (June to September). High nitrate concentrations over the late summer and early autumn period were consistent with a number of site and management factors including 1) the location of the experimental site on a free draining soil type, 2) increased fertiliser N inputs over the late spring to early summer period and 3) the application of regular irrigation over the summer months which likely maintained soil moisture levels close to field capacity (Figure 26).

Total P and DRP concentrations over this period remained low and averaged 0.06 mg/L and 0.06 mg/L respectively (Figure 28b). Measured P losses from the system were minimal (0.20 kg P/ha; Figure 28c).

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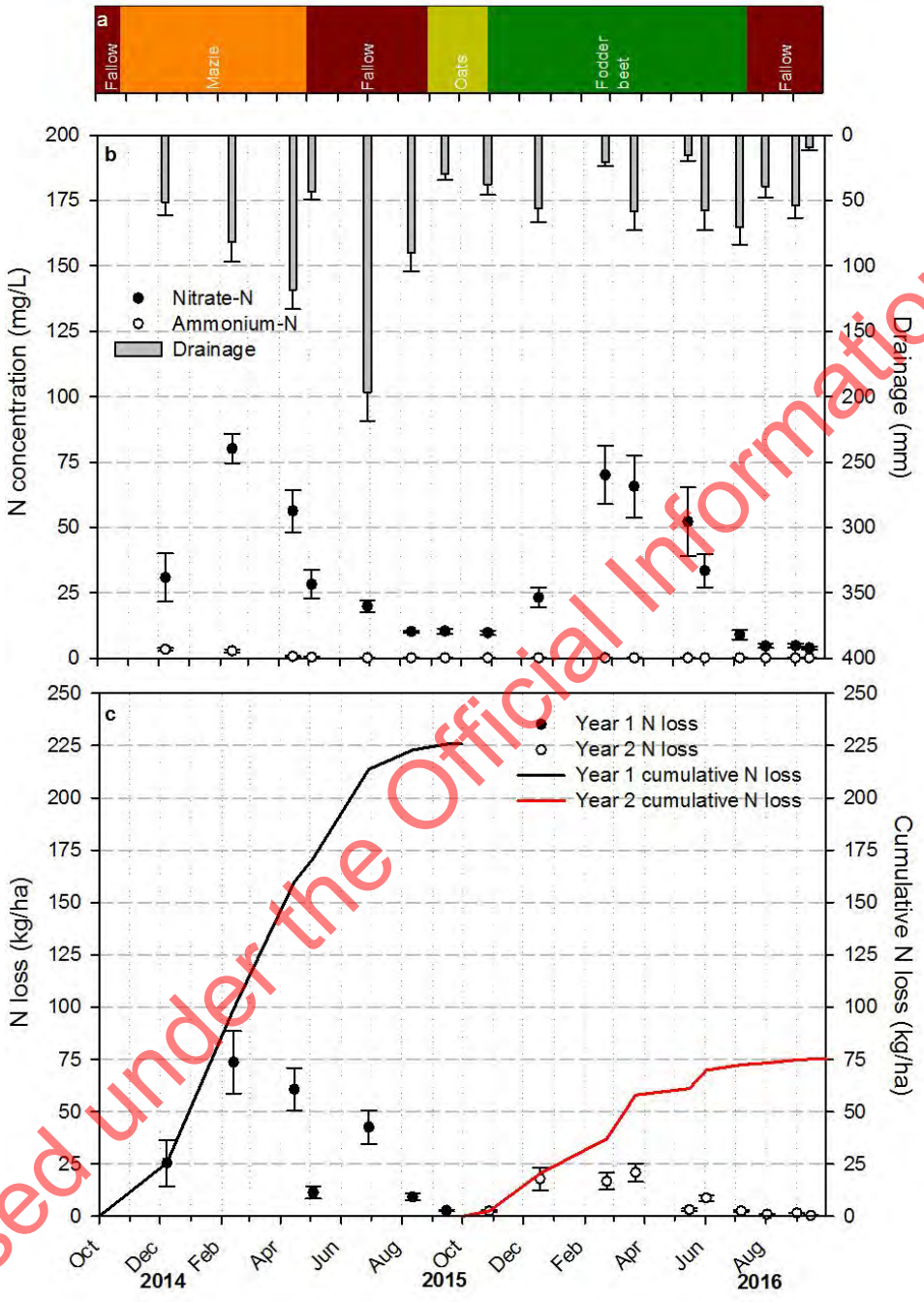

Figure 27. Summary of crop sequence (a), measured drainage and inorganic N concentrations (nitrate-N and ammonium-N) in drainage (b) and measured system losses of inorganic N in drainage for Year 1 (1 October 2014 to 30 September 2015) and for Year 2 (1 October 2015 to 30 September 2016) (c) Site 5 — Manawatu. Mean drainage is calculated from the volume of leachate collected at each sampling event, corrected for the surface area of the fluxmeters. Bars around each point represent the standard error of the mean. Lower limit of detections: nitrate-N: 0.02 mg/L; ammonium-N: 0.01 mg/L. Fluxmeters were installed on 29 September 2014.

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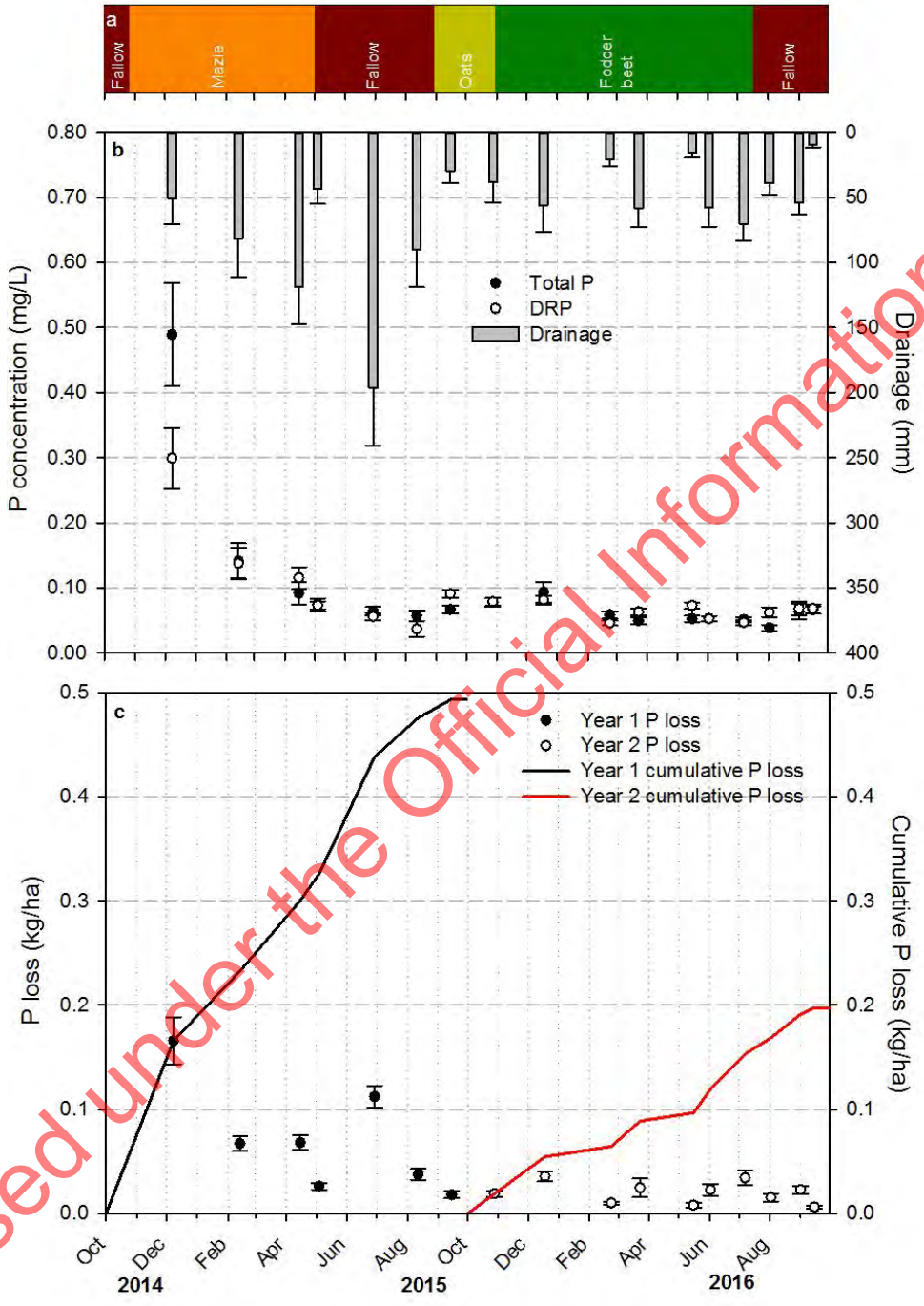

Figure 28. Summary of crop sequence (a), measured drainage and P concentrations (total P and DRP) in drainage (b) and measured system losses of total P in drainage for Year 1 (1 October 2014 to 30 September 2015) and for Year 2 (1 October 2015 to 30 September 2016) (c) Site 5 — Manawatu. Mean drainage is calculated from the volume of leachate collected at each sampling event, corrected for the surface area of the fluxmeters. Bars around each point represent the standard error of the mean. Lower limit of detections: Total P: 0.02 mg/L; DRP: 0.001 mg/L. Fluxmeters were installed on 29 September 2014.

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3.6 Site 6 — Manawatu

3.6.1 Background site and crop management history

Site 6 is located near Ohakune on a mixed cropping enterprise. Soil type is an Ohakune brown loam. Fluxmeters were installed at the site in April 2015. Key site characteristics are described in Table 12.

Table 12. Summary of key farm and site characteristics, Site 6 — Manawatu.

Location	Ohakune
Farming system	Mixed cropping
Topography	Flat
Soil type	Ohakune brown loam
Key soil characteristics[1]	Soil order: Typic orthic allophanic Texture: Silt loam Topsoil bulk density: 0.85 g/cm^3 Subsoil bulk density: 0.90 g/cm^3 Drainage class: Information not yet available N leaching vulnerability: Information not yet available
Previous land use history	Converted from pasture to mixed cropping in 2008.
Fluxmeter installation date	20 April 2015
Irrigation infrastructure	Travelling irrigator

[1]No description of the Ohakune brown loam is available online.

Since installation of the units there have been two crops of winter wheat. The first wheat crop was sown in May 2015 and harvested in February 2016. The site remained fallow until June 2016 when the current winter wheat crop was sown. Respective N and P inputs have totalled 69 kg N/ha and 0 kg P/ha (2015 wheat) and 0 kg N/ha and 20 kg P/ha (2016 wheat) (Table 13).

Table 13. Summary of crop management practices since fluxmeter installation (20 April 2015), Site 6 — Manawatu.

Crop management practices	Sequence 1 – Winter wheat	Sequence 2 – Winter wheat
Variety	'Wakanui'	'Wakanui'
Planting population	120 kg seed/ha	120 kg seed/ha
Planting date	6 May 2015	10 June 2016
Harvest date[1]	25 February 2016	Current crop
Cultivation practices	Disc followed by power harrow	Disc followed by power harrow
Fertiliser practices (product)[2]	150 kg N/ha Urea (S)	300 kg/ha MOP (P) 220 kg/ha Super10 (P)
Summed N and P (elemental)	N = 69 kg/ha P = 0 kg/ha	N = 0 kg/ha P = 20 kg/ha
Stock type	No stock	No stock
Stock density	-	-
Additional stock information	-	-

[1]Commercial harvest date. [2]B = base application, P = planting application, S= side dressing application(s).

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3.6.2 General weather conditions

Year 1 (1 October 2014 to 30 September 2015)

Rainfall for the Year 1 period was 1401 mm, 8% above the long-term average for the region (1300 mm) (Figure 29a). The mid-autumn to early winter period (1 April to 30 June 2015) was particularly wet with close to two times the rainfall (572 mm) compared to the long-term average for the same period (304 mm).

Mean air temperature for the 12 month period was 10.1°C, cooler than the long-term average (11.0°C) (Figure 29b) while solar radiation totalled 4970 MJ/m^2, slightly less than the long-term average of 5330 MJ/m^2 (Figure 29c).

Year 2 (1 October 2015 to 30 September 2016)

Rainfall and mean air temperature for the Year 2 period was 1222 mm and 11.0°C, comparable to respective long-term averages for the region (Figure 29a and b). Most rainfall occurred between May and September 2016 (768 mm). Solar radiation for this period totalled 4912 MJ/m^2, lower than the long-term average (Figure 29c).

3.1.1 Soil nitrogen and phosphorus fertility levels

Soil samples for N and P fertility analyses were taken during installation of the fluxmeters in April 2015 and prior to sowing of the current wheat crop in June 2016.

Mineral N (0–100 cm)

Samples taken in April 2015 and June 2016 had high concentrations of mineral N (284 and 167 kg N/ha respectively) with the majority of this N present in the nitrate-N form (85–94%) (Figure 30a).

AMN (0–100 cm)

AMN concentrations were moderate (133 kg N/ha) and high (287 kg N/ha) for respective April 2015 and June 2016, within or above the normal concentrations suggested for wheat production (100–150 kg N/ha; Figure 30a).

Olsen P (0–20 cm)

Olsen P concentrations were moderate (24–26 mg/L, 0–20 cm depth) for both sampling occasions and within the normal concentrations suggested for wheat production (20–30 mg/L) (Figure 30b).

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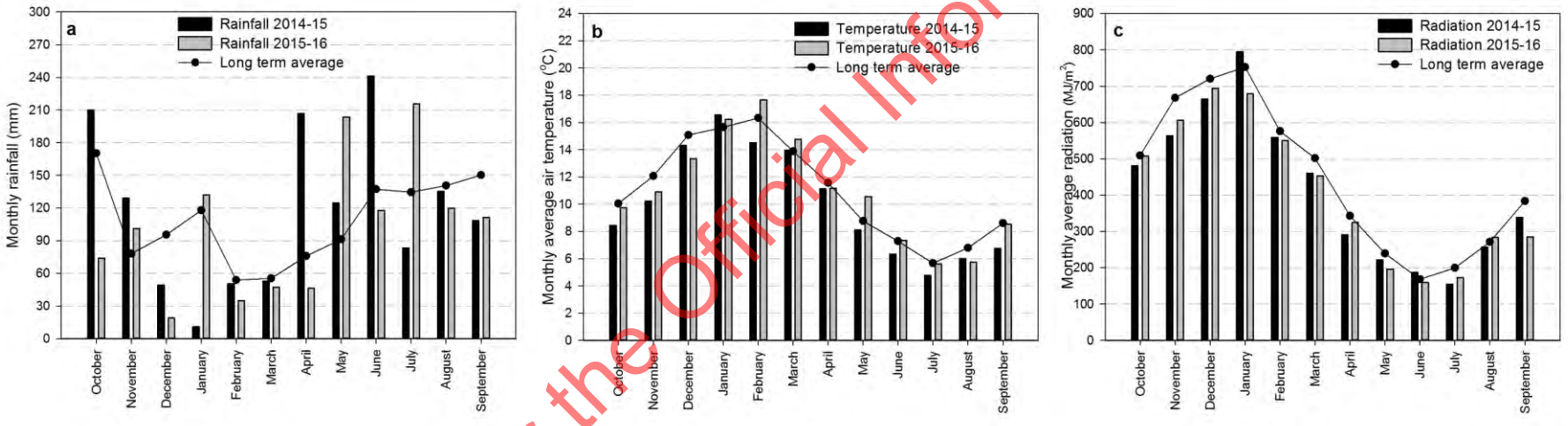

Figure 29. Monthly (a) rainfall (mm), (b) average air temperature (°C) and average solar radiation (MJ/m^2) for 1 October 2014 to 30 September 2016 at Ohakune (rainfall and temperature: NIWA Station 31624) and Mount Ruapehu (radiation; NIWA Station 18464). Long-term climate data (2008–14) presented are for the Ohakune station.

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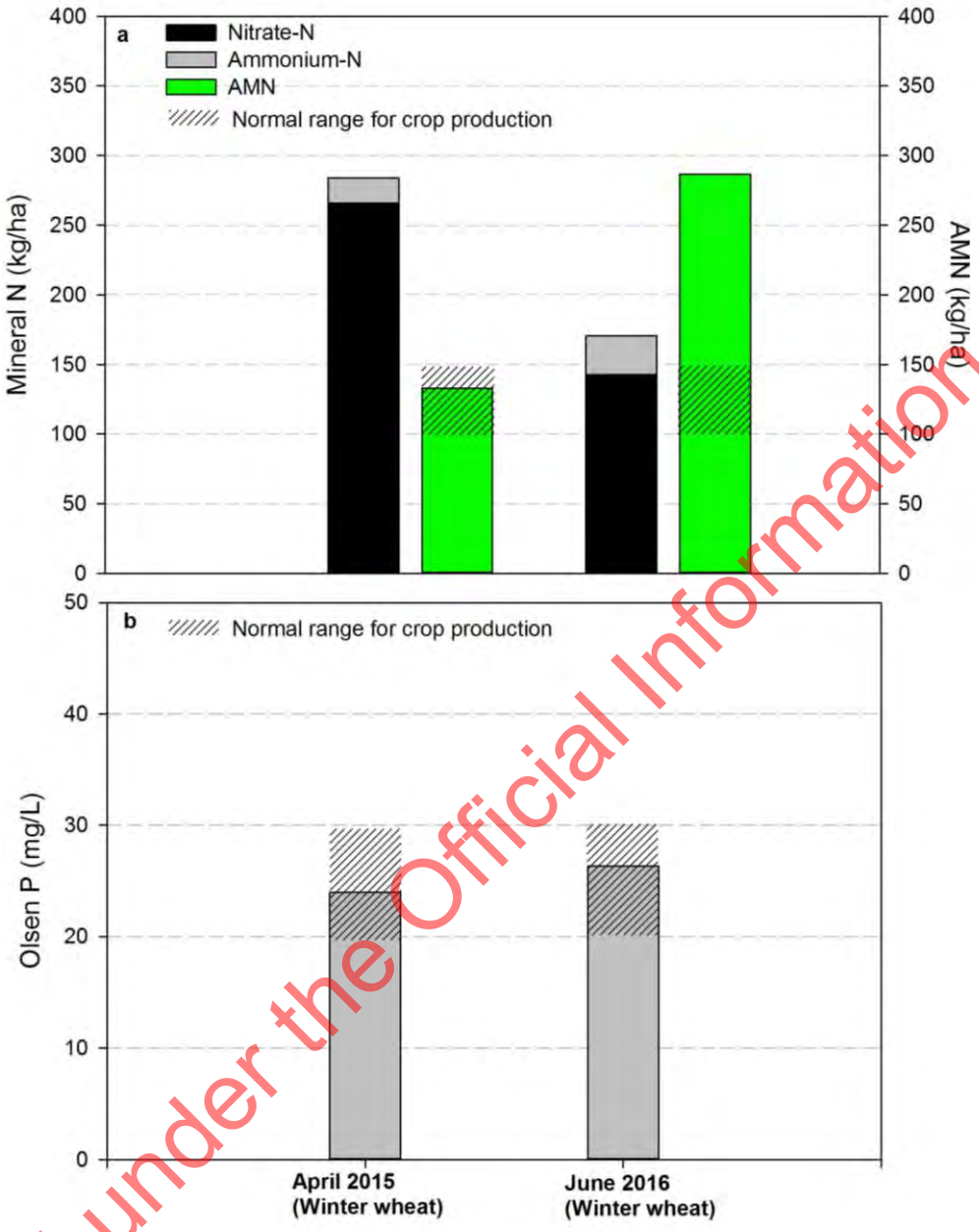

Figure 30. Soil mineral N and AMN (0–100 cm depth) (a) and Olsen P (0–20 cm depth) (b) at Site 6 — Manawatu for samples taken in April 2015 and June 2016. Normal ranges suggested for crop production are provided by Hill Laboratories (http://www.hill-laboratories.com/page/pageid/2145845703/Crop_Guides).

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3.6.3 Soil water balance

Year 1 (1 October 2014 to 30 September 2015)

The soil water balance for Site 6 is shown in Figure 31. Rainfall and irrigation for the Year 1 period totalled 1401 mm and 0 mm respectively. There was frequent and often heavy rainfall over the mid-autumn through to early spring period (April 2015 to September 2015) and consequently modelled soil water contents for all depths remained high over this period (> 110 mm). There were a number of significant rainfall events including 138 mm over 7 days in early April 2015 and 100 mm over 2 days in mid-June 2015. Drainage collection commenced in July 2015.

Year 2 (1 October 2015 to 30 September 2016)

Rainfall and irrigation for the Year 2 period totalled 1222 mm and 0 mm respectively. Rainfall occurred at regular intervals over the monitoring period, however the late autumn and winter period (May to August 2016) was especially wet with prolonged periods of rainfall including 103 mm over 7 days in late May, 85 mm over 8 days in late June and 141 mm over 9 days in late August (Figure 31).

Modelled soil water contents followed a similar trend to Year 1, decreasing over the summer period and early autumn period (in response to less rainfall and crop water use) before increasing to high levels (> 110 mm) over the winter to early spring period. There were six drainage collections, three between early November 2015 and late February 2016 and three between mid-June and mid-September 2016.

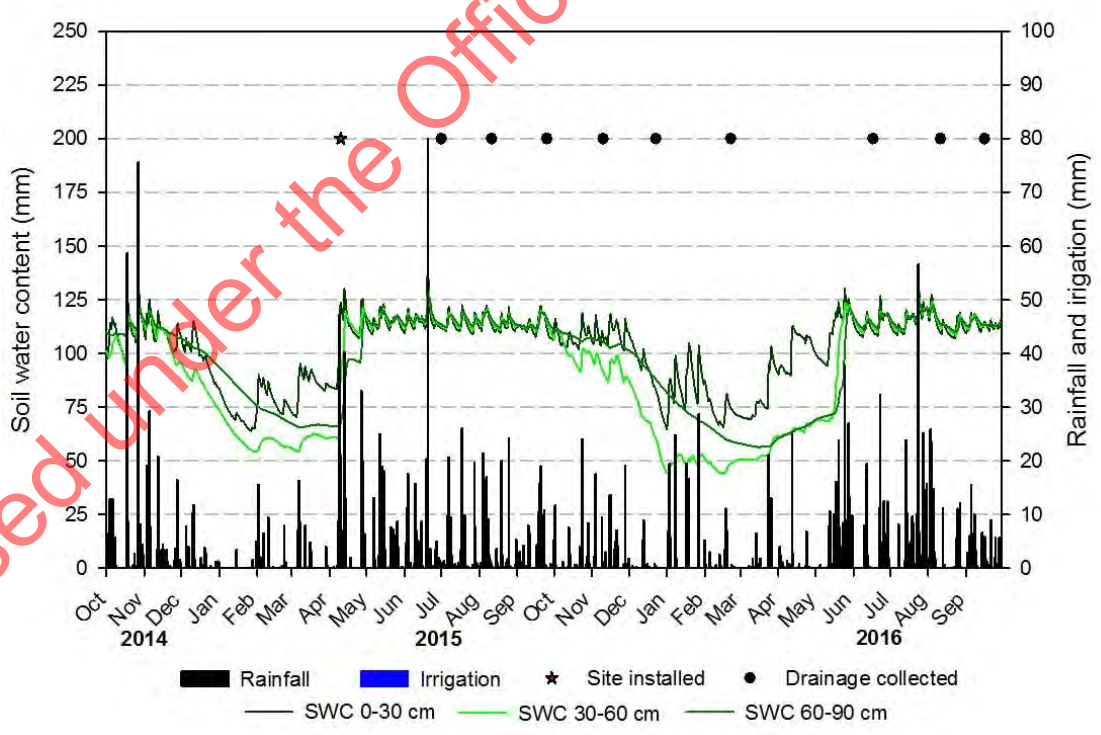

Figure 31. Summary of daily rainfall, irrigation and modelled soil water content (0–30 cm, 30–60 cm and 60–90 cm) from 1 October 2014, Site 6 — Manawatu.

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3.6.4 Losses of N and P in drainage water

Year 1 (1 October 2014 to 30 September 2015)

Drainage samples were collected on three occasions in the first year following installation of the fluxmeters. Total drainage volume was 196 mm (Figure 32b).

Nitrate-N and ammonium-N concentrations in drainage for this period averaged 17.5 mg/L and 0.7 mg/L respectively (Figure 32b). Nitrate-N concentrations increased from 12 mg/L in July to around 20 mg/L in August and September. Ammonium-N concentrations remained low for the duration of winter drainage period (< 0.8 mg/L). Measured mineral N losses from the system totalled 38 kg N/ha (Figure 32c) with the majority of N lost as nitrate-N (37 kg N/ha).

Total P and DRP concentrations averaged 0.11 mg/L and 0.09 mg/L respectively (Figure 33b). Measured P losses from the system were low, totalling 0.21 kg P/ha with DRP loss accounting for 0.19 kg P/ha (Figure 33c).

Year 2 (1 October 2015 to 30 September 2016)

Drainage samples were collected on six occasions in the second year following installation of the fluxmeters. Total drainage volume was 228 mm (Figure 32b).

Nitrate-N and ammonium-N concentrations in drainage for this period averaged 8.3 mg/L and 0.3 mg/L respectively (Figure 32b). Measured mineral N losses from the system totalled 16 kg N/ha (Figure 32c) and were lower than those observed in Year 1 (38 kg N/ha), reflecting lower nitrate-N concentrations in drainage over the Year 2 monitoring period. Nitrogen was lost almost entirely as nitrate-N.

Total P and DRP concentrations over this period remained low, averaging 0.03 mg/L and 0.03 mg/L respectively (Figure 33b). Measured P losses from the system were minimal (0.06 kg P/ha; Figure 33c).

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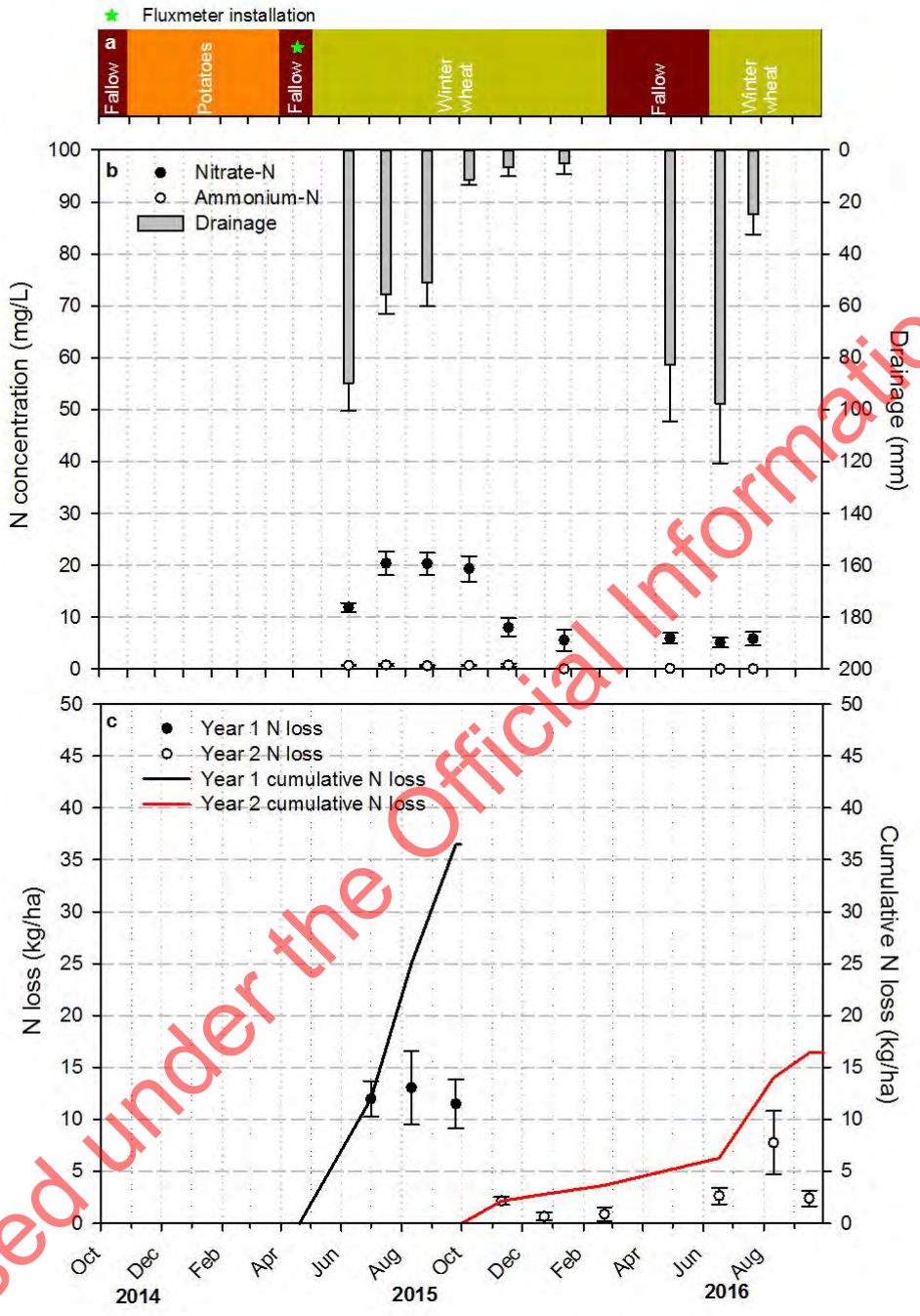

Figure 32. Summary of crop sequence (a), measured drainage and inorganic N concentrations (nitrate-N and ammonium-N) in drainage (b) and measured system losses of inorganic N in drainage for Year 1 (1 October 2014 to 30 September 2015) and for Year 2 (1 October 2015 to 30 September 2016) (c) Site 6 — Manawatu. Mean drainage is calculated from the volume of leachate collected at each sampling event, corrected for the surface area of the fluxmeters. Bars around each point represent the standard error of the mean. Lower limit of detections: nitrate-N: 0.02 mg/L; ammonium-N: 0.01 mg/L.

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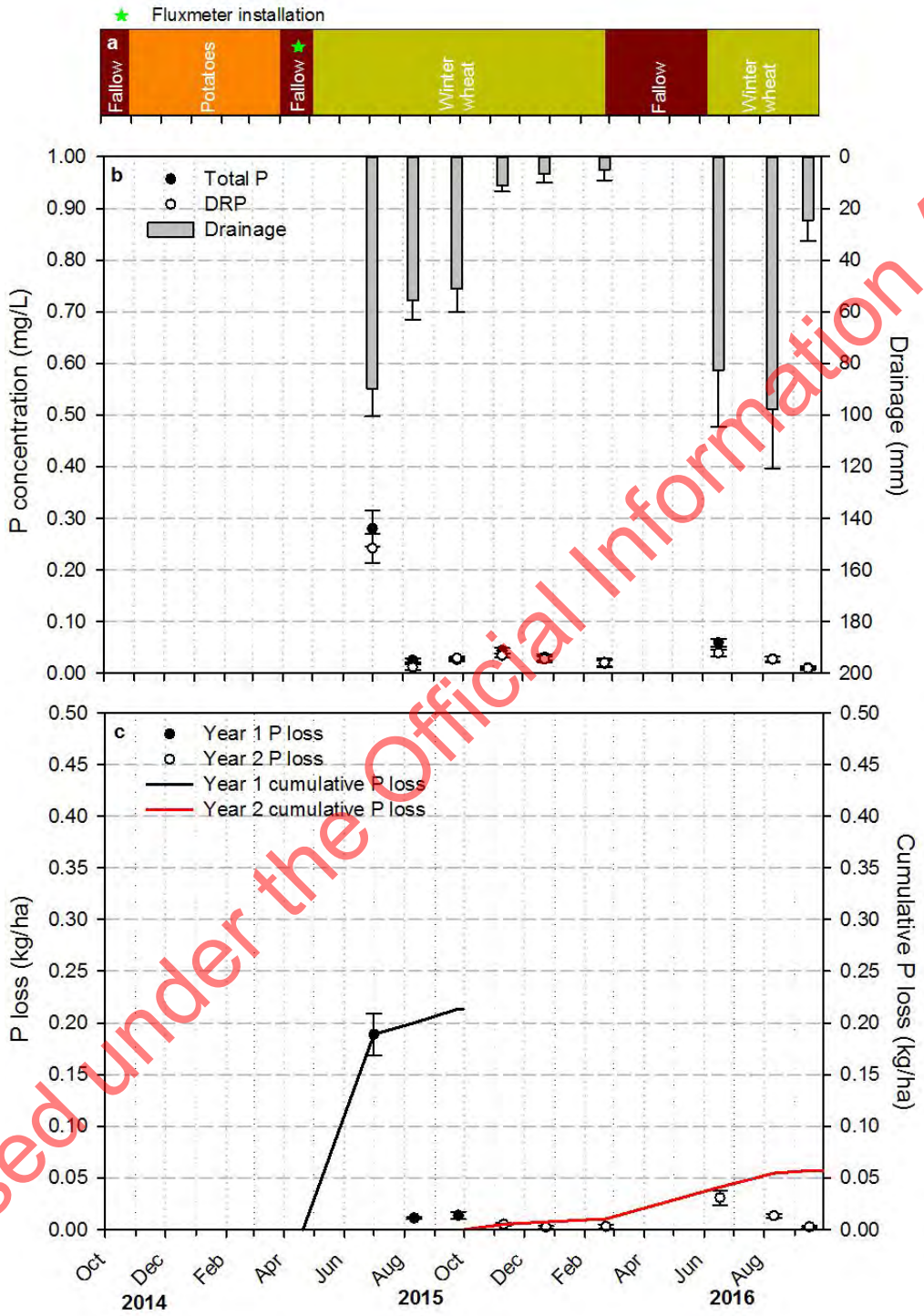

Figure 33. Summary of crop sequence (a), measured drainage and P concentrations (total P and DRP) in drainage (b) and measured system losses of total P in drainage for Year 1 (1 October 2014 to 30 September 2015) and for Year 2 (1 October 2015 to 30 September 2016) (c) Site 6 — Manawatu. Mean drainage is calculated from the volume of leachate collected at each sampling event, corrected for the surface area of the fluxmeters. Bars around each point represent the standard error of the mean. Lower limit of detections: Total P: 0.02 mg/L; DRP: 0.001 mg/L.

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3.7 Site 7 — Hawke's Bay

3.7.1 Background site and crop management history

Site 7 is located near Otane on a mixed cropping and livestock grazing enterprise. Soil type is a Waimakariri silt loam. Fluxmeters were installed at the site in September 2014. Key site characteristics are described in Table 14.

Table 14. Summary of key farm and site characteristics, Site 7 — Hawke's Bay.

Location	Otane
Farming system	Mixed cropping, livestock grazing
Topography	Flat
Soil type	Waimakariri silt loam
Key soil characteristics[1]	Soil order: Weathered fluvial recent Texture: Silt loam over sandy loam Topsoil bulk density: 1.09 g/cm^3 Subsoil bulk density: 1.30 g/cm^3 Drainage class: Well drained N leaching vulnerability: Low
Previous land use history	Intensive cropping for past 10 years
Fluxmeter installation date	8 September 2014
Irrigation infrastructure	Centre pivot

[1]A full description of the Waimakariri silt loam is available online at https://smap.landcareresearch.co.nz/home. Listed characteristics are taken from S-MAP factsheets and are not based on measured site values.

Since installation of the units there have been four crops including carrots, two Italian ryegrass crops and peas (Table 15). Carrots were sown in September 2014 and harvested in January 2015. The site was then planted with Italian ryegrass in February 2015 for autumn and winter grazing before being direct drilled with peas in October 2015. The pea crop was harvested in January 2016 and the site subsequently planted with Italian ryegrass for autumn and winter grazing. The site is due to be planted to peas in mid-October. Respective N and P inputs have totalled 40 kg N/ha and 40 kg P/ha (carrots), 55 kg N/ha and 0 kg P/ha (ryegrass 2015), 0 kg N/ha and 32 kg P/ha (peas) and 169 kg N/ha and 0 kg P/ha (ryegrass 2016) (Table 15).

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Table 15. Summary of crop management practices since fluxmeter installation (8 September 2014), Site 7 — Hawke's Bay.

Crop management practices	Sequence 1 — Carrots	Sequence 2 — Italian ryegrass	Sequence 3 — Peas	Sequence 4 — Italian ryegrass
Variety	'Nando'	'Moata'	'Ashton'	'Moata'
Planting population	5 kg/ha	28 kg/ha	214 kg seed/ha	25 kg/ha
Planting date	26 September 2014	28 February 2015	25 October 2015	22 January 2016
Harvest date[1]	22 January 2015	15 September 2015[2]	8 January 2016	20 September 2016[2]
Cultivation practices	Deep ripping followed by rotary hoe and bed formation	Levelled followed by speed disking	Disked and rolled followed by direct drill	Levelled followed by speed disking
Fertiliser practices (product)[3]	250 kg/ha Yaramila 16 (P)	120 kg/ha Urea (S)[4]	350 kg/ha Super ten with 15% boron (B)	367 kg/ha Urea (S)[5]
Summed N and P (elemental)	N = 40 kg/ha P = 40 kg/ha	N = 55 kg/ha P = 0 kg/ha	N = 0 kg/ha P = 32 kg/ha	N = 169 kg/ha P = 0 kg/ha
Stock type	No stock	Grazing lambs	No stock	Grazing lambs
Stock density	-	20 sheep/ha	-	20 sheep/ha
Additional stock information	-	Mid-April to September	-	Mid-April to September

[1]Commercial harvest date. [2]Reflects the date the ryegrass was sprayed off. [3]B = base application, P = planting application, S= side dressing application(s). [4]Applied as a single application in early April. [5]Applied in early April (217 kg/ha) and mid-August (150 kg/ha)

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3.7.2 General weather conditions

Year 1 (1 October 2014 to 30 September 2015)

Rainfall and mean air temperature for the Year 1 period was 661 mm, 14% below than the long-term average for the region (765 mm) (Figure 34a). Rainfall for the winter to early spring period (June to September 2015) was 309 mm, comparable with the long-term average for this period (333 mm).

Average air temperature for the 12 month period was12.2°C, cooler than the long-term average for the region (12.6°C) (Figure 34b) while solar radiation totalled 5658 MJ/m^2, slightly higher than the long-term average of 5366 MJ/m^2 (Figure 34c).

Year 2 (1 October 2015 to 30 September 2016)

Rainfall for the Year 2 period was 573 mm, 25% below the long-term average for the region. The period between February and July was particularly dry with 56% less rainfall recorded compared to the long-term average (444 mm).

Average air temperature for the 12 month period was 13.8°C, warmer than the long-term average while solar radiation totalled 5368 MJ/m^2, comparable to the long-term average for the region.

3.7.3 Soil nitrogen and phosphorus fertility levels

Soil samples for N and P fertility analyses were taken during installation of the fluxmeters in September 2014 and prior to establishment of crops in February 2015 (ryegrass), September 2015 (peas), February 2016 (ryegrass) and September 2016 (peas).

Mineral N (0–100 cm)

Samples taken in September 2014, February 2015 and February 2016 had moderate concentrations of mineral N (101–129 kg N/ha) with the majority of N present as nitrate-N (80–82%). In contrast mineral N concentrations were low for samples taken in September 2015 and September 2016 (35–41 kg N/ha) with the a greater proportion of this N present as ammonium-N (51–72%) (Figure 35a).

AMN (0–100 cm)

AMN concentrations were generally low for all sampling occasions (57–101 kg N/ha) and below normal concentrations suggested for carrot and ryegrass production (100–150 kg N/ha; Figure 35a).

Olsen P (0–20 cm)

Olsen P concentrations were moderate for all sampling occasions (26–31 mg/L). Concentrations were slightly below normal concentrations suggested for carrot (35–75 mg/L) and pea (30–55 mg/L) production but within normal concentrations suggested for ryegrass production (20–30 mg/L) (Figure 35b).

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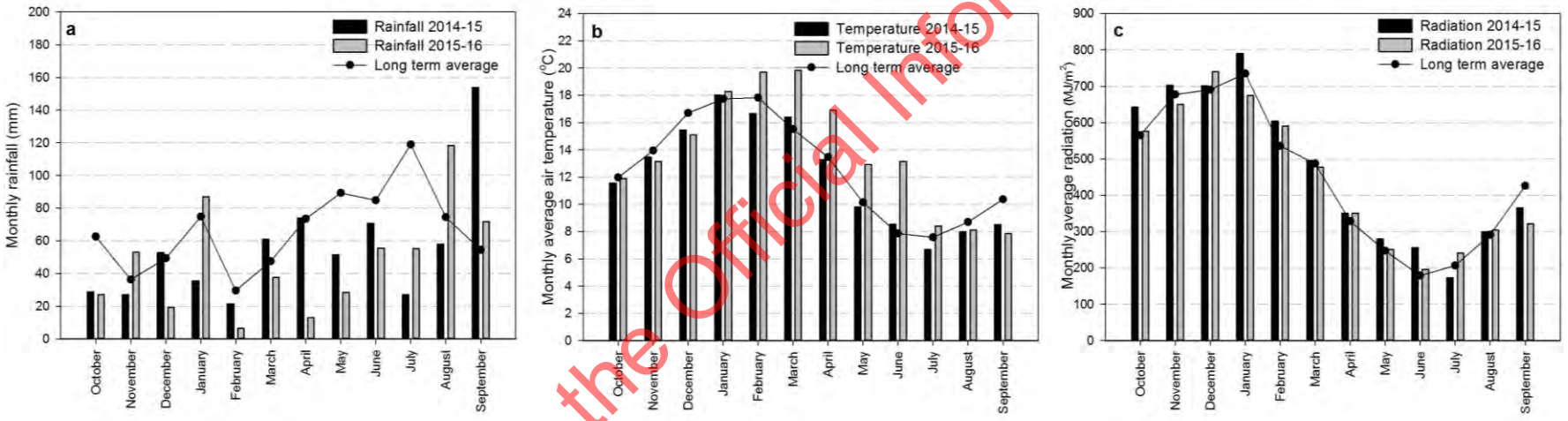

Figure 34. Monthly (a) rainfall (mm), (b) average air temperature (°C) and average solar radiation (MJ/m^2) for 1 October 2014 to 30 September 2016 at Te Aute (rainfall: Hawke's Bay Regional Council Station) and Waipawa (temperature and radiation; NIWA Station 31620). Long-term climate data (2008–14) are presented for the Waipawa station.

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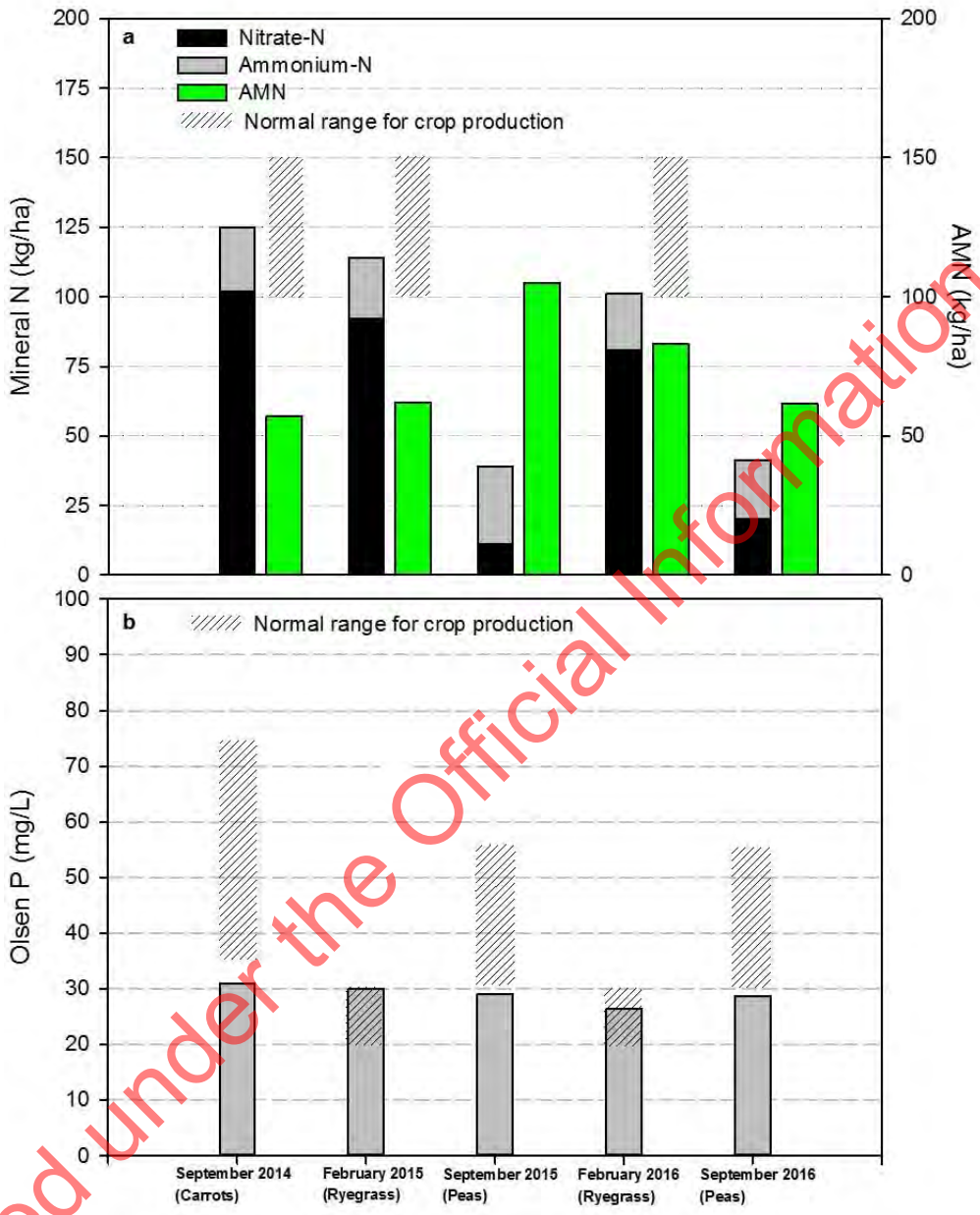

Figure 35. Soil mineral N and AMN (0–100 cm depth) (a) and Olsen P (0–20 cm depth) (b) at Site 7 — Hawke's Bay for samples taken in September 2014, February 2015, September 2015, February 2016 and September 2016. Normal ranges suggested for crop production are provided by Hill Laboratories (http://www.hill-laboratories.com/page/pageid/2145845703/Crop_Guides).

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3.7.4 Soil water balance

Year 1 (1 October 2014 to 30 September 2015)

The soil water balance for Site 7 is shown in Figure 36. Rainfall and irrigation for the Year 1 period totalled 661 mm and 88 mm respectively. There were two rainfall events over 50 mm, one in early April 2015 (53 mm over 4 days) and one in late September (119 mm over 5 days). The range in individual irrigation application volumes was 3 to 20 mm.

Modelled soil water contents tended to decrease over the summer and early autumn period before increasing over the autumn through to early spring period. In general, drainage samples were collected when modelled soil moisture contents increased above 100 mm (Figure 36).

Year 2 (1 October 2015 to 30 September 2016)

Rainfall and irrigation for the Year 2 period totalled 573 mm and 140 mm respectively. The largest rainfall event occurred in early August when 80 mm was recorded over 4 days (Figure 36). Irrigation was applied between late November and early April with application volumes ranging from 10 to 20 mm.

Modelled soil water contents tended to decrease from early December onwards in response to less rainfall and an increase in crop water use. However, in contrast to Year 1, soil water contents remained at low levels through the autumn and early winter period (March to June) before increasing to high levels (> 100 mm) over the late winter and early spring period (August to September). There were five drainage collections, two between early November 2015 and late February 2016 and three between mid-June and mid-September 2016.

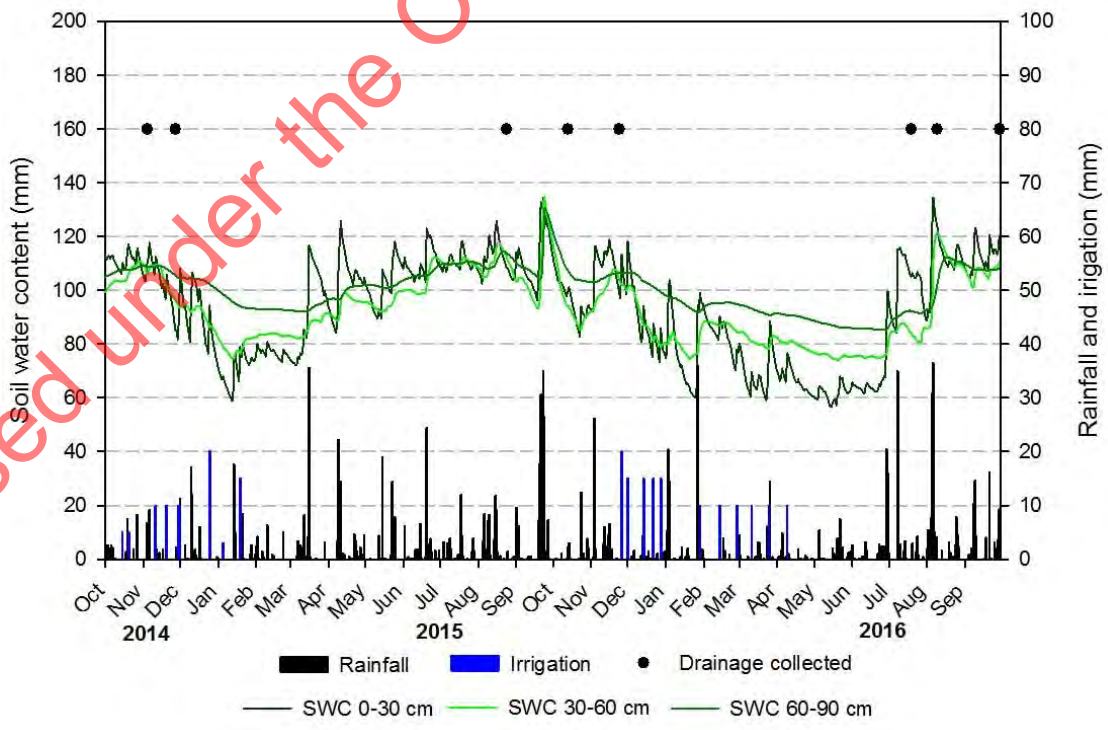

Figure 36. Summary of daily rainfall, irrigation and modelled soil water content (0–30 cm, 30–60 cm and 60–90 cm) from 10 October 2014, Site 7 – Hawke's Bay. Fluxmeters were installed on 8 September 2014.

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3.7.5 Losses of N and P in drainage water

Year 1 (1 October 2014 to 30 September 2015)

Drainage samples were collected on three occasions following installation of the fluxmeters. Total drainage volume was 20 mm (Figure 37b).

Nitrate-N and ammonium-N concentrations in drainage for this period averaged 4.2 mg/L and 1.1 mg/L respectively (Figure 37b). Due to low drainage volumes measured mineral N losses from the system was low totalling 1.7 kg N/ha (Figure 37c), with the majority of this N lost as nitrate-N (1.3 kg N/ha).

Total P and DRP concentrations averaged 0.22 mg/L and 0.14 mg/L respectively (Figure 38b). Measured P losses from the system were minimal (< 0.01 kg P/ha; Figure 38c).

Year 2 (1 October 2015 to 30 September 2016)

Drainage samples were collected on five occasions in the second year following installation of the fluxmeters. Total drainage volume of 21 mm (Figure 37b).

Nitrate-N and ammonium-N concentrations in drainage for this period averaged 12.3 mg/L and 0.2 mg/L respectively (Figure 37b) while respective total P and DRP concentrations averaged 0.38 mg/L and 0.37 mg/L respectively. As in Year 1, low drainage volumes meant that mineral N and total P losses were low (1.7 kg N/ha and 0.06 kg P/ha; Figures 37c and 38c respectively).

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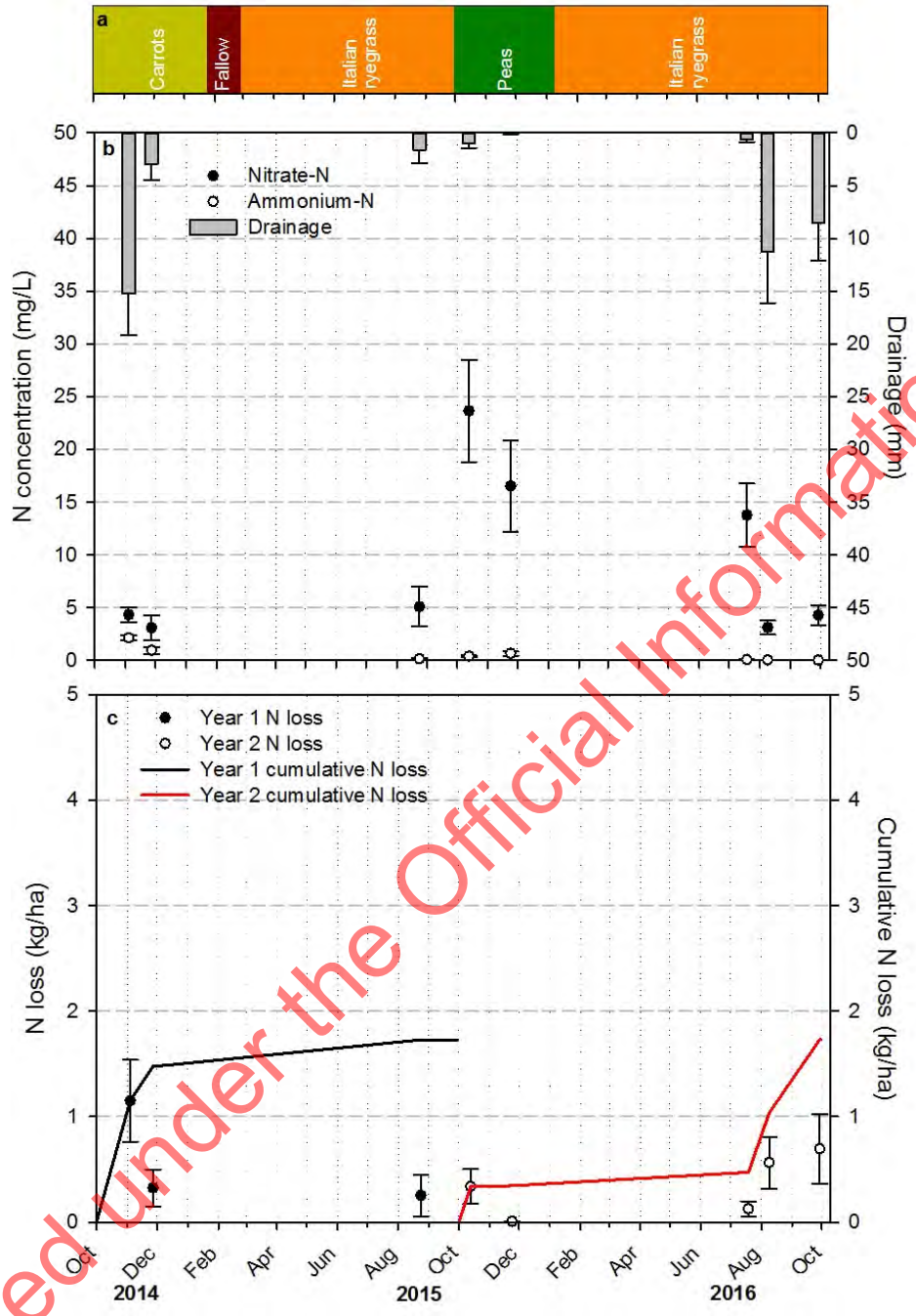

Figure 37. Summary of crop sequence (a), measured drainage and inorganic N concentrations (nitrate-N and ammonium-N) in drainage (b) and measured system losses of inorganic N in drainage for Year 1 (1 October 2014 to 30 September 2015) and for Year 2 (1 October 2015 to 30 September 2016) (c) Site 7 — Hawke's Bay. Mean drainage is calculated from the volume of leachate collected at each sampling event, corrected for the surface area of the fluxmeters. Bars around each point represent the standard error of the mean. Lower limit of detections: nitrate-N: 0.02 mg/L; ammonium-N: 0.01 mg/L. Fluxmeters were installed on 8 September 2014.

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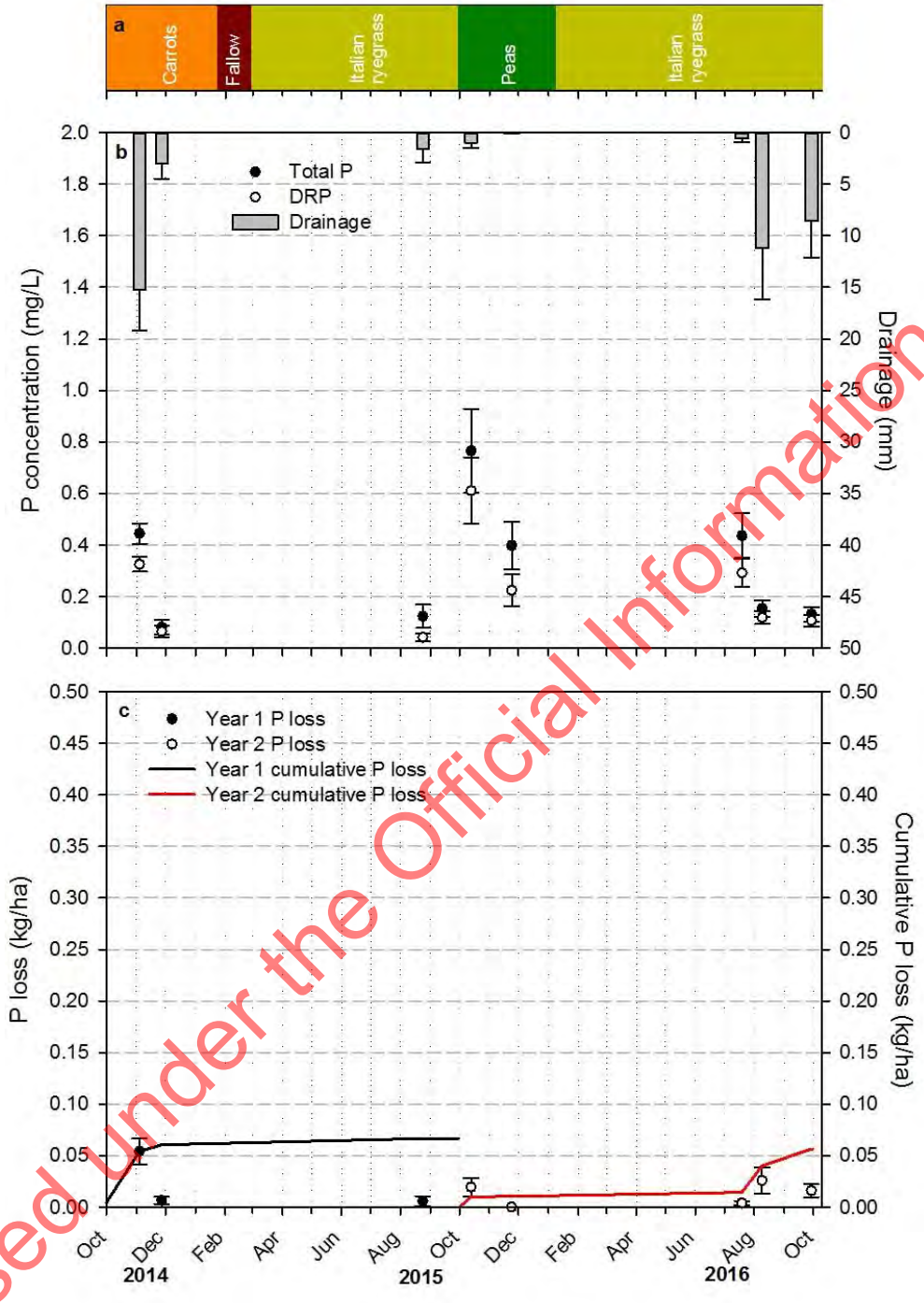

Figure 38. Summary of crop sequence (a), measured drainage and P concentrations (total P and DRP) in drainage (b) and measured system losses of total P in drainage for Year 1 (1 October 2014 to 30 September 2015) and for Year 2 (1 October 2015 to 30 September 2016) (c) Site 7 — Hawke's Bay. Mean drainage is calculated from the volume of leachate collected at each sampling event, corrected for the surface area of the fluxmeters. Bars around each point represent the standard error of the mean. Lower limit of detections: Total P: 0.02 mg/L; DRP: 0.001 mg/L. Fluxmeters were installed on 8 September 2014.

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3.8 Site 8 – Hawke's Bay

3.8.1 Background site and crop management history

Site 8 is located near Hastings on a mixed cropping and livestock grazing enterprise. Soil type is a Waimakariri silt loam. Fluxmeters were installed at the site in October 2014. Key site characteristics are described in Table 16.

Table 16. Summary of key farm and site characteristics, Site 8 — Hawke's Bay.

Location	Hastings
Farming system	Mixed cropping, livestock grazing
Topography	Flat
Soil type	Waimakariri silt loam
Key soil characteristics[1]	Soil order: Weathered fluvial recent Texture: Silt loam over sandy loam Topsoil bulk density: 1.09 g/cm^3 Subsoil bulk density: 1.30 g/cm^3 Drainage class: Well drained N leaching vulnerability: Low
Previous land use history	Mixed cropping since 2002 (under orchard prior to 2002)
Fluxmeter installation date	2 October 2014
Irrigation infrastructure	Gun

[1]A full description of the Waimakariri silt loam is available online at https://smap.landcareresearch.co.nz/home. Listed characteristics are taken from S-MAP factsheets and are not based on measured site values.

Since installation of the fluxmeters there have been three crops including sweetcorn, Italian ryegrass and processing tomatoes (Table 17). Sweetcorn was sown in December 2014 and harvested in March 2015. The site was then planted with Italian ryegrass in March 2015 for autumn and winter grazing before being planted with process tomatoes in October 2015. The tomato crop was harvested in March 2016 and the site subsequently sown to Italian ryegrass for autumn and winter grazing. The site is due to be planted to sweetcorn in mid-October. Respective N and P inputs for the sweetcorn, ryegrass (2015), process tomatoes and ryegrass (2016) crops have totalled 308 kg N/ha and 41 kg P/ha (sweetcorn), 0 kg N/ha and 0 kg P/ha (ryegrass 2015), 271 kg N/ha and 85 kg P/ha (process tomatoes) and 0 kg N/ha and 0 kg P/ha (ryegrass 2016) (Table 17).

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Table 17. Summary of crop management practices since fluxmeter installation (2 October 2014), Site 8 — Hawke's Bay.

Crop management practices	Sequence 1 — Sweetcorn	Sequence 2 — Italian ryegrass	Sequence 3 — Process tomatoes	Sequence 4 — Italian ryegrass
Variety	'Punch'	'Tabu'	'H3402'	'Moata'
Planting population	67,000 seeds/ha	30 kg/ha	25,000 plants/ha	30 kg/ha
Planting date	8 December 2014	28 March 2015	27 October 2015	19 March 2016
Harvest date[1]	20 March 2015	30 September 2015[2]	5 March 2016	21 September 2016[2]
Cultivation practices	Disc followed by power harrow	Disc	Plough followed by power harrow and bed formation	Deep rip followed by disc and cultipress
Fertiliser practices (product)[3]	250 kg/ha Cropzeal20 (B)[4] 300 kg/ha Urea (B)[4] 175 kg/ha Cropzeal 16 (P) 200 kg/ha Urea (P)	None applied	300 kg/ha DAP (P) 400 kg/ha SOP (P) 100 kg/ha Yara Mila Faster (P) 200 kg/ha CAN (S) 350 kg/ha Mila complex (S) 125 kg/ha Nitrabor (S) 175 kg/ha KNO_3 (S)	None applied
Summed N and P (elemental)	N = 308 kg/ha P = 41 kg/ha	N = 0 kg/ha P = 0 kg/ha	N = 219 kg/ha P = 85 kg/ha	N = 0 kg/ha P = 0 kg/ha
Stock type	No stock	Sheep	No stock	Sheep
Stock density	-	25 lambs/ha	-	25 lambs/ha
Additional stock information	-	May to September 2015	-	May to September 2016

[1]Commercial harvest date. [2]Reflects the date the ryegrass was sprayed off. [3]B = base application, P = planting application, S= side dressing application(s). [4]Applied at initial planting on 29 October 2014; crop was later re-sown on 8 December 2014 because of poor emergence.

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3.8.2 General weather conditions

Year 1 (1 October 2014 to 30 September 2015)

Rainfall for the Year 1 period was 651 mm, 8% below the long-term average for the region (711 mm) (Figure 39a). Rainfall for the winter to early spring period (1 June to 30 September) was 294 mm, comparable with the long-term average (277 mm).

Average air temperature was 12.6°C, cooler than the long-term average (13.3°C) (Figure 39b) while solar radiation totalled 5844 MJ/m^2 was higher than the long-term average of 5391 MJ/m^2 (Figure 39c).

Year 2 (1 October 2015 to 30 September 2016)

Rainfall for the Year 2 period was 596 mm, 16% below the long-term average for the region. The period between February and July was particularly dry with half the amount of rainfall recorded (204 mm) compared to the long-term average (409 mm).

Average air temperature for the 12 month period was 13.8°C, warmer than the long-term average while solar radiation totalled 5485 MJ/m^2 was comparable to the long-term average for the region.

3.8.3 Soil nitrogen and phosphorus fertility levels

Soil samples for N and P fertility analyses were taken during installation of the fluxmeters in September 2014, April 2015, October 2015, April 2016 and October 2016 prior to establishment of the respective sweetcorn (2015), ryegrass (2015), tomato, ryegrass (2016) and sweetcorn (2016) crops.

Mineral N (0–100 cm)

Mineral N concentrations were moderate for samples taken in September 2014 (126 kg N/ha) and low for samples taken in September 2015 (29 kg N/ha) and September 2016 (34 kg N/ha). In contrast concentrations were high for samples taken at the end of the summer cropping sequences in April 2015 and 2016 (233–363 kg N/ha). Nitrate N was the predominant form of mineral N for all sampling occasions (70–95%).

AMN (0–100 cm)

AMN concentrations remained fairly consistent across the four sampling occasions (88 to 119 kg N/ha), slightly below normal concentrations suggested for sweetcorn and tomato production (100–150 kg N/ha) (Figure 40a).

Olsen P (0–20 cm)

Olsen P concentrations were moderate for all sampling occasions (34 to 40 mg/L). Concentrations were slightly above the normal concentrations suggested for maize (15–30 mg/L) and ryegrass (20–30 mg/L), but below those suggested for tomatoes (70–150 mg/L) (Figure 40b).

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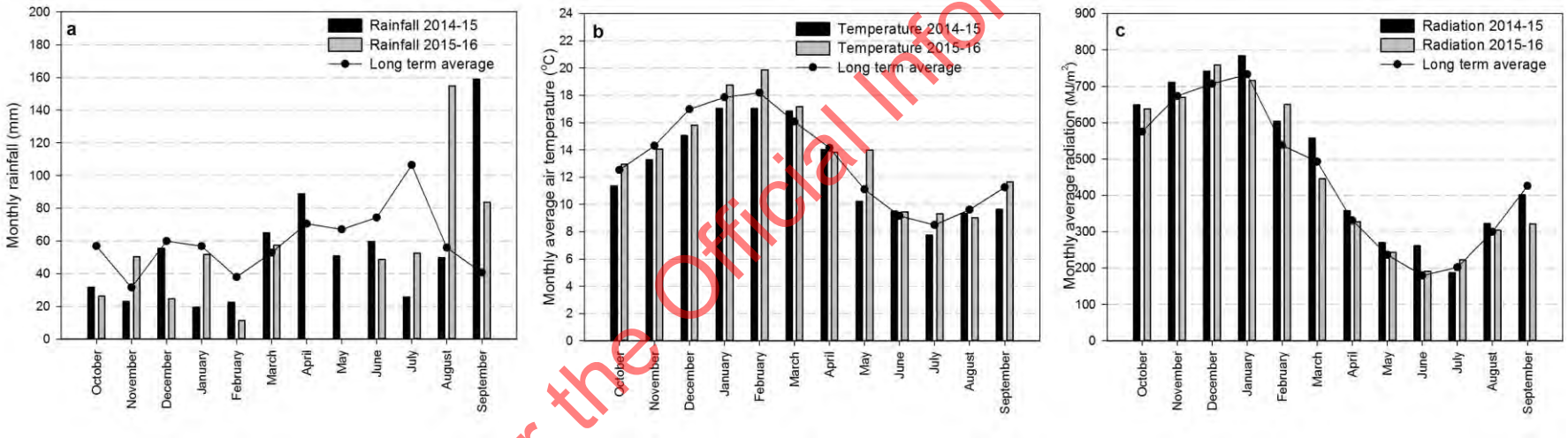

Figure 39. Monthly (a) rainfall (mm), (b) average air temperature (°C) and average solar radiation (MJ/m^2) for 1 October 2014 to 30 September 2016 at Longlands (rainfall; Hort Plus station) and Whakatu (temperature and radiation; NIWA Station 15876). Long-term rainfall (2004–14) and long-term temperature and radiation (2001–14) data are presented for the Longlands and Whakatu stations respectively.

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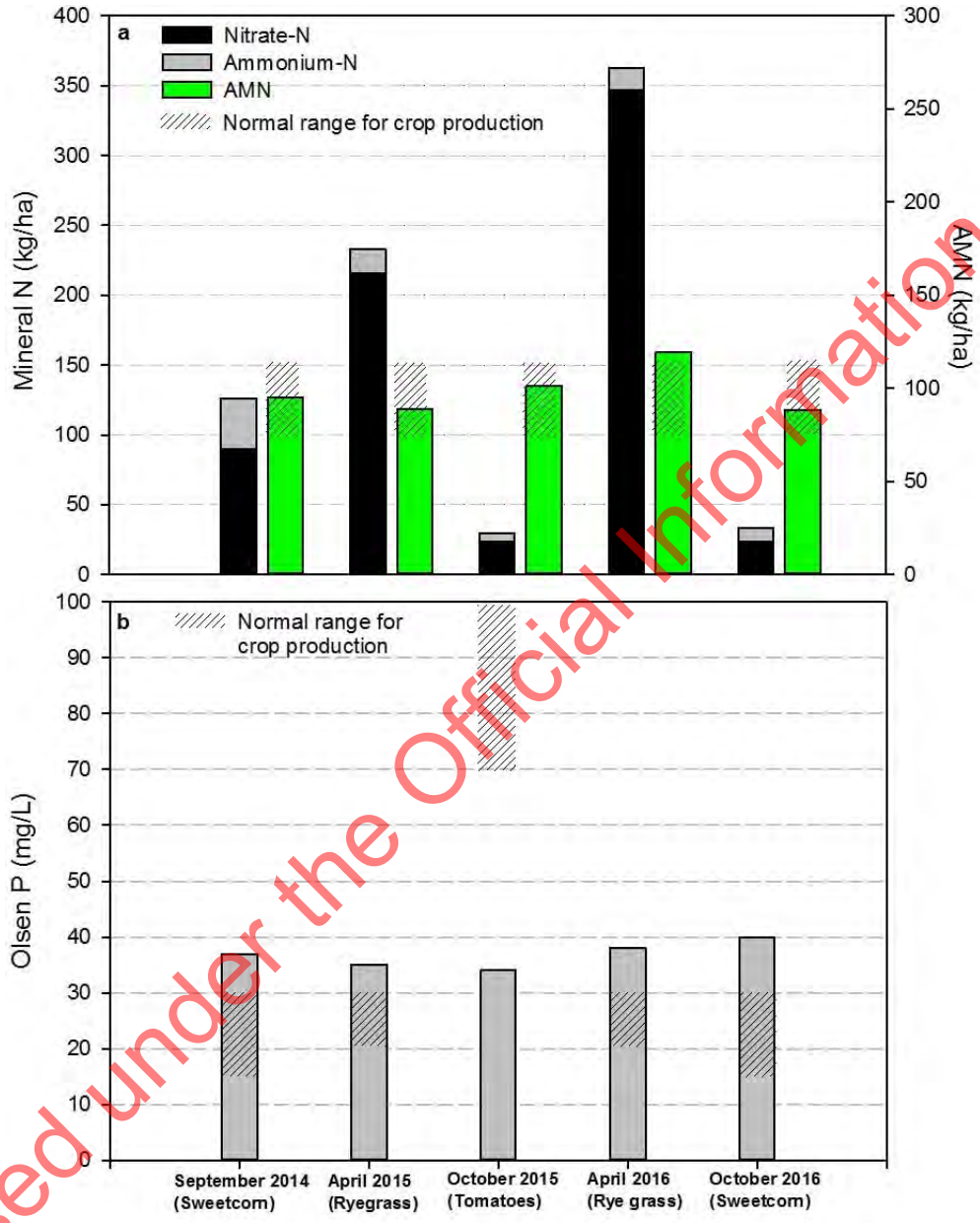

Figure 40. Soil mineral N and AMN (0–100 cm depth) (a) and Olsen P (0–20 cm depth) (b) at Site 8 — Hawke's Bay for samples taken in September 2014, April 2015 and October 2015. Normal ranges suggested for crop production are provided by Hill Laboratories (http://www.hill-laboratories.com/page/pageid/2145845703/Crop_Guides).

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3.8.4 Soil water balance

Year 1 (1 October 2014 to 30 September 2015)

The soil water balance for Site 8 is shown in Figure 41. Rainfall and irrigation for the Year 1 period totalled 651 mm and 76 mm respectively. There were two rainfall events over 50 mm, one in early April 2015 (66 mm over 3 days) and one in late September (146 mm over 6 days). Irrigation was applied at 38 mm per application.

Modelled soil water contents at the 60–90 cm depth remained low for the duration of the monitoring period (< 80 mm) except for a period in late September 2015 when values increased following a significant rainfall event. One small drainage sample was collected after this event.

Year 2 (1 October 2015 to 30 September 2016)

Rainfall and irrigation for the Year 2 period totalled 596 mm and 150 mm respectively. The largest rainfall event occurred in early August when 116 mm was recorded over 3 days (Figure 41). Irrigation was applied five times between late December and mid-February at between 11 and 44 mm per application.

There was a progressive decrease in modelled soil water contents over the summer through to early winter period (December 2015 to June 2016). This trend was consistent with below average rainfall over this period, particularly over the autumn period (March to May) where rainfall was 53% below the long-term average for this period (Figure 39). There were no drainage samples collected during the monitoring period.

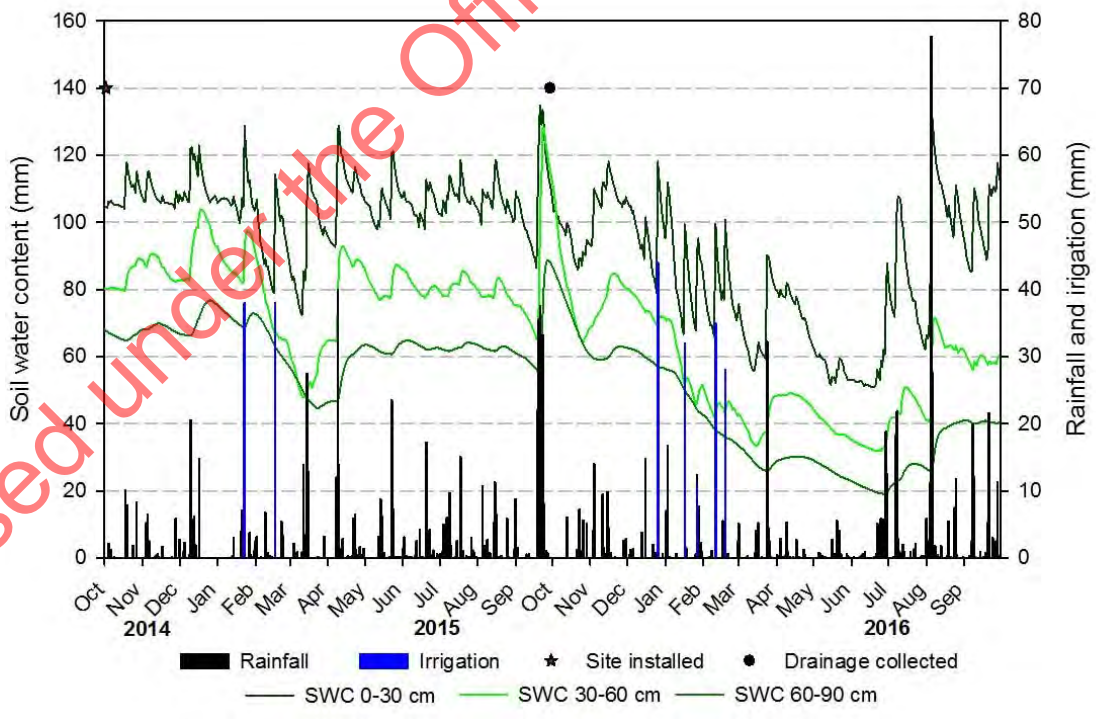

Figure 41. Summary of daily rainfall, irrigation and modelled soil water content (0–30 cm, 30–60 cm and 60–90 cm) from 1 October 2014, Site 8 — Hawke's Bay.

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3.8.5 Losses of N and P in drainage water

Year 1 (1 October 2014 to 30 September 2015)

Captured drainage for Year 1 was 0.3 mm. There was only one drainage sampling in this period in late September 2015 (Figure 42b).

Nitrate-N and ammonium-N concentrations in drainage averaged 21.5 mg/L and 3.1 mg/L respectively (Figure 42b) while respective total P and DRP concentrations averaged 0.38 mg/L and 0.23 mg/L (Figure 43b). Due to low drainage volumes, measured mineral N and total P losses were minimal (< 0.5 kg N/ha and < 0.1 kg P/ha; Figures 42c and 43c respectively)

Year 2 (1 October 2015 to 30 September 2016)

There were no drainage samples collected in the second year following installation of the fluxmeters (Figure 42b) and consequently there are no losses of N and P to report.

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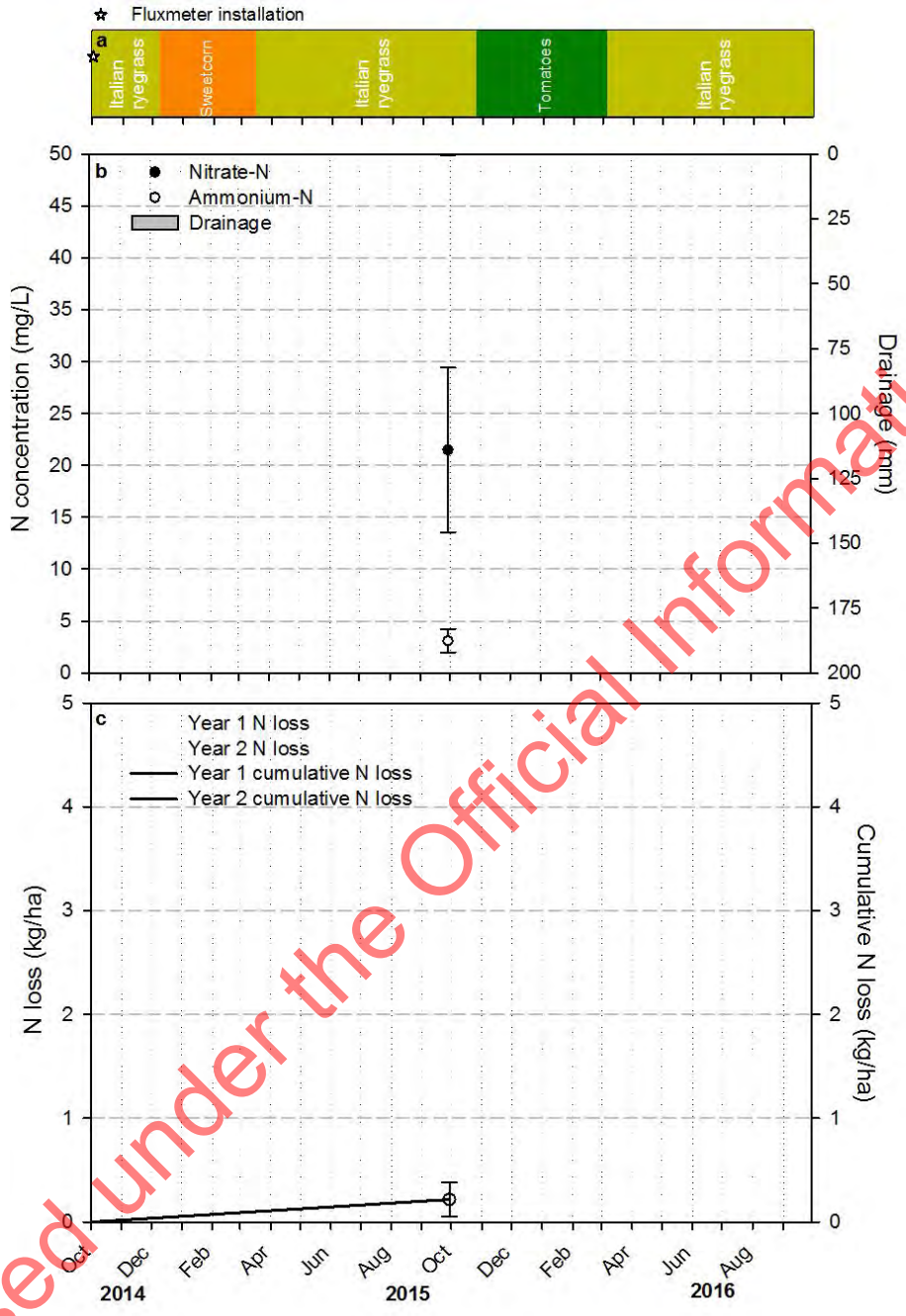

Figure 42. Summary of crop sequence (a), measured drainage and inorganic N concentrations (nitrate-N and ammonium-N) in drainage (b) and measured system losses of inorganic N in drainage for Year 1 (1 October 2014 to 30 September 2015) and for Year 2 (1 October 2015 to 30 September 2016) (c) Site 8 — Hawke's Bay. Mean drainage is calculated from the volume of leachate collected at each sampling event, corrected for the surface area of the fluxmeters. Bars around each point represent the standard error of the mean. Lower limit of detections: nitrate-N: 0.02 mg/L; ammonium-N: 0.01 mg/L.

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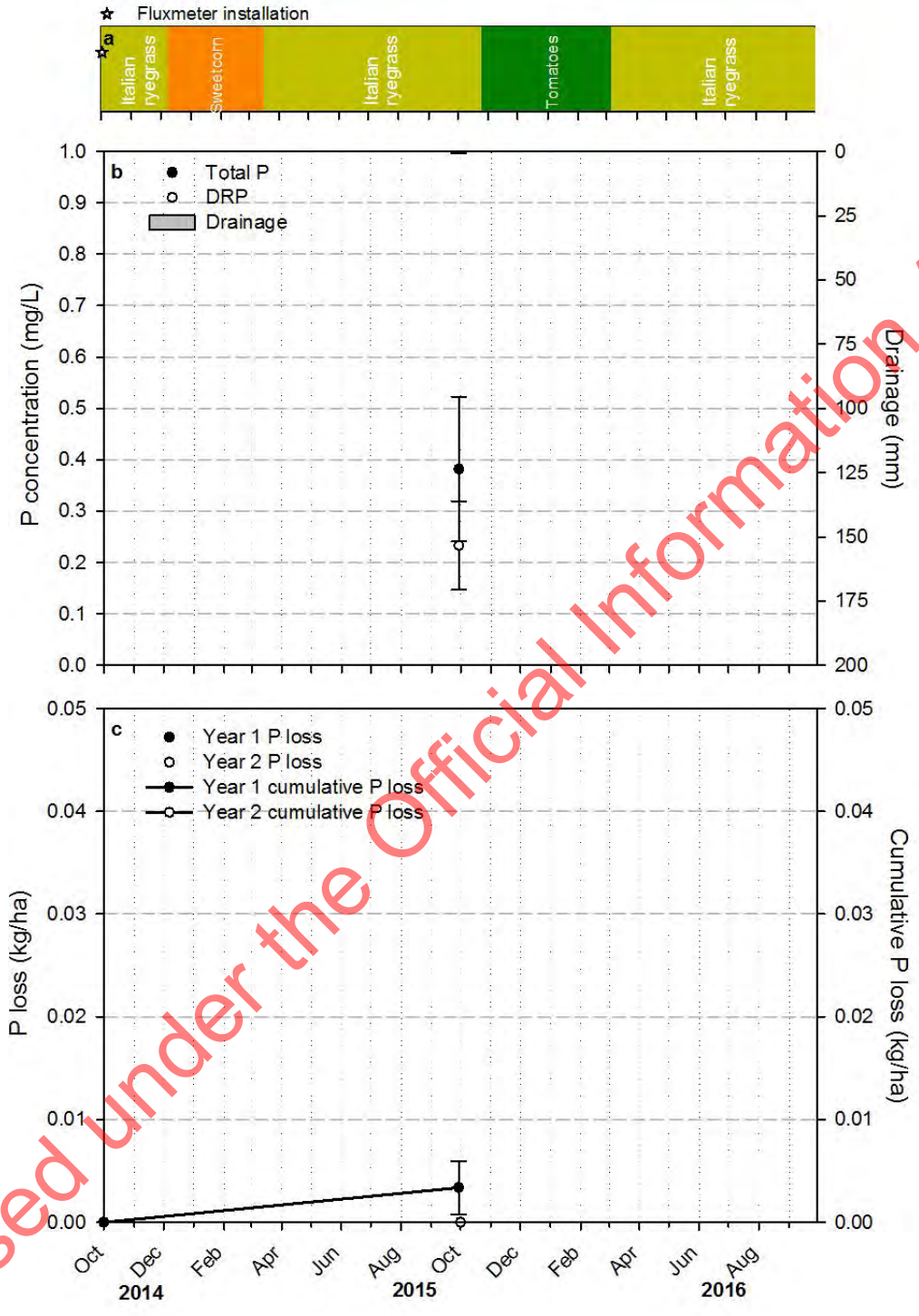

Figure 43. Summary of crop sequence (a), measured drainage and P concentrations (total P and DRP) in drainage (b) and measured system losses of total P in drainage for Year 1 (1 October 2014 to 30 September 2015) and for Year 2 (1 October 2015 to 30 September 2016) (c) Site 8 — Hawke's Bay. Mean drainage is calculated from the volume of leachate collected at each sampling event, corrected for the surface area of the fluxmeters. Bars around each point represent the standard error of the mean. Lower limit of detections: Total P: 0.02 mg/L; DRP: 0.001 mg/L.

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3.9 Site 9 – Hawke's Bay

3.9.1 Background site and crop management history

Site 9 is located near Takapau on a mixed cropping and livestock grazing enterprise. Soil type is a Takapau silt loam. Fluxmeters were installed at the site in September 2014. Key site characteristics are described in Table 18.

Table 18. Summary of key farm and site characteristics, Site 9 — Hawke's Bay.

Location	Takapau
Farming system	Mixed cropping, livestock grazing
Topography	Flat
Soil type	Takapau silt loam
Key soil characteristics[1]	Soil order: Typic allophanic brown Texture: Silty loam Topsoil bulk density: 1.09 g/cm^3 Subsoil bulk density: 1.42 g/cm^3 Drainage class: Well drained N leaching vulnerability: Medium
Previous land use history	Mixed cropping and pasture. Converted to permanent cropping 4 years ago.
Fluxmeter installation date	4 September 2014
Irrigation infrastructure	Centre pivot

[1]A full description of the Takapau silt loam is available online at https://smap.landcareresearch.co.nz/home. Listed characteristics are taken from S-MAP factsheets and are not based on measured site values.

Since installation of the fluxmeters there have been three crops including peas, beans, barley and Italian ryegrass (Table 19). Peas were sown in September 2014 and harvested in December 2014. The site was then planted with beans in (December 2014) which were subsequently grazed by 2-year-old bulls between late April and mid-May 2015 (the crop was bypassed by the processor). Following grazing the site remained fallow until August 2015 before being planted with barley. The barley crop was harvested in January 2016 and the site planted with Italian ryegrass in March 2016 for autumn and winter grazing. The Italian ryegrass will be harvested for seed in January 2017. Respective N and P inputs have totalled 0 kg N/ha and 0 kg P/ha (peas), 50 kg N/ha and 30 kg P/ha (beans), 113 kg N/ha and 23 kg P/ha (barley) and 46 kg N/ha and 0 kg P/ha (Italian ryegrass) (Table 19).

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Table 19. Summary of crop management practices since fluxmeter installation (4 September 2014), Site 9 — Hawke's Bay.

Crop management practices	Sequence 1 — Peas	Sequence 2 — Beans	Sequence 3 — Barley	Sequence 4 — Italian ryegrass
Variety	'Ashton'	'Clarion'	'Jimpy'	'Moata'
Planting population	200 kg/ha	380,000 seeds/ha	130 kg seed/ha	15 kg seed/ha
Planting date	12 September 2014	30 December 2014	24 August 2015	4 March 2016
Harvest date[1]	26 December 2014	24 April 2015[2]	30 January 2016	Current crop
Cultivation practices	Deep rip (40 cm) followed by discing and power harrow	Ploughed and then rolled	Disced followed by powerharrow	Ploughed and then rolled
Fertiliser practices (product)[3]	None applied	200 kg/ha Potash gold (P) 125 CAN kg/ha (S)	2000 kg/ha Lime (B) 140 kg/ha Urea (B) 150 kg/ha Potash super (B) 80 kg/ha Cropmaster DAP (P) 75 kg/ha Urea (S)	400 kg/ha Urea (S)[4]
Summed N and P (elemental)	N = 0 kg/h P = 0 kg/ha	N = 50 kg/ha P = 30 kg/ha	N = 113 kg/ha P = 23 kg/ha	N = 184 kg/ha P = 0 kg/ha
Stock type	No stock	2-year old bulls	No stock	Sheep and beef
Stock density	-	4.2 cows/ha	-	6.5 to 10 lambs/ha 10 ewes/ha 1.3 yearlings and heifers/ha
Additional stock information	-	-	-	200 x 8 week lambs in July and August 300 lambs and 300 ewes from mid-September to early October 20 x 2 year old bulls and 20 x yearlings from September to October

[1]Commercial harvest date. [2]Crop was bypassed and subsequently grazed by cattle over a 4-week period between late-April and mid-May 2015. [3]B = base application, P = planting application, S= side dressing application(s). [4]Applied as 100 kg/ha in mid-April, 100 kg/ha in mid-September and 200 kg/ha in mid-November.

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3.9.2 General weather conditions

Year 1 (1 October 2014 to 30 September 2015)

Rainfall for the Year 1 period was 1035 mm, 7% below the long-term average for the region (1112 mm) (Figure 44a). Rainfall for the winter and spring period (June to September 2015) was 655 mm, comparable with the long-term average for this period (627 mm).

Mean air temperature for the 12 month period was 11.3°C cooler than the long-term average (11.8 °C) (Figure 44b) while solar radiation totalled 4968 MJ/m^2, comparable with the long-term average of 5006 MJ/m^2 (Figure 44c).

Year 2 (1 October 2015 to 30 September 2016)

Rainfall and mean air temperature for the Year 2 period was 989 mm, 11% below the long-term average for the region (Figure 44a). Rainfall for the winter and spring period (June to November 2016) was 569 mm, slightly less than the long-term average for this period (627 mm).

Mean air temperature for the 12 month period was 12.1°C slightly warmer than the long-term average (Figure 44b) while solar radiation totalled 5319 MJ/m^2, moderately higher than the long-term average (Figure 44c).

3.9.3 Soil nitrogen and phosphorus fertility levels

Soil samples for N and P fertility analyses were taken during installation of the fluxmeters in September 2014 and prior to establishment of the respective bean, barley and Italian ryegrass crops in January 2015, August 2015 and January 2016.

Mineral N (0–60 cm)

Mineral N concentrations increased from low in September 2014 (32 kg N/ha) to moderate in January 2015 (71 kg N/ha) and then high in August 2015 (185 kg N/ha) (Figure 45a). Samples for the August soil sampling were taken a few weeks after a base application of urea fertiliser (Table 19). Increased mineral N concentrations for this sample reflect this N application in addition to previous management history which included grazing of the earlier legume crop by bulls and associated urinary N inputs (April to May 2015). Mineral N concentrations for samples taken in January 2016 were low (58 kg N/ha). Nitrate N was the predominant form of mineral N for all sampling occasions (63–100%).

AMN (0–60 cm)

AMN concentrations (0–60 cm depth) remained consistently high across the three sampling occasions (182 to 219 kg N/ha) and were above normal concentrations suggested for barley and Italian ryegrass (100–150 kg N/ha) (Figure 45a).

Olsen P (0–20 cm)

Olsen P concentrations were moderate for samples taken in September 2014, January 2015 and August 2015 (21 to 27 mg/L) and low for samples taken in January 2016 (17 mg/L) (Figure 45b). Concentrations were slightly below normal concentrations suggested for peas (30–55 mg/L), beans (35–75 mg/L) and ryegrass (20–30 mg/L), but within normal concentrations suggested for barley (20–30 mg/L).

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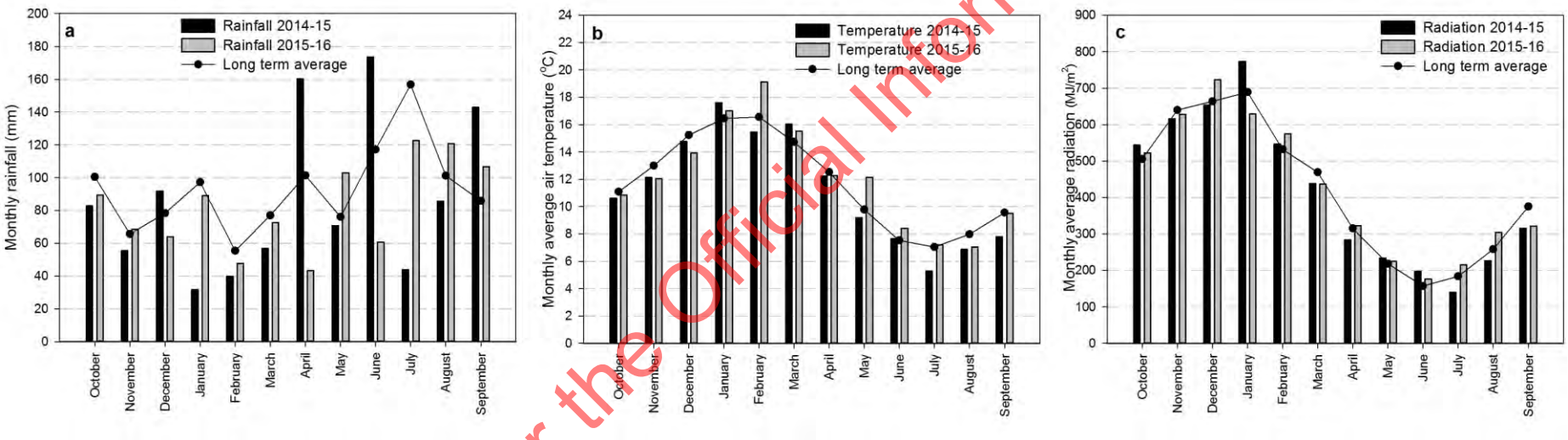

Figure 44. Monthly (a) rainfall (mm), (b) average air temperature (°C) and average solar radiation (MJ/m^2) for 1 October 2014 to 30 September 2016 at Takapau (rainfall and temperature; NIWA Station 25820) and Waipawa (radiation; NIWA Station 31620). Long-term climate data (2006–14) are presented for the Takapau and Waipawa stations.

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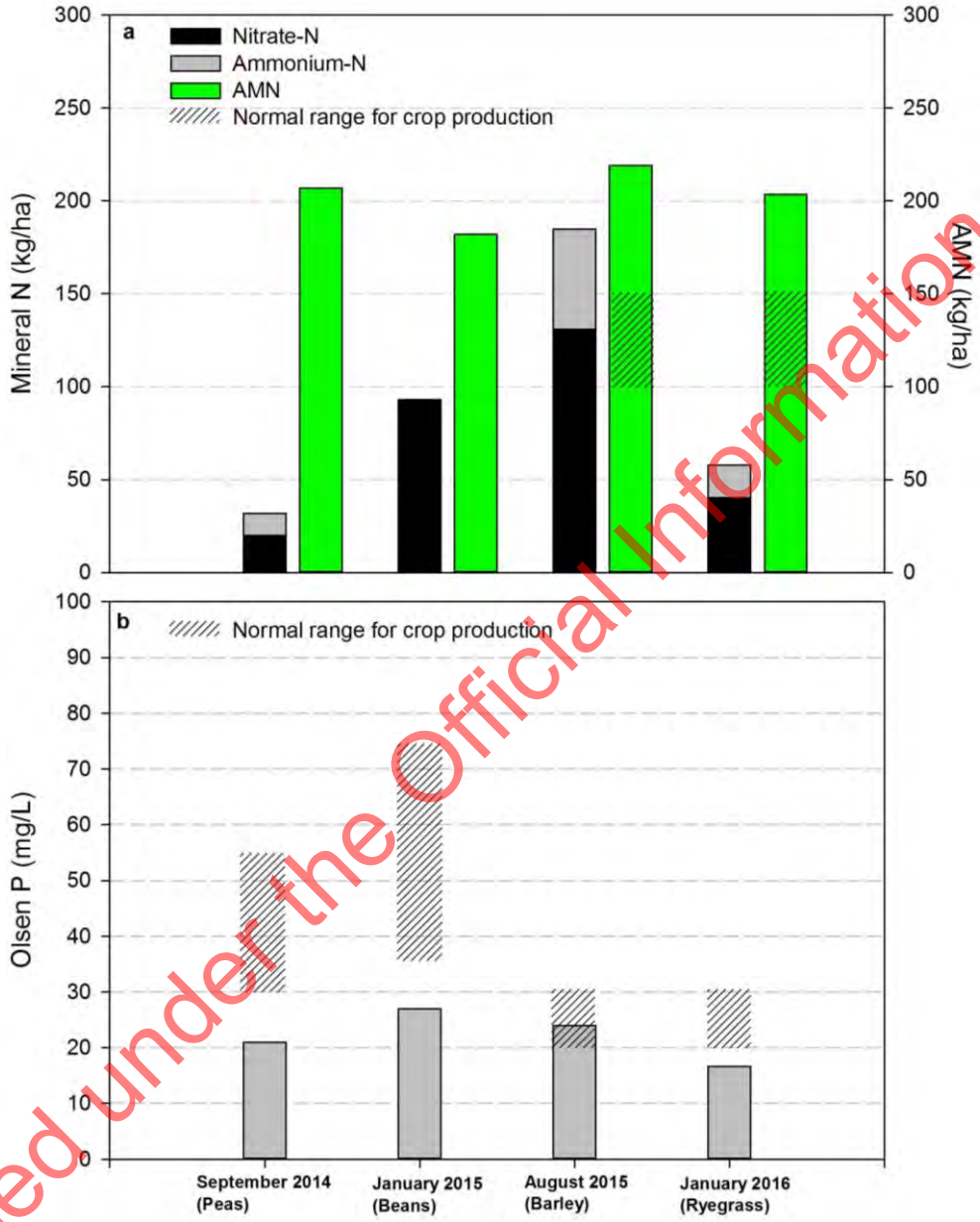

Figure 45. Soil mineral N and AMN (0–60 cm depth) (a) and Olsen P (0–20 cm depth) (b) at Site 9—– Hawke's Bay for samples taken in September 2014, January 2015, August 2015 and January 2016. Normal ranges suggested for crop production are provided by Hill Laboratories (http://www.hill-laboratories.com/page/pageid/2145845703/Crop_Guides).

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3.9.4 Soil water balance

Year 1 (1 October 2014 to 30 September 2015)

The soil water balance for Site 9 is shown in Figure 46. Rainfall and irrigation for the Year 1 period totalled 1035 mm and 103 mm respectively. There were three rainfall events over 50 mm, one in early April 2015 (86 mm over 3 days), one in mid-June (71 mm over 3 days) and one in late September (116 mm over 6 days). The range in individual irrigation application volumes was 10 to 30 mm.

Modelled soil water contents increased to above 100 mm from mid-April 2015 and remained at elevated for the duration of the late autumn through to early spring period. The majority of drainage samples were collected during this period.

Year 2 (1 October 2015 to 30 September 2016)

Rainfall and irrigation for the Year 2 period totalled 989 mm and 150 mm respectively. The largest rainfall events occurred in early August when 61 mm was recorded over 4 days (Figure 46). There were seven irrigation applications between late November and early January (irrigation volumes ranged from 10 to 25 mm per application).

Modelled soil water contents remained at comparatively high levels for the 0–30 and 30–60 cm depths (> 80 mm) for the duration of the monitoring period. For the 60–90 cm depth, modelled soil water contents remained at lower levels over the summer to autumn period (December to May) before increasing in August in response to regular rainfall. Six drainage samples were collected over the Year 2 monitoring period including two between early October and late November 2015 and four between early July and mid-September 2016.

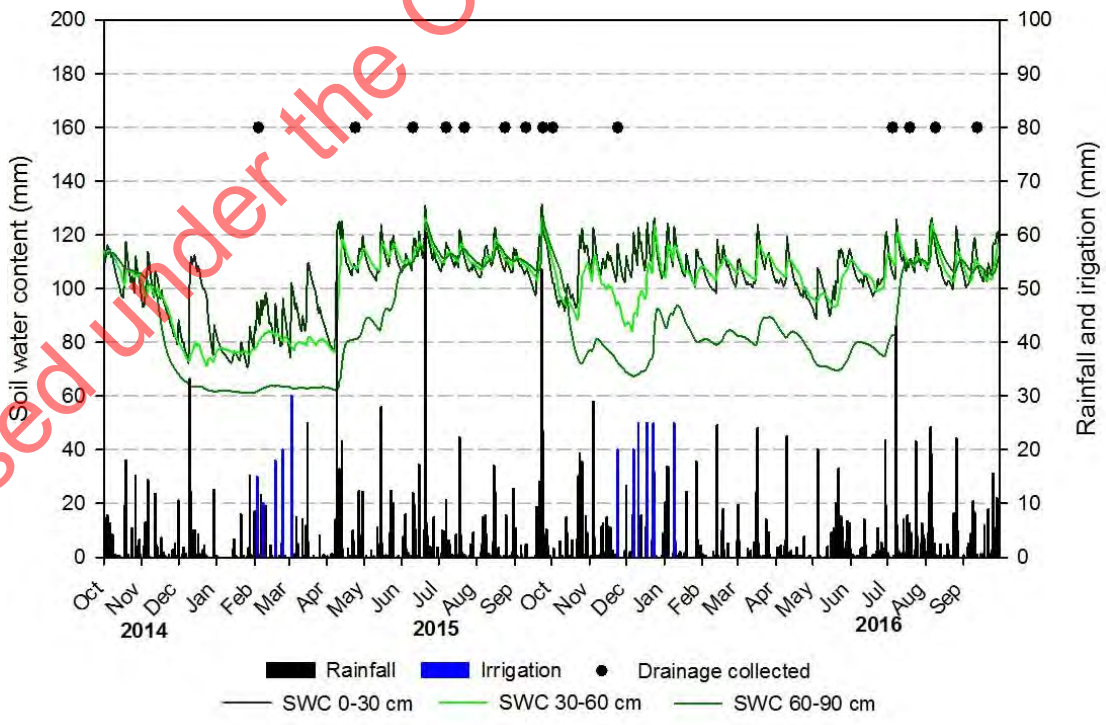

Figure 46. Summary of daily rainfall, irrigation and modelled soil water content (0–30 cm, 30–60 cm and 60–90 cm) from 1 October 2014, Site 9 — Hawke's Bay. Fluxmeters were installed on 4 September 2014.

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3.9.5 Losses of N and P in drainage water

Year 1 (1 October 2014 to 30 September 2015)

Drainage samples were collected on eight occasions in the first year following installation of the fluxmeters. Total drainage volume was 62 mm (Figure 47b).

Nitrate-N and ammonium-N concentrations in drainage for this period averaged 9.5 mg/L and 1.7 mg/L respectively (Figure 47b). Nitrate-N concentrations tended to increase over the monitoring period and peaked at 21.2 mg/L in late September 2015 while ammonium-N concentrations remained low for the duration of the period (< 3.5 mg/L). Net mineral N losses from the system totalled 7.3 kg N/ha (Figure 47c) with the majority of N lost as nitrate-N (6.5 kg N/ha).

Total P and DRP concentrations averaged 0.43 mg/L and 0.16 mg/L respectively (Figure 48b). Measured P losses from the system were low, totalling 0.21 kg P/ha with DRP loss accounting for 0.06 kg P/ha (Figure 48c).

Year 2 (1 October 2015 to 30 September 2016)

Drainage samples were collected on six occasions in the second year following installation of the fluxmeters. Total drainage volume was 66 mm (Figure 47b).

Nitrate-N and ammonium-N concentrations in drainage for this period averaged 21.7 mg/L and 0.02 mg/L respectively (Figure 47b). Nitrate-N concentrations were higher than those observed in Year 1 (9.5 mg/l) and consequently net mineral N losses from the system were higher at 17.4 kg N/ha (Figure 47c). Nitrate-N concentrations peaked in early July 2016 (27.4 mg/L).

Total P and DRP concentrations averaged 0.10 mg/L and 0.05 mg/L respectively (Figure 48b). Measured P losses from the system were minimal (0.06 kg P/ha; Figure 48c).

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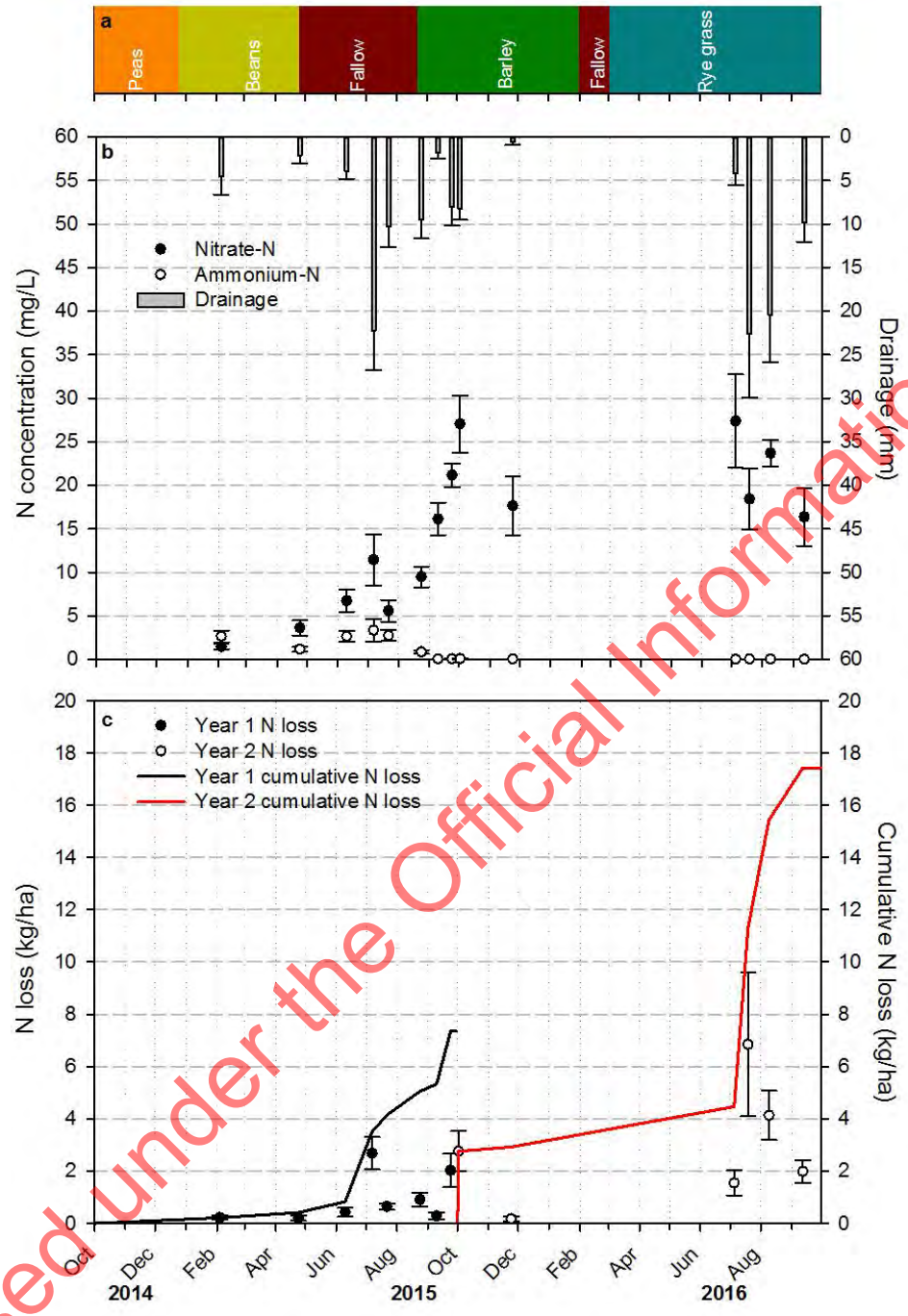

Figure 47. Summary of crop sequence (a), measured drainage and inorganic N concentrations (nitrate-N and ammonium-N) in drainage (b) and measured system losses of inorganic N in drainage for Year 1 (1 October 2014 to 30 September 2015) and for Year 2 (1 October 2015 to 30 September 2016) (c) Site 9 — Hawke's Bay. Mean drainage is calculated from the volume of leachate collected at each sampling event, corrected for the surface area of the fluxmeters. Bars around each point represent the standard error of the mean. Lower limit of detections: nitrate-N: 0.02 mg/L; ammonium-N: 0.01 mg/L. Fluxmeters were installed on 4 September 2014.

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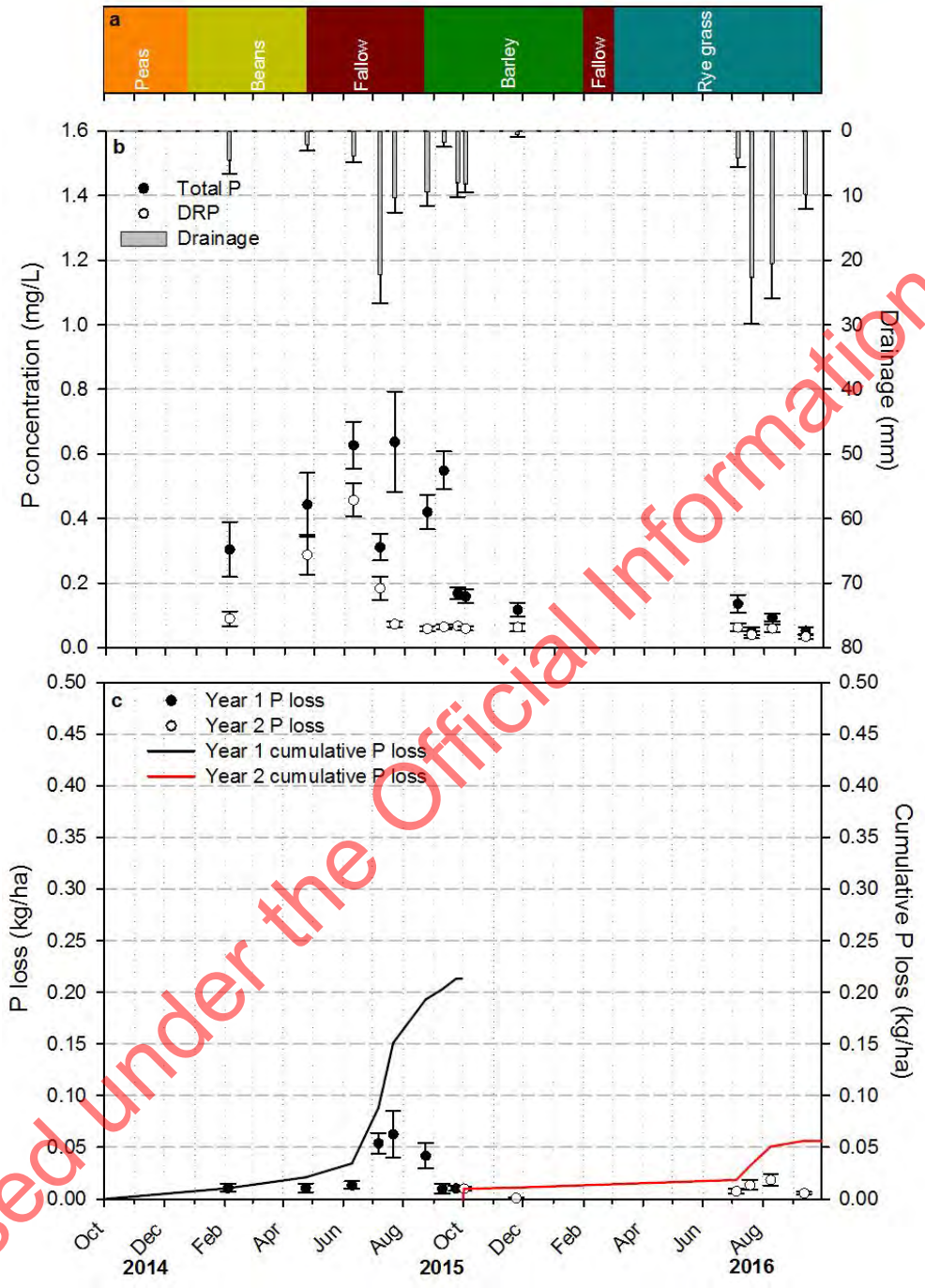

Figure 48. Summary of crop sequence (a), measured drainage and P concentrations (total P and DRP) in drainage (b) and measured system losses of total P in drainage for Year 1 (1 October 2014 to 30 September 2015) and for Year 2 (1 October 2015 to 30 September 2016) (c) Site 9 — Hawke's Bay. Mean drainage is calculated from the volume of leachate collected at each sampling event, corrected for the surface area of the fluxmeters. Bars around each point represent the standard error of the mean. Lower limit of detections: Total P: 0.02 mg/L; DRP: 0.001 mg/L. Fluxmeters were installed on 4 September 2014.

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3.10 Site 10 — Matamata/Pukekohe

3.10.1 Background site and crop management history

Site 10 is located near Matamata on a mixed cropping and livestock grazing enterprise. Soil type a Waihou silt loam. Fluxmeters were installed at the site in May 2015. Key site characteristics are listed in Table 20.

Table 20. Summary of key farm and site characteristics, Site 10 — Matamata.

Location	Matamata
Farming system	Mixed cropping, livestock grazing
Topography	Gentle rolling
Soil type	Waihou silt loam
Key soil characteristics[1]	Soil order: Typic orthic allophanic Texture: Loam over sandy loam Topsoil bulk density: 0.78 g/cm^3 Subsoil bulk density: 0.86 g/cm^3 Drainage class: Well drained N leaching vulnerability: Low
Previous land use history	Converted from dairy pasture to mixed cropping in 2014; the first crop following conversion was potatoes.
Fluxmeter installation date	13 May 2015
Irrigation infrastructure	Centre pivot

[1]A full description of the Waihou silt loam is available online at https://smap.landcareresearch.co.nz/home. Listed characteristics are taken from S-MAP factsheets and are not based on measured site values.

Since installation of the fluxmeters there have been three crops including Italian ryegrass, potatoes and onions (Table 21). Italian ryegrass was sown in May 2015, sprayed off in September 2015 and the site sown with potatoes in October 2015. Following harvesting of the potato crop in March 2016, the site remained fallow until July when onions (the current crop) were planted. Respective N and P inputs have totalled 18 kg N/ha and 0 kg P/ha (Italian ryegrass), 291 kg N/ha and 120 kg P/ha (potato) and 44 kg N/ha and 96 kg P/ha (onion) (Table 21).

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Table 21. Summary of crop management practices since fluxmeter installation (13 May 2015), Site 10 – Matamata.

Crop management practices	Sequence 1 — Italian ryegrass	Sequence 2 — Potatoes	Sequence 3 — Onions
Variety	'Tama'	'Russet ranger'	Information not yet available
Planting population	25 kg/ha	41,500 seeds/ha	710,000 plants/ha
Planting date	10 May 2015	14 October 2015	3 July 2016
Harvest date[1]	19 September[2]	15 March 2016	Current crop
Cultivation practices	Disking followed by sowing and rolling	Hoeing followed by deep ripping and power harrow	Shallow rip followed by power harrow and bed formation
Fertiliser practices (product)[3]	40 kg/ha Urea (P)	750 kg/ha potato pre-plant mix (B) 1500 kg/ha potato planting mix (P) 320 kg/ha Sustain N (S)[4]	5 t/ha lime (B) 5 t/ha lime (P) 800 kg/ha serpentine super (P) 250 kg/ha DAP (S)
Summed N and P (elemental)	N = 18 kg/ha P = 0 kg/ha	N = 291 kg/ha P = 120 kg/ha	N = 44 kg/ha P = 96 kg/ha
Stock type	No stock	No stock	No stock
Stock density	-	-	-
Additional stock information	-	-	-

[1]Commercial harvest date. [2] Date ryegrass was sprayed off. [3]B = base application, P = planting application, S= side dressing application(s). [4]Split over four applications between December 2015 and February 2016.

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3.10.2 General weather conditions

Year 1 (1 October 2014 to 30 September 2015)

Rainfall for the Year 1 period was 1043 mm, 8% less than the long-term average for the region (1131 mm) (Figure 49a). Over the winter and spring period (June to November 2015), rainfall totalled 575 mm, comparable with the long-term average for this period (570 mm).

Mean air temperature for the 12 month period was 12.8°C, cooler than the long-term average for the region (13.5°C) (Figure 49b). Solar radiation totalled 5469 MJ/m^2, slightly higher than the long-term average of 5290 MJ/m^2 (Figure 49c).

Year 2 (1 October 2015 to 30 September 2016)

Rainfall for the Year 2 period was 1050 mm, 7% less than the long-term average for the region (Figure 49a). However the winter and spring period (June to November 2016) was wetter than average with 688 mm recorded compared to the long-term average of 570 mm for this period.

Air temperature averaged 13.6°C for the 12 month period, comparable to the long-term average (13.5°C) (Figure 49b). Solar radiation totalled 5013 MJ/m^2, slightly lower than the long-term average for region (Figure 49c).

3.10.3 Soil nitrogen and phosphorus fertility levels

Soil samples for N and P fertility analyses were taken during installation of the fluxmeters in May 2015, two weeks after planting of the potato crop in October 2015 and one week after planting of the onion crop in July 2017.

Mineral N (0–100 cm)

Mineral N concentrations were high for all sampling occasions, ranging between 298 and 367 kg N/ha, with the majority of this nitrogen present in the nitrate-N form (88–97%). Samples takes in October were taken 2 weeks after a base application of potato pre-plant mix (Table 21) and consequently high mineral N concentrations for this sample reflect this N fertiliser application. However, samples taken in May 2015 and July 2016 were taken prior to the application of N fertiliser and consequently reflect residual mineral N in the soil profile at the end of the respective crop sequences.

AMN (0–100 cm)

AMN concentrations were moderate for the May 2015 and October 2015 samples (126–169 kg N/ha) and high for the July 2016 samples (337 kg N/ha). Overall values were within or above the normal concentrations suggested for Italian ryegrass, potato and onion production (100–150 kg N/ha) (Figure 50a).

Olsen P (0–20 cm)

Olsen P concentrations were moderate for all sampling occasions (34–42 mg/L) and within normal concentrations suggested for Italian ryegrass (20–30 mg/L) and potato production (30–60 mg/L) but slightly below normal concentrations for onion production (45–90 mg/L) (Figure 50b).

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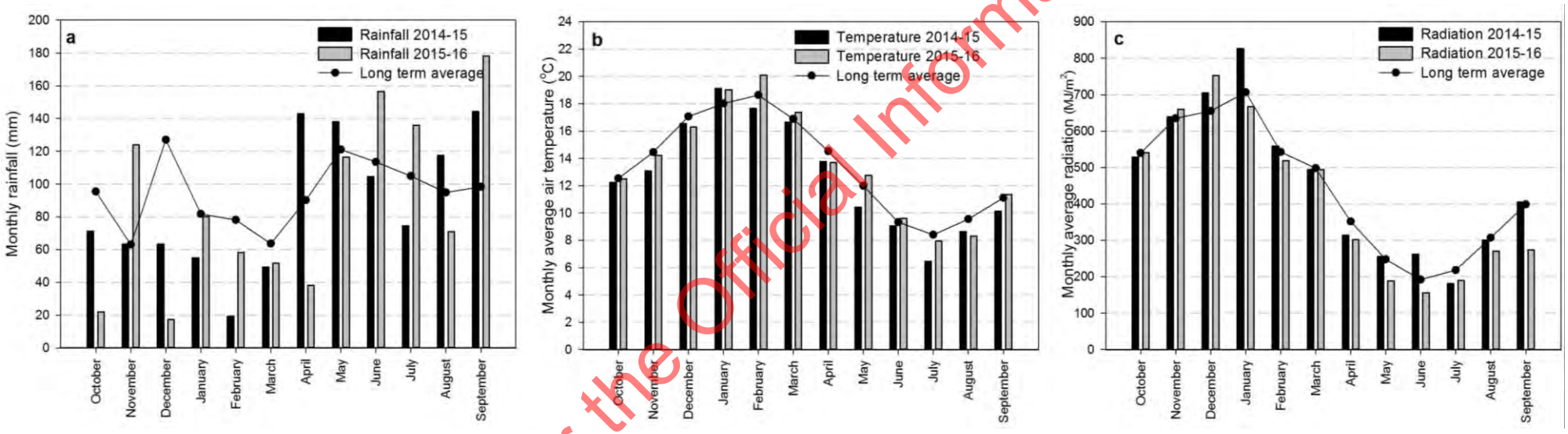

Figure 49. Monthly (a) rainfall (mm), (b) average air temperature (°C) and average solar radiation (MJ/m^2) for 1 October 2014 to 30 September 2016 at Matamata (rainfall and temperature; NIWA Station 25820) and Toenepi (radiation; NIWA Station 31620). Long-term climate data (2001–14) are presented for the Matamata and Toenepi stations.

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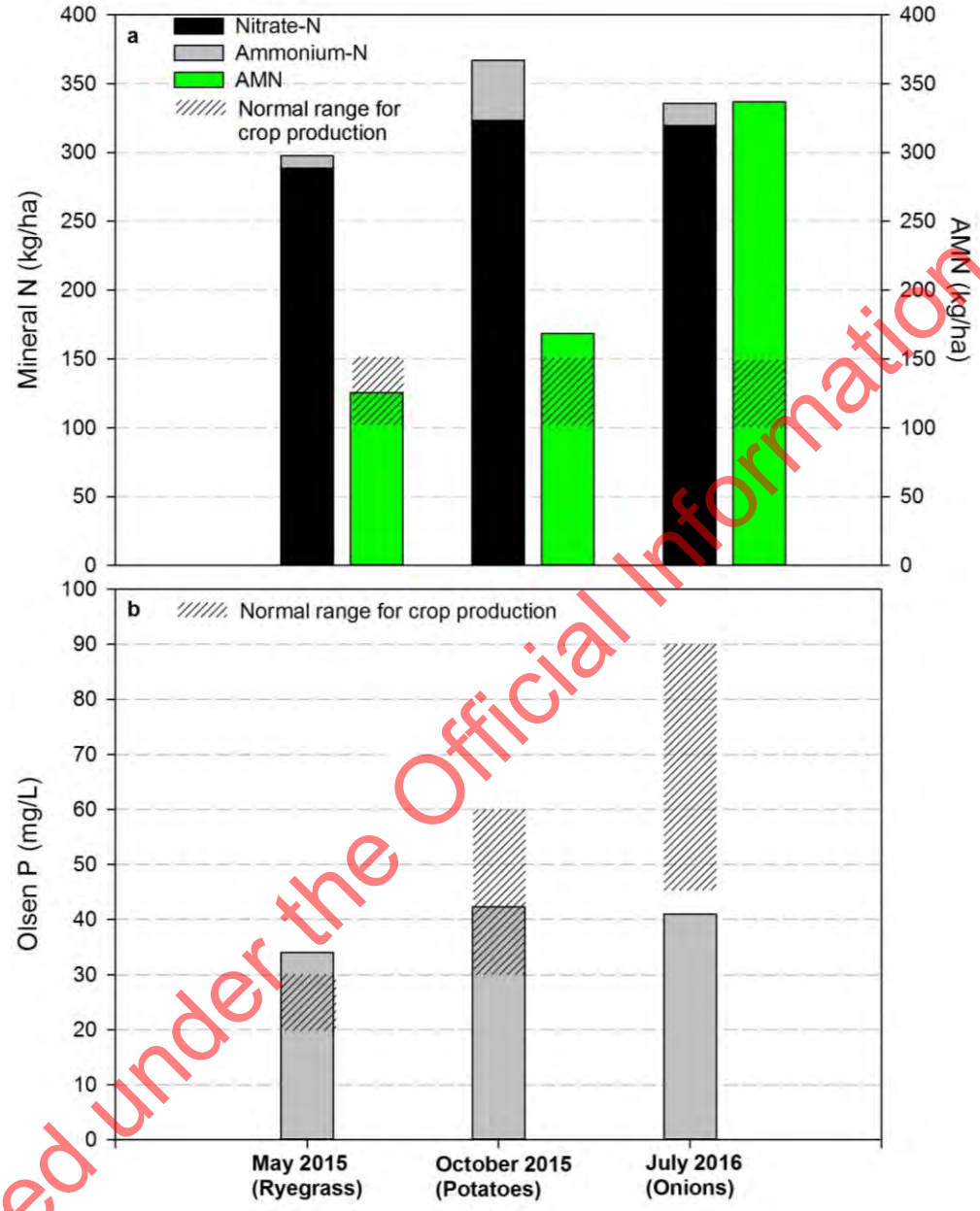

Figure 50. Soil mineral N and AMN (0–100 cm depth) (a) and Olsen P (0–20 cm depth) (b) at Site 10 — Matamata for samples taken in May 2015, October 2015 and July 2016. Normal ranges suggested for crop production are provided by Hill Laboratories (http://www.hill-laboratories.com/page/pageid/2145845703/Crop_Guides).

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3.10.4 Soil water balance

Year 1 (1 October 2014 to 30 September 2015)

The soil water balance for Site 10 is shown in Figure 51. Rainfall and irrigation for the Year 1 period totalled 1043 mm and 80 mm respectively. There were three rainfall events over 50 mm, one in mid-April 2015 (77 mm over 1 day), one in late-May (62 mm over 3 days) and one in mid-September (81 mm over 3 days). The range in individual irrigation application volumes was 25 to 30 mm.

Modelled soil water contents increased to above 150 mm at all depths from mid-April 2015 and remained at elevated levels for the duration of the late autumn through to early spring period. Drainage samples were collected from mid-July 2015 onwards.

Year 2 (1 October 2015 to 30 September 2016)

Rainfall and irrigation for the Year 2 period totalled 1050 mm and 120 mm respectively. There were consistent periods of rainfall over the late autumn to early spring period (May to September 2016) with a number of events over 50 mm including 96 mm over 2 days in late June and 92 mm over 5 days in late September. There were four irrigation applications between mid-December and late January (irrigation volumes ranged from 25 to 35 mm per application).

Modelled soil water contents remained high at all depths (> 125 mm) through the spring period (September to November) before declining over the summer through to mid-autumn period (December to March) in response to less frequent rainfall and crop water use. Soil water contents increased to high levels from mid-June onwards. Six drainage samples were collected, three between late October 2015 and mid-January 2016 and three between mid-July and mid-September 2016.

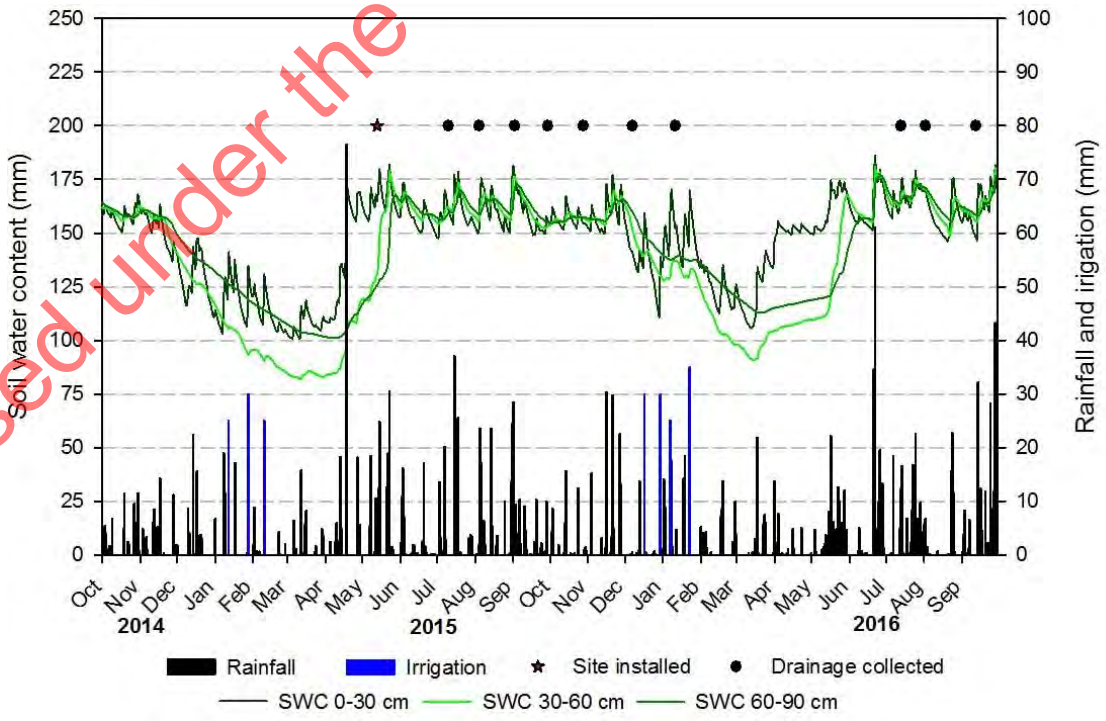

Figure 51. Summary of daily rainfall, irrigation and modelled soil water content (0–30 cm, 30–60 cm and 60–90 cm) from 1 October 2014, Site 10 — Matamata.

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3.10.5 Losses of N and P in drainage water

Year 1 (1 October 2014 to 30 September 2015)

Drainage samples were collected on four occasions in the first year following installation of the fluxmeters. Total drainage volume was 150 mm (Figure 52b).

Nitrate-N and ammonium-N concentrations in drainage for this period averaged 17.2 mg/L and 0.4 mg/L respectively (Figure 52b). Nitrate-N concentrations were fairly consistent over the monitoring period ranging from 15.9 to 19.1 mg/L, while ammonium-N concentrations remained low (< 0.8 mg/L). Measured mineral N losses from the system totalled 29.8 kg N/ha (Figure 52c) with the majority of N lost as nitrate-N (29.5 kg N/ha).

Total P and dissolved DRP concentrations averaged 0.08 mg/L and 0.07 mg/L respectively (Figure 53b). Net P losses from the system were minimal, totalling 0.07 kg P/ha (Figure 53c).

Year 2 (1 October 2015 to 30 September 2016)

Drainage samples were collected on six occasions in the second year following installation of the fluxmeters. Total drainage volume was 112 mm (Figure 52b).

Nitrate-N and ammonium-N concentrations in drainage for this period averaged 14.5 mg/L and 0.5 mg/L respectively (Figure 52b). Nitrate-N concentrations remained relatively consistent over the monitoring period (range was 10.4 to 18.2 mg/L). Measured mineral N losses from the system totalled 12.4 kg N/ha (Figure 52c) with N lost almost entirely as nitrate-N.

Total P and DRP concentrations over this period remained low, averaging 0.04 mg/L and 0.02 mg/L respectively (Figure 33b). Consequently, measured P losses from the system were minimal (< 0.05 kg P/ha; Figure 33c).

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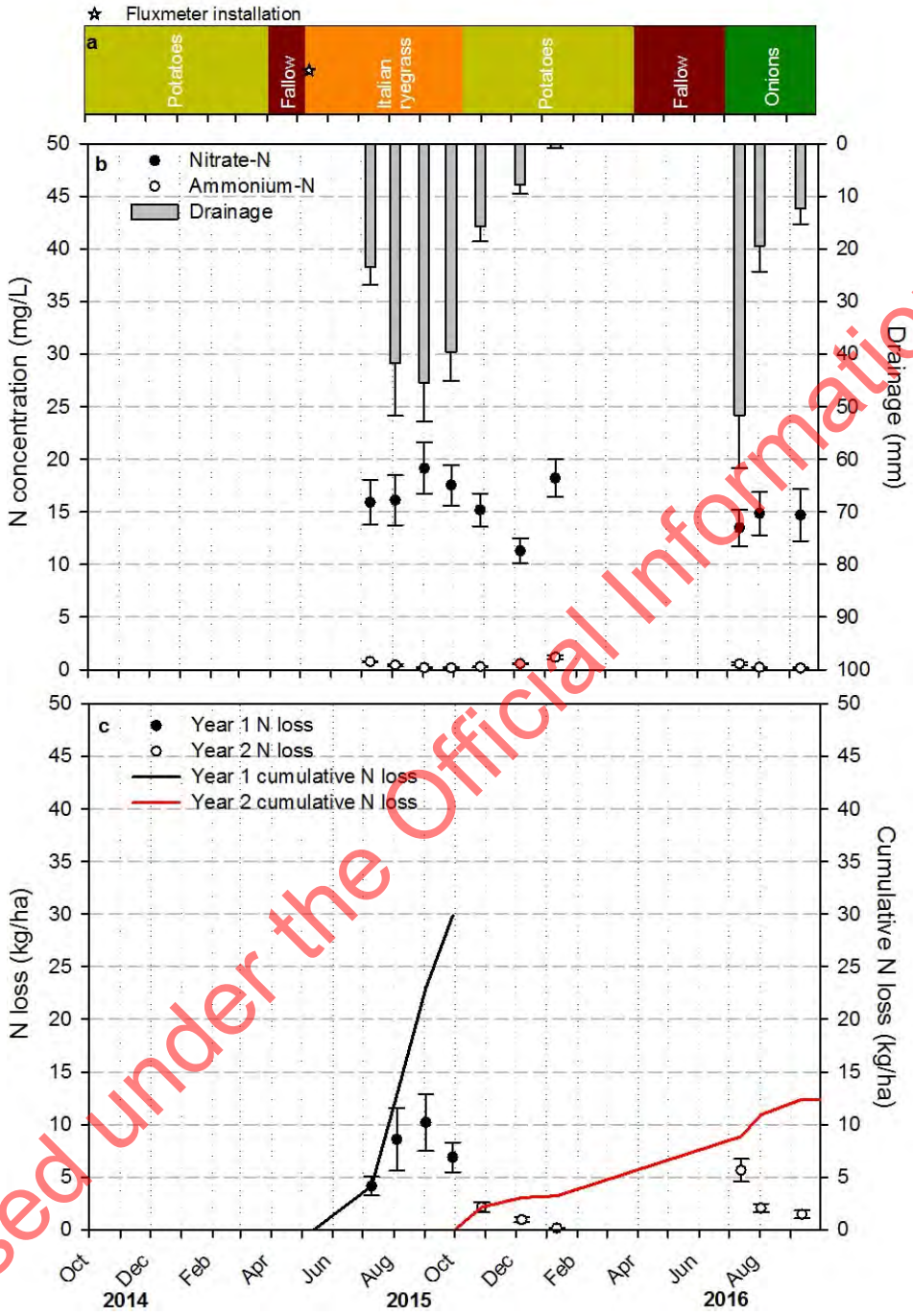

Figure 52. Summary of crop sequence (a), measured drainage and inorganic N concentrations (nitrate-N and ammonium-N) in drainage (b) and measured system losses of inorganic N in drainage for Year 1 (1 October 2014 to 30 September 2015) and for Year 2 (1 October 2015 to 30 September 2016) (c) Site 10 — Matamata. Mean drainage is calculated from the volume of leachate collected at each sampling event, corrected for the surface area of the fluxmeters. Bars around each point represent the standard error of the mean. Lower limit of detections: nitrate-N: 0.02 mg/L; ammonium-N: 0.01 mg/L.

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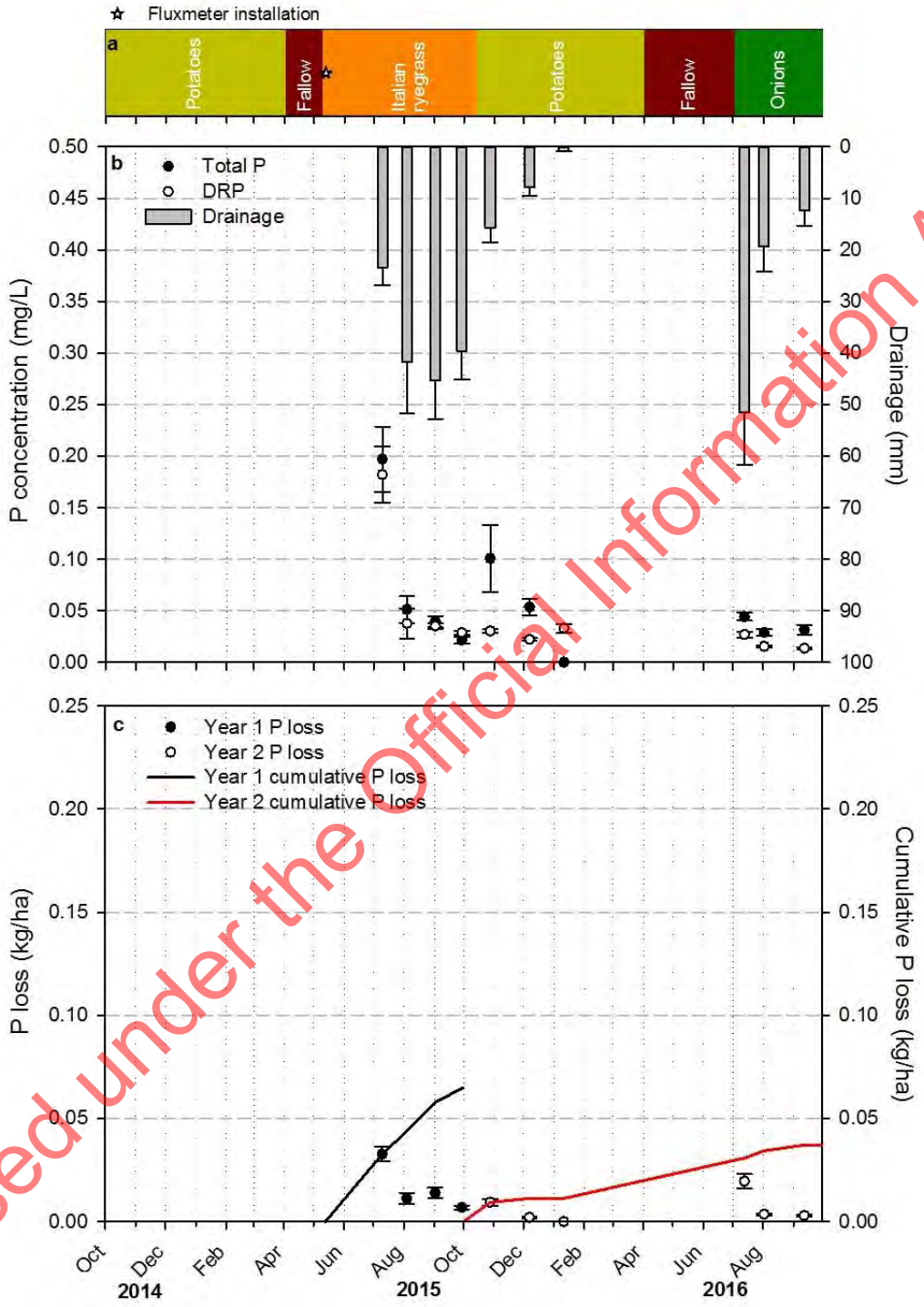

Figure 53. Summary of crop sequence (a), measured drainage and P concentrations (total P and DRP) in drainage (b) and measured system losses of total P in drainage for Year 1 (1 October 2014 to 30 September 2015) and for Year 2 (1 October 2015 to 30 September 2016) (c) Site 10 — Matamata. Mean drainage is calculated from the volume of leachate collected at each sampling event, corrected for the surface area of the fluxmeters. Bars around each point represent the standard error of the mean. Lower limit of detections: Total P: 0.02 mg/L; DRP: 0.001 mg/L.

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3.11 Site 11 — Matamata/Pukekohe

3.11.1 Background site and crop management history

Site 11 is located near Pukekohe on an intensive vegetable cropping enterprise. Soil type is a Patumahoe clay loam. Fluxmeters were installed at the site in March 2015. Key site characteristics are described in Table 22.

Table 22. Summary of key farm and site characteristics, Site 11 — Pukekohe.

Location	Pukekohe
Farming system	Intensive vegetable production
Topography	Flat
Soil type	Patumahoe clay loam
Key soil characteristics[1]	Soil order: Mottled orthic granular Texture: Loam over clay Topsoil bulk density: 1.09 g/cm^3 Subsoil bulk density: 1.09 g/cm^3 Drainage class: Imperfectly drained N leaching vulnerability: Medium
Previous land use history	For past 10 years the site has been in an onion-potato-green crop rotation
Fluxmeter installation date	10 March 2015
Irrigation infrastructure	Gun/lateral

[1]A full description of the Patumahoe clay loam is available online at https://smap.landcareresearch.co.nz/home. Listed characteristics are taken from S-MAP factsheets and are not based on measured site values.

Since installation there have two crops including potato sown in June 2015 and harvested in November 2015 and the current onion crop sown in May 2016 (Table 23). Respective N and P inputs have totalled 318 kg N/ha and 30 kg P/ha (potato) and 136 kg N/ha and 76 kg P/ha (onion) (Table 23).

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Table 23. Summary of crop management practices since fluxmeter installation (10 March 2015), Site 11 — Pukekohe.

Crop management practices	Sequence 1 — Potatoes	Sequence 2 — Fallow	Sequence 3 — Onions
Variety	'Victoria'	-	'Ayoba'
Planting population	46,000 seeds/ha	-	520,000 plants/ha
Planting date	9 June 2015	-	15 May 2016
Harvest date[1]	15 November 2015	-	Current crop
Cultivation practices	Deep rip followed by power harrow and bed formation	-	Ripped followed by power harrow and planting
Fertiliser practices (product)[2]	1000 kg/ha Green Complex (P) 300 kg/ha Ammonium sulphate (P) 500 kg/ha CAN (S)[3]	-	150 kg/ha DAP (P) 550 kg/ha Hydro complex (S)[4] 270 kg/ha Yara Actyva (S)
Summed N and P (elemental)	N = 318 kg/ha P = 30 kg/ha	-	N = 136 kg/ha P = 76 kg/ha
Stock type	No stock	-	No stock
Stock density	-	-	-
Additional stock information	-	-	-

[1] Commercial harvest date. [2]B = base application, P = planting application, S= side dressing application(s). [3]Split over two applications between August and September 2015. [4]Split over two applications between August and September 2016.

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3.11.2 General weather conditions

Year 1 (1 October 2014 to 30 September 2015)

Rainfall for the Year 1 period was 1166 mm, comparable with the long-term average for the region (1183 mm) (Figure 54a). Rainfall for the winter and spring period (June to November) was 665 mm, also comparable with the long-term average for this period (648 mm).

Mean air temperature was 14.3°C, slightly lower than the long-term average (14.6°C) (Figure 54b) while solar radiation totalled 5166 MJ/m^2 was comparable to the long-term average of 5215 MJ/m^2 (Figure 54c).

Year 2 (1 October 2015 to 30 September 2016)

Rainfall for the Year 2 period was 1273 mm, 8% higher than long-term average for the region (Figure 54a). The winter to early spring period (June to September 2016) was particularly wet with 619 mm recorded, 33% higher than long-term average for this period (648 mm).

Mean air temperature over the 12 month period was 14.9°C, slightly warmer than the long-term average (Figure 54b). Solar radiation totalled 4956 MJ/m^2, slightly lower than the long-term average (Figure 54c).

3.11.3 Soil nitrogen and phosphorus fertility levels

Soil samples for N and P fertility analyses were taken during installation of the fluxmeters in March 2015, one week after sowing of the potato crop in June 2015 and 7 weeks after sowing of the onion crop in July 2016.

Mineral N (0–100 cm)

Samples taken in March 2015 and June 2015 had high concentrations of mineral N (212 kg N/ha and 319 kg N/ha respectively) (Figure 55a). For the March samples, the majority of mineral N was present in the nitrate-N form (94%), whereas for the June samples ammonium N concentrations were elevated (54% of mineral N) and reflected applications of ammonium-based fertiliser at planting. Samples taken in July 2016 had moderate concentrations of mineral N (145 kg N/ha) with 96% of this nitrogen present in the nitrate-N form.

AMN (0–100 cm)

AMN concentrations were low in the March 2015 and June 2015 samples (60 to 77 kg N/ha) and below the normal concentrations suggested for potatoes (100–150 kg N/ha) (Figure 55a). AMN concentrations were moderate in the July 2015 samples (184 kg N/ha) and within normal concentrations suggested for onion production (100–150 kg N/ha).

Olsen P (0–20 cm)

Olsen P concentrations were very high for all sampling occasions (148–213 mg/L) and well above normal concentrations suggested for potato (30–60 mg/L) and onion (45–90 mg/L) production (Figure 55b).

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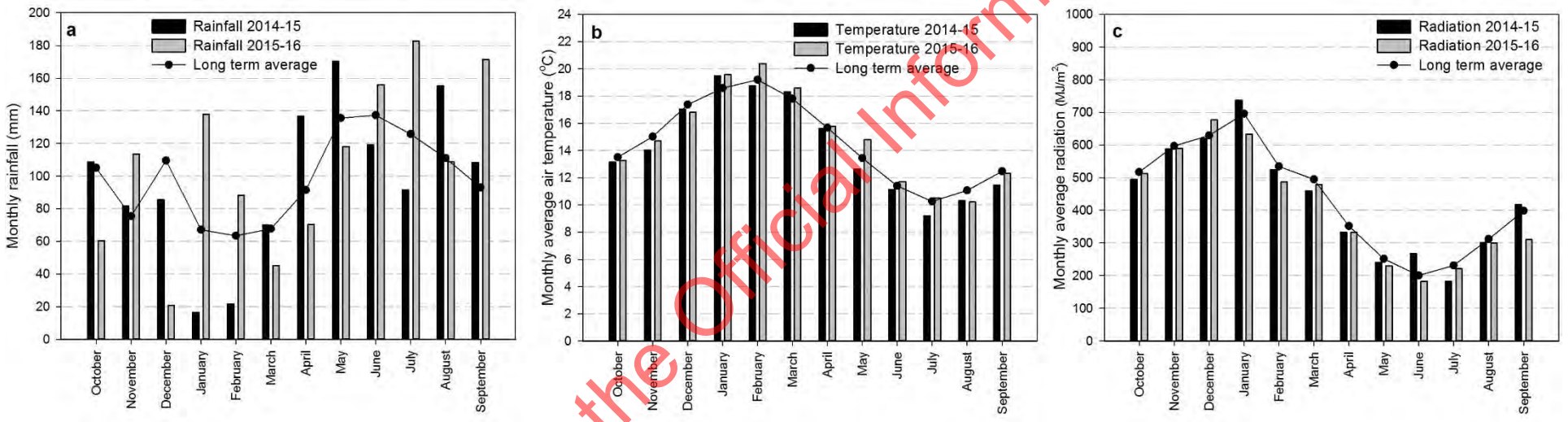

Figure 54. Monthly (a) rainfall (mm), (b) average air temperature (°C) and average solar radiation (MJ/m^2) for 1 October 2014 to 30 September 2016 at Pukekohe (NIWA Station 1962). Long-term climate data (2001–14) are presented for the Pukekohe station.

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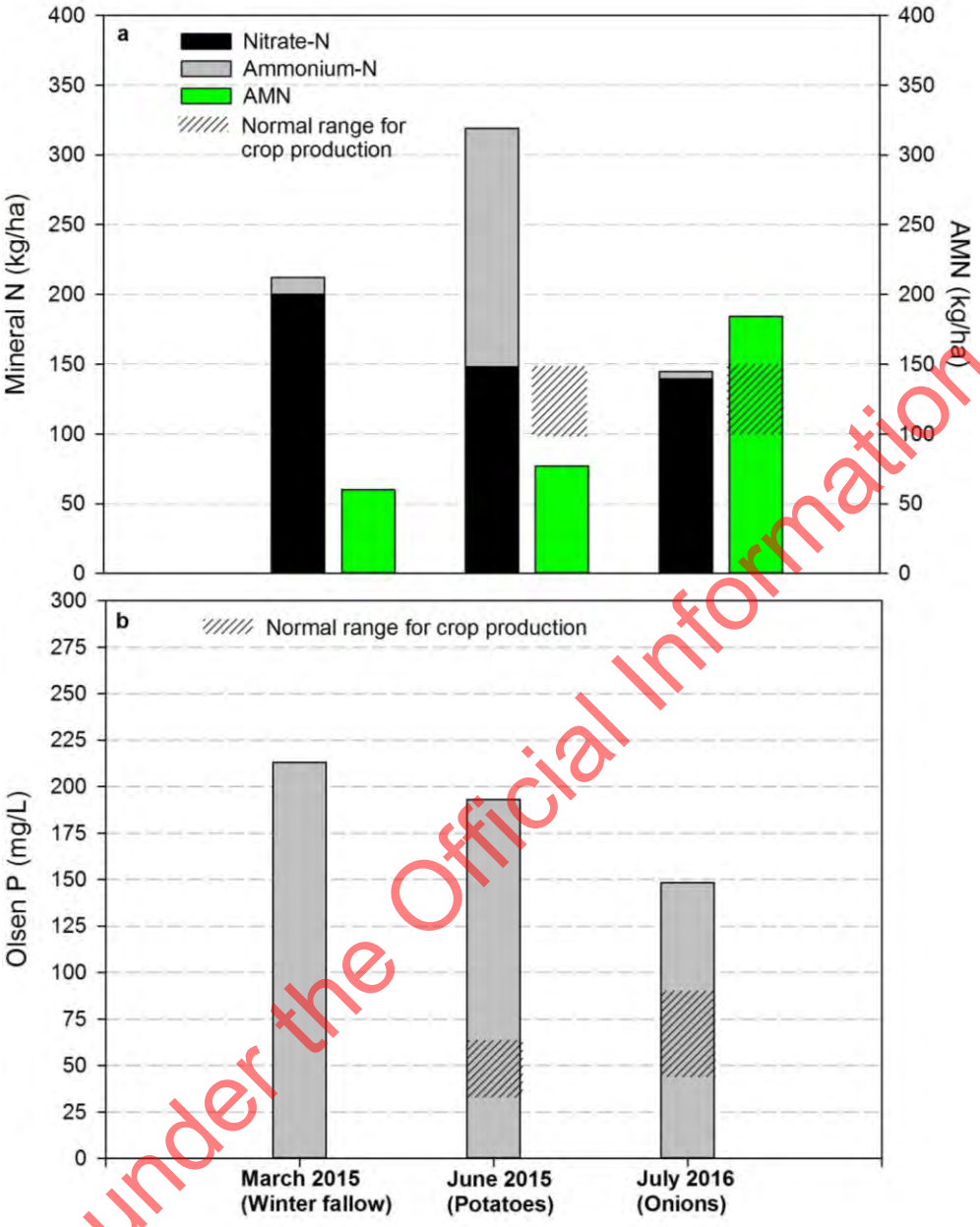

Figure 55. Soil mineral N and AMN (0–100 cm depth) (a) and Olsen P (0–20 cm depth) (b) at Site 11 — Pukekohe for samples taken in March 2015, June 2015 and July 2016. Normal ranges suggested for crop production are provided by Hill Laboratories (http://www.hill-laboratories.com/page/pageid/2145845703/Crop_Guides).

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3.11.4 Soil water balance

Year 1 (1 October 2014 to 30 September 2015)

The soil water balance for Site 11 is shown in Figure 56. Rainfall and irrigation for the Year 1 period totalled 1166 mm and 0 mm respectively. There was frequent and often heavy rainfall over the late autumn to early spring period (April to September 2015) and consequently modelled soil water contents for all depths remained elevated over this period (> 120 mm). Drainage collection commenced in mid-July 2015.

Year 2 (1 October 2015 to 30 September 2016)

Rainfall and irrigation for the Year 2 period totalled 1273 mm and 0 mm respectively. As in Year 1, there was frequent and often heavy rainfall over the late autumn to early spring period (April to September 2016) with a number of significant rainfall events including 70 mm over 2 days in late August and 110 mm over a 10 day period in mid-September.

Modelled soil moisture contents decreased for all depths over the spring period (September November 2015) before increasing to elevated levels (> 110 mm) in late November from where they remained elevated for the remainder of the monitoring period. Four drainage samples were collected, one in early March and three between July and September.

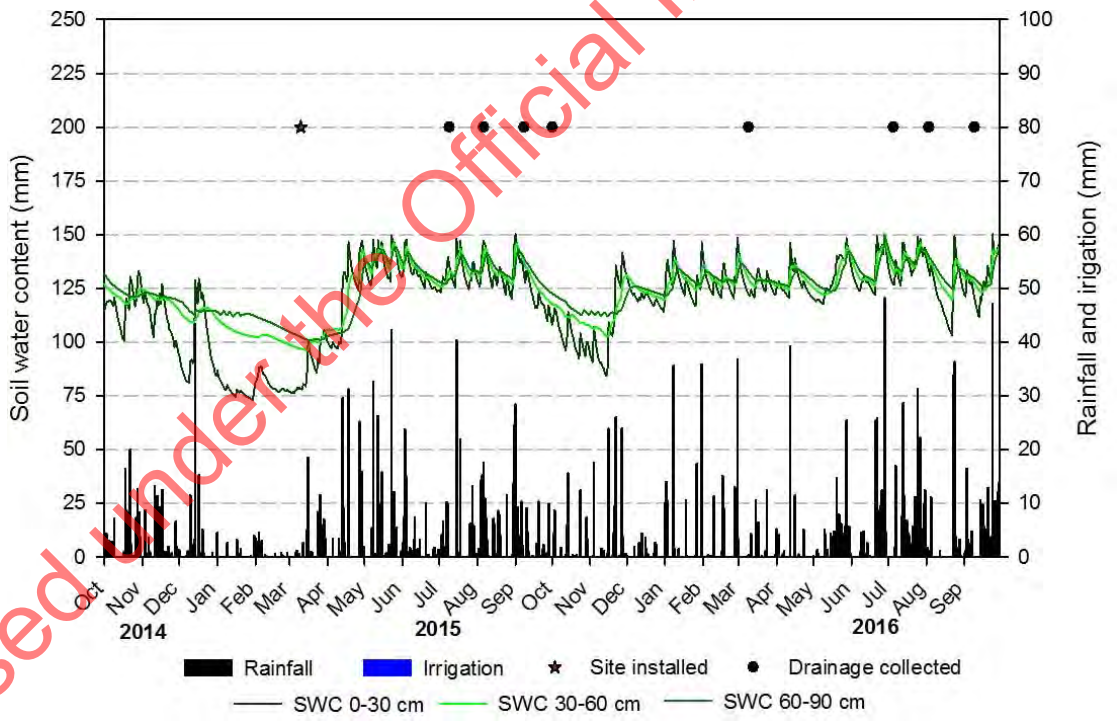

Figure 56. Summary of daily rainfall, irrigation and modelled soil water content (0–30 cm, 30–60 cm and 60–90 cm) from 1 October 2014, Site 11 — Pukekohe.

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3.11.5 Losses of N and P in drainage water

There have been a total of eight drainage samplings since installation of the fluxmeter units in March 2015. For six of these samplings, volumes collected in the fluxmeter units were considerably higher than those predicted by the soil water balance and consequently have not been used to date to calculate N and P losses (only concentrations are provided below). The cause of increased sample volumes is not yet clear, however it is appears unlikely that this is due to groundwater intrusion due to the elevated location of the site relative to the surrounding countryside and little evidence of gleying in the soil profile. Furthermore, measured nitrate concentrations remained relatively high for the duration of the monitoring period (19 to 50 mg/L) suggesting that captured water originated from the overlying soil profile as opposed to more diluted groundwater.

An alternative approach being considered is to estimate losses using a combination of measured N and P concentrations and modelled drainage volumes (as is the common approach for measuring losses using devices like suction cups). To ensure a high level of confidence in the predictions, additional soil physical measurements are being collected from the site. These will be used in the soil water balance model to predict drainage volumes. An onsite rain gauge will also be installed to accurately quantify inputs from rainfall and irrigation.

Year 1 (1 October 2014 to 30 September 2015)

Samples were collected on four occasions in the first year following installation of the fluxmeters (Figure 57b). Nitrate-N and ammonium-N concentrations in drainage for this period averaged 33.5 mg/L and 0.25 mg/L respectively (Figure 57b). Nitrate-N concentrations ranged from 22.8 to 50.0 mg/L and peaked in late September while ammonium-N concentrations remained consistently low (< 1 mg/L). Total P and DRP concentrations averaged 0.03 mg/L and 0.03 mg/L respectively (Figure 57c).

Year 2 (1 October 2015 to 30 September 2016)

Samples were collected on four occasions in the second year following installation of the fluxmeters (Figure 57b). Nitrate-N and ammonium-N concentrations in drainage for this period averaged 22.0 mg/L and 0.04 mg/L respectively (Figure 57b). Nitrate-N concentrations appeared to decline from high levels in spring 2015 (50.0 mg/L) to moderate levels (19.0 mg/L) in spring 2016. Total P and DRP concentrations over this period remained low, averaging 0.03 mg/L and 0.02 mg/L respectively (Figure 57c).

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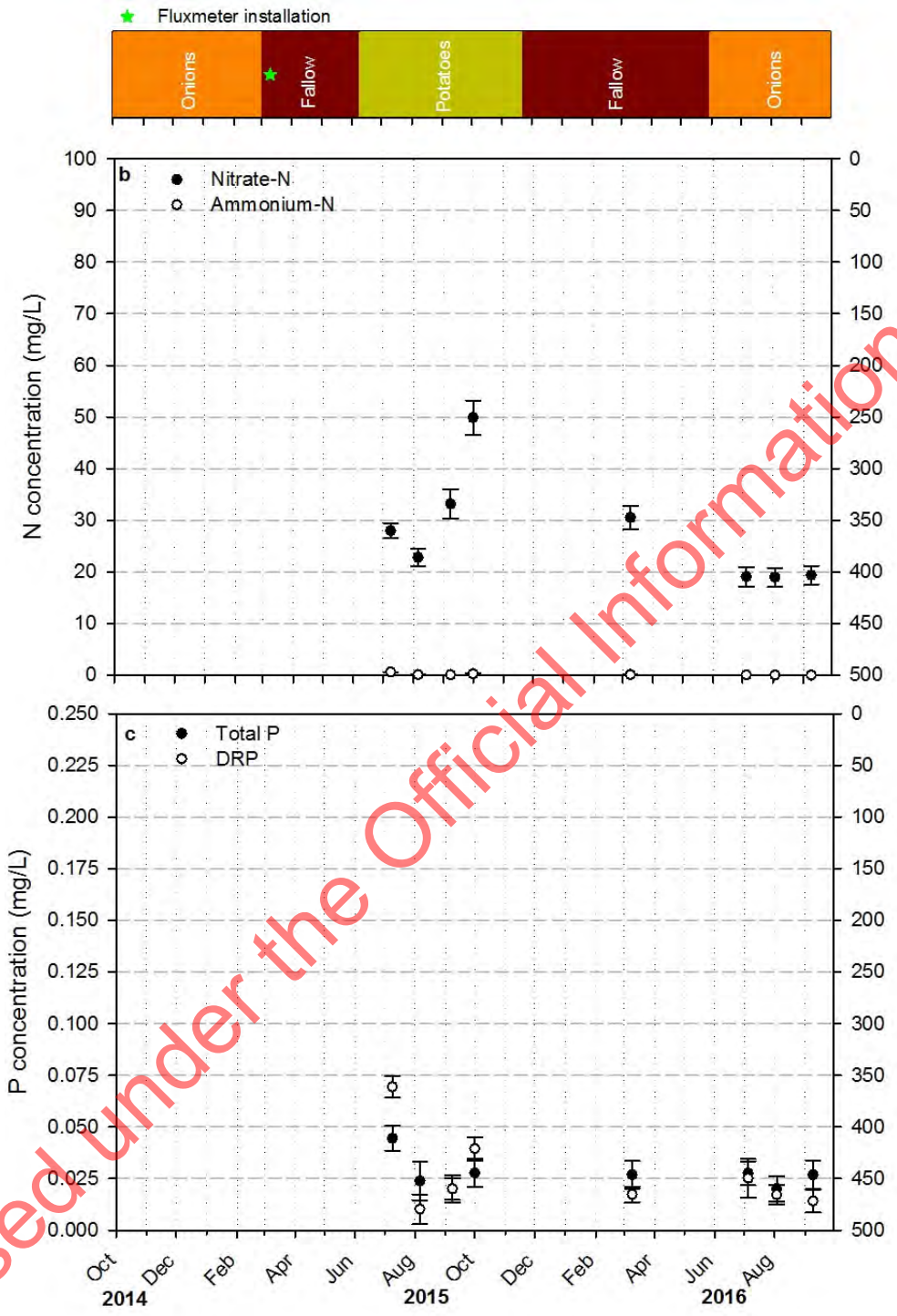

Figure 57. Summary of crop sequence (a) measured inorganic N concentrations (nitrate-N and ammonium-N) (b) and measured P concentrations (total P and DRP) (c) in drainage for Year 1 (1 October 2014 to 30 September 2015) and for Year 2 (1 October 2015 to 30 September 2016) at Site 11 — Pukekohe. Bars around each point represent the standard error of the mean. Lower limit of detections: nitrate-N: 0.02 mg/L; ammonium-N: 0.01 mg/L; total P: 0.02 mg/L; DRP: 0.001 mg/L.

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3.12 Site 12 — Matamata/Pukekohe

3.12.1 Background site and crop management history

Site 12 is located near Tuakau on a mixed cropping and livestock grazing enterprise. Soil type is a Patumahoe clay loam. Fluxmeters were installed at the site in April 2015. Key site characteristics are described in Table 24.

Table 24. Summary of key farm and site characteristics, Site 12 — Pukekohe.

Location	Tuakau
Farming system	Mixed cropping, livestock
Topography	Gently sloping
Soil type	Patumahoe clay loam
Key soil characteristics[1]	Soil order: Mottled orthic granular Texture: Loam over clay Topsoil bulk density: 1.09 g/cm^3 Subsoil bulk density: 1.09 g/cm^3 Drainage class: Imperfectly drained N leaching vulnerability: Medium
Previous land use history	Intensive vegetable production for more than 10 years.
Fluxmeter installation date	7 April 2015
Irrigation infrastructure	Gun

[1]A full description of the Patumahoe clay loam is available online at https://smap.landcareresearch.co.nz/home. Listed characteristics are taken from S-MAP factsheets and are not based on measured site values.

Following installation in April 2015, the site remained fallow over the winter and early spring period before being planted with potatoes in November 2015. The potato crop was harvested in April 2016. Respective N and P inputs for the potato crop have totalled 215 kg N/ha and 30 kg P/ha (Table 25). The site is currently fallow with a mustard crop due to be planted in November 2016.

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Table 25. Summary of crop management practices since fluxmeter installation (7 April 2015), Site 12 — Pukekohe.

Crop management practices	Sequence 1 — Winter fallow	Sequence 2 — Potatoes	Sequence 3 — Fallow
Variety	-	'Rua'	Site currently fallow
Planting population	-	56,250	-
Planting date	-	2 November 2015	-
Harvest date[1]	-	28 April 2016	-
Cultivation practices	-	Subsoil ripping followed by power harrow and bed formation	-
Fertiliser practices (product)[2]	-	1000 kg/ha potato mix (P) 350 kg/ha CAN (S)[3]	-
Summed N and P (elemental)	-	N = 215 kg/ha P = 30 kg/ha[3]	-
Stock type	-	-	-
Stock density	-	-	-
Additional stock information	-	-	-

[1]Commercial harvest date. [2]B = base application, P = planting application, S= side dressing application(s). [3]Split over two applications between November 2015 and January 2016.

3.12.2 General weather conditions

Year 1 (1 October 2014 to 30 September 2015)

Rainfall for the Year 1 period was 1166 mm, comparable with the long-term average for the region (1183 mm) (Figure 58a). Rainfall for the winter and spring period (June to November) was 665 mm, also comparable with the long-term average for this period (648 mm).

Mean air temperature was 14.3°C, slightly lower than the long-term average (14.6°C) (Figure 58b) while solar radiation totalled 5166 MJ/m^2, comparable to the long-term average of 5215 MJ/m^2 (Figure 58c).

Year 2 (1 October 2015 to 30 September 2016)

Rainfall for the Year 2 period was 1273 mm, 8% higher than long-term average for the region (1183 mm) (Figure 58a). The winter to early spring period (June to September 2016) was particularly wet with 619 mm recorded, 33% higher than long-term average for this period (648 mm).

Mean air temperature over the 12 month period was 14.9°C, slightly warmer than the long-term average (Figure 58b) while solar radiation totalled 4956 MJ/m^2, moderately lower than the long-term average of 5215 MJ/m^2 (Figure 58c).

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3.12.3 Soil nitrogen and phosphorus fertility levels

Soil samples for N and P fertility analyses were taken during installation of the fluxmeters in April 2015, following planting of the potato crop in November 2015 and in August 2016 while the site was fallow. The April 2015 and November 2015 samples were taken from the original site area while the August 2016 samples were taken from a replacement location in the same field but approximately 150 m further east.

Mineral N (0–100 cm)

Samples taken April 2015 and November 2015 had high concentrations of mineral N (186 to 541 kg N/ha) (Figure 59a). The very high concentrations of mineral N for the November 2015 samples reflected a recent application of base fertiliser. A high proportion of this mineral N was present in an ammonium-N form (45%). Samples taken in August 2016 from the replacement site also had high concentrations of mineral N (153 kg N/ha). Nitrate-N was the predominant form of mineral N for samples taken in April 2015 and August 2016 (84 to 89%).

AMN (0–100 cm)

Only the top 0–20 cm soil core was analysed for AMN in the April 2015 samples; AMN concentrations were low for this sample (49 kg N/ha), but consistent with samples taken from long-term intensive cropping soils (Figure 59a). AMN concentrations (0–100 cm depth) were moderate (100 to 153 kg N/ha) for samples taken in November 2015 and August 2016.

Olsen P (0-20 cm)

Olsen P concentrations were high for all sampling occasions (101–124 mg/L) and well above normal levels required for potato production (30–60 mg/L) (Figure 59b).

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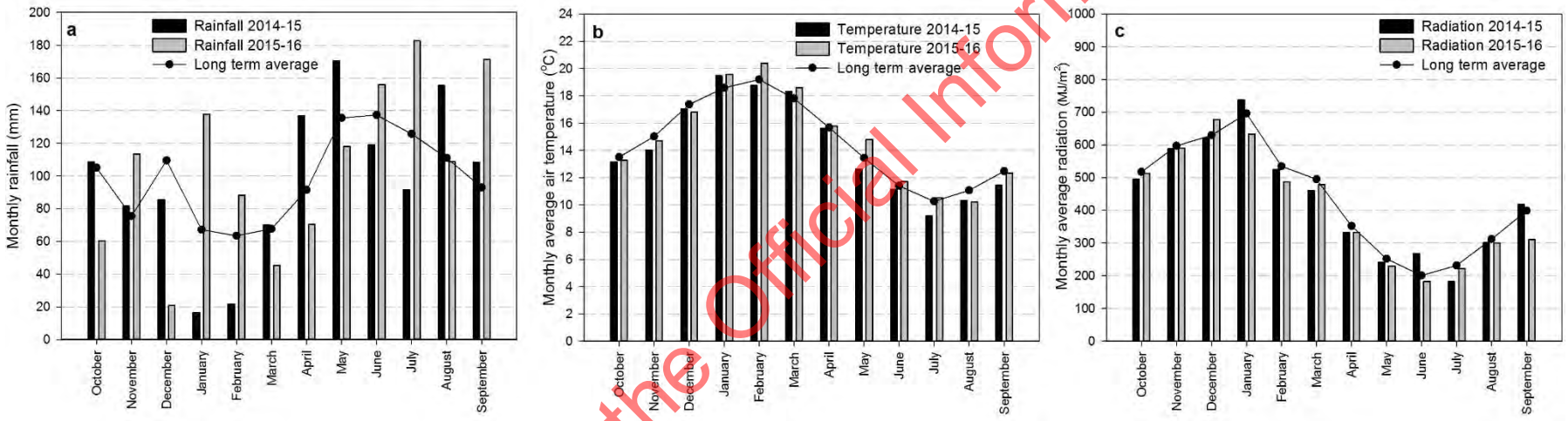

Figure 58. Monthly (a) rainfall (mm), (b) average air temperature (°C) and average solar radiation (MJ/m^2) for 1 October 2014 to 30 September 2016 at Pukekohe (NIWA Station 2006). Long-term climate data (2001–14) are presented for the Pukekohe station.

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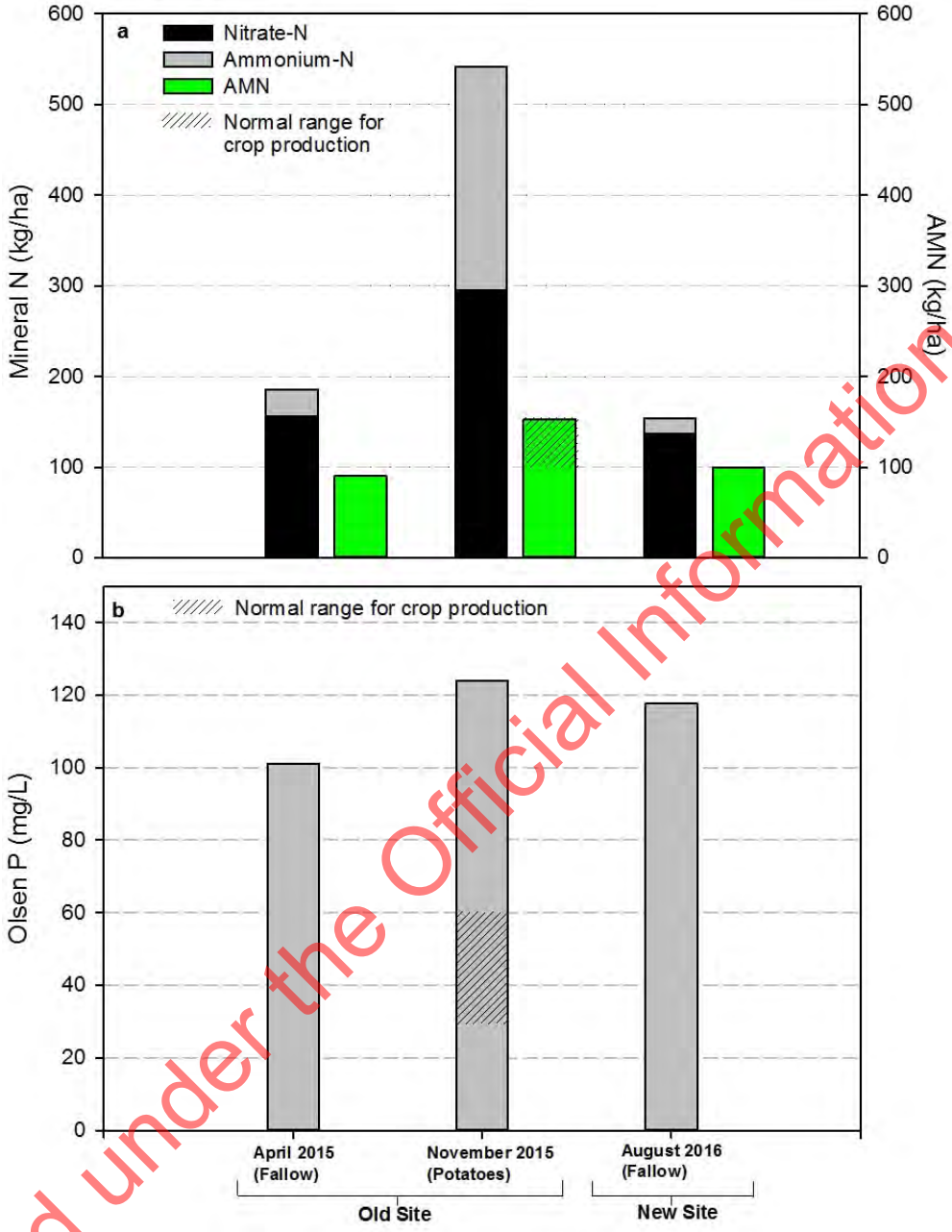

Figure 59. Soil mineral N (0–100 cm depth) and AMN (0–100 cm depth) (a) and Olsen P (0–20 cm depth) (b) at Site 12 — Pukekohe for samples taken from the old site in April and November 2015 and from the new site in August 2016. AMN concentrations for samples taken in April 2015 were determined only for the 0–20 cm depth.

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3.12.4 Soil water balance

Year 1 (1 October 2014 to 30 September 2015)

The soil water balance for Site 12 is shown in Figure 60. Rainfall and irrigation for the Year 1 period totalled 1166 mm and 0 mm respectively. There was frequent and often heavy rainfall over the late autumn through to early spring period (1 April to 30 September 2015) and consequently modelled soil water contents for all depths remained elevated over this period (> 150 mm). Drainage was sampled on three occasions following installation of the fluxmeters in April 2015.

Year 2 (1 October 2015 to 30 September 2016)

Rainfall and irrigation for the Year 2 period totalled 1273 mm and 140 mm respectively.

The largest rainfall event occurred in late February where 51 mm was recorded in 4 days (Figure 60). There were four irrigations of 35 mm per application between mid-December and late February.

Modelled soil water contents decreased slightly over the summer period (December to February), but on the whole remained elevated for all depths (> 110 mm) for the duration of the monitoring period. Elevated soil moisture levels were consistent with frequent rainfall and irrigation. Five drainage samples were collected between October and February.

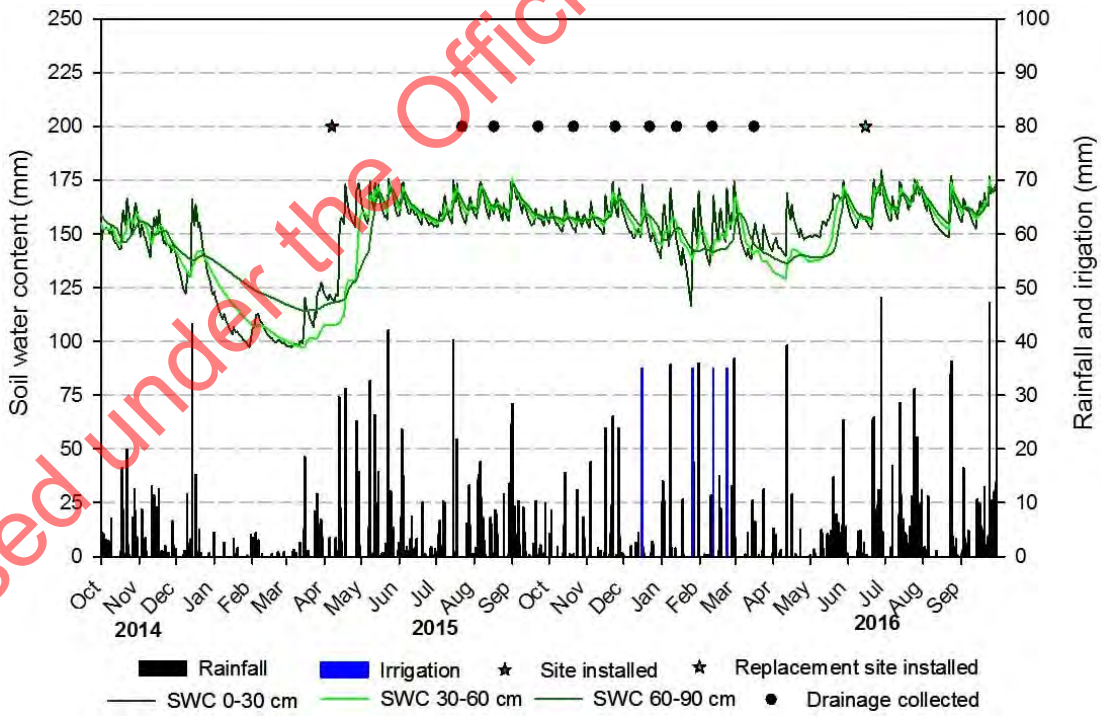

Figure 60. Summary of daily rainfall, irrigation and modelled soil water content (0–30 cm, 30–60 cm and 60–90 cm) 1 October 2014, Site 12 — Pukekohe.

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3.12.5 Losses of N and P in drainage water

During the first year of monitoring, drainage volumes captured in the fluxmeters were considerably higher than those predicted by the soil water balance and consequently net losses of N and P have not been calculated. Elevated drainage volumes in the units was attributed to the presence of a compact ash layer at 80 to 90 cm through which the installation holes for the fluxmeter units were augured (Figure 62a). It was hypothesised that these holes drained water moving laterally across this layer resulting in captured volumes far greater than those predicted by the water balance model. The presence of Pukekawa School a short distance upslope of the site (Figure 62b) likely contributed to subsurface flow volumes through runoff from roof and tarmac surfaces. The experimental site was subsequently re-established in June 2016 in an area east of the current site and well away from the school (Figure 62b). No ash layer was evident in a subsequent soil profile examination of this area and the soil appeared to be free draining to a depth of at least 1 m.

Since reinstallation there has been one drainage sample collected in December 2016. While drainage volumes were similar to those predicted by the soil water balance, further sample collection over the coming months is required to confirm the success of the reinstall.

Figure 62. Picture of a Patumahoe clay loam soil profile (taken adjacent to the fluxmeter site) showing evidence of an ash layer at 80–90 cm (a) and location of fluxmeter Site 12 relative to Pukekawa school (b).

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4 ACKNOWLEDGEMENTS

The Root Zone Reality project (401484) is a collaborative initiative between the Ministry for Primary Industries (Sustainable Farming Fund), the Foundation for Arable Research, Horticulture New Zealand, Environment Canterbury, Horizons Regional Council, Hawke's Bay Regional Council, Ravensdown Fertiliser Cooperative and Plant & Food Research. The Project Manager is Diana Mathers, Foundation for Arable Research. The HortNZ Northern Fluxmeters project (HortNZ RI 1009) is a collaborative initiative between Horticulture New Zealand, Auckland Regional Council, Waikato Regional Council and Plant & Food Research. The Project Manager is Angela Halliday, Horticulture New Zealand.

We thank our grower collaborators for their support and interest in the project, and for providing information about their farming systems and crop management practices.

We are grateful to Matthew Taylor (Waikato Regional Council) for assistance with soil profile evaluation at Site 12.

We are grateful for the hard work of the installation and monitoring teams: Shane Maley, Mike George, Gina Clemens, Steve Thomas, Steve Green, Matt Norris, Carlo van den Dijssel, Paulo Zuccarini, Nathan Arnold, Adrian Hunt, Christina Finlayson, Glen Clark and Peter Wright.

5 REFERENCES

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Meissner R, Rupp H, Seeger J, Ollesch G, Gee GW 2010. A comparison of water flux measurements: passive wick-samplers versus drainage lysimeters. European Journal of Soil Science 61(4): 609–621.

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APPENDIX 1. SUMMARY OF CROP SAMPLING PROTOCOLS USED ACROSS THE FLUXMETER NETWORK SITES

Crop	Sampling protocol
Barley	**Mid-season harvest:** Four samples were collected from each fluxmeter cluster. Each comprised a whole-plant sample harvested from a 0.52 m^2 quadrat cut at ground level. There was no separation of components. **Final harvest:** Four samples were collected from each fluxmeter cluster. Each comprised a whole-plant sample harvested from a 0.52 m^2 quadrat cut at ground level. The sample was separated into grain and straw components.
Clover (seed)	**Mid-season harvest:** No mid-season harvest was taken. **Final harvest:** Four samples were collected from each fluxmeter cluster. Each comprised a whole-plant sample harvested from a 0.27 m^2 quadrat cut at ground level. The sample was separated into seed and residue components.
Cabbage	**Mid-season harvest**: Four individual plants were taken from within each cluster area. There was no separation of components. **Final harvest**: One individual plant was taken from above each fluxmeter location giving four plant samples per cluster area. There was no separation of components.
Process beans	**Mid-season harvest**: Four samples were collected from each fluxmeter cluster. Each comprised a whole-plant sample harvested from a 0.25 m^2 quadrat cut at ground level. There was no separation of components. **Final harvest**: Four samples were collected from each fluxmeter cluster. Each comprised a whole-plant sample harvested from a 0.25 m^2 quadrat cut at ground level. The sample was separated into bean and leaf/stem residue components.
Process carrots	**Mid-season harvest**: Four samples were collected from each fluxmeter cluster. Each comprised a whole-plant sample (tops and roots) harvested from a 0.56 m^2 quadrat. There was no separation of components. **Final harvest**: Four samples were collected from each fluxmeter cluster. Each comprised a whole-plant sample (tops and roots) harvested from a 0.56 m^2 quadrat. The sample was separated into root and leaf/stem residue components.
Fodder beet	**Mid-season harvest**: Population was recorded from a single 2 m row within each cluster and a single whole plant taken for analyses of dry matter and N uptake. The sample was separated into crop and residue components. **Final harvest**: Population and total fresh weight were recorded from samples taken from two 6 m rows from within each cluster. A two plant subsample was taken for analyses of dry matter and N uptake. The sample was separated into crop and residue components.
Lettuce	**Mid-season harvest**: Three individual lettuces (above-ground component) were collected from a 0.69 m^2 area from each fluxmeter cluster. There was no separation of components. **Final harvest**: Three individual lettuces (above-ground component) were collected from a 0.69 m^2 area from each fluxmeter cluster. There was no separation of components.
Maize (grain)	**Mid-season harvest**: Four samples were collected from each fluxmeter cluster. Each comprised a whole-plant sample harvested from a 3.04 m^2 quadrat (2 m x 2 rows) cut at ground level. There was no separation of components. **Final harvest**: Four samples were collected from each fluxmeter cluster. Each comprised a whole-plant sample harvested from a 3.04 m^2 quadrat (2 m x 2 rows) cut at ground level. The sample was separated into cob and stover components.

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Crop	Sampling protocol
Process peas	**Mid-season harvest**: Four samples were collected from each fluxmeter cluster. Each comprised a whole-plant sample harvested from a 0.25 m^2 quadrat cut at ground level. There was no separation of components. **Final harvest**: Four samples were collected from each fluxmeter cluster. Each comprised a whole-plant sample harvested from a 0.25 m^2 quadrat cut at ground level. The sample was separated into pea seeds and pod, leaf and stem residue components.
Potatoes	**Mid-season harvest**: One composite sample was collected from each fluxmeter cluster. Each comprised a whole-plant sample harvested from a 0.45 m^2 quadrat cut at ground level. There was no separation of components. **Final harvest**: Two composite samples were collected from each fluxmeter cluster. Each comprised a whole-plant sample harvested from a 0.25 m^2 quadrat cut at ground level. There was no separation of components.
Spinach	**Mid-season harvest**: One composite sample was collected from each fluxmeter cluster. Each comprised a whole-plant sample harvested from a 0.45 m^2 quadrat cut at ground level. There was no separation of components. **Final harvest**: Two composite samples were collected from each fluxmeter cluster. Each comprised a whole-plant sample harvested from a 0.25 m^2 quadrat cut at ground level. There was no separation of components.
Sweetcorn	**Mid-season harvest**: Four samples were collected from each fluxmeter cluster. Each comprised a whole-plant sample harvested from a 3.04 m^2 quadrat (2 m x 2 rows) cut at ground level. There was no separation of components. **Final harvest**: Four samples were collected from each fluxmeter cluster. Each comprised a whole-plant sample harvested from a 3.04 m^2 quadrat (2 m x 2 rows) cut at ground level. The sample was separated into cob and stover components.
Process tomatoes	**Mid-season harvest**: Four samples were collected from each fluxmeter cluster. Each comprised of three individual plants harvested from a 1.0 m^2 quadrat (0.5 m x 1 bed) cut at ground level. There was no separation of components. **Final harvest**: Four samples were collected from each fluxmeter cluster. Each comprised of three individual plants harvested from a 1.0 m^2 quadrat (0.5 m x 1 bed) cut at ground level. The sample was separated into tomato and residue components.
Ryegrass (seed)	**Mid-season harvest**: Four samples were collected from each fluxmeter cluster. Each comprised a whole-plant sample harvested from a 0.52 m^2 quadrat cut at ground level. There was no separation of seed and residue components. **Final harvest**: Four samples were collected from each fluxmeter cluster. Each comprised a whole-plant sample harvested from a 0.52 m^2 quadrat cut at ground level. There was no separation of seed and residue components.
Wheat	**Mid-season harvest**: Four samples were collected from each fluxmeter cluster. Each comprised a whole-plant sample harvested from a 0.25 m^2 quadrat cut at ground level. There was no separation of seed and residue components. **Final harvest**: Four samples were collected from each fluxmeter cluster. Each comprised a whole-plant sample harvested from a 0.25 m^2 quadrat cut at ground level. The sample was separated into grain and straw components.

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APPENDIX 2. LOCATION OF NIWA CLIMATE STATIONS USED TO COLLECT WEATHER DATA AND DISTANCE OF THESE STATIONS FROM EACH SITE.

Site	Temperature	Solar radiation	Rainfall	Vapour pressure	Wind run	MSL pressure
Site 1 – Canterbury	Methven Three Springs, 1 km	Methven Three Springs, 1 km	Methven Three Springs, 1 km	Winchmore, 20 km	Methven Three Springs, 1 km	Methven Three Springs, 1 km
Site 2 – Canterbury	Methven, 13 km	Methven, 13 km	Methven, 13 km	Winchmore, 16 km	Methven, 13 km	Methven, 13 km
Site 3 – Canterbury	Chertsey, 23 km	Lincoln, 29 km	Ashburton, 36 km	Lincoln, 29 km	Chertsey, 23 km	Methven, 52 km
Site 4 – Manawatu	Levin, 2 km	Levin, 2 km	Levin, 2 km	Levin, 2 km	Levin, 2 km	Levin, 2 km
Site 5 – Manawatu	Palmerston North, 33 km	Palmerston North, 33 km	Bulls, 5 km	Palmerston North, 33 km	Palmerston North, 33 km	Levin, 46 km
Site 6 – Manawatu	Ohakune, 9 km	Mt Ruapehu, Chateau, 23 km	Ohakune, 9 km	Mt Ruapehu, Chateau, 23 km	Mt Ruapehu, Chateau, 23 km	Ohakune, 9 km
Site 7 – Hawke's Bay	Waipawa, 8 km	Waipawa, 8 km	Te Aute, 1 km[1]	Waipawa, 8 km	Waipawa, 8 km	Waipawa, 8 km
Site 8 – Hawke's Bay	Whakatu, 10 km	Whakatu, 10 km	Longlands, 1 km[2]	Whakatu, 10 km	Whakatu, 10 km	Whakatu, 10 km
Site 9 – Hawke's Bay	Takapau, 7 km	Dannevirke, 30 km	Takapau, 7 km	Takapau, 7 km	Takapau, 7 km	Takapau, 7 km
Site 10 – Matamata/Pukekohe	Matamata, 7 km	Toenepi, 22 km	Matamata, 7 km	Matamata, 7 km	Toenepi, 22 km	Matamata, 7 km
Site 11 – Matamata/Pukekohe	Pukekohe, 2 km	Pukekohe, 2 km	Pukekohe, 2 km	Pukekohe, 2 km	Pukekohe, 2 km	Auckland Aero, 25 km
Site 12 – Matamata/Pukekohe	Pukekohe, 19 km	Pukekohe, 19 km	Pukekohe, 19 km	Pukekohe, 19 km	Pukekohe, 19 km	Auckland Aero, 41 km

[1]Hawkes Bay regional council climate station. [2]Hortplus climate station.

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DISCOVER. INNOVATE. GROW.

ITEM 4

From: Michelle Sands
To: Martin Workman; Irene Parminter; Jennie McMurran
Cc: Kay Baxter; Mike Chapman; Ngaio Neumegen; Claire Graeme
Subject: Essential Freshwater - Impacts on domestic food supply and NZ ability to manage greenhouse gas emiss ons
Date: Tuesday, 2 Apr l 2019 4:08:33 PM
Attachments:

FW information on pr ce of vegetable farms and profit per hectare.eml
RE Meeting Actions eml

Hi Martin, Irene and Jennie,

The essential freshwater proposed intensification rule discussed yesterday, could have a severe effect on domestic food supply and creates an unnecessary regulatory barrier to NZ s transition to a low emissions economy This email outlines some of our concerns

Transition to a low emissions economy

- If the world is to prevent warming above 1 5 degrees, emissions need to be reduced without delay Horticulture presents an opportunity for NZ to transition to a low emissions economy If agriculture emissions are to be reduced, then the amount animals eat will need to be reduced and therefore less animal feed needs to be grown
- The proportion of crops in arable rotations must shift to include a greater proportion of vegetables to feed humans as part of our transition to a low emissions economy, and in response to changing dietary preferences
- The proposed intensification rule would prevent NZ growing more vegetables for humans The proposed high risk rule provides a simple consenting pathway for vegetables grown to feed animals
- The proposed intensification rule, requiring consents for new orchards to manage potential water quality effects cannot be justified All new orchards are likely to be irrigated to some degree, but irrigation of orchards does not equate to water decline in the same way irrigated pasture might Irrigated orchards have lesser water quality impacts compared to other activities on similar land This rule is not effects based, but it does creates a barrier to NZ s transition to a low emissions economy
- The ICCC are looking at options to incentivise land use change towards horticulture The intensification rule MfE has proposed is in conflict with climate change policy objectives and (as discussed below) is not directed at reducing water quality effects

Land use change definition and crop rotation

- The intensification rule requires consent for all new vegetable growing land use change Vegetables are grown in crop rotations that move on and off different land parcels It is unclear if this rule captures all vegetable growing, i e vegetables that are grown in arable /extensive rotations on leased land, or just those grown in intensive rotations on grower owned land Will there be an area threshold for land use change? Will land use change include a % of farm enterprise? (I have provided example rotations and overseer modelling of these rotations – see email attached)
- The rule proposes new vegetable land use cannot be consented unless it has a lesser N discharge than the previous land use It is likely this rule will prohibit new intensive vegetable growing and may prohibit extensive vegetable growing, depending on the definitions and mathematics of how the leaching is calculated
- The intensification rule appears to be a land use rule It is unclear how it would provide for crop rotation Would existing growers rotating onto new land be captured? How will the N load associated with vegetable growing be rotated with the crop on to a new growing area?
- If the rule applies to the rotation and not the land, does that mean the vegetable component of a crop rotation will need a consent and the remaining arable part not? or will all parts of the rotation be bundled?
- This proposal is stricter than WRC PC1, because PC1 has policy that directs multiple contaminant and receiving water effects assessments, and therefore it would be possible to gain non-complying consent under proposed PC1 We are currently in caucusing on PC1 It is very likely that changes will be made to PC1 to provide a more straight forward consenting pathway for new vegetable growing
- It is unclear how the intensification rule will be applied In the meeting it seemed that it would be an NES which applied where rules in plans are less strict We are in the process of working with ECan, WRC, HBRC and Horizons on rules that assess effects from growing, using a multiple contaminant approach and GMP This proposed intensification rule has the potential to over-ride all current plans that provide a consenting pathway for new vegetable growing and to prohibit new vegetable growing nationally
- I suggest you speak to ECan, WRC and HBRC The proposed approaches for vegetable production going through schedule 1 processes are different in these regions, but all aim to provide for crop rotation

Why does NZ need new growing land?

-

- The Ministry of Health recommends NZers eat 3+ a day That is approximately 15 million servings of vegetables per day to maintain our current populations health
- NZ needs vegetable growing land to replace land lost to urban expansion and to feed our growing population Some vegetables are also exported (about 20%, but less than 5% grown in intensive rotations)
- If MfE sets an N cap for vegetables, (which wasn t discussed yesterday) as well as the intensification rule, growers will not be able to intensify their current land to increase yields to offset land lost to urban expansion, and they will not be able to expand on to new land to reduce the intensity of their growing to reduce N leaching risk to meet an N cap The N cap policy will lead to a reduced yield/ha and the intensification policy will result in a reduced ha These policies work together to reduce domestic food supply

Loss of existing growing land.

- Intensive vegetable growing land, is the land that supplies domestic markets (>95% crops for domestic) and is located near urban centres, land is lost from these rotations to urban expansion continuously
- Attached is an email sent to MPI that looks at StatsNZ data, this shows increasing yield off a reducing footprint for vegetables over time From a soils health perspective, growers cannot keep increasing yields off an ever reducing footprint
- Pukekohe has land that is currently used for intensive vegetables, but zoned future urban Under the proposed intensification rule, how will this growing area and the food produced be replaced? For example: look in the area around Calcutta road and Foy road, You can see on google maps this land is currently in intensive vegetable production Some of this land was re-zoned urban in Franklin District Plan, more was re-zoned in the AUP and the detail of urban form within the urban limit is currently subject to a structure plan

https://unitaryplanmaps aucklandcouncil govt nz/upviewer/
https://unitaryplanmaps aucklandcouncil govt nz/upviewer/
https://www google com/maps/place/Calcutta+Rd,+Pukekohe+2120/@-37 2203438,174 8843095,531m/data=!3m1!1e3!4m5!3m4!1s0x6d12aa4e27e013cd:0x3a42ec4528f55caa!8m2!3d-37 2226591!4d174 88803?hl=en-NZ

- All intensive growing land around Levin is currently unconsented If the One Plan was enforced or the review of the One Plan develops a rule that looks to reduce some of this growing area, the proposed intensification rule, would mean this vegetable growing land could not be replaced elsewhere in NZ
- In Canterbury some land has potato mop top virus, that land won t be able to support potato growing in the next 20 years The intensification rule, may mean this growing land could not be replaced elsewhere in NZ

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The vegetable growing land in Gisborne on the Waipaoa River floodplain has an over-allocated water resource If an irrigation scheme cannot be developed, the growing that takes place in this catchment, will need to shift elsewhere, but given the proposed intensification rule it won t be able to

- The growing on the Heretauanga Plains, is faced with water allocation limitations and the possible WCO reduces storage options If these regulations reduce the amount the amount of vegetables that can be grown on the Heretaunga Plains, then the proposed MfE intensification rule would prevent this growing land being replaced elsewhere

Section 32 analysis

- Intensive vegetable rotations grow greens and these aren t grown in arable rotations This rule will result in tonnes of vegetables being lost from our domestic food system Imported fresh greens will need to be air freighted at higher costs to consumers and with an unsustainable carbon footprint If we want to meet our health needs, this policy will drive NZers to eat more frozen and processed vegetables These will also need to be imported

- Your analysis should look at the impact on domestic food supply and health impacts of the loss of vegetables from NZ diet It will be important to consider how many years of life the rule will subtract from the NZ population (Health loss is measured in disability-adjusted life years (DALYs)

- From a diversity perspective, it will be confronting when you analyse the social impact of which growers you are targeting

- From an economics perspective you should look at the jobs lost as well as impact on GDP Intensive vegetable growing employs thousands of people (See Deloitte report)

- The N cap policy, is very unlikely to result in water quality improvement If it is ill-designed, it will result in land use change away from growing Land lost to vegetable growing, is likely to be converted to urban If the NPS soils prevents urban growth and the N cap prevents using this land for growing vegetables for humans, the land will be used to grow crops for animals The high risk activity consenting pathway means that using the land for fodder and forage crops and winter grazing will be straight forward to consent, provided a pastoral farmer buys the land off the vegetable grower and manages it within a large enterprise Both alternative land uses are likely to result in measurable water quality decline and soil health decline or loss, (and global warming)

- You will need to justify the social and economic effects against the water quality benefits
  - Which rivers and lakes are impacted by vegetable growing?
  - What proportion of rivers and lakes do these represent?
  - How many kilometres of water course do MfE calculate will be improved with this rule?
  - Of those rivers and lakes that have poor water quality and a high proportion of vegetables in the catchment, what other land uses (urban point sources, dairy, arable) and other pressures (flood defence, drainage) are present in these catchments?
  - Will other pressures impact on the ability of water quality improvements to be achieved?
  - Will this policy drive further land use change away from growing?
  - What will the water impact of alternative land uses be?

Good management practice

- What effects based justification do you have for prohibiting new vegetables growing when new high risk pastoral activities are provided a consenting pathway at GMP?

- Using Nitrogen Kg/ha over a whole farm to compare land uses, is extremely biased towards large farms, because averaging disguises the intensive blocks on large farms In reality intensive blocks may discharge a greater load than small intense vegetable farms, but this detail is lost in the averaging of large farms When the kg/ha method is applied to horticulture it does not target effects it targets small farms In particular it targets intensive vegetable and market garden rotations, these are the growing systems influenced by Asian vegetable growing traditions In addition the Kg/ha method requires a fair method of comparing kg/ha leaching from different land uses, Overseer has limitations for this purpose

- We are of the view that the rules that target horticulture need to be effects based, and need to reflect the reality of growing, this includes crop rotations and soil health management

- The horticulture industry is committed to moving growers to good management practice, and in catchments where there are water quality issues that growing contributes to, we are committed to risk based FEP s that require undertaking additional mitigations

- We have developed an audited EMS under NZGAP which provides a method of delivering GMP improvements through audited FEP s This EMS is accepted by ECAN and is in the process of being accepted by WRC

- In the December I sent a memo David Parker and Damien O Connor I proposed RDA criteria for new vegetable growing areas based on GMP and assessment across contaminants and audited FEPs A similar approach is being proposed in PC1 We are of the view that this approach could be used as assessment criteria for new vegetable growing

Further work

- I will do my best to help collate more evidence over the next week or so, including planning and technical evidence

- I have already sent MfE numerous reports that demonstrates the impact the proposal would have, so if you need help interpreting this information please let me know I am happy to work with officials

- Mike Chapman, will follow this email up and discuss how we can help you develop workable policy

Michelle Sands
Manager – Natural Resources and Environment | Horticulture New Zealand
P: 04 470 5664 | **M:** 021 610 653
A: Level 4, Co-Operative Bank House, 20 Ballance St, Wellington 6011

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From:	Michelle Sands
To:	Irene Parminter; Jennie.McMurran2@mfe.govt.nz
Cc:	"Roger Bannister"
Subject:	FW: information on price of vegetable farms and profit per hectare
Date:	Wednesday, 20 March 2019 6:34:42 PM
Attachments:	Farm Scale economic reports (3.29 MB).msg Overseer Nutrient Modelling results (002).docx HortNZ Memo_DParker_DOConnor_FINAL_corrected.pdf 14210 - Matthew Norris - The MPI SFF root zone reality project FINAL.pdf Deloitte Pukekohe Food Story Final Report.pdf

Hi Irene, and Jenni,

We haven't spoken for a while about the Ag-Package. Further to the email below, I thought I would provide you both with an update on where we are at with a various regional processes and some feedback I have been receiving from growers:

What is the definition of commercial vegetable growing

HortNZ represents growers of vegetables for human consumption. There are some challenges in defining the activity especially for extensive growing rotations. It's something we need to work through with regional plans, but it's also going to be important for any national rules.

For example, Some grow commercial vegetables exclusively on land that is used for growing vegetables. Others grow commercial vegetables as part of arable rotations on cropping land, and some grow commercial vegetables in pasture rotations on land that is usually used for grazing animals. Different growers might grow different crops at different times of the year on the same piece of land, and farmers might graze animals on that land at times also.

What is Land use change in the context of commercial vegetables

A number of plans which have grand-parenting allocation regimes have rules managing intensification through land use change. One issue for commercial vegetable growing is around leased land and crop rotations. A grower might be growing the same area of the same crop rotation, but moving onto new land that's not been used for vegetables before. In the ECan Hort Plan change, PC1 and TANK we are working towards definitions of land use change for commercial vegetables, which are about area rather than location, so growers can shift growing onto new land without it being defined as land use change.

However even with the land area rather than location definition, there is still an issue with how a grand-parented N load is assigned to land in the first place. This issue is discussed in the memo to Ministers attached. In ECan Hort Plan change at the moment, the proposed approach is a moving land use consent. We are working through this issue in PC1 at the moment, through caucusing , and are looking at land use and discharge consents. When we have made a bit more progress, I will share the planning and legal assessment - in about month.

The other issue is thresholds for land use change. In the proposed TANK V8, there is a land use change threshold that is related to 10% if the farm area, after which the load increase is assessed to determine whether the change has resulted in intensification. I support the load aspect of this rule, but the 10% area threshold creates a lot more flexibility for intensification within large farms rather than small, (and therefore creep in the catchment load limit and potential for adverse water quality effects). I have suggested the intensification area threshold should be same for everyone – because the effects are related to load discharged to the receiving environment, not the amount of land the consent applicant owns.

Is there a threshold at which an arable rotation becomes a commercial vegetable rotation? Or for a Dairy of Beef farm with existing cropping, how much extra cropping could they have before it is a land use change? At present there is a large amount of arable land (500,000 ha - ten times as much as commercial vegetable land). Some arable rotations which are predominately for feeding animals include some commercial vegetables. One thing we think is important as part of a transition to a low emissions economy is for the ag sector to pivot towards more horticulture and fewer animals. If there are fewer animals in NZ in future, an arable grower may wish to increase the vegetables for humans in their rotations and decrease vegetables and

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crops for animals. Increasing vegetables for humans in the rotation, may not lead to more leaching, for example fodder/forage parts of the rotation may have higher leaching than process veggies part of rotations, or the pasture part of a rotation could be increased to offset. I've attached the rootzone reality lysimeter Project report. This project measured short term leaching so it can't be compared to Overseer models directly, but you can see a range of leaching rates under crops for humans and crops for animals. Any policy that favours large farms (eg kg/ha averaged over whole farm) disadvantages growers compared to pastoral farmers.

Most vegetables in NZ are grown for domestic supply and therefore the potential for increases in the growing area for most types of vegetables is related to population growth (and increases in healthy eating we hope, if we all ate 3+ we would need to increase supply). This is particularly true for the vegetables that are in the highest leaching rotations, which grow winter greens for NZers to eat in winter when it's cold and rainy and things don't grow very well in most places, but we still need to eat 3+.

Many growers feel that growing vegetables for domestic supply should not be as restrained as land use activities for export (which is most of the rest of the ag sector including fruit). At the moment policy is forcing the most constraint on rotations growing vegetables for domestic supply, and this is not effects based. Given only 50,000 ha of NZ is in commercial vegetables, current national and regional scale water quality problems are not attributable to vegetables. The effects of vegetables are negligible at the catchment scale, with adverse effects at a local sub-catchment scale in a limited number of places – these are generally small, low energy, lowland systems that are partially urban and sometimes highly modified by flood protection and drainage schemes, eg, Ngakaroa Stream, Whakapipi stream, Karamu stream, Lakes Horowhenua and Waiwiri, etc. We are of the view specific and targeted mitigations are required in these receiving environments, rather than expecting national or regional rules to tackle these specific localised issues.

One of the challenges with differentiating domestic versus export rotations, is that many growers grow domestic and some export crops, e.g. onions for export being part of a domestic potato rotation, and therefore defining rotations on the degree to which they are domestic or export is complex – but could be done approximately as a rolling average. The vegetable crops that have the most potential for expansion as part of a transition to a low emissions economy are those that can be exported. E.g. potatoes, onions, process vegetables. These vegetables can be grown in extensive and arable rotations. (in addition some crops for export can be grown indoors such as tomatoes, cucumbers, capsicums – these are low leaching growing systems)

I think the challenge here, is defining thresholds, that do not disadvantage small farms compared to large farms, that enable a transition to a low emissions economy and promote the health of NZ population while maintaining and improving water quality.

What is the appropriate activity status for commercial vegetables.

In the proposed PC1, land use change to commercial vegetables is non-complying. We are seeking an RDA for new commercial vegetable growing land. The strict activity status for changes to commercial vegetables in the Waikato was related to high leaching rates (kg/ha) for vegetables grown in the Pukekohe/north Waikato area. In some parts of NZ, vegetables are grown in more extensive rotations and in arable rotations. For example in Hawkes Bay where a lot of process veggies are grown, leaching rates are in the order of 5 – 50kg/ha depending on location and are comparable and in some cases lesser than pastoral and orcharding land uses. (Overseer report attached).

Sometimes there is an assumption that the highest leaching occurs because people are undertaking an activity in the "wrong place". We don't think that is the case with vegetable growing. We see the highest leaching occurring in the Pukekohe /north Waikato area. This location has favourable, soil, temperature and rainfall. It is not as dependent on irrigation at the east-coast growing regions, and because of its mild climate, vegetables are grown all year around and so are very important for national domestic food supply. The leaching in the Pukekohe/North Waikato area is high measured as kg/ha, but it still only makes up 3% of the nitrogen load in the Waikato River. This is because it has a very small footprint. That footprint produces a large proportion of NZ's domestic food, (attached Deloitte Pukekohe food story report),

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Vegetable Rotation	Leaching Overseer 6.1 (kg/ha/yr)	Leaching Overseer 6.2.3 (kg/ha/yr)
Extensive: Potato (summer) > Onions > Carrots > Squash > Oats and Rye > Barley (grain) > Oats and Rye	58	114
Intensive: Squash > Broccoli > Oats and Rye > Lettuce (summer) > Mustard > Onions > Oats and Rye > Potato (Winter).	65	174
Market garden: Broccoli > Mustard > Lettuce > Cabbage > Mustard > Spinach > Cauliflower > Cabbage > Mustard.	73	159

HortNZ has supported a consented activity status for new commercial vegetables, and for existing growing in those parts of NZ where the most intensive vegetable rotations are located. We acknowledge vegetable growing is an intense activity with specific good management practices, which differ from pastoral GMPS. We have promoted an NES with independently audited FEPs as an alternative regulatory regime for vegetables.

In the transition period to allocation (hopefully with a carve out for vegetables) if there are national rules, due to the scale of effects of vegetables growing and the health and climate benefits of eating vegetables, we think discretion for consenting commercial vegetables should be limited, with a presumption that provided criteria are met, consent will be granted.

Happy to catch up any time, to discuss these issues or provide further clarification and examples and data where I can.

Michelle Sands
Manager – Natural Resources and Environment | Horticulture New Zealand
P: 04 470 5664 | **M:** 021 610 653

From: Michelle Sands
Sent: Wednesday, 20 March 2019 12:18 p.m.
To: 'Andre Silveira' <Andre.Silveira@mfe.govt.nz>
Cc: Sam King <Sam.King@mfe.govt.nz>; 'Irene Parminter' <Irene.Parminter@mfe.govt.nz>; 'Jennie.McMurran2@mfe.govt.nz' <Jennie.McMurran2@mfe.govt.nz>; 'Stuart Miller' <Stuart.Miller@mpi.govt.nz>; 'frances.skilton@mpi.govt.nz' <frances.skilton@mpi.govt.nz>
Subject: RE: information on price of vegetable farms and profit per hectare

Hi Andre,

I've copied this email to a few people – Sam because I've discussed these matters with him before, Irene and Jennie because it links to the Ag-Package and also Stuart and Frances at MPI who I'm working with on NPS soils – I think they may find this discussion useful for their work too.

I have sent Sam information before on the gross margin of vegetable rotations (previous email attached). The reports attached are Overseer and economic analysis. Some are a few years old, so keep that in mind with the

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economics. With the Overseer keep in mind the different versions of Overseer referred to in the reports. Because Overseer has been less developed for representing vegetables, we have seen some dramatic shifts in leaching estimates with versions, for example, the 2014 Lower Waikato report which includes the Overseer and economic modelling for PC1, was updated for a new version of Overseer in 2017 (not the economics or rotations) and there were large increases in estimated leaching – summarised below.

Vegetable Rotation	**Leaching Overseer 6.1 (kg/ha/yr)**	**Leaching Overseer 6.2.3 (kg/ha/yr)**
Extensive: Potato (summer) > Onions > Carrots > Squash > Oats and Rye > Barley (grain) > Oats and Rye	58	114
Intensive: Squash > Broccoli > Oats and Rye > Lettuce (summer) > Mustard > Onions > Oats and Rye > Potato (Winter).	65	174
Market garden: Broccoli > Mustard > Lettuce > Cabbage > Mustard > Spinach > Cauliflower > Cabbage > Mustard.	73	159

I asked four growers for land costs, these are summarised below. The widest range is the South Auckland area – I think that probably relates to the urban pressure on some blocks, and also because about half of this land is used for extensive rotations and half for intensive.

	Lease irrigation supplied/Ha	**Lease (includes non irrigated)/Ha**	**Buy /Ha**
	$ GST excluded	**$ GST excluded**	**$ GST excluded**
Lincoln /Rolleston	1500 - 2000		80,000 - 125,000
South Auckland (Pukekohe, Bombay, Tuakau,Pukekawa, Patamahoe, Puni,)	1500 - 3200	1200 - 2500	75000, 100,000, 125,000, 170,000, 200,000
Waikato		2500	80000
Hawkes Bay	3000		50000
Canterbury	3000		50000
Horowhenua		2000 - 2500	75000

When analysing the land costs above, its important to keep in mind not all land is growing the same rotation. The rotations in the Lincoln, about half of South Auckland and Horowhenua are most likely to be intensive vegetables, in the Waikato, Hawkes Bay and Canterbury, it's more likely to be extensive. In the Overseer reports the gross margin is calculated for different rotations, and there is some discussion on the proportion of the rotations in some areas, for example in the South Auckland area its about 50% extensive, 45% intensive and 5% market garden. The economic reports reflect a higher GM/Ha for intensive vegetables and market gardens, but lesser land is used for growing.

The thing to keep in mind, is domestic food supply. I've attached a memo I wrote to Minsters Parker and O'Connor just before Christmas. In the appendix it summarises the proportion of each crop that is consumed domestically, and in the attached Overseer reports there are example rotations in different locations, so you

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can see what is grown in what rotation. The modelled rotations are simplified because Overseer has a limited range of vegetables that can be modelled and numerous other constraints, for example with the Levin modelling I'm aware that the largest intensive rotation in that region actually grows more than 20 vegetable crops, but the Overseer modelling represents five. Certain crops like potatoes, carrots, process veggies can grow in extensive rotations with pasture and arable crops, brassicas and leafy greens are grown in intensive rotations (sometimes with potatoes and pasture). In market garden rotations a wide variety of brassicas and greens are grown.

The risk is if policy and economics drive growers out of intensive rotations and into extensive rotations, this is likely to produce a greater proportion of vegetables for export and process, and a lesser proportion of fresh veggies and vegetables for domestic supply. Also, from a water quality perspective while the leaching per ha is higher with the more intensive rotations, from a N load perspective (which is actually what causes water quality effects in receiving environments), because the land area is smaller, the effects of intensive vegetables are not necessarily greater than less productive and more extensive land uses.

When considering the impact on domestic food supply, I think a regulatory approach for vegetables which is different to pastoral farming is warranted. In the memo I wrote to Minsters, I proposed an NES for commercial vegetables, operating within a "carve – out" so catchment limits are not breached. The method proposed is a hybrid with a carve out for vegetables and a natural capital allocation for all land to provide for lease land – I note the carve out for vegetables is also compatible with an underlying trading scheme, particularly one with no initial allocation.

If you need help interpreting this information or more specific analysis I can ask the economist who did this work to provide some thing more specific. Let me know if you need more or different information.

I'm based in Wellington, if you want to meet send me a calendar invite.

Best regards

Michelle Sands
Manager – Natural Resources and Environment | Horticulture New Zealand
P: 04 470 5664 | **M:** 021 610 653

From: Andre Silveira <Andre.Silveira@mfe.govt.nz>
Sent: Thursday, 28 February 2019 4:13 p.m.
To: Michelle Sands <Michelle.Sands@hortnz.co.nz>
Cc: Sam King <Sam.King@mfe.govt.nz>
Subject: RE: information on price of vegetable farms and profit per hectare

Hi Michelle,

Thanks for your time and availability.

Having your colleagues' guidance on a few references and a range of case studies would be very helpful. Particularly if they are from different regions of the country.

Nga mihi
Andre

From: Michelle Sands <Michelle.Sands@hortnz.co.nz>
Sent: Thursday, 28 February 2019 3:44 PM
To: Andre Silveira <Andre.Silveira@mfe.govt.nz>
Subject: Re: information on price of vegetable farms and profit per hectare

Hi Andre,

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I'm in a hearing today, I've passed your email on to vegetable sector colleagues. We don't collect this information, but we might be able to provide some case studies, I'll cone back to you, but please feel feee to give me a call.

Michelle Sands
Manager – Natural Resources and Environment | Horticulture New Zealand
P: 04 470 5664 | M: 021 610 653
A: Level 4, Co-Operative Bank House, 20 Ballance St, Wellington 6011

On Thu, Feb 28, 2019 at 12:04 PM +1300, "Andre Silveira" <Andre.Silveira@mfe.govt.nz> wrote:

> Hi Michelle,
>
> I hope this message finds you well.
> My manager Sam King suggested I check whether you could share information on the price of vegetable farms in the last couple of years.
>
> At the moment we are using trimestral figures from Real Estate Institute NZ from 2017 and 2018, but these only refer to the price
> of farms in the horticultural sector in general.
>
> It would be important to have a more detailed view of the sector.
> Thanks very much in advance.
>
> Kind regards,
> Andre
>
> Andre Silveira (PhD) – Policy Analyst
> Water Taskforce – Ministry for the Environment
> Email: Andre.Silveira@mfe.govt.nz
> Phone: 0224930623
>
> **********
>
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>
> **********

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ITEM 5

From: Martin Workman
To: Vaughan.paynes@waikatoregion.govt.nz
Cc: Cheryl Barnes; Roger Bannister; Janice Rodenburg; Jo Burton; Nicola Scott
Subject: Regional Sector Water Group Draft Agenda for review
Date: Tuesday, 2 April 2019 8:49:36 AM
Attachments: Regional Sector Water Sub agenda 12 April.docx

Kia ora Vaughan

I've attached a draft agenda for your feedback for the Regional Sector Water Group meeting on 12 April. Clare W. has asked us to also attend for 30 minutes the Regional CEO meeting on 11 April, and there will be a water item at CEEEFs on morning of 12 April. You will be sick of us! We will work through how we make the most of these different times rather than just repeat things. Any suggestions on what you would like to be covered would be welcomed. We have left Three Waters off this agenda as I understand you are meeting separately on this.

We are getting to a critical stage with key advice on the NPS and NES parts of the Essential Freshwater package going to Ministers by 18 April. We will endeavour to provide the regional sector sub group with our latest draft proposals on 10 April so you can provide feedback on 12 April. This doesn't allow much time but we want to give you the most up to date version we can.

Martin Workman – Director Water
Ministry for the Environment – Manatu Mo Te Taiao and Ministry for Primary Industries
Mobile: 022 517 3268 Email: martin.workman@mfe.govt.nz Website: www.mfe.govt.nz
23 Kate Sheppard Place, PO Box 10362, Wellington 6143

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ITEM 5.1

Regional Sector Water Sub-Group

Meeting 12 April 2019

Agenda

	Item	Detail	Timing
1	Attendance - apologies		13.00 -
2	Minutes – Actions from previous meeting	Approval – noting • Out of Scope • Out of Scope • Meeting to discuss letter response to EFW • Out of Scope	
3	Out of Scope		- 13.10
4	Up-date on EFW work programme - Check in on plans to respond to 9 issues identified by Councils		13.10 – 13.20
5	Implementation of NPS-FM timeframes		13.20 – 13.50
6	A near-final rural package	Seeking comments from the Advisory Group to accompany briefing	13.50 – 14.20
7	Proposed changes to NPS-FM - including how Te Mana o Te Wai is expressed in the NPS		14.20 – 15.00

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ITEM 6

From: Arron Cox
To: Pim De Monchy
Cc: Nathan Capper; Stephen Park; Glenn Ellery; Rob Donald
Subject: RE: Request regarding Wanaka Development
Date: Tuesday, 2 April 2019 6:43:05 AM
Attachments: image001.png

Kia ora Pim,

Thanks for your tautoko. We are seeking reports so I will get into contact with Rob.

Appreciate your support.

Arron Cox

From: Pim De Monchy <Pim.deMonchy@boprc.govt.nz>
Sent: Monday, 1 April 2019 4:59 PM
To: Arron Cox <Arron.Cox@mfe.govt.nz>
Cc: Nathan Capper <Nathan.Capper@mfe.govt.nz>; Stephen Park <Stephen.Park@boprc.govt.nz>; Glenn Ellery <Glenn.Ellery@boprc.govt.nz>; Rob Donald <Rob.Donald@boprc.govt.nz>
Subject: RE: Request regarding Wanaka Development

Hi Arron

Is it data you are after, or reports showing the impacts of sediment and/or estimating reductions needed?

If it is data, then I recommend you contact our Data Services Manager Glenn Ellery.
If it is reports, then Stephen Park is your go to, or Science Manager Rob Donald.

Here is a link to a recent Council report presented by Stephen in December with a focus on two estuaries in the central BOP. Note starting at p55 and in particular p86.

https://cdn.boprc.govt.nz/media/796319/2018-11-30-public-regional-direction-and-delivery-committee-meeting-agenda-11-december-2018.pdf

Cheers
Pim

Pim De Monchy
Coastal Catchments Manager
Bay of Plenty Regional Council Toi Moana

P: 0800 884 880 **DD:** 0800 884 881 x8518
E: Pim.deMonchy@boprc.govt.nz
M: 021 649 818 **W:** www.boprc.govt.nz
A: PO Box 364, Whakatane 3158, New Zealand

Thriving together – mo te taiao, mo nga tangata

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From: Nathan Capper [mailto:Nathan.Capper@mfe.govt.nz]
Sent: Monday, 1 April 2019 1:56 p.m.
To: Pim De Monchy; Stephen Park
Cc: Arron Cox
Subject: FW: Request regarding Wanaka Development

Ahi ahi pai gents,

Please see Arron's request for some support / technical commissioned report information for deposited and suspended sediment in the Bay of Plenty.
Do any of you have information that might help inform this request ?

Stephen I know you have done a fair bit in this space with Caine T hence the inclusion.

Nathan Capper
Bay of Plenty Regional Council (Secondee, Fresh Water task Force)
Nathan.Capper@mfe.govt.nz
Or Nathan.capper@boprc.govt.nz
Mob: 027 519 0335

From: Arron Cox <Arron.Cox@mfe.govt.nz>
Sent: Monday, 1 April 2019 1:21 PM
To: Nathan Capper <Nathan.Capper@mfe.govt.nz>
Subject: RE: Request regarding Wanaka Development

Kia ora Nathan,

Thanks for having a quick korero with me today re sediment impact testing.

Part of the Essential Freshwater work involves setting attributes for deposited and suspended sediment. As part of the impact testing of the proposed sediment attributes we want to look at technical reports from developments around Aotearoa to; look at the effect of the developments in the receiving water bodies, and to compare changes in sediment loading against the proposed attributes.

We are keen to talk to people in Toi Moana about the Eastern Link project to see what data is available for assessment. You also mentioned a large greenfield development that could be interesting. Would you be able to put me in contact with the officers that could help with this?

Appreciate you help!

Arron Cox

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From: Stephen Fragaszy <Stephen.Fragaszy@mfe.govt.nz>
Sent: Monday, 1 April 2019 10:45 AM
To: Ulrich Glasner <Ulrich.Glasner@qldc.govt.nz>
Cc: Arron Cox <Arron.Cox@mfe.govt.nz>; Andrew Rossaak <andrew.rossaak@morphum.com>
Subject: Request regarding Wanaka Development

Hi Ulrich,

I hope you're doing well these days and the beginning of autumn is nice down in Queenstown. I'm writing with a request for information and also a suggestion for a contact at Otago Regional Council regarding these matters. The specifics are in the attached letter from Morphum who are doing some work on our behalf.

In essence, we are doing impact testing of potential sediment attributes proposed by NIWA/Cawthron. Morphum are leading this in relation to urban development interactions with in-stream sediment. They're developing a number of case studies and thought that the Wanaka lake development would be a particularly good one since it is one of the few in that type of climate/geology group and also in quickly growing but relatively small towns.

If you could help to provide the requested information, and/or the appropriate person to contact at ORC, we'd really appreciate that. If you are interested in seeing the proposals, let me know and I can provide some summary information or if you're interested in a long read, the full report. Thanks very much for helping us with this and hope we get to catch up again soon.

Regards,
Stephen Fragaszy – Policy analyst – Freshwater Policy – Water Directorate
Ministry for the Environment – Manatu Mo Te Taiao
Telephone: 022 493 0597; s 9(2)(a) Email: stephen.fragaszy@mfe.govt.nz Website: www.mfe.govt.nz
23 Kate Sheppard Place, Thorndon, Wellington 6143

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ITEM 7

From: Annabelle Ellis
To: Toby.Barach@boprc.govt.nz
Subject: At-Risk Catchments
Date: Thursday, 4 April 2019 2:57:42 PM
Attachments: image001.png
image002.png
image003.png
image004.png

Kia ora Toby

Nice to chat the other week and good to hear you're enjoying life at BOPRC.
Apologies for the delay in emailing it was a combination of Nathan losing your business card, well he actually handed it out to someone else instead of his, and then I've been away.

From my recollection of our phone conversation you were keen to get a bit more information on our At-Risk Catchments (ARC) project, please find further details below.

The Project

The ARC project is part of the government's work programme aimed at improving water quality and ecosystem health. You can find out more about the work programme here.

The ARC project picks up on the Land and Water Forum (LAWF) recommendations to identify at-risk catchments, ensure plans are in place for those catchments, and take action where necessary. LAWF described 'at-risk' catchments as those where:

- there is a clear decline in water quality in a catchment or downstream receiving waterbody;
- where the water resource is under pressure from existing or anticipated future land use change, leading to a likely decline in water quality; or
- where the waterbody is vulnerable to irreversible detrimental change, and urgent action is needed.

Last year we asked regional councils, iwi/hapu, ENGOs and industry to nominate catchments they considered to be 'at-risk'. In addition, we collated existing agency lists for similar work (such as the Ministry's vulnerable catchments list and the Department of Conservation's stretch goal: 50 freshwater ecosystems are restored from mountains to sea) and compiled a long-list of approximately 1000 potential at-risk catchments. Thank you for BOPRC's contribution to this.

A workshop on 14-15 November 2018 was attended by a range of representatives from regional council, iwi/hapu, ENGOs and industry, I believe Rebecca Burton attended from BOPRC.
The project team presented the proposed project approach and asked workshop attendees to work with us to develop a smaller sub-set of catchments to consider trialling interventions in. Valuable feedback was received over the course of the two days. Key outcomes from the workshop included:

a first cut of selection criteria and a list of focus catchments (28 identified) for further refinement;

ideas for interventions in those catchments, both regulatory and non-regulatory; and

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recommendations on how to improve the process for identifying and grouping catchments.

Feedback from the workshop, and from our advisory groups Kahui Wai Maori, Freshwater Leaders Group and Science and Technical Advisory Group, prompted us to reflect on the proposed scope and approach of the project and how best to achieve the desired results.

We recognised that there was a need to clarify and better explain the intent and deliverables of the project, and improve engagement, particularly with iwi/hapu.

Clarifying the project approach

We clarified our approach by further defining two work streams;

the first will focus on **national level information** to enable targeting of regulation, investment and potentially other interventions. This would include continued work on developing criteria for risk assessment that will then be applied across all catchments nationally.

The second work stream will focus on **exemplars**, a small group of catchments that will be identified through further discussion with partners and stakeholders. We will work collaboratively with agency partners (DoC and MPI), Regional Councils, iwi/hapu and communities in these catchments to identify appropriate measures to help improve the health of waterways from the bottom-up, and to identify gaps that could be filled by regulatory or non-regulatory interventions. This small group of catchments will be representative of a range of pressures and issues.

Work this year

Both work streams will draw on input from interested parties. For example, the 'national level information' work stream will have matauranga Maori and western science input. As we look at individual exemplar catchments we will engage with iwi/hapu and communities, as well as the relevant regional council in each area.

We have been continuing to work closely with a sub-group of the Kahui Wai Maori advisory group and other experts, including holding a workshop with experts in February to better capture national level information on the vulnerability, risks and pressures in each catchment in a way that reflects both Te Ao Maori and western world views and plan to hold more.

We are also continuing discussions with people in some individual catchments about using these catchments as examples, or 'exemplars' of ways of collaborating to improve freshwater health and to identify gaps in the current system. These catchments will be representative examples of nationally relevant issues and are likely to have community and council-led initiatives underway.

Next steps

We will be taking a staged approached to exemplar catchments, and we're continuing discussions to determine where initial catchments will be. It is likely we will work directly with a few catchments this year and more will be identified over time. We are also seeking to work collaboratively with other Government agencies to optimise synergies with those working on catchment initiatives.

If you'd like to keep up to date with the Essential Freshwater work programme, including this project, you are welcome to subscribe to our newsletter by clicking on this link http://www.mfe.govt.nz/subscribe making sure you tick the 'fresh water' box.

If you have any further questions please don't hesitate to contact me on 022 009 7624.

Nga mihi,
Annabelle

Annabelle Ellis
Kaiwhakahaere/Manager, Water Taskforce
Ministry for the Environment – Manatu Mo Te Taiao
Mobile: 022 009 7624 Website: www.mfe.govt.nz
Environment House, 23 Kate Sheppard Place, Thorndon

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PO Box 10362, Wellington 6143

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From: Cheryl Barnes <Cheryl.Barnes@mfe.govt.nz>
Sent: Thursday, 4 April 2019 8:34 AM
To: s 9(2)(a) ; millan@wairuaenergy.co.nz; Jacinta Ruru <jacinta.ruru@otago.ac.nz>; asykes@annettesykes.com; s 9(2)(a) ; Jamie.Ataria@lincoln.ac.nz; tanira.kingi@scionresearch.com; Traci (thcg) <traci@thcg.co.nz>; paul@fomana.co.nz; riki@wakataurua.co.nz; s 9(2)(a) ; Wira Gardiner s 9(2)(a) >; maia@whaialegal.co.nz; s 9(2)(a) ; John W Penno <s 9(2)(a) >; N.M Shadbolt <n.m.shadbolt@massey.ac.nz>; Tom Lambie <tom.lambie@ecan.govt.nz>; Allen (Jadegarden) <allen@jadegarden.co.nz>; Corina Jordan <corina.jordan@beeflambnz.com>; Steph Howard s 9(2)(a) ; Mandy Bell <mandy@agresourced.co.nz>; Hugh Logan s 9(2)(a) ; Bryce Johnson s 9(2)(a) ; Gary (EDS) <gary@eds.org.nz>; Marnie (Choosecleanwater) <marnie@choosecleanwater.org.nz>; Dewesa (landcorp) <dewesa@landcorp.co.nz>; Dr Marc Schallenberg <marc.schallenberg@otago.ac.nz>; Graeme Gleeson <gbg.redley@xtra.co.nz>; Governance <Governance@ecan.govt.nz>; s 9(2)(a) Taylor, Ken <Ken.Taylor@agresearch.co.nz>; acanning@fishandgame.org.nz; Bryce Cooper <bryce.cooper@niwa.co.nz>; Clive Howard-Williams (niwa.co.nz) <clive.howard-williams@niwa.co.nz>; C.Daughney@gns.cri.nz; ClarksonB@landcareresearch.co.nz; Graham.Sevicke-Jones@es.govt.nz; ian.hawes@waikato.ac.nz; Jennifer.Webster-Brown@lincoln.ac.nz; Joanne Clapcott (cawthron.org.nz) <Joanne.Clapcott@cawthron.org.nz>; jon.roygard@horizons.govt.nz; Dr Mike Joy (vuw.ac.nz) <mike.joy@vuw.ac.nz>; R.G.Death@massey.ac.nz; Ra@kahungunuwairarapa.iwi.nz; d.hikuroa@auckland.ac.nz; Bill Bayfield <bill.bayfield@ecan.govt.nz>; Vaughan Payne <vaughan.payne@waikatoregion.govt.nz>; Pat Doughtery <pat.dougherty@ncc.govt.nz>; Douglas Leeder (boprc.govt.nz) <douglas.leeder@boprc.govt.nz>; Iain Maxwell (hbrc.govt.nz) <iain@hbrc.govt.nz>; Fiona McTavish (boprc.govt.nz) <Fiona.McTavish@boprc.govt.nz>; James Palmer (hbrc.govt.nz) <james.palmer@hbrc.govt.nz>; Andrew Robb (wcrc.govt.nz) <andrewr@wcrc.govt.nz>; Mike Scarsbrook (waikatoregion.govt.nz) <Mike.Scarsbrook@waikatoregion.govt.nz>; Clare Wooding <clare.wooding@lgnz.co.nz>
Cc: Vicky Robertson <Vicky.Robertson@mfe.govt.nz>; Natasha Lewis <Natasha.Lewis@mfe.govt.nz>; Amanda Moran <amanda.moran@mfe.govt.nz>; Melanie Mark-Shadbolt <Melanie.Mark-Shadbolt@mfe.govt.nz>; Claire Richardson <Claire.Richardson@mfe.govt.nz>; Vicki Connor <Vicki.Connor@mfe.govt.nz>; Janice Rodenburg <Janice.Rodenburg@mfe.govt.nz>
Subject: Essential Freshwater Advisory Network Update #6

Kia ora koutou,

We are heading at pace towards the decision-making phase of our work. As you know, the current timeline sees Ministers making decisions on policy proposals in May, which means we have this month to finalise our recommendations.

We met Ministers Parker and O'Connor this week, and they are positive about where the work programme is getting to, and appreciative of the constructive input of the advisory groups.

Role of advisory group members in public consultation

We are also planning ahead for the formal public consultation process on the package. The timeframe for that is of course dependent on Ministerial decision making, but we are currently aiming to start the formal consultation process in mid-late July. There are some expectations around Government consultation that we need to meet, including publishing proposals and giving the public the opportunity to attend meetings to ask questions, discuss detail and provide feedback.

We will be talking further with Kahui Wai Māori about how best to engage with Māori audiences.

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More generally, I want to confirm that once the package is in the public arena all advisory group members are free to comment as they see fit.

We have confirmed with Minister Parker that:

- The main consultation document is proposed to include short statements from each of the advisory groups summing up their views – what they support and where there are differences of view.
- Consultation meetings would begin with a short scene-setting video. The video would begin with a comment from Minister Parker and Minister O'Connor.
- Advisory network members would be free to attend any roadshow meetings to join the discussion.
- Advisory network members would be free to express their individual views on the policy proposals – at meetings, in the media, and elsewhere, once the package is in the public domain.

Kāhui Wai Māori update

Te Kāhui Wai Māori met on Monday and Tuesday this week.

Te Kāhui Wai and their contracted researchers have been working tirelessly to complete their own work programme while also engaging with officials on the Essential Freshwater programme. This is an ambitious workload for individuals who have numerous other professional and hapū/whānau commitments, and I am grateful for their continuing commitment to this kaupapa. I am also mindful that the Essential Freshwater programme is merely the latest step in a long journey for Te Kāhui members, and for Māoridom as a whole. Nāku te rourou, nāu te rourou, ka ora ai te iwi.

Te Kāhui's engagement with officials has focused on the importance of Te Mana o te Wai as an overarching framework for freshwater care that underpins policy, practice and decision-making. They have stressed the need for the Crown to work with Māori to establish a Te Tiriti-compliant partnership between Māori and the Crown at a central and regional level that recognises Māori rights and obligations to freshwater. Members have also collaborated with officials to design short-term changes to the NPS-FM that will strengthen and clarify Te Mana o te Wai. They have also discussed immediate actions that could be taken now to prevent further degradation of waterways.

Te Kāhui intend to complete their final report and advice to Minister Parker before the end of April.

Science and Technical Advisory Group update

The Science and Technical Advisory Group (STAG) met last week (26 March).

STAG members have advised the Ministry on a wide range of science topics. Key areas of discussion have been how "maintain or improve" is defined, potential sediment attributes, a potential amendment to the dissolved oxygen attribute to apply to all rivers, and managing all aspects of ecosystem health. STAG have also prioritised ecosystem health metrics for further work, guided by the Biophysical Ecosystem Health Framework. Some of the priorities for further work are metrics for aquatic life and habitat. Another area identified as a priority is the way nutrients are managed in the Freshwater NPS. The group supports managing nutrients in a way that is protective of a wide range of ecosystem components, and will be discussing this matter further.

Freshwater Leaders Group Update

The Freshwater Leaders Group (FLG) met on 20 and 21 March. The group spent much of their time in detailed discussions on aspects of the proposed National Policy Statement and National Environmental Standard. They also focussed on the policy proposals that will have a particular impact on agriculture.

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The FLG workshopped allocation options, and provided useful input to the team who are now further developing proposals.

The FLG also had a briefing on urban water quality issues and three waters, which clarified how these issues are being considered alongside rural water quality issues.

This group is making progress on a report summarising its thinking on the proposals.

Coming up:

- Regional hui

The Ministry for the Environment is holding a series of hui in regions around the country in May. This is part of resetting the Ministry's relationship with Māori, and we intend to hold quarterly regional hui across a range of topics. These hui sit alongside but do not replace existing relationships on specific issues such as the Kāhui Wai Māori collaboration.

The main topic on the agenda for these hui in May will be climate change, but we will also provide information about our other work programmes including an overview of the Essential Freshwater work. This will be current information about what's on the agenda (as set out in the March Essential Freshwater newsletter). The intent is to set the scene and signal that there will be formal consultation later this year.

- Environment Aotearoa 2019

The Ministry for the Environment, together with Stats NZ, reports regularly on the state of our environment. We publish a report every six months on a different domain – air, atmosphere and climate, land, fresh water, and marine – and a synthesis report on the state of New Zealand's environment as a whole every three years.

The next report in the series is *Environment Aotearoa 2019,* due to be released on 18 April. This is a synthesis report, bringing together the data and findings from across the domain reports in the past three years, to report on the state of our environment as a whole. It will include data and findings on fresh water from the 2017 Our Fresh water report which identified that our fresh water environment faces a number of serious challenges.

I will send you an overview of what EA 2019 says as soon as it is released.

Next meetings

Regional Councils Group – 12 April

Science and Technical Advisory Group – 16 April

Freshwater Leaders Group – 16, 17 April

Kahui Wai Māori – 29, 30 April

We are also looking ahead to potentially scheduling a further joint meeting in May.

As always, thank you for your ongoing contribution to this important work. Please feel free to get in touch.

Nga mihi,

Cheryl Barnes

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Cheryl Barnes, Deputy Secretary, Water & Climate Change
Ministry for the Environment – Manatū Mō Te Taiao
Mobile: 022 068 3941 Email: cheryl.barnes@mfe.govt.nz Website: www.mfe.govt.nz
No.3 The Terrace, PO Box 10362, Wellington 6143

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ITEM 9

From: Stephen Lamb
To: Heather Martindale
Cc: Claire Graeme
Subject: RE: N cap
Date: Friday, 5 April 2019 5:38:58 PM
Attachments: image001.png
image002.png
image003.png
image004.png
image005.jpg
image006.png
image007.png
image008.png
Summary of PPC10 Nitrogen Allocation April 2019.docx

Hi

Attached is a summary which will give you the basics. As with all of this topic there is more detail and complexity sitting in the wings!

One of your colleagues is also making enquires of PC10 – Sam King who is looking at *Fair Allocation* within the Essential Freshwater work programme.

From the phone conversation with Claire – we did talk about the impact of a hypothetical 70 kgN/ha limit. You will see from the Table LR 6 in the Lake Rotorua Groundwater Catchment the average Dairy NDA is 64.5 kgN/ha. The average benchmark/start point is 102 kgN/ha. The catchment does have high rainfall and leaky soils.

One possibility you might want to consider to address the difficulty of the biophysical range across NZ is to consider whether an approach that targets on farm practice in the first instance is useful. Comparing Dairy (high nitrogen loss activity) Overseer information would give you nitrogen loss but not performance – because of the biophysical influences. If you took all the Overseer data and removed the biophysical (drainage and soils) and applied a standard approach you would identify the top nitrogen loss enterprises in terms of farm practice/intensity. This might be more defendable? There may be enterprises where because of biophysical they would not be able to keep farming even though they were low(er) intensity operations. Farmers may be penalised because of their biophysical conditions rather than being penalised on their practice. At a national level the first step could be to drive best practice, with the 2nd step to look at where we should be farming or how we deliver sustainable limits. Just a thought (and I can't take any credit for it) and there would need to be some thinking about the data process.

Overall from our conversation I keep coming back to the practicalities of monitoring, resourcing, compliance etc. One opportunity is whether a national regulation would come with a national database system? This might provide a pathway for regional councils who do not have the capacity to be supported. There is the potential to simplify certain aspects of an implementation approach – such as identifying 5 or so critical pieces of information (such as winter stock numbers) which would indicate a closer look at any enterprise – and then applying a more forensic approach to the target enterprises – but implementation would be a challenge whatever approach is taken. I assume you will be looking at this as the policy options develop. Again we have some very experienced data/implementation people who would be happy to help.

Cheers

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Stephen Lamb
Environmental Strategy Manager
Bay of Plenty Regional Council Toi Moana

P: 0800 884 880 **DD:** 0800 884 881 x9327
E: Stephen.Lamb@boprc.govt.nz
M: 027 508 6052 **W:** www.boprc.govt.nz
A: PO Box 364, Whakatane 3158, New Zealand

Thriving together – mo te taiao, mo nga tangata

From: Heather Martindale [mailto:Heather.Martindale@mfe.govt.nz]
Sent: Friday, 5 April 2019 11:03 a.m.
To: Stephen Lamb
Cc: Claire Graeme
Subject: RE: N cap

Hi Stephen,

Just following up on Claire's email below. Are you please able to send us a summary of the maximum N-caps under plan change 10?

Kind regards

Heather Martindale – Senior Analyst, LUCAS
Ministry for the Environment – Manatu Mo Te Taiao
Email: heather.martindale@mfe.govt.nz Website: www.mfe.govt.nz
23 Kate Sheppard Place, PO Box 10362, Wellington 6143

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From: Claire Graeme <claire.graeme@mfe.govt.nz>
Sent: Thursday, 4 April 2019 2:38 PM
To: Stephen.lamb@boprc.govt.nz
Cc: Heather Martindale <Heather.Martindale@mfe.govt.nz>
Subject: N cap

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Hi Stephen
Thanks very much for the discussion. Could you please send us through a summary of the main provisions of Plan Change 10 re: maximum caps?

Cheers
Claire

Claire Graeme – Principal Adviser, Co-locator from MPI, seconded to the Water Directorate
Ministry for the Environment – Manatu Mo Te Taiao
Phone: 021 0200 9554 Email: claire.graeme@mfe.govt.nz Website: www.mfe.govt.nz
23 Kate Sheppard Place, Thorndon, Wellington 6143

I work Mondays andTuesdays until 2:00 and don't work Fridays.

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Lake Rotorua Nutrient Management (Proposed Plan Change 10):

Summary of Nitrogen Allocation

Proposed Plan Change 10 (PPC10) is currently before the Environment Court. The Hearing is being dealt with on a two-stage process:

- Stage 1: Allocation
- Stage 2: Implementation.

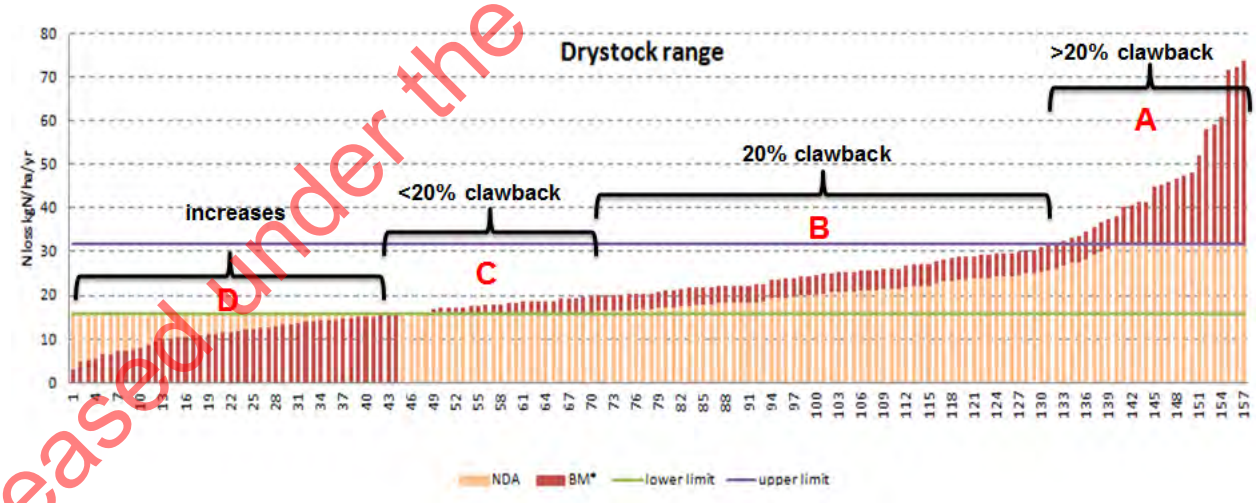
The Stage 1 hearing is complete and a decision is anticipated in the near future.

The allocation methodology is based on sector averages with ranges. The required reductions relate to pastoral land uses under Dairy or Drystock sectors. The Allocation methodology is specified within PPC10 in Schedule LR One. It is used to calculate Nitrogen Discharge Allocations for all Dairy and Drystock blocks. Farming enterprises generally consist of a number of blocks.

Figure 1 shows the "before" and "after" situation for drystock properties. The top of the red lines are the benchmark start points, the top of the orange lines is the resultant NDA allocation.

- In Area A properties are required to reduce more than the standard sector % reduction (20% for Drystock, 31.3% for Dairy). They must drop to the upper range boundary.
- In Area B properties are required to reduce by the standard sector % reduction – and end up within the range.
- In Area C properties are required to reduce by less than the standard sector % reduction – as they can't drop below the range.
- In Area D properties lift to the lower range boundary.

Figure 1: Drystock property reductions



This results in the following NDA allocations (Table LR 6, Schedule LR One). These limits are in Overseer 6.2.0 numbers and are then expressed as a percentage of the relevant reference file. The reference files are designed to allow transition through Overseer versions while retaining an equal effort approach.

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Table LR 6: Allocation parameters and figures

	Dairy	Drystock
Standard sector % reduction	31.3%	20.0%
Nitrogen Discharge Allowance average	64.5	25.6
Lower Nitrogen Discharge Allocation range boundary	54.6	18.0
Upper Nitrogen Discharge Allocation range boundary	72.8	54.6
Sector contribution from Integrated Framework	35.3%	17.2%

Table notes: a) the Nitrogen Discharge Allocation average shows the average for blocks within the range. The application of the methodology results in some blocks being given an increase in relative NDA. The non-benchmarked blocks receive the lower range boundary NDA of 18.0kgN/ha/yr for drystock and 54.6 kgN/ha/yr for dairy.

The NDA is required to be met in 2032. Managed Reduction Targets (MRT) are applied (2022, 2027) and Nutrient Management Plans (NMPS) must be provided for farming enterprises that show the pathway from the start point through to 2032. The NMPs have 5 year timeframes but can be reviewed. They contain committed actions to deliver the MRTs and NDA. Compliance is against the actions within the NMPs.

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From: Lynne Best
To: "gael.ogilvie@aucklandocuncil.govt.nz"; "chris.mclay@waikatoregion.govt.nz"; "clare.barton@ncc.govt.nz"; "colind@nrc.govt.nz"; Iain Maxwell (hbrc.govt.nz); Dennis Bush-King; "Sarah.Omundsen@boprc.govt.nz"; Fred McLay; "gary.bedford@trc.govt.nz"; Ged Shirley; "Katherine.Trought@ecan.govt.nz"; Nic Peet; "hve@marlborough.govt.nz"; Nigel Corry (GW); "Pere.Hawes@marlborough.govt.nz"; Tony Phipps; "vin.smith@es.govt.nz"; Jon Roygard; "Stefanie.Rixecker@ecan.govt.nz"; "dave.allen@aucklandcouncil.govt.nz"; "Keita.Kohere@gdc.govt.nz"; "Chris.ingle@boprc.govt.nz"; "Gavin.palmer@orc.govt.nz"; "hadleym@wcrc.govt.nz"; "nick.zaman@gdc.govt.nz"; "Nadeine.dommisse@ecan.govt.nz"; "Tracey.may@waikatoregion.govt.nz"; "heatherm@wcrc.govt.nz"; "tom@hbrc.govt.nz"; "namouta.poutasi@boprc.govt.nz"; "brent.sinclair@waikatoregion.govt.nz"; James Palmer (hbrc.govt.nz); "gina.ferguson@marlborough.govt.nz"; Liz Lambert; Clare Wooding; Rina Douglas; Mike Scarsbrook (waikatoregion.govt.nz); "Alistair.Cross@gw.govt.nz"
Cc: Stephen Fragaszy
Subject: Sediment working group - data request for turbidity and urban impact testing
Date: Thursday, 11 April 2019 2:54:09 PM
Attachments: image001.png

Tena koutou katoa colleagues

As you know we have had a small working group with MfE on sediment. A couple of issues are being analysed as Mfe heads towards further policy advice to government. Where you are able to assist your help is much appreciated**.**

Two issues are:

Mfe is going to put out a data request as follows

“we will also have a general information request regarding continuous turbidity monitoring in the very near future. We will be asking councils to provide all datasets from their continuous turbidity monitoring at sites that have longer than 2-year records. We plan to do this via the typical information request channel, but we are going to request a very quick turnaround time given it has implications for the proposed suspended sediment attribute grading period and potentially also bottom lines’

Please see below a note to encourage those councils involved with urban impact testing through Morphum **i.e** Auckland, GWRC, Waikato, Bay of Plenty, Taranaki, Otago, and ECan to be as open as possible in sharing data – I understand there may be some sensitive development issues. The work is designed to help deal with issues of conflicting national drivers around urban development and the NPSFM

Many thanks in advance for any help you can provide.

Regards
Nic

From: Stephen Fragaszy <Stephen.Fragaszy@mfe.govt.nz>
Sent: Monday, 8 April 2019 8:49 AM
To: Nic Peet <Nic.Peet@horizons.govt.nz>; 'Ben Tait ' <bentait@nrc.govt.nz>; 'Dave Allen' <dave.allen@aucklandcouncil.govt.nz>; 'Duncan Kervell ' <duncank@nrc.govt.nz>; Gary Bedford <gary.bedford@trc.govt.nz>; Iain Maxwell (hbrc.govt.nz) <iain@hbrc.govt.nz>; Jon Roygard <jon.roygard@horizons.govt.nz>; 'Lisa McGlinchy' <lisa.mcglinchey@tasman.govt.nz>; Matt

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Hickman <Matthew.Hickman@gw.govt.nz>; Claire Conwell <Claire.Conwell@mfe.govt.nz>
Cc: Jo Burton <Jo.Burton@mfe.govt.nz>; Roger Bannister <Roger.Bannister@mfe.govt.nz>; Claire Conwell <Claire.Conwell@mfe.govt.nz>
Subject: RE: Draft notes from the 27th meeting

Hi Nic,

Thanks for looking over the notes.

The regional councils we've contacted with information requests for the urban development impact testing side of things are Auckland, GWRC, Waikato, Bay of Plenty, Taranaki, Otago, and ECan.

Our contractors are already working quite closely with Auckland, and we have a meeting with GWRC set up this week. So it's really only the others where the contractors thought there might be some hesitance. Gary, I will write you separately about the Mt Messenger bypass project in Taranaki we're hoping to assess.

On a separate note, we will also have a general information request regarding continuous turbidity monitoring in the very near future. We will be asking councils to provide all datasets from their continuous turbidity monitoring at sites that have longer than 2-year records. We plan to do this via the typical information request channel, but we are going to request a very quick turnaround time given it has implications for the proposed suspended sediment attribute grading period and potentially also bottom lines.

Regards,
Stephen Fragaszy – Policy analyst – Freshwater Policy – Water Directorate
Ministry for the Environment – Manatu Mo Te Taiao
Telephone: 022 493 0597; s 9(2)(a) Email: stephen.fragaszy@mfe.govt.nz Website: www.mfe.govt.nz
23 Kate Sheppard Place, Thorndon, Wellington 6143

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From: Nic Peet <Nic.Peet@horizons.govt.nz>
Sent: Monday, 8 April 2019 8:23 AM
To: Stephen Fragaszy <Stephen.Fragaszy@mfe.govt.nz>; 'Ben Tait ' <bentait@nrc.govt.nz>; 'Dave

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Allen' <dave.allen@aucklandcouncil.govt.nz>; 'Duncan Kervell ' <duncank@nrc.govt.nz>; Gary Bedford <gary.bedford@trc.govt.nz>; Iain Maxwell (hbrc.govt.nz) <iain@hbrc.govt.nz>; Jon Roygard <jon.roygard@horizons.govt.nz>; 'Lisa McGlinchy' <lisa.mcglinchey@tasman.govt.nz>; Matt Hickman <Matthew.Hickman@gw.govt.nz>; Claire Conwell <Claire.Conwell@mfe.govt.nz>
Cc: Jo Burton <Jo.Burton@mfe.govt.nz>; Roger Bannister <Roger.Bannister@mfe.govt.nz>
Subject: RE: Draft notes from the 27th meeting

Hi Stephen
Thanks for these – I will have a read.

In relation to the urban data which councils are involved – I am assuming Auckland, Greater wellington as a start point ?
Thanks
Nic

From: Stephen Fragaszy <Stephen.Fragaszy@mfe.govt.nz>
Sent: Thursday, 4 April 2019 5:01 PM
To: Nic Peet <Nic.Peet@horizons.govt.nz>; 'Ben Tait ' <bentait@nrc.govt.nz>; 'Dave Allen' <dave.allen@aucklandcouncil.govt.nz>; 'Duncan Kervell ' <duncank@nrc.govt.nz>; Gary Bedford <gary.bedford@trc.govt.nz>; Iain Maxwell (hbrc.govt.nz) <iain@hbrc.govt.nz>; Jon Roygard <jon.roygard@horizons.govt.nz>; 'Lisa McGlinchy' <lisa.mcglinchey@tasman.govt.nz>; Matt Hickman <Matthew.Hickman@gw.govt.nz>; Claire Conwell <Claire.Conwell@mfe.govt.nz>
Cc: Jo Burton <Jo.Burton@mfe.govt.nz>; Roger Bannister <Roger.Bannister@mfe.govt.nz>
Subject: Draft notes from the 27th meeting

Hi all,

I've attached my draft notes from the group meeting on the 27th. Please let me know if I've mischaracterised anything, especially in the "key conclusions" part up top. I would imagine using some of that (after finalising it) in advice to describe the group's views, so please check if you're happy with that section in particular. Also, let me know if you would like me to send you the notes from the call MFE had with the council sediment expert group once they are finalised?

On a separate note, we are in the thick of impact testing the proposed attributes. We and our contractors for the urban component (Morphum) have been in touch with a few councils to try and get data and information regarding particular housing/infrastructure development projects. In essence, we want to assess how developments affect in-stream sediment outcomes and interact with the proposed attributes. Morphum are concerned that council staff may be somewhat reluctant to provide information given the sensitivity of some of the developments.

Would it be possible for you (Nic as the head of the group, or however else you all see fit) to communicate with the concerned councils that the information request is related to impact testing objectives and that we are doing it as part of our attempt to make sure we have "road-tested" the proposed attributes? The request isn't related to oversight of councils' particular development activities or anything of the like. I would appreciate it greatly if you could help communicate this and therefore potentially smooth the process. I'd be happy to draft something if that is appropriate and would be helpful. Thanks for considering how to approach this.

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Otherwise, thanks again for your time preparing and on the day. As always, I found it to be immensely helpful.

Regards,

Stephen Fragaszy – Policy analyst – Freshwater Policy – Water Directorate
Ministry for the Environment – Manatu Mo Te Taiao
Telephone: 022 493 0597; s 9(2)(a) Email: stephen.fragaszy@mfe.govt.nz Website: www.mfe.govt.nz
23 Kate Sheppard Place, Thorndon, Wellington 6143

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Sediment Working Group notes to Regional Sector Water Sub-Group

This document briefly summarises the views of an RMG working group tasked to work with MfE officials as MfE develops national policy on sediment and its impacts on water quality and ecosystem health.

We note and appreciate the openness and spirit in which MfE has approached the work. In keeping with this spirit of openness and trust, we have shared this brief summary with MfE.

The basis of the MfE proposal, as we understand it, is that sediment attributes will be proposed to be included in the NPSFM and associated NOF, with a view that the attribute will be compulsory and entail appropriate monitoring, accounting and management of sediment sources, alongside reporting against attainment of attribute states.

The opportunities

1. Broadly, the RMG sub-group is supportive of a sediment attribute. It highlights the issues, provides a national basis for action and a nationally consistent approach to monitoring and terminology;
2. Sediment is a pervasive issue across much of NZ and requires tackling on a significantly larger scale than most councils are currently able to do – including sediment in the NOF would help;
3. The drivers of sediment loss to water are likely to increase with climate change, so setting a framework for action is important;
4. Better alignment of national policy e.g. we currently have national instruments pulling in different directions – particularly around urban development e.g. NPSFM vs NPSUDC;
5. Focus action on fixing sediment sources rather than simply policy – we often have the tools but not at the scale required;
6. Integrating freshwater sediment management with coastal / marine processes.

The challenges

1. The proposed attributes are complex. On one level this has some attraction; i.e., the 12 level classification allows a degree of differentiation that reflects natural variability. However, the consequence for a compulsory attribute is that this translates into real challenges in terms of the resource needed to measure and monitor in stream, especially within first and second order streams as the proposed attribute requires. Councils will be faced with moving monitoring networks creating new monitoring sites, the cost of which is substantial, and will need to be secured through long term planning or annual budget reprioritisation. It will also take time before monitoring data is available to support development and implementation of policy;
2. The level of complexity makes it difficult for communities faced with taking action on sediment to understand what they are trying to address. Conversation with communities and iwi are often in terms of 'total load' of sediment – the 12-band classification will need to be converted to make it 'real';

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3. The attribute bands are narrow and will potentially be masked by in field variability in sampling;
4. There are some potential challenges in linking land use management to changes in attribute bands. This may be further complicated by the rapid changes in land use in some catchments (eg, those subject to urban growth);
5. The attributes potentially move us away from an FMU / catchment planning approach which is the foundation of NPSFM implementation and discussions with communities and iwi; This may add unhelpful complexity to the management framework.
6. Compulsory attributes lock in a cycle of council planning and monitoring potentially at the expense of addressing the issue of sediment loss Ii.e. in many cases lack of policy is less of an issue than the scale of the on the ground challenge;
7. The proposal doesn't deal with conflicting national policy drivers e.g. Urban development vs freshwater quality;
8. The link to the coastal / marine receiving environment is yet to be developed and this is an important aspect of community values.

Potential way forward

We suggest that MfE considers the following instead of the straight introduction of compulsory national sediment attributes

1. Staged implementation. Options here include government signalling the intent to have compulsory national sediment attributes in 2-5 years;
2. Include attributes now as non-compulsory;
3. Trial implementation of sediment attributes in 1-5 key catchments nationally. There is potential to link to at risk catchments where sediment is a particular issue. Work out what needs refining, what the practical barriers are, what the costs for monitoring look like and how effective the attributes are at driving land management improvements;
4. Staged implementation would allow priority to be given to most impacted catchments and would provide a road tested methodology for the rest of the country to adopt – essentially best practice;
5. Alternatively, MfE could consider implementing monitoring requirements now and attributes 3-5 years later although this is less attractive in terms of demonstrating interventions.

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ITEM 11

From: Stephen Fragaszy
To: Tim Davie; Jean-Charles Perquin
Cc: Dan Elder; Jo Burton
Subject: Continuous turbidity monitoring data request
Date: Friday, 12 April 2019 11:29:20 AM
Attachments: image001.png
Sediment working group - data request for turbidity and urban impact testing .eml
example_df.Rdata

Hi Tim and Jean-Charles,

As we've discussed previously, we at MFE are interested in collating and analysing continuous turbidity monitoring datasets that councils hold for the purpose of evaluating the proposed suspended sediment attributes. We have assessed data from one Horizons site with continuous monitoring data, and we would like to replicate that across all sites from which we can access continuous monitoring data.

We believe this will help us consider the appropriate grading period, how to incorporate spot versus continuous monitoring within the attribute framework, and for testing the viability of the proposed bottom lines.

If we get the information by early May, we would intend to present initial results at the SWIM workshop per our discussion on the 25th of March. We would also incorporate it into our application that visualises the proposed sediment classification systems, existing SOE turbidity and deposited sediment monitoring sites and their medians, and provides information on the bottom lines.

If you are comfortable with this, I have included the information request in the template below and attached an example R data format. I've also attached a letter from the RMG sediment working group supporting this information request (and an unrelated one on impact testing). Please let me know if you have any questions on this – I'm available by email and the 021 number in my signature block.

Reference	Request details
#1	**Continuous turbidity monitoring data** **Request date: 11 April 2019** **Due date: 3 May 2019 (to support the forthcoming cabinet paper on Essential Freshwater** *This request will be carried out by the Ministry (Stephen Fragaszy, Water – Stephen.fragaszy@mfe.govt.nz)* **Request 1:** We would like to obtain for all continuous turbidity monitoring sites the following data with the following items as the "columns" of the data table: 1. REC2 Segment ID of monitoring station 2. Time-stamp of measurement 3. Turbidity measurement (please identify whether NTU or FNU) 4. Flow (if available) 5. Site ID (if it has a specific name) 6. Site name We would prefer this data as an R object similar to the format of the example we have attached. If it is easier for you to provide an Excel or other CSV file, we would appreciate you providing the file with columns as per the table above to the extent possible.

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Regards,

Stephen Fragaszy – Policy analyst – Freshwater Policy – Water Directorate
Ministry for the Environment – Manatu Mo Te Taiao
Telephone: 022 493 0597; s 9(2)(a) Email: stephen.fragaszy@mfe.govt.nz Website: www.mfe.govt.nz
23 Kate Sheppard Place, Thorndon, Wellington 6143

http://intranet/sites/all/files/Lockup-8pt.png

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ITEM 11.2

Date_time	Flow (L/s)	Turbidity (N	SiteID	SiteName	REC2_segment
########	228039	71.554	ZY64	Cool swimr	234832
########	230766	70.79	ZY64	Cool swimr	234832
########	229856	70.97	ZY64	Cool swimr	234832
########	229174	71.15	ZY64	Cool swimr	234832
########	228493	71.33	ZY64	Cool swimr	234832
########	228266	71.285	ZY64	Cool swimr	234832
########	227812	71.24	ZY64	Cool swimr	234832
########	226906	71.195	ZY64	Cool swimr	234832
########	226228	70.656	ZY64	Cool swimr	234832
########	225776	70.116	ZY64	Cool swimr	234832
########	226454	69.577	ZY64	Cool swimr	234832

From: Dave Rennison
To: Andrew Rossaak
Cc: Arron Cox; Stephen Fragaszy; Claire Conwell
Subject: RE: Sediment control/monitoring data for TGM
Date: Tuesday, 16 April 2019 8:46:29 AM
Attachments: image001.jpg
image002.png
image003.png
image004.png

Hi Andrew

I'll be ready for a call at 2pm today. You can call either my landline or mobile. Look forward to catching up.

Cheers

Dave Rennison | Senior Project Consents & Compliance Officer, Environmental Regulation
GREATER WELLINGTON REGIONAL COUNCIL
Te Pane Matua Taiao
Shed 39, 2 Fryatt Quay, Pipitea, Wellington 6011
T: 04 830-4042 | M: 021 846 752 www.gw.govt.nz

From: Andrew Rossaak <andrew.rossaak@morphum.com>
Sent: Monday, 15 April 2019 3:10 PM
To: Dave Rennison <Dave.Rennison@gw.govt.nz>
Cc: Arron Cox <arron.cox@mfe.govt.nz>; Stephen Fragaszy <Stephen.Fragaszy@mfe.govt.nz>; Claire.Conwell@mfe.govt.nz
Subject: RE: Sediment control/monitoring data for TGM

Hi Dave,

Can I suggest we make it tomorrow (Tue) at 2pm?

Either Arron or I will initiate the phone call.

Kind regards
Andrew

Andrew Rossaak (M.Sc) | Science Team Leader | P. 09 377 9779 | M. 021 638 192 | www.morphum.com | @MorphumNZ (twitter)

From: Dave Rennison <Dave.Rennison@gw.govt.nz>
Sent: Monday, 15 April 2019 3:03 PM
To: Andrew Rossaak <andrew.rossaak@morphum.com>
Cc: Arron Cox <arron.cox@mfe.govt.nz>
Subject: RE: Sediment control/monitoring data for TGM

Hi Andrew

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Sorry this afternoon has not worked out for me but I am free tomorrow afternoon any time. Please let me know what time you want to talk. I don't believe we are set up for Skype here (I've never used it) so could you just give me a call? Also I'm not 100% sure who's supposed to be in the conversation (see attached email) so if you could please make sure the right people are involved.

Look forward to hearing from you.

Cheers

Dave Rennison | Senior Project Consents & Compliance Officer, Environmental Regulation
GREATER WELLINGTON REGIONAL COUNCIL
Te Pane Matua Taiao
Shed 39, 2 Fryatt Quay, Pipitea, Wellington 6011
T: 04 830-4042 | M: 021 846 752 www.gw.govt.nz

From: Andrew Rossaak <andrew.rossaak@morphum.com>
Sent: Monday, 15 April 2019 2:13 PM
To: Arron Cox <arron.cox@mfe.govt.nz>; Dave Rennison <Dave.Rennison@gw.govt.nz>
Subject: RE: Sediment control/monitoring data for TGM

Hi Dave,

I am available to discuss the data that would be useful with you on skype, either this afternoon or tomorrow after 11:30.

Kind regards
Andrew

Andrew Rossaak (M.Sc) | Science Team Leader | P. 09 377 9779 | M. 021 638 192 | www.morphum.com | @MorphumNZ (twitter)

From: Arron Cox <Arron.Cox@mfe.govt.nz>
Sent: Monday, 15 April 2019 10:01 AM
To: Andrew Rossaak <andrew.rossaak@morphum.com>; Dave.Rennison@gw.govt.nz
Subject: FW: Sediment control/monitoring data for TGM

Kia ora Andrew,

Please meet Dave from GWRC…he will be helping us source information for Transmission Gully.

Are you free for a call today or tomorrow. Will be good to have you on the other end so you can detail what we want.

Arron

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From: Dave Rennison <Dave.Rennison@gw.govt.nz>
Sent: Friday, 12 April 2019 9:14 AM
To: Arron Cox <Arron.Cox@mfe.govt.nz>; Stu Farrant <stu.farrant@morphum.com>; Stephen Fragaszy <Stephen.Fragaszy@mfe.govt.nz>; Claire Conwell <Claire.Conwell@mfe.govt.nz>; Claire Conwell (gw.govt.nz) <Claire.Conwell@gw.govt.nz>
Subject: RE: Sediment control/monitoring data for TGM

Hi Arron, Monday's fine, afternoon is best, any time after 1:30. Cheers

Dave Rennison | Senior Project Consents & Compliance Officer, Environmental Regulation
GREATER WELLINGTON REGIONAL COUNCIL
Te Pane Matua Taiao
Shed 39, 2 Fryatt Quay, Pipitea, Wellington 6011
T: 04 830-4042 | M: 021 846 752 www.gw.govt.nz

From: Arron Cox <Arron.Cox@mfe.govt.nz>
Sent: Friday, 12 April 2019 8:39 AM
To: Stu Farrant <stu.farrant@morphum.com>; Stephen Fragaszy <Stephen.Fragaszy@mfe.govt.nz>; Dave Rennison <Dave.Rennison@gw.govt.nz>; Claire Conwell <Claire.Conwell@mfe.govt.nz>; Claire Conwell <Claire.Conwell@gw.govt.nz>
Subject: FW: Sediment control/monitoring data for TGM

Sorry Dave,

Have been on leave the last few days! How are you placed Monday for a phone call? Stu are you free Monday too?

Arron

From: Dave Rennison <Dave.Rennison@gw.govt.nz>
Sent: Wednesday, 10 April 2019 1:32 PM
To: Arron Cox <Arron.Cox@mfe.govt.nz>
Subject: RE: Sediment control/monitoring data for TGM

Hi Arron, were you still planning to call me today? I am still free until about 3pm. Cheers

Dave Rennison | Senior Project Consents & Compliance Officer, Environmental Regulation
GREATER WELLINGTON REGIONAL COUNCIL
Te Pane Matua Taiao
Shed 39, 2 Fryatt Quay, Pipitea, Wellington 6011
T: 04 830-4042 | M: 021 846 752 www.gw.govt.nz

From: Arron Cox <Arron.Cox@mfe.govt.nz>
Sent: Wednesday, 3 April 2019 3:35 PM
To: Claire Conwell <Claire.Conwell@mfe.govt.nz>; Dave Rennison <Dave.Rennison@gw.govt.nz>
Cc: Stephen Fragaszy <Stephen.Fragaszy@mfe.govt.nz>
Subject: RE: Sediment control/monitoring data for TGM

Kia ora Dave,

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Are you free this week on Monday, Tuesday next for a meeting?

Arron

From: Claire Conwell <Claire.Conwell@mfe.govt.nz>
Sent: Wednesday, 3 April 2019 3:34 PM
To: Dave Rennison <Dave.Rennison@gw.govt.nz>
Cc: Arron Cox <Arron.Cox@mfe.govt.nz>; Stephen Fragaszy <Stephen.Fragaszy@mfe.govt.nz>
Subject: RE: Sediment control/monitoring data for TGM

Hi Dave
Thanks very much for the reply. Either Arron Cox or I will get back to you to set up a meeting. As mentioned the team from Morphum Environmental will be undertaking the review & analysis for this so will see if they have time to come to a meeting too – will be easier for them to get to the point of the data/info they're needing.

Will also be in Shed 39 tomorrow, if you're available & want a quick chat I can give you a bit more context on this too.

Thanks again
Claire

From: Dave Rennison <Dave.Rennison@gw.govt.nz>
Sent: Tuesday, 2 April 2019 12:28 PM
To: Claire Conwell <Claire.Conwell@mfe.govt.nz>
Cc: Richard Percy <Richard.Percy@gw.govt.nz>; Jo Frances <Jo.Frances@gw.govt.nz>; Matthew Hickman <Matthew.Hickman@gw.govt.nz>
Subject: RE: Sediment control/monitoring data for TGM

Hi Claire

We'll be happy to help and I suggest we meet up to discuss exactly what you need as there are large volumes of information on many different levels. Some initial thoughts are:

- The application material. This should all be available on NZTA website
- Any available Compliance Monitoring data and reports. There are numerous reports: baseline, quarterly, biannual and annual over several years and we will need to discuss which of these contain the information you're after and who is best to supply it. There is also a substantial compliance Register on stream turbidity events, pond efficiency and erosion and sediment control failures.
- Detailed complaints register for the project. We hold some limited information on public complaints to us – there have been fairly few – but the Project is required to hold a permanent record of any complaints received by it, which might be larger.
- Dates construction started and dates it finished (or is expected to be completed). We can dig this up
- Closest down-stream State of the Environment monitoring site (if known) and water quality and sediment data from this site (I can pull this last part together via the ESci

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team). The Project also has upstream and downstream monitors in the six main streams along the Project alignment

I imagine you will also be in touch with the Project about this.

Could you please let us know when you would like to drop by and discuss?

Thanks

Dave Rennison | Senior Project Consents & Compliance Officer, Environmental Regulation
GREATER WELLINGTON REGIONAL COUNCIL
Te Pane Matua Taiao
Shed 39, 2 Fryatt Quay, Pipitea, Wellington 6011
T: 04 830-4042 | M: 021 846 752 www.gw.govt.nz

Begin forwarded message:

From: Claire Conwell <Claire.Conwell@mfe.govt.nz>
Date: 1 April 2019 at 2:45:37 PM NZDT
To: "richard.percy@gw.govt.nz" <richard.percy@gw.govt.nz>, "jo.frances@gw.govt.nz" <jo.frances@gw.govt.nz>
Cc: Stephen Fragaszy <Stephen.Fragaszy@mfe.govt.nz>, "matthew.hickman@gw.govt.nz" <matthew.hickman@gw.govt.nz>
Subject: Sediment control/monitoring data for TGM

Hi Richard, Jo

Getting in touch with my MfE 'hat' on as part of my secondment work. One of my tasks is assisting Stephen Fragaszy with the sediment attribute development work – this is for a project for the Essential Freshwater Policy Program, with a focus on urban environments.

One item that has been identified in testing the proposals is to look at urban development and transport plans – the Transmission Gully project has been listed as a specific example we're keen on compiling the available data for.
[Jo – the Kenepuru (old hospital) site came to mind too if time permits, but just giving you a heads up for now in case there is further interest in this – will let you know.]

For the TGM work MfE are keen to work up the available data to test out the proposed sediment thresholds.

Morphum Environmental are engaged to provide expert advice and analysis to MfE on this, and they will be the ones reviewing/analysing any data. To complete this work, we are looking for available case studies that span the range of sediment attributes. These ideally are medium to large scale land development projects in different areas of New Zealand – a couple of other urban centers across NZ are also

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being looked at .

For the TGM information, it would be great if MfE could get copies of the following material, or links to where this information may be found:

- The application material (Consent, including AEE and earthworks plan/report(s) and amendments).
- Any available Compliance Monitoring data and reports (Stream water quality and flow data, including baselines and any post construction as well as rainfall).
- Detailed complaints register for the project.
- Dates construction started and dates it finished (or is expected to be completed)
- Closest down-stream State of the Environment monitoring site (if known) and water quality and sediment data from this site
  (I can pull this last part together via the ESci team)

The focus of the review will be on the stream water quality, sediment controls and the effectiveness of these.
Matt H also has some more background on this sediment proposal too, otherwise I'm happy to have a chat further on this too, & assist in pulling this information together.

Thanks for your help on this
Claire

Claire Conwell – Secondee, Freshwater Policy
Ministry for the Environment – Manatu Mo Te Taiao
1645 Website: www.mfe.govt.nz
3 The Terrace, PO Box 10362, Wellington 6143

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Nick Vincent

From: Irene Parminter
Sent: Tuesday, 16 July 2019 11:13 AM
To: Nic.Peet@horizons.govt.nz; jon.roygard@horizons.govt.nz
Subject: FW: Request for assistance - Essential Freshwater work

Hi Nick and Jon. Mike McCartney suggested I contact you both about the request I made (below).

If possible, I would like to give you a call to discuss which sub-catchments are under the One Plan (I think all except the Turakina?) and test the results with you. If that is possible, please let me know suitable times and numbers to call you on.

Thank you

Irene

Irene Parminter – Senior Policy Analyst
Ministry for the Environment – Manatū Mō Te Taiao
Mob: 022 517 3371 Email: irene.parminter@mfe.govt.nz Website: www.mfe.govt.nz
Environment House, Kate Sheppard Place, PO Box 10362, Wellington 6143

From: Michael McCartney <michael.mccartney@horizons.govt.nz>
Sent: Tuesday, 16 July 2019 10:28 AM
To: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Subject: Re: Request for assistance - Essential Freshwater work

Thanks Irene - happy for you to discuss the context around these catchments with relevant staff. The two Group Managers you should engage with are Dr Nick Peet (regulatory under One Plan and Dr Jon Roygard (water quality science). Regards M

Sent from my iPad

On 16/07/2019, at 10:18 AM, Irene Parminter <Irene.Parminter@mfe.govt.nz> wrote:

> Dear Michael,
> The Government's Essential Freshwater programme includes proposals to address excessive nitrogen leaching in catchments with high nitrogen impacts. The Government will likely be consulting on the proposals as part of the larger Essential Freshwater consultation, currently proposed for August 2019. If the proposals are progressed, the proposed set of high nitrogen-impact catchments will be included in the consultation document.
>
> Initial modelling has developed a set of potential catchments where the policy would apply. In preparation for consultation, MfE would like to ground-truth this initial modelling with councils. The modelling indicates that the following sub-catchments in your region may meet the criteria for high nitrogen impacts:

NZ segment	River Name	Catchment Name
7229170	Turakina River	Turakina River
7239012	Mangaone Stream	Manawatu River
7238671	Mangaone Stream	Manawatu River

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7237913	Mangaone Stream	Manawatu River
7240287	Taonui Stream	Manawatu River
7235776	Makino Stream	Manawatu River
7235250	Makino Stream	Manawatu River
7233102	Tutaenui Stream	Rangitikei River
7235226	Makino Stream	Manawatu River
7232883	Tutaenui Stream	Rangitikei River
7232564	Tutaenui Stream	Rangitikei River
7232372	Tutaenui Stream	Rangitikei River
7232235	Tutaenui Stream	Rangitikei River
7232236	Tutaenui Stream	Rangitikei River
7232085	Tutaenui Stream	Rangitikei River
7231629	Tutaenui Stream	Rangitikei River
7231613	Tutaenui Stream	Rangitikei River

However we are aware that most of these sub-catchments are covered by the One Plan consent requirements, and therefore may be excluded from the proposals. With your agreement, I would like to discuss these sub-catchments with your staff, to check the modelling result prior to consultation. Please could you advise who I should contact, and their contact details as soon as convenient.

Thank you

Irene

Irene Parminter – Senior Policy Analyst
Ministry for the Environment – Manatū Mō Te Taiao
Mob: 022 517 3371 Email: irene.parminter@mfe.govt.nz Website: www.mfe.govt.nz
Environment House, Kate Sheppard Place, PO Box 10362, Wellington 6143

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Nick Vincent

From: Irene Parminter
Sent: Tuesday, 16 July 2019 11:04 AM
To: Mike Scarsbrook (waikatoregion.govt.nz)
Subject: FW: Request for assistance

Hi Mike. Can I give you a call about this request? If so, when would suit (and what is the best number to call you on)?

Thank you

Irene

From: Vaughan Payne <Vaughan.Payne@waikatoregion.govt.nz>
Sent: Tuesday, 16 July 2019 10:27 AM
To: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Cc: Martin Workman <martin.workman@mfe.govt.nz>; Nicola Scott <Nicola.Scott@mfe.govt.nz>; Mike Scarsbrook (waikatoregion.govt.nz) <Mike.Scarsbrook@waikatoregion.govt.nz>; Tracey May <Tracey.May@waikatoregion.govt.nz>
Subject: Re: Request for assistance

Kia ora Irene

Thanks for your email. Can you please work directly with Mike Scarsbrook who I've copied into this email.

Nga mihi

Vaughan

Sent from my iPhone

Vaughan Payne | CHIEF EXECUTIVE | Office of the Chief Executive
WAIKATO REGIONAL COUNCIL | Te Kaunihera ā Rohe o Waikato
Take a look at the work we do
P: +6478590595
M: +64212462314
F: facebook.com/waikatoregion
Private Bag 3038, Waikato Mail Centre, Hamilton, 3240

On 16/07/2019, at 10:01 AM, Irene Parminter <Irene.Parminter@mfe.govt.nz> wrote:

> Dear Vaughan,
> The Government's Essential Freshwater programme includes proposals to address excessive nitrogen leaching in catchments with high nitrogen impacts. The Government will likely be consulting on the proposals as part of the larger Essential Freshwater consultation, currently proposed for August 2019. If the proposals are progressed, the proposed set of high nitrogen-impact catchments will be included in the consultation document.
>
> Initial modelling has developed a set of potential catchments where the policy would apply. In preparation for consultation, MfE would like to ground-truth this initial modelling with councils. The modelling indicates that the following sub-catchments in your region may meet the criteria for high nitrogen impacts:

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NZ segment	River Name	Catchment Name
3046191	NA	Piako River
3058413	Waitakaruru Stream	Piako River

With your agreement, I would like to discuss these catchments with your staff, to check the modelling result prior to consultation. Please could you advise who I should contact, and their contact details as soon as convenient.

Thank you

Irene

Irene Parminter – Senior Policy Analyst
Ministry for the Environment – Manatū Mō Te Taiao
Mob: 022 517 3371 Email: irene.parminter@mfe.govt.nz Website: www.mfe.govt.nz
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Nick Vincent

From: Irene Parminter
Sent: Tuesday, 16 July 2019 1:00 PM
To: James Palmer (hbrc.govt.nz)
Subject: RE: Request for assistance with Essential Freshwater work

Thank you James for your very speedy reply. I will be in touch with Iain and Andy today.

Irene

From: James Palmer <james.palmer@hbrc.govt.nz>
Sent: Tuesday, 16 July 2019 12:16 PM
To: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Cc: Martin Workman <martin.workman@mfe.govt.nz>; Nicola Scott <Nicola.Scott@mfe.govt.nz>; Nick Martelli <Nick.Martelli@mfe.govt.nz>; Iain Maxwell (hbrc.govt.nz) <iain@hbrc.govt.nz>; Andy Hicks <andy@hbrc.govt.nz>; Tom Skerman <Tom@hbrc.govt.nz>
Subject: Re: Request for assistance with Essential Freshwater work

Hi Irene, please work through Iain Maxwell and Andy Hicks.

Thanks, James

Sent from my iPhone

On 16/07/2019, at 10:39 AM, Irene Parminter <Irene.Parminter@mfe.govt.nz> wrote:

> Dear James,
> The Government's Essential Freshwater programme includes a proposal to address excessive nitrogen leaching in catchments with high nitrogen impacts. The Government will likely be consulting on the proposal as part of the larger Essential Freshwater consultation, currently proposed for August 2019. If these proposals are progressed, the proposed set of high nitrogen-impact catchments will be included in the consultation document.
>
> Initial modelling has developed a set of potential sub-catchments where the policy would apply. In preparation for consultation, MfE would like to ground-truth this initial modelling with councils. The modelling indicates that the following sub-catchment in your region may meet the criteria for high nitrogen impacts:
>
> | NZ segment | River Name | Catchment Name |
> |---|---|---|
> | 8213095 | Karewarewa Stream | Ngaruroro River |
>
> With your agreement, I would like to discuss this sub-catchment with your staff, to check the modelling result prior to consultation. Please could you advise who I should contact, and their contact details as soon as convenient.
>
> Thank you
>
> Irene Parminter

Irene Parminter – Senior Policy Analyst
Ministry for the Environment – Manatū Mō Te Taiao
Mob: 022 517 3371 Email: irene.parminter@mfe.govt.nz Website: www.mfe.govt.nz
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Nick Vincent

From: Irene Parminter
Sent: Tuesday, 16 July 2019 11:44 AM
To: Fiona McTavish (boprc.govt.nz); Rob Donald; Nicola Green; Julie Bevan
Subject: RE: Request for assistance with Essential Freshwater

Thank you Fiona, much appreciated.

Rob I will be in touch shortly

Irene

From: Fiona McTavish <Fiona.McTavish@boprc.govt.nz>
Sent: Tuesday, 16 July 2019 11:43 AM
To: Irene Parminter <Irene.Parminter@mfe.govt.nz>; Rob Donald <Rob.Donald@boprc.govt.nz>; Nicola Green <Nicola.Green@boprc.govt.nz>; Julie Bevan <Julie.Bevan@boprc.govt.nz>
Cc: Martin Workman <martin.workman@mfe.govt.nz>; Nicola Scott <Nicola.Scott@mfe.govt.nz>; Nick Martelli <Nick.Martelli@mfe.govt.nz>
Subject: RE: Request for assistance with Essential Freshwater

Kia ora Irene

Yes, Rob Donald would be the best person to talk with and I've cced him to this email.

Kind regards

Fiona

Fiona McTavish
Chief Executive
Bay of Plenty Regional Council Toi Moana

P: 0800 884 880 **DD:** 0800 884 881 x9339
E: Fiona.McTavish@boprc.govt.nz
M: 027 705 3916 **W:** www.boprc.govt.nz
A: PO Box 364, Whakatāne 3158, New Zealand

Thriving together – mō te taiao, mō ngā tāngata

From: Irene Parminter [mailto:Irene.Parminter@mfe.govt.nz]
Sent: Tuesday, 16 July 2019 10:50 a.m.
To: Fiona McTavish
Cc: Martin Workman; Nicola Scott; Nick Martelli
Subject: Request for assistance with Essential Freshwater

Dear Fiona,
The Government's Essential Freshwater programme includes proposals to address excessive nitrogen leaching in catchments with high nitrogen impacts. The Government will likely be consulting on the proposals as part of the larger Essential Freshwater consultation, currently proposed for August 2019. If the proposals are progressed, the proposed set of high nitrogen-impact catchments will be included in the consultation document.

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Initial modelling has developed a set of potential catchments where the policy would apply. In preparation for consultation, MfE would like to ground-truth this initial modelling with councils. The modelling indicates that the following catchment in your region may meet the criteria for high nitrogen impacts:

NZ segment	River Name	Catchment Name
4076553	Whakatane River	Whakatane River

I would like to discuss this catchment with your staff, to check the modelling result prior to consultation. One of your staff members, Nicola Green, was a member of the Advisory Group that considered the policy earlier in June, and she has already put me in contact with Rob Donald. With your agreement, I will work with Rob to check the modelling. If there are other staff members I should contact instead/as well, please let me know.

Thank you

Irene

Irene Parminter – Senior Policy Analyst
Ministry for the Environment – Manatū Mō Te Taiao
Mob: 022 517 3371 Email: irene.parminter@mfe.govt.nz Website: www.mfe.govt.nz
Environment House, Kate Sheppard Place, PO Box 10362, Wellington 6143

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Nick Vincent

From: Irene Parminter
Sent: Tuesday, 16 July 2019 1:00 PM
To: James Palmer (hbrc.govt.nz)
Subject: RE: Request for assistance with Essential Freshwater work

Thank you James for your very speedy reply. I will be in touch with Iain and Andy today.

Irene

From: James Palmer <james.palmer@hbrc.govt.nz>
Sent: Tuesday, 16 July 2019 12:16 PM
To: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Cc: Martin Workman <martin.workman@mfe.govt.nz>; Nicola Scott <Nicola.Scott@mfe.govt.nz>; Nick Martelli <Nick.Martelli@mfe.govt.nz>; Iain Maxwell (hbrc.govt.nz) <iain@hbrc.govt.nz>; Andy Hicks <andy@hbrc.govt.nz>; Tom Skerman <Tom@hbrc.govt.nz>
Subject: Re: Request for assistance with Essential Freshwater work

Hi Irene, please work through Iain Maxwell and Andy Hicks.

Thanks, James

Sent from my iPhone

On 16/07/2019, at 10:39 AM, Irene Parminter <Irene.Parminter@mfe.govt.nz> wrote:

> Dear James,
> The Government's Essential Freshwater programme includes a proposal to address excessive nitrogen leaching in catchments with high nitrogen impacts. The Government will likely be consulting on the proposal as part of the larger Essential Freshwater consultation, currently proposed for August 2019. If these proposals are progressed, the proposed set of high nitrogen-impact catchments will be included in the consultation document.
>
> Initial modelling has developed a set of potential sub-catchments where the policy would apply. In preparation for consultation, MfE would like to ground-truth this initial modelling with councils. The modelling indicates that the following sub-catchment in your region may meet the criteria for high nitrogen impacts:
>
> | NZ segment | River Name | Catchment Name |
> |---|---|---|
> | 8213095 | Karewarewa Stream | Ngaruroro River |
>
> With your agreement, I would like to discuss this sub-catchment with your staff, to check the modelling result prior to consultation. Please could you advise who I should contact, and their contact details as soon as convenient.
>
> Thank you
>
> Irene Parminter

Irene Parminter – Senior Policy Analyst
Ministry for the Environment – Manatū Mō Te Taiao
Mob: 022 517 3371 Email: irene.parminter@mfe.govt.nz Website: www.mfe.govt.nz
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ITEM 18

From: Irene Parminter
To: patrick.lynch@waiktoregion.govt.nz
Cc: Chris McLay; Jennie McMurran; Nicola Scott
Subject: Essential Freshwater policy programme at MfE - enforcement aspects - Chris has suggested you may be able to help!
Date: Thursday, 18 April 2019 3:56:54 PM

Hi Patrick. I am one of the team working on part of the Government's Essential Freshwater policies (outlined here: http://www.mfe.govt.nz/node/24402/) – in particular Jennie McMurran and I are looking at whether and how to include national direction on Farm Environment Plans in a National Environmental Standard. Other members of the team are looking at regulations for high-risk landuse activities, stock exclusion and intensification. Chris McLay has heard the team present where we have got to so far in the process on a couple of occasions, and has strongly advised us to talk to you about enforcement aspects! If you are willing to help, that would be very much appreciated. What do you think about this? If you are able to help us, we could perhaps talk with you in the week of 6-10 May? We have just completed a brief, and are likely to have more of a steer from Ministers by then. We can discuss logistics closer to the time but we could skype you or potentially have a face to face meeting.

I am about to go on leave for a week so will be in contact again in the week of the 29th April.

Kind regards

Irene

Irene Parminter – Senior Policy Analyst
Ministry for the Environment – Manatu Mo Te Taiao
Mob: 022 517 3371 Email: irene.parminter@mfe.govt.nz Website: www.mfe.govt.nz
Environment House, Kate Sheppard Place, PO Box 10362, Wellington 6143

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ITEM 19

Nick Vincent

From: Irene Parminter
Sent: Monday, 22 July 2019 10:30 AM
To: Rohana Sergent
Subject: RE: when is a good time for me to call you?

Hi Ro – thanks for getting back to me. If possible I would like to talk before midday (apologies). I could just talk to Andy? But if neither is available I will take the 4.30 slot please ☺

Irene

From: Rohana Sergent <Rohana.Sergent@hbrc.govt.nz>
Sent: Monday, 22 July 2019 10:21 AM
To: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Subject: RE: when is a good time for me to call you?

4:30 he had an appointment cancelled if that helps?
Ro

From: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Sent: Monday, 22 July 2019 9:01 AM
To: Andy Hicks <andy@hbrc.govt.nz>; Iain Maxwell <iain@hbrc.govt.nz>
Subject: when is a good time for me to call you?

Hi – just thought I would let you know we have progressed the alternative approach – which is to simply look at monitoring data for Total Nitrogen. On that basis, the catchments highlighted in Hawkes Bay are the Mohaka – the upper part of the catchment near Taupo – and the Tukituki (but that already has a plan change addressing high nitrogen losses so would not be included).

Would be good to get your feedback on both the approaches we have tried, and any fish hooks in the water quality monitoring data e.g. whether they are affected by point source discharges or non-pastoral land uses. When would suit for me to call you?

Irene

From: Andy Hicks <andy@hbrc.govt.nz>
Sent: Thursday, 18 July 2019 4:35 PM
To: Irene Parminter <Irene.Parminter@mfe.govt.nz>; Iain Maxwell (hbrc.govt.nz) <iain@hbrc.govt.nz>
Subject: RE: Request for assistance with Essential Freshwater work

Hi Irene, Monday sounds good – and thanks for the details on the approach taken,

Cheers,
Andy

From: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Sent: Wednesday, 17 July 2019 4:52 PM
To: Andy Hicks <andy@hbrc.govt.nz>; Iain Maxwell <iain@hbrc.govt.nz>
Subject: RE: Request for assistance with Essential Freshwater work

Hi Andy and Iain. Thanks for emailing me back. Completely understand about manic!

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Is it OK if we delay to Monday please? - as I will be away from the office on Friday and hard to catch by phone. Also, some different approaches to the modelling are being considered – so delaying our conversation until next week may enable time for that to be advanced.

In the meantime, I have pasted a map below that may help, and also a summary of the approach taken to the existing modelling.

Modelling Summary:

- Estimates of current median concentrations of total nitrogen (TN) and nitrate-nitrogen (NO3-N) for every segment of the river network were provided by predictions made using statistical models fitted to observations of TN and NO3N at 764 and 855 state of environment monitoring sites respectively
- All segments in the network were assessed based on the receiving waters - comparing current load of nitrogen with "maximum allowable load" (MAL)
- The MAL was defined in relation to the bottom lines in the current NOF for lakes and rivers, and for estuaries, the work by Plew et al was used to define bottom lines for chlorophyll-a.
- Catchment pressure is the ratio of the current TN load to the MAL

And this paragraph from Ton Snelder's draft paper (which is too draft to send out) is also helpful:
Catchment pressure was defined in three steps. First, the ratio of the current load to MAL was defined for every receiving environment in the drainage network. Second, the digital drainage network representing each individual sea-draining catchment (i.e., defined by the entire drainage path upstream of a terminal segment) was traversed in the upstream direction. Beginning at the most downstream receiving environment, which is defined as a critical point, the ratio of the current load to MAL at each receiving environment is compared with the ratio for next upstream receiving environment. If the ratio at the next upstream receiving environment is greater than that of the downstream critical point, the upstream receiving environment is defined as a critical point and the process continues upstream. Third, having defined the critical points on the drainage network of every sea-draining catchment, the sub-catchments upstream of each critical point are identified and assigned a catchment pressure value equalling the ratio of the current load to MAL of the associated critical point.
Sea-draining catchments can have one critical point (the most downstream receiving environment) or multiple critical points, which include the most downstream receiving environment. Maps of catchment pressure were defined by colouring the sub-catchments upstream of each critical point using a colour scale that reflects their pressure value.

For the map below I have included all the catchments with pressure score over 2 – this filter brings up parts of 3 catchments, Tukituki, Taipo and Karewarewa (in the Ngaruroro catchment). As the Tukituki plan already addresses high nitrogen leaching, it would not be included in the proposal.

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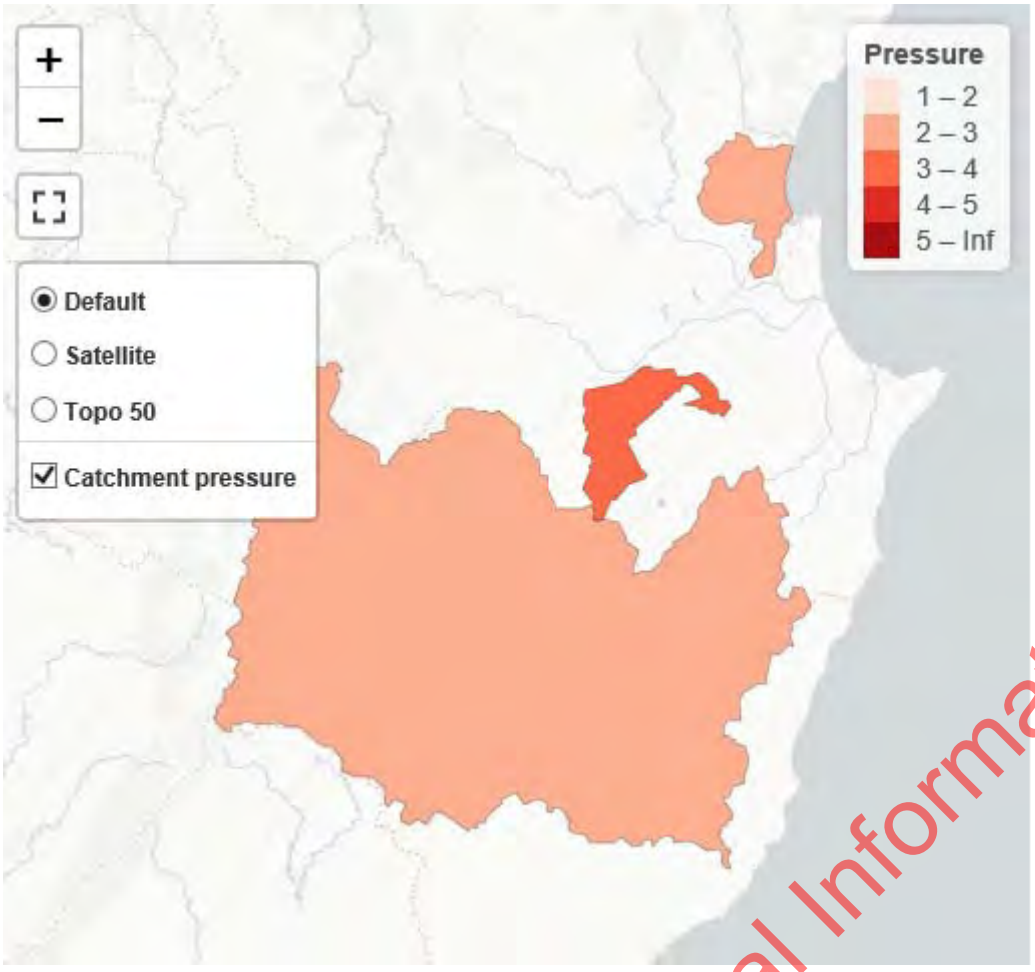

Thanks again

Irene

From: Andy Hicks <andy@hbrc.govt.nz>
Sent: Wednesday, 17 July 2019 4:35 PM
To: Irene Parminter <Irene.Parminter@mfe.govt.nz>; Iain Maxwell (hbrc.govt.nz) <iain@hbrc.govt.nz>
Subject: RE: Request for assistance with Essential Freshwater work

Kia ora Irene, Iain and I are both manic at the moment, but can one of us give you a call sometime Friday to follow up?
Cheers,
Andy

From: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Sent: Tuesday, 16 July 2019 1:02 PM
To: Iain Maxwell <iain@hbrc.govt.nz>; Andy Hicks <andy@hbrc.govt.nz>
Subject: RE: Request for assistance with Essential Freshwater work

Hi Andy and Iain. Just following up on my email to James. Can I give you a call please? When would suit, and what numbers should I call you on?

Thank you

Irene

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From: James Palmer <james.palmer@hbrc.govt.nz>
Sent: Tuesday, 16 July 2019 12:16 PM
To: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Cc: Martin Workman <martin.workman@mfe.govt.nz>; Nicola Scott <Nicola.Scott@mfe.govt.nz>; Nick Martelli <Nick.Martelli@mfe.govt.nz>; Iain Maxwell (hbrc.govt.nz) <iain@hbrc.govt.nz>; Andy Hicks <andy@hbrc.govt.nz>; Tom Skerman <Tom@hbrc.govt.nz>
Subject: Re: Request for assistance with Essential Freshwater work

Hi Irene, please work through Iain Maxwell and Andy Hicks.

Thanks, James

Sent from my iPhone

On 16/07/2019, at 10:39 AM, Irene Parminter <Irene.Parminter@mfe.govt.nz> wrote:

> Dear James,
> The Government's Essential Freshwater programme includes a proposal to address excessive nitrogen leaching in catchments with high nitrogen impacts. The Government will likely be consulting on the proposal as part of the larger Essential Freshwater consultation, currently proposed for August 2019. If these proposals are progressed, the proposed set of high nitrogen-impact catchments will be included in the consultation document.
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>
> Thank you
>
> Irene Parminter

Irene Parminter – Senior Policy Analyst
Ministry for the Environment – Manatū Mō Te Taiao
Mob: 022 517 3371 Email: irene.parminter@mfe.govt.nz Website: www.mfe.govt.nz
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Nick Vincent

From: Irene Parminter
Sent: Wednesday, 31 July 2019 4:18 PM
To: Janine Dowding
Cc: Barry Johnson
Subject: RE: Request for assistance

Many thanks Janine, I really appreciate your quick reply.

Barry, can I give you a call tomorrow please? When would suit?

Kind regards

Irene.

From: Janine Dowding <Janine.Dowding@tasman.govt.nz>
Sent: Wednesday, 31 July 2019 2:38 PM
To: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Cc: Martin Workman <martin.workman@mfe.govt.nz>; Nicola Scott <Nicola.Scott@mfe.govt.nz>; Barry Johnson <Barry.Johnson@tasman.govt.nz>
Subject: RE: Request for assistance

Dear Irene
Your best point of contact is Barry Johnson. Barry is our Environmental Policy Manager and he can involve other staff as appropriate. Barry's contact detail are: ph. 03 543 8975 or 021 376 680 and his email address is Barry.Johnson@tasman.govt.nz
Regards
Janine

Janine Dowding
Chief Executive Officer
DDI 03 543 8444 | Janine.Dowding@tasman.govt.nz
Private Bag 4, Richmond 7050, NZ

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From: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Sent: Wednesday, 31 July 2019 1:38 PM
To: Janine Dowding Janine.Dowding@tasman.govt.nz
Cc: Martin Workman <martin.workman@mfe.govt.nz>; Nicola Scott <Nicola.Scott@mfe.govt.nz>
Subject: Request for assistance

Dear Janine,
The Government's Essential Freshwater programme includes proposals to address excessive nitrogen leaching in catchments with high nitrogen impacts. The Government will likely be consulting on the proposals as part of the

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larger Essential Freshwater consultation, currently proposed for late August-early September 2019. If the proposals are progressed, the proposed set of high nitrogen-impact catchments will be included in the consultation document.

An initial review of water quality monitoring sites has developed a set of potential catchments where the policy would apply. In preparation for consultation, MfE would like to ground-truth this initial review with councils. In your region, the Motupipi catchment in Golden Bay may meet the criteria for high nitrogen impacts.

With your agreement, I would like to discuss this catchment with your staff, to check whether this catchment does in fact meet the criteria, prior to consultation. Please could you advise who I should contact, and their contact details as soon as convenient.

Thank you

Irene

Irene Parminter – Senior Policy Analyst
Ministry for the Environment – Manatū Mō Te Taiao
Mob: 022 517 3371 Email: irene.parminter@mfe.govt.nz Website: www.mfe.govt.nz
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Nick Vincent

From: Irene Parminter
Sent: Thursday, 1 August 2019 5:42 PM
To: Trevor James
Subject: RE: Neimann, Borck and Pearl Creeks in the Waimea Plains

Thank you again Trevor. Quite a difference from the Motupipi!

Irene

From: Trevor James <Trevor.James@tasman.govt.nz>
Sent: Thursday, 1 August 2019 4:55 PM
To: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Subject: Neimann, Borck and Pearl Creeks in the Waimea Plains

Hi Irene,

Further to our conversation today.

Water quality for these waterways is not on LAWA but it is here https://www.tasman.govt.nz/my-council/key-documents/more/environment-reserves-and-open-space/environmental-monitoring-reports/?path=/EDMS/Public/Other/Environment/EnvironmentalMonitoring/WaterMonitoring/SurfaceWater/RiverWater/StateOfEnvironmentReports/2015

NO3-N for these creeks averages around 8g/m3.

Cheers,

Trevor

Trevor James
Senior Resource Scientist - Environmental
DDI 03 543 8562 | **Mobile** 022 612 7681 | Trevor.James@tasman.govt.nz
Private Bag 4, Richmond 7050, NZ

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ITEM 22

From: Gary Bedford
To: Irene Parminter; Basil Chamberlain
Subject: RE: Request for assistance- Waingongoro Rv Taranaki and the EFM programme
Date: Thursday, 1 August 2019 9:56:01 AM

Hi Irene
As per the voice message I've left with you, I look forward to discussing the state of the Waingongoro Rv with you. My mob is 0274 839 257. My schedule over the next couple of days is messy, but feel free to give me a call. Next week is more settled. By way of background that might be useful for you, in terms of Basil's comments:
In terms of the NPS requirements re periphyton/chl-a, my staff advise me:

For the Waingongoro River at Eltham Rd, we have collected 21 samples between June 2017 and June 2019 (the July results are not yet available). There have been only 4 occasions where flows have not permitted sample collection at this site.

The results are in the range 1.6 – 137 mg chl-a/m^2, with a median of 19.9 mg chl-a/m^2 and **92nd percentile 110 mg chl-a/m^2.**
This tentatively places the site in the B band (>50 - =120 mg chl-a/m^2). The site is in the default class for the NOF bands and so the 92nd percentile is used.

In terms of MCIs, which we measure at 6 sites within the river from the National Park boundary to the sea: the median MCI value are (from top to bottom of the catchment) 132; 129; 103; 96; 95; 91. The last four sites are all showing trend analysis of significant improvement.

Regards

Gary Bedford
Director - Environment Quality

From: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Sent: Wednesday, 31 July 2019 4:24 PM
To: Basil Chamberlain <Basil.Chamberlain@trc.govt.nz>
Cc: Gary Bedford <Gary.Bedford@trc.govt.nz>
Subject: RE: Request for assistance

Many thanks for your quick reply Basil. I look forward to hearing from your experts – my phone number is below.

Kind regards

Irene

Irene Parminter – Senior Policy Analyst
Ministry for the Environment – Manatu Mo Te Taiao
Mob: 022 517 3371 Email: irene.parminter@mfe.govt.nz Website: www.mfe.govt.nz
Environment House, Kate Sheppard Place, PO Box 10362, Wellington 6143

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From: Basil Chamberlain <Basil.Chamberlain@trc.govt.nz>
Sent: Wednesday, 31 July 2019 4:19 PM
To: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Cc: Gary Bedford <Gary.Bedford@trc.govt.nz>
Subject: RE: Request for assistance

Irene
I will pass this on thanks, but note at outset that the Waingongoro might have DIN levels that are relatively a bit higher than most on the Ring Plain for a range of mainly hydrological flow source reasons. However, in term of impacts as measured by periphyton for example, I think that there would be compliance with guideline criteria for all or almost all of the time, basically because of the steep short-run nature of the stream, as with all Ring Plain streams.
However, our experts will advise in due course
Regards
Basil

Basil Chamberlain
Chief Executive

From: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Sent: Wednesday, 31 July 2019 1:38 PM
To: Basil Chamberlain <Basil.Chamberlain@trc.govt.nz>
Cc: Martin Workman <martin.workman@mfe.govt.nz>; Nicola Scott <Nicola.Scott@mfe.govt.nz>
Subject: Request for assistance

Dear Basil,
The Government's Essential Freshwater programme includes proposals to address excessive nitrogen leaching in catchments with high nitrogen impacts. The Government will likely be consulting on the proposals as part of the larger Essential Freshwater consultation, currently proposed for late August/early September 2019. If the proposals are progressed, the proposed set of high nitrogen-impact catchments will be included in the consultation document.

An initial review of water quality monitoring sites has developed a set of potential catchments where the policy would apply. In preparation for consultation, MfE would like to ground-truth this initial review with councils. In your region, the Waingongoro Stream in South Taranaki may meet the criteria for high nitrogen impacts.

With your agreement, I would like to discuss this catchment with your staff, to check whether this catchment does in fact meet the criteria, prior to consultation. Please could you advise who I should contact, and their contact details as soon as convenient.

Thank you

Irene

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Irene Parminter – Senior Policy Analyst
Ministry for the Environment – Manatu Mo Te Taiao
Mob: 022 517 3371 Email: irene.parminter@mfe.govt.nz Website: www.mfe.govt.nz
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Please consider the environment before printing this e-mail.

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ITEM 23

Nick Vincent

From: Irene Parminter
Sent: Monday, 5 August 2019 4:38 PM
To: Andy Hicks
Subject: Follow up question

Hi Andy. Can I ask a quick question about the high nitrate levels in the Waingongoro Stream please? I have checked a few documents and LAWA and its not clear why the nitrate levels are high. Is it OK if I ring you tomorrow sometime please? Or if its an easy question, let me know (I recall you mentioned a catchment that had elevated levels for geological reasons but I didn't note the name of the catchment).

Thanks

Irene

From: Andy Hicks <andy@hbrc.govt.nz>
Sent: Monday, 22 July 2019 11:10 AM
To: Irene Parminter <Irene.Parminter@mfe.govt.nz>; Iain Maxwell (hbrc.govt.nz) <iain@hbrc.govt.nz>
Subject: RE: when is a good time for me to call you?

Hi Irene, I think that new approach sounds sensible. Simple is often better.

Perhaps give me a call on 027 536 9979 between 3:30 and 5pm today?

Cheers,
Andy

From: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Sent: Monday, 22 July 2019 9:01 AM
To: Andy Hicks <andy@hbrc.govt.nz>; Iain Maxwell <iain@hbrc.govt.nz>
Subject: when is a good time for me to call you?

Hi – just thought I would let you know we have progressed the alternative approach – which is to simply look at monitoring data for Total Nitrogen. On that basis, the catchments highlighted in Hawkes Bay are the Mohaka – the upper part of the catchment near Taupo – and the Tukituki (but that already has a plan change addressing high nitrogen losses so would not be included).

Would be good to get your feedback on both the approaches we have tried, and any fish hooks in the water quality monitoring data e.g. whether they are affected by point source discharges or non-pastoral land uses. When would suit for me to call you?

Irene

From: Andy Hicks <andy@hbrc.govt.nz>
Sent: Thursday, 18 July 2019 4:35 PM
To: Irene Parminter <Irene.Parminter@mfe.govt.nz>; Iain Maxwell (hbrc.govt.nz) <iain@hbrc.govt.nz>
Subject: RE: Request for assistance with Essential Freshwater work

Hi Irene, Monday sounds good – and thanks for the details on the approach taken,

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Cheers,
Andy

From: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Sent: Wednesday, 17 July 2019 4:52 PM
To: Andy Hicks <andy@hbrc.govt.nz>; Iain Maxwell <iain@hbrc.govt.nz>
Subject: RE: Request for assistance with Essential Freshwater work

Hi Andy and Iain. Thanks for emailing me back. Completely understand about manic!

Is it OK if we delay to Monday please? - as I will be away from the office on Friday and hard to catch by phone. Also, some different approaches to the modelling are being considered – so delaying our conversation until next week may enable time for that to be advanced.

In the meantime, I have pasted a map below that may help, and also a summary of the approach taken to the existing modelling.

Modelling Summary:

- Estimates of current median concentrations of total nitrogen (TN) and nitrate-nitrogen (NO3-N) for every segment of the river network were provided by predictions made using statistical models fitted to observations of TN and NO3N at 764 and 855 state of environment monitoring sites respectively
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- The MAL was defined in relation to the bottom lines in the current NOF for lakes and rivers, and for estuaries, the work by Plew et al was used to define bottom lines for chlorophyll-a.
- Catchment pressure is the ratio of the current TN load to the MAL

And this paragraph from Ton Snelder's draft paper (which is too draft to send out) is also helpful:
Catchment pressure was defined in three steps. First, the ratio of the current load to MAL was defined for every receiving environment in the drainage network. Second, the digital drainage network representing each individual sea-draining catchment (i.e., defined by the entire drainage path upstream of a terminal segment) was traversed in the upstream direction. Beginning at the most downstream receiving environment, which is defined as a critical point, the ratio of the current load to MAL at each receiving environment is compared with the ratio for next upstream receiving environment. If the ratio at the next upstream receiving environment is greater than that of the downstream critical point, the upstream receiving environment is defined as a critical point and the process continues upstream. Third, having defined the critical points on the drainage network of every sea-draining catchment, the sub-catchments upstream of each critical point are identified and assigned a catchment pressure value equalling the ratio of the current load to MAL of the associated critical point.
Sea-draining catchments can have one critical point (the most downstream receiving environment) or multiple critical points, which include the most downstream receiving environment. Maps of catchment pressure were defined by colouring the sub-catchments upstream of each critical point using a colour scale that reflects their pressure value.

For the map below I have included all the catchments with pressure score over 2 – this filter brings up parts of 3 catchments, Tukituki, Taipo and Karewarewa (in the Ngaruroro catchment). As the Tukituki plan already addresses high nitrogen leaching, it would not be included in the proposal.

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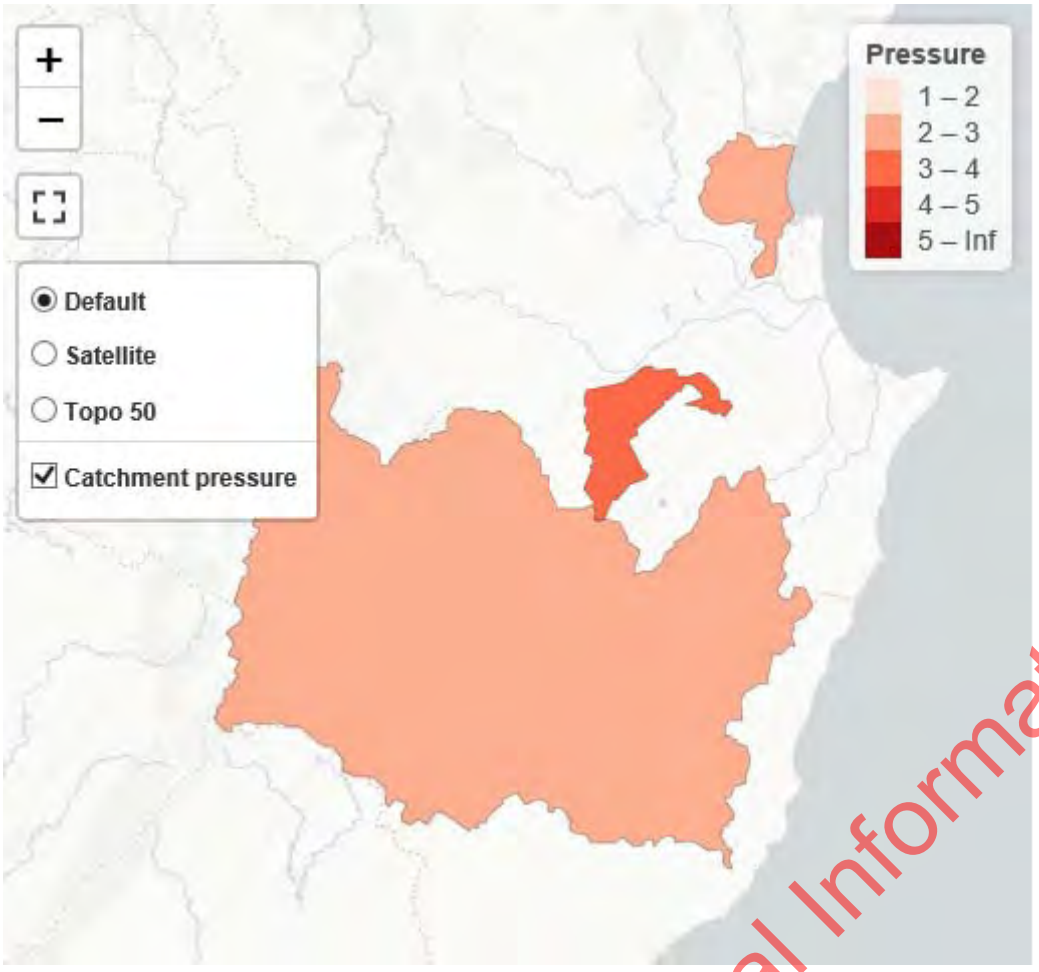

Thanks again

Irene

From: Andy Hicks <andy@hbrc.govt.nz>
Sent: Wednesday, 17 July 2019 4:35 PM
To: Irene Parminter <Irene.Parminter@mfe.govt.nz>; Iain Maxwell (hbrc.govt.nz) <iain@hbrc.govt.nz>
Subject: RE: Request for assistance with Essential Freshwater work

Kia ora Irene, Iain and I are both manic at the moment, but can one of us give you a call sometime Friday to follow up?
Cheers,
Andy

From: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Sent: Tuesday, 16 July 2019 1:02 PM
To: Iain Maxwell <iain@hbrc.govt.nz>; Andy Hicks <andy@hbrc.govt.nz>
Subject: RE: Request for assistance with Essential Freshwater work

Hi Andy and Iain. Just following up on my email to James. Can I give you a call please? When would suit, and what numbers should I call you on?

Thank you

Irene

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From: James Palmer <james.palmer@hbrc.govt.nz>
Sent: Tuesday, 16 July 2019 12:16 PM
To: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Cc: Martin Workman <martin.workman@mfe.govt.nz>; Nicola Scott <Nicola.Scott@mfe.govt.nz>; Nick Martelli <Nick.Martelli@mfe.govt.nz>; Iain Maxwell (hbrc.govt.nz) <iain@hbrc.govt.nz>; Andy Hicks <andy@hbrc.govt.nz>; Tom Skerman <Tom@hbrc.govt.nz>
Subject: Re: Request for assistance with Essential Freshwater work

Hi Irene, please work through Iain Maxwell and Andy Hicks.

Thanks, James

Sent from my iPhone

On 16/07/2019, at 10:39 AM, Irene Parminter <Irene.Parminter@mfe.govt.nz> wrote:

> Dear James,
> The Government's Essential Freshwater programme includes a proposal to address excessive nitrogen leaching in catchments with high nitrogen impacts. The Government will likely be consulting on the proposal as part of the larger Essential Freshwater consultation, currently proposed for August 2019. If these proposals are progressed, the proposed set of high nitrogen-impact catchments will be included in the consultation document.
>
> Initial modelling has developed a set of potential sub-catchments where the policy would apply. In preparation for consultation, MfE would like to ground-truth this initial modelling with councils. The modelling indicates that the following sub-catchment in your region may meet the criteria for high nitrogen impacts:
>
> | NZ segment | River Name | Catchment Name |
> |---|---|---|
> | 8213095 | Karewarewa Stream | Ngaruroro River |
>
> With your agreement, I would like to discuss this sub-catchment with your staff, to check the modelling result prior to consultation. Please could you advise who I should contact, and their contact details as soon as convenient.
>
> Thank you
>
> Irene Parminter

Irene Parminter – Senior Policy Analyst
Ministry for the Environment – Manatū Mō Te Taiao
Mob: 022 517 3371 Email: irene.parminter@mfe.govt.nz Website: www.mfe.govt.nz
Environment House, Kate Sheppard Place, PO Box 10362, Wellington 6143

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Nick Vincent

From: Irene Parminter
Sent: Wednesday, 14 August 2019 8:28 AM
To: Dave.allen@aucklandcouncil.govt.nz
Subject: FW: Request for assistance - in confidence

Hi Dave, can I give you a quick phone-call on this please? When would suit?

Thanks

Irene

Irene Parminter – Senior Policy Analyst
Ministry for the Environment – Manatū Mō Te Taiao
Mob: 022 517 3371 Email: irene.parminter@mfe.govt.nz Website: www.mfe.govt.nz
Environment House, Kate Sheppard Place, PO Box 10362, Wellington 6143

From: Kerry Harrington <Kerry.Harrington@aucklandcouncil.govt.nz> **On Behalf Of** Stephen Town
Sent: Wednesday, 14 August 2019 8:25 AM
To: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Cc: Nicola Scott <Nicola.Scott@mfe.govt.nz>; Martin Workman <martin.workman@mfe.govt.nz>
Subject: RE: Request for assistance - in confidence

Kia ora Irene

On behalf of Stephen Town, I acknowledge receipt of your email message.

Dave Allen, Manager Natural Environment Strategy is the staff member to whom you could speak, and he may be contacted at Dave.allen@aucklandcouncil.govt.nz or DDI:+64 9 890 4704

Many thanks

Kerry Harrington
Executive Assistant to Chief Executive, Stephen Town
Executive Assistant to Director Urban Growth and Housing, Penny Pirrit
Te Kaunihera o Tāmaki Makaurau / Auckland Council
Level 15, Te Wharau o Tāmaki Auckland House, 135 Albert Street, Auckland
Private Bag 92300, Victoria Street West, Auckland 1142
P: +64 9 890 7742 | +64 21 825 642
E: kerry.harrington@aucklandcouncil.govt.nz

From: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Sent: Tuesday, 13 August 2019 4:51 PM
To: Stephen Town <Stephen.Town@aucklandcouncil.govt.nz>
Cc: Nicola Scott <Nicola.Scott@mfe.govt.nz>; Martin Workman <martin.workman@mfe.govt.nz>
Subject: Request for assistance - in confidence

Dear Stephen,

The Government's Essential Freshwater programme includes consideration of proposals to address excessive nitrogen leaching in catchments with high nitrate levels. The Government will likely be consulting on the

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proposals as part of the larger Essential Freshwater consultation, currently proposed to start in late August- early September 2019.

We are considering the set of catchments where some of the policy options could apply. In preparation for consultation, MfE is testing this set with councils. In your region the following catchments appear to meet the criteria for high nitrate levels: Waitangi Stream (catchment id 3067) and the Whangamaire Stream (catchment id 3289).

With your agreement, I would like to discuss these catchments with a member of your staff, to check our understanding of these catchments prior to consultation, in particular the main sources of nitrate losses. Please could you advise who I should contact, and their contact details as soon as convenient.

Thank you.

Kind regards

Irene

Irene Parminter – Senior Policy Analyst
Ministry for the Environment – Manatū Mō Te Taiao
Mob: 022 517 3371 Email: irene.parminter@mfe.govt.nz Website: www.mfe.govt.nz
Environment House, Kate Sheppard Place, PO Box 10362, Wellington 6143

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Nick Vincent

From: Irene Parminter
Sent: Wednesday, 14 August 2019 4:48 PM
To: Dave Allen
Subject: RE: Economic Impact Assessment of EFW proposals - needing assistance ASAP from Policy SIG please

Thanks – some interesting data in the presentation.

From: Dave Allen <Dave.Allen@aucklandcouncil.govt.nz>
Sent: Wednesday, 14 August 2019 4:39 PM
To: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Subject: RE: Economic Impact Assessment of EFW proposals - needing assistance ASAP from Policy SIG please

http://www.knowledgeauckland.org.nz/assets/publications/Franklin-nitrate-issue-Laura-Buckthought-Debra-Yan-06June-25-2019.pdf

Dave Allen
Manager Natural Environment Strategy
Auckland Plan Strategy & Research Department
Chief Planning Office
021 927 368
Auckland Council, Level 22, 135 Albert Street

From: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Sent: Wednesday, 14 August 2019 4:26 PM
To: Dave Allen <Dave.Allen@aucklandcouncil.govt.nz>
Subject: RE: Economic Impact Assessment of EFW proposals - needing assistance ASAP from Policy SIG please

Thanks Dave, and thank you also for the conversation earlier.

Irene

From: Dave Allen <Dave.Allen@aucklandcouncil.govt.nz>
Sent: Wednesday, 14 August 2019 3:50 PM
To: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Subject: FW: Economic Impact Assessment of EFW proposals - needing assistance ASAP from Policy SIG please

Irene
See below for description of the Freshwater Management Tool that Auckland Council (Healthy Waters) has been developing over last 2 years.
Fyi
Dave

Dave Allen
Manager Natural Environment Strategy
Auckland Plan Strategy & Research Department
Chief Planning Office

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021 927 368
Auckland Council, Level 22, 135 Albert Street

From: Dave Allen
Sent: Wednesday, 7 August 2019 7:10 PM
To: Clare Wooding <clare.wooding@lgnz.co.nz>
Cc: Emma Moran <Emma.Moran@es.govt.nz>; Blair Keenan (Blair.Keenan@waikatoregion.govt.nz) <Blair.Keenan@waikatoregion.govt.nz>; Coral Grant <coral.grant@aucklandcouncil.govt.nz>; Nick Brown <Nick.Brown@aucklandcouncil.govt.nz>; Tom Stephens <tom.stephens@aucklandcouncil.govt.nz>
Subject: FW: Economic Impact Assessment of EFW proposals - needing assistance ASAP from Policy SIG please

No sooner had I hit send, then I came across a nice summary of the FWMT's purpose, as follows:

Freshwater Management Tool
The Freshwater Management Tool (FWMT) is a continuous simulation, process-based distributed model accounting for contaminants lost from land to water in the Auckland region. The FWMT simulates variation in the build-up, wash-off and transformation of six major contaminants throughout the region's stream and river network including, nutrients (nitrogen, phosphorus), heavy metals (zinc, copper), sediment (total suspended solids) and faecal indicator bacteria (E. coli). The FWMT enables the effects of mitigation upon those contaminant processes to be simulated.

The FWMT enables scenarios for investing in devices to be modelled (e.g., stormwater ponds, rain-gardens, wetlands, etc), device practices, rural land practices and land use diversification or change (across land parcels, piped networks and/or instream). The FWMT also includes optimisation routines to determine the optimal mix of options (devices, practices) throughout the regional landscape to be selected that derive edge-of-field, instream or downstream (received at coast) outcomes for contaminant concentration or loads. From this, the FWMT will help inform community discussion of what future objectives to set for contaminants and how best to achieve these through the Water Quality Targeted Rate and regulatory change.

The FWMT is the most advanced such water quality model in New Zealand, requiring an iterative build to overcome the limitations of such complexity – the first version is being delivered in two instalments, with the current state capability of version 1 delivered by August 2019 and the scenario or future state capability by March 2020.

Regards
Dave Allen
Manager Natural Environment Strategy
Auckland Plan Strategy & Research Department
Chief Planning Office
021 927 368
Auckland Council, Level 22, 135 Albert Street

From: Dave Allen
Sent: Wednesday, 7 August 2019 6:56 PM
To: Clare Wooding <clare.wooding@lgnz.co.nz>
Cc: Emma Moran <Emma.Moran@es.govt.nz>; Blair Keenan (Blair.Keenan@waikatoregion.govt.nz) <Blair.Keenan@waikatoregion.govt.nz>; Coral Grant <coral.grant@aucklandcouncil.govt.nz>; Nick Brown <Nick.Brown@aucklandcouncil.govt.nz>; Tom Stephens <tom.stephens@aucklandcouncil.govt.nz>
Subject: RE: Economic Impact Assessment of EFW proposals - needing assistance ASAP from Policy SIG please

Hi Clare,

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Sorry about the slight delay in getting back to you. I've canvassed your email with our technical staff based in the Research and Evaluation Unit (RIMU) (Coral Grant) and Healthy Waters department (Tom Stephens) and can advise as follows, based on their feedback.

Firstly, Auckland Council supports a risk based approach, and using a range of tools to help establish where efforts should be put by relevant parties. In this regard, testing of scenarios in terms of their costs, benefits, and effectiveness, is an important aspect of regulatory development prior to formal consultation. In the case of proposals to consider changes to nutrient management (DIN and DRP) for trophic state outcomes, Auckland Council staff similarly consider that this needs more assessment across a broader range of scenarios and geographic areas. Southland and Waikato region alone is probably not sufficient as noted, as it may relate to putting in hard options for Essential Freshwater consultation. The periphyton guidance for the 'instream criteria approach' may be sufficient in the meantime, until further certainty around DIN and DRP approaches can be resolved.

Auckland Council has invested considerable time and resource over the last two years developing its open source Freshwater Management Tool (FWMT), which seeks to simultaneously model multiple contaminants under different scenarios (objectives and nature of interventions). The model outputs seek to derive optimal action plans to achieve desired outcomes with associated costs, all over a multiple decade horizon with expected growth/land use changes considered. Version 1 (current state) has recently been completed (although supporting documentation is now being written up), with version 2 (future state) scheduled for completion in ~April 2020. The current model (version 1) does not extend to DRP, but could in future provide a basis to consider DIN within the limitations of data inputs, and maybe Total Phosphorus (TP) as a further parameter to consider. Nick Brown/Tom Stephens can advise on future potential options there.

More broadly, RIMU staff are also considering future monitoring needs as it seeks to assess the management of N and P from a trophic state perspective, for both hard (fewer) and soft (predominant) streams across the Auckland region.

I reiterate Auckland's interest in considering the range of contaminants through the FWMT modelling approach, and the dynamic nature of changes in land use (particularly growth related) and associated planning and regulatory measures (eg, Auckland Unitary Plan, Network Discharge Consent etc), as it relates to a more durable and integrated approach for securing land and water management outcomes. More generally, I believe that it would be valuable for the Regional Sector Water Subgroup (RSWS) to become more familiar with the FWMT, and its potential. In this regard, even if Healthy Waters staff (Nick Brown, Tom Stephens) could simply forward an introductory Powerpoint presentation on the FWMT to the RSWS members, it might highlight this initiative as one to take on board.

Regards,
Dave

Dave Allen
Manager Natural Environment Strategy
Auckland Plan Strategy & Research Department
Chief Planning Office
021 927 368
Auckland Council, Level 22, 135 Albert Street

From: Clare Wooding <clare.wooding@lgnz.co.nz>
Sent: Friday, 2 August 2019 11:48 AM
To: Dave Allen <Dave.Allen@aucklandcouncil.govt.nz>
Cc: Emma Moran <Emma.Moran@es.govt.nz>; Blair Keenan (Blair.Keenan@waikatoregion.govt.nz) <Blair.Keenan@waikatoregion.govt.nz>
Subject: FW: Economic Impact Assessment of EFW proposals - needing assistance ASAP from Policy SIG please

Hi Dave

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We are keen to explore using Auckland as a case study to support the work we have already done (see reference to a report). The report is very much in confidence as it refers to the Government's proposals and they are still confidential.

Can you advise who we might talk to in Auckland re this please to explore? We are aware we need an urban focus.

Clare

From: Clare Wooding <clare.wooding@lgnz.co.nz>
Sent: Friday, 26 July 2019 1:15 PM
To: ls@wcrc.govt.nz; Matthew Hickman <Matthew.Hickman@gw.govt.nz>; Joanna.Noble@gdc.govt.nz; Pere.Hawes@marlborough.govt.nz; Gavin@hbrc.govt.nz; Andrew.Parrish@ecan.govt.nz; Anita.Dawe@orc.govt.nz; benl@nrc.govt.nz; chris.spurdle@trc.govt.nz; Julie.Bevan@boprc.govt.nz; Lucy.Hicks@es.govt.nz; Matt.heale@ncc.govt.nz; Phill.Reid@aucklandcouncil.govt.nz; Tony.Quickfall@waikatoregion.govt.nz; Blair.Dickie@waikatoregion.govt.nz; cameron.smith@ecan.govt.nz; ceri.edmonds@hbrc.govt.nz; david.phizacklea@boprc.govt.nz; Jenny.Fuller@aucklandcouncil.govt.nz; Olivia.Cook@ecan.govt.nz; Rachael.Brown@orc.govt.nz; Rebecca.Tayler@horizons.govt.nz; Stephen.Lamb@envbop.govt.nz; matt.heale@ncc.govt.nz; barry.johnson@tasman.govt.nz; Tom Bowen <Tom.Bowen@horizons.govt.nz>
Cc: Emma Moran <Emma.Moran@es.govt.nz>; Blair Keenan <Blair.Keenan@waikatoregion.govt.nz>; Vin Smith <Vin.Smith@es.govt.nz>; Iain Maxwell <iain@hbrc.govt.nz>
Subject: Economic Impact Assessment of EFW proposals - needing assistance ASAP from Policy SIG please

Good afternoon all

You will be aware the Regional Sector has been actively involved in providing advice on the Essential Freshwater proposals via the Regional Sector Water Subgroup (RSWS).

The RSWS has recently commissioned an Economic Impact Assessment on aspects of the proposals – concentrating on DIN and DRP and elements of the agricultural package (FEPs, stock exclusion, NCap). This was lead by Emma Moran (ES) and Blair Keenan (WRC). It focuses on case studies for Southland and Waikato because good information and existing models were available.

The work tested the proposals for DIN and DRP proposals for the Waikato-Waipa catchment (pre-Plan Change 1) because of their particular relevance to soft-bottomed rivers and streams. There was also a pre-existing economic model developed for the Healthy Rivers/Wai Ora Plan Change 1 process.

Proposals for FEPs, stock exclusion and a N Cap were modelled for catchments in Southland.

The RSWS now wants to extend this work to enable a better understanding of the impacts of the proposals. **We need more case studies so we would like Policy SIG members to consider whether there is work you have already done which tests different scenarios, focused particularly on DIN and DRP. We may be able to use the information as it is or we may want to explore using your existing information, models or other analytical approaches to run different scenarios.**

We need this asap please. We are then looking to test the applicability of these scenarios to similar catchments. This will build on the case studies already done.

If you can assist, can you information to be sent directly to me as I'm playing a coordinating role. If there are questions about the suitability of your work please give Emma (03 211 5115 or 027 905 5616) or Blair (07 859 0898) a call.

Thank you

Clare

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Clare Wooding
Principal Policy Advisor
Local Government New Zealand
DDI 04 924 1220 **M** 029 924 1220
E clare.wooding@lgnz.co.nz
W www.lgnz.co.nz

We are.
LGNZ.

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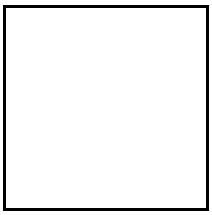

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Nick Vincent

From: Irene Parminter
Sent: Wednesday, 14 August 2019 8:26 AM
To: Stephen Town
Subject: RE: Request for assistance - in confidence

Thank you Kerry, much appreciated.

Irene

From: Kerry Harrington <Kerry.Harrington@aucklandcouncil.govt.nz> **On Behalf Of** Stephen Town
Sent: Wednesday, 14 August 2019 8:25 AM
To: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Cc: Nicola Scott <Nicola.Scott@mfe.govt.nz>; Martin Workman <martin.workman@mfe.govt.nz>
Subject: RE: Request for assistance - in confidence

Kia ora Irene

On behalf of Stephen Town, I acknowledge receipt of your email message.

Dave Allen, Manager Natural Environment Strategy is the staff member to whom you could speak, and he may be contacted at Dave.allen@aucklandcouncil.govt.nz or DDI:+64 9 890 4704

Many thanks

Kerry Harrington
Executive Assistant to Chief Executive, Stephen Town
Executive Assistant to Director Urban Growth and Housing, Penny Pirrit
Te Kaunihera o Tāmaki Makaurau / Auckland Council
Level 15, Te Wharau o Tāmaki Auckland House, 135 Albert Street, Auckland
Private Bag 92300, Victoria Street West, Auckland 1142
P: +64 9 890 7742 | +64 21 825 642
E: kerry.harrington@aucklandcouncil.govt.nz

From: Irene Parminter <Irene.Parminter@mfe.govt.nz>
Sent: Tuesday, 13 August 2019 4:51 PM
To: Stephen Town <Stephen.Town@aucklandcouncil.govt.nz>
Cc: Nicola Scott <Nicola.Scott@mfe.govt.nz>; Martin Workman <martin.workman@mfe.govt.nz>
Subject: Request for assistance - in confidence

Dear Stephen,

The Government's Essential Freshwater programme includes consideration of proposals to address excessive nitrogen leaching in catchments with high nitrate levels. The Government will likely be consulting on the proposals as part of the larger Essential Freshwater consultation, currently proposed to start in late August- early September 2019.

We are considering the set of catchments where some of the policy options could apply. In preparation for consultation, MfE is testing this set with councils. In your region the following catchments appear to meet the criteria for high nitrate levels: Waitangi Stream (catchment id 3067) and the Whangamaire Stream (catchment id 3289).

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With your agreement, I would like to discuss these catchments with a member of your staff, to check our understanding of these catchments prior to consultation, in particular the main sources of nitrate losses. Please could you advise who I should contact, and their contact details as soon as convenient.

Thank you.

Kind regards

Irene

Irene Parminter – Senior Policy Analyst
Ministry for the Environment – Manatū Mō Te Taiao
Mob: 022 517 3371 Email: irene.parminter@mfe.govt.nz Website: www.mfe.govt.nz
Environment House, Kate Sheppard Place, PO Box 10362, Wellington 6143

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