

Are woodchip denitrifying bioreactors a viable edge-of-field N-mitigation strategy for New Zealand farming?: Insights from field-trials & comparisons with constructed wetlands



Lee Burbery



Phil Abraham, Richard Sutton, Erin McGill, Louise Weaver,
Andrew Pearson, Theo Sarris



Aldrin Rivas, Greg Barkle, Roland Stenger

LuWQ 2025, Aarhus

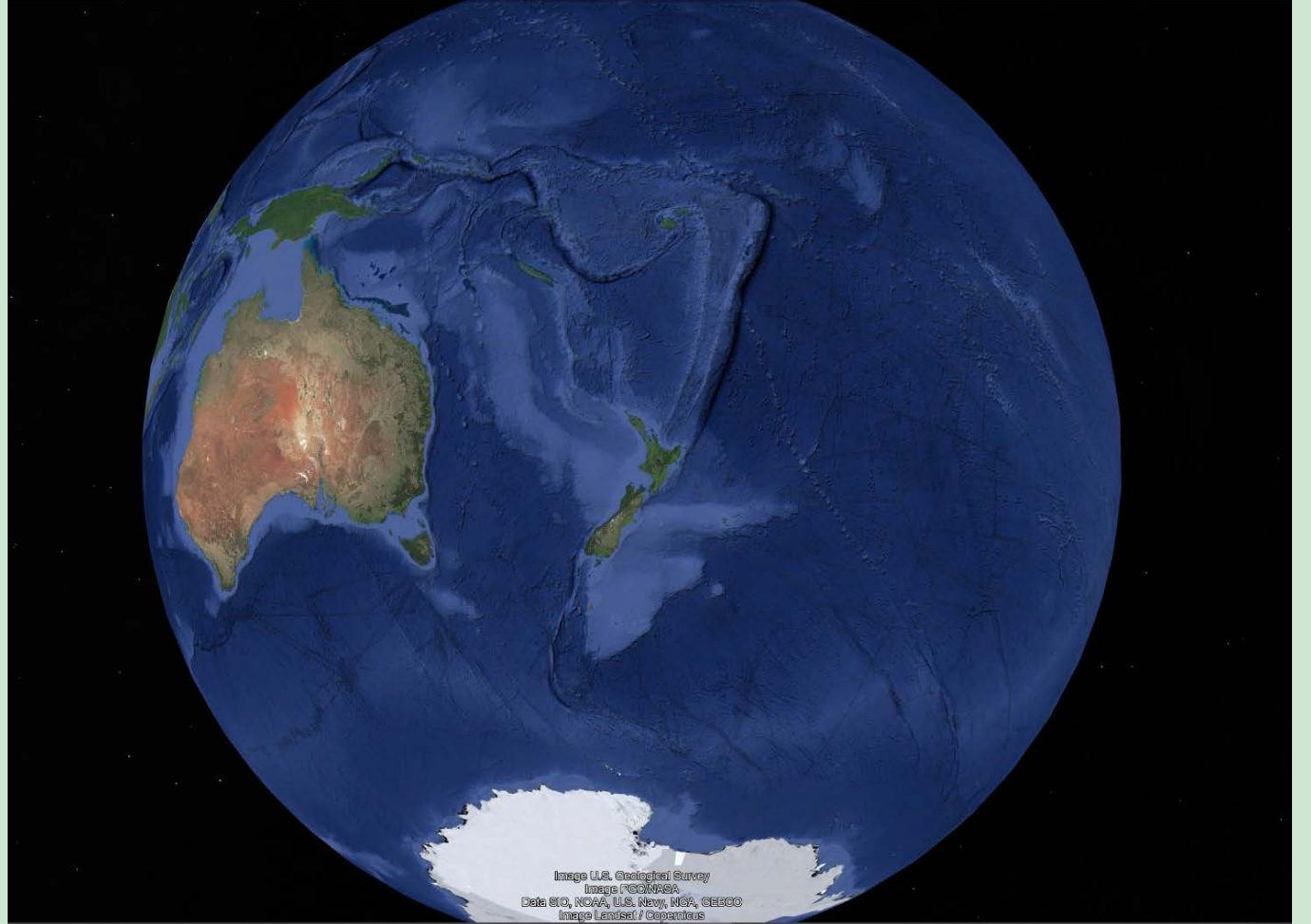
5 June 2025



Talk outline

- NZ – geography/farming landscape
- Status of applied R&D woodchip denitrifying bioreactors in NZ
 - Denitrification beds & walls
- Treatment performance
- Cost-effectiveness
- Future outlook

NZ overview



DairyNZ 

Aotearoa / New Zealand – “Land of the Long White Cloud”

Area:

268,000 km² total NZ

132,000 km² (~50%) agricultural land

~83% pastoral grassland

~13% dairy farms

Population:



People: 5.3 million



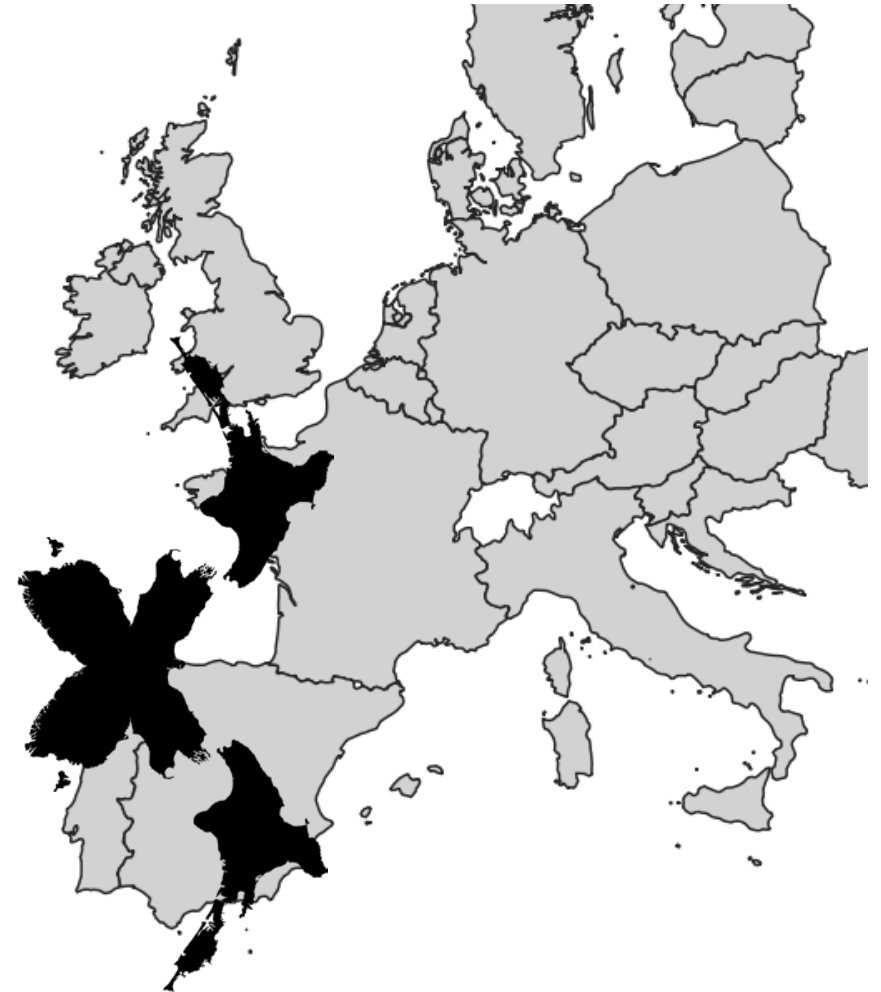
Sheep: 24 million sheep



Dairy cows: 5.9 million
~2.8 cows/ha

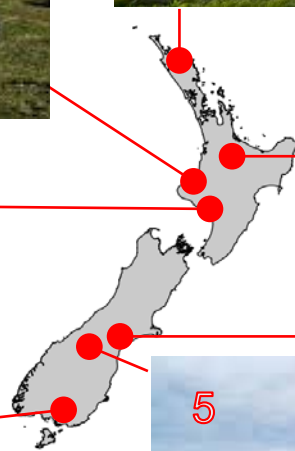


Beef cows: 3.7 million



Varied typologies/N-leaching rates (kg N/ha)

min
Median
 max



Woodchip denitrifying bioreactors in NZ



Woodchip denitrification beds (n = 13)

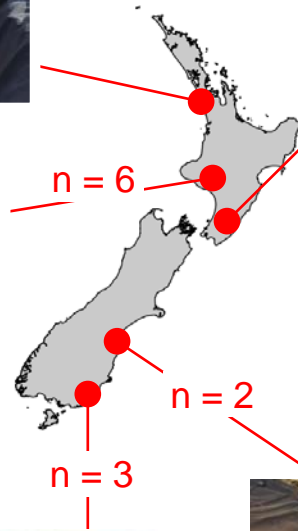
Waikato
60 m³
2 - 6 kg N/yr (2017-19)



Wairarapa
110 m³
est. 26 kg N/yr (2017)



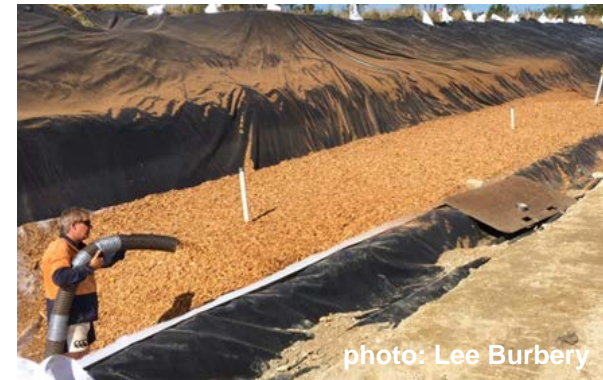
Manawatu & Hawkes Bay
72 - 300 m³
~188 kg N/year (2022 -)



Canterbury
25 m³
? kg N/year (2017-18)



Southland
100 m³
16.1 kg N/year (2015-17)

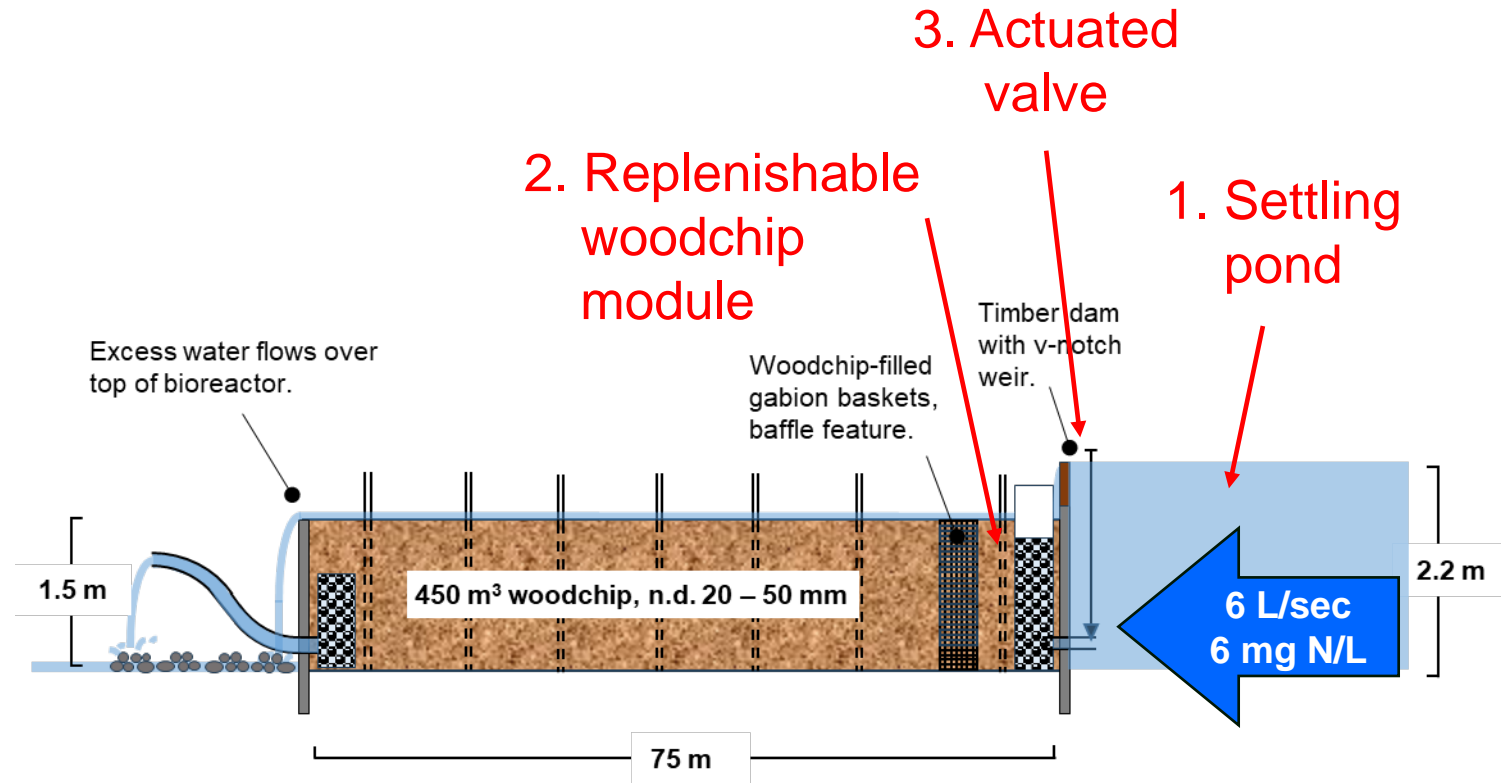


Canterbury
450 m³
490 kg N/year (2021-)

In-stream bioreactor example

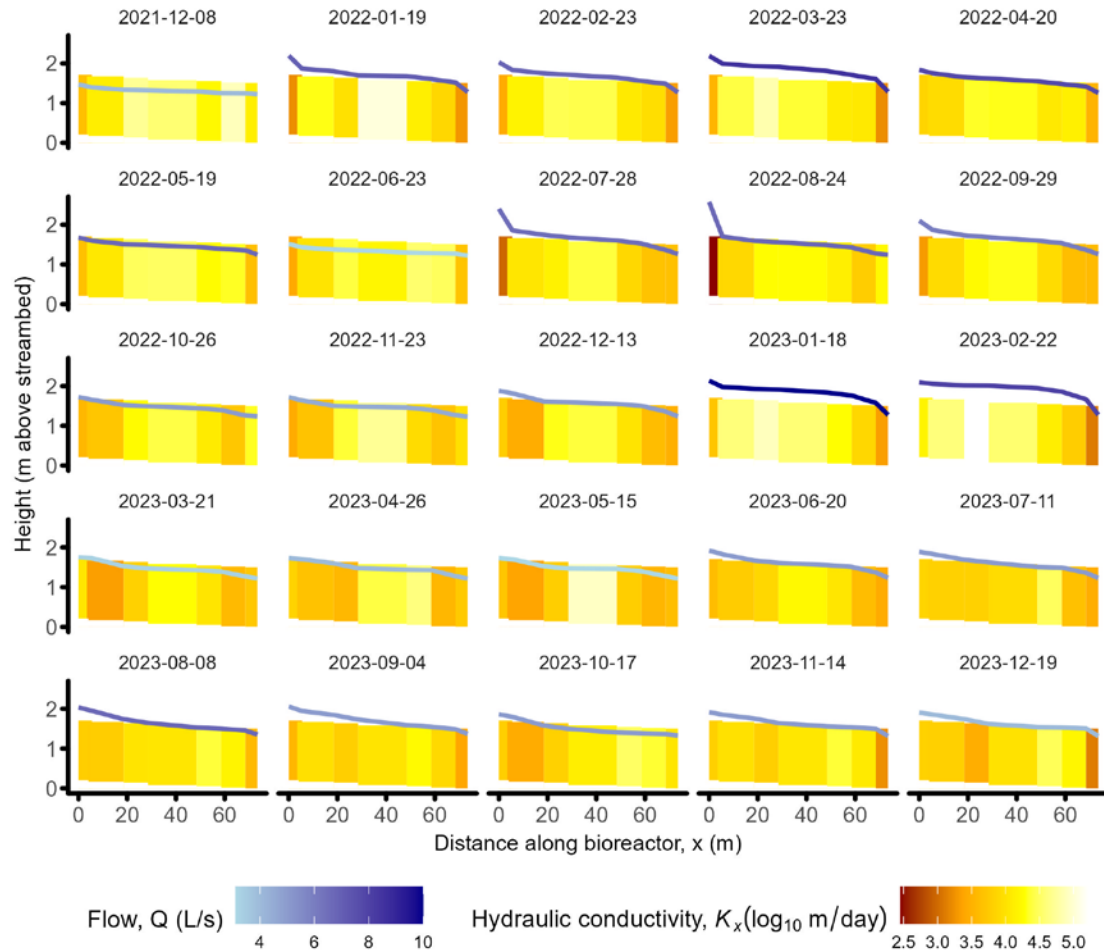


450 m³ woodchip (built 2020)

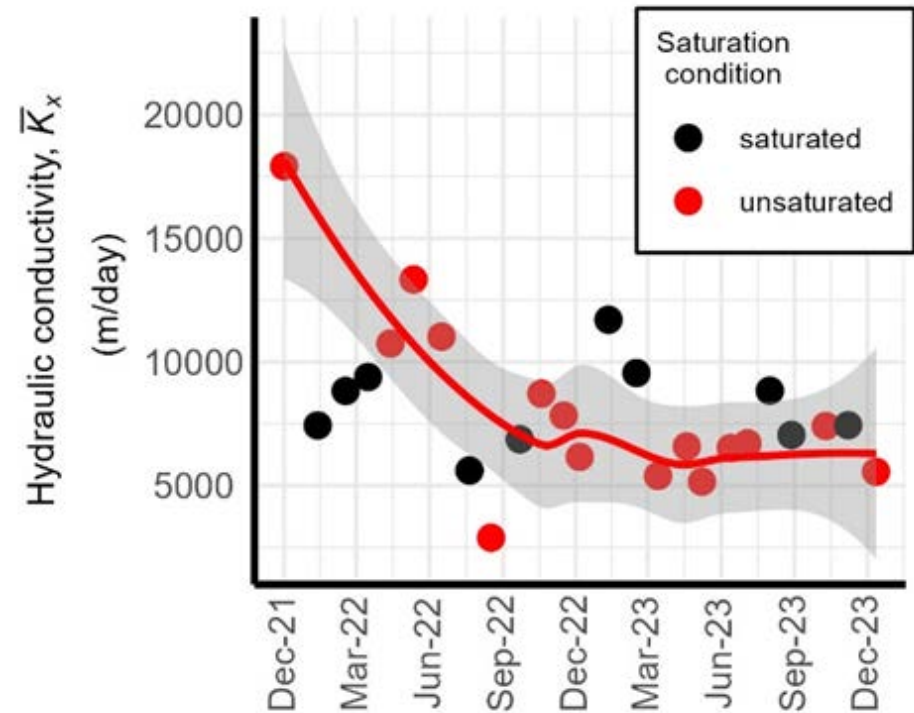




Hydraulic performance



Clogging with sediment
60% reduction in K_{sat} over 2 years

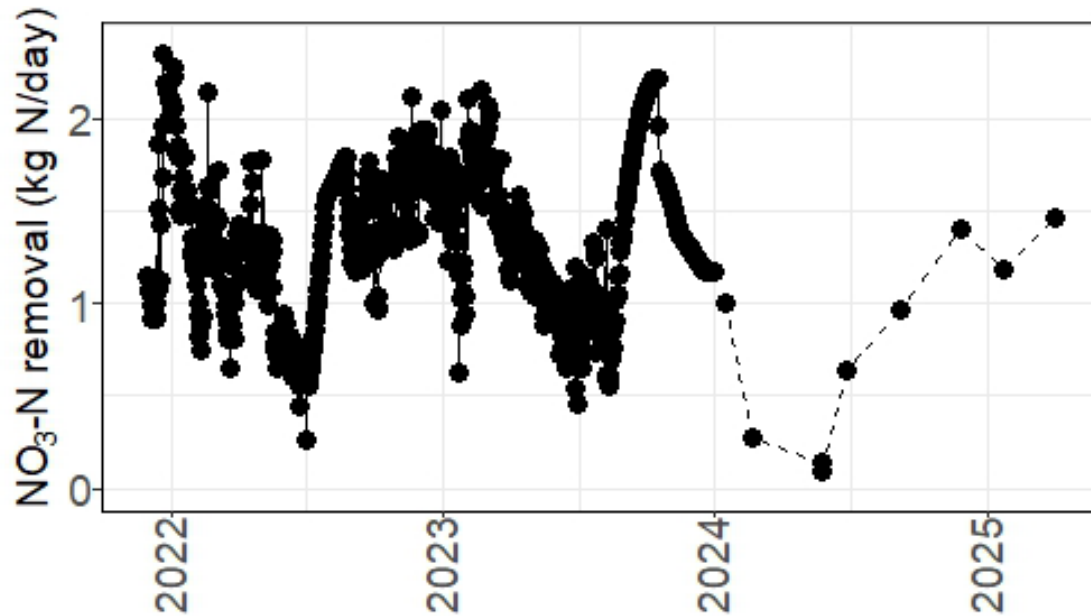


Treatment performance (medians)

Flow: 5.9 L/sec

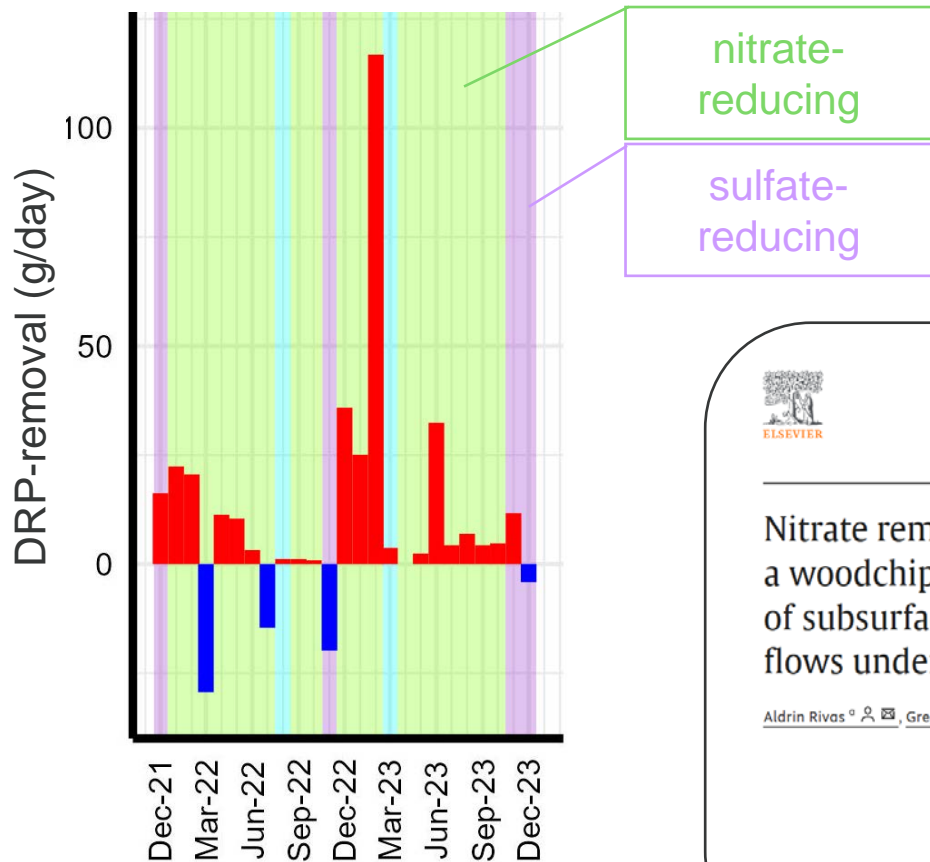
$[\text{NO}_3\text{-N}]_{\text{in}}$ 5.3 mg/L


N-removal: 1.3 kg/day = 490 kg/year



Also removes phosphorus & pathogens

8 kg DRP removed



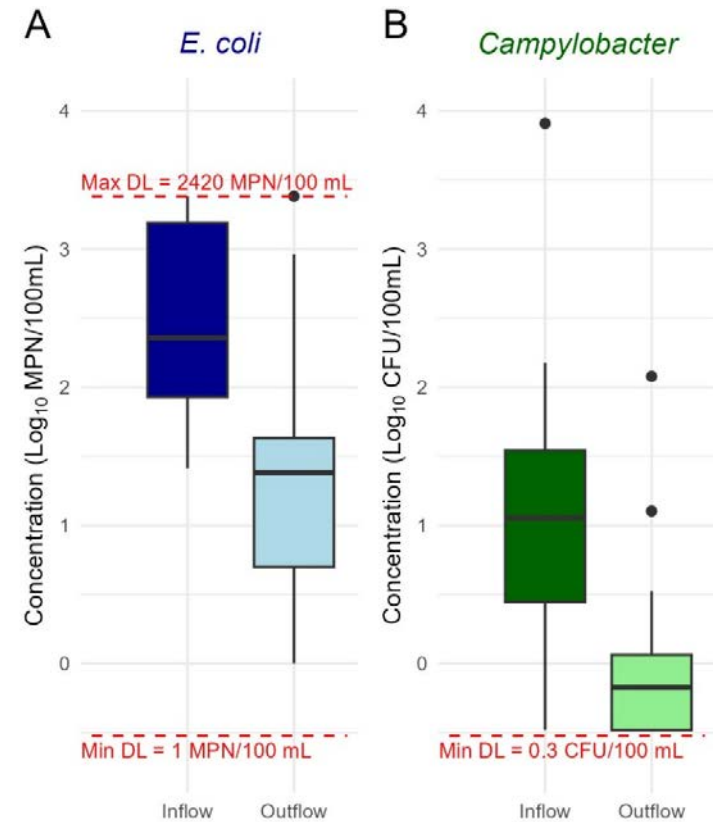
 Ecological Engineering
Volume 148, 1 April 2020, 105786

Nitrate removal and secondary effects of a woodchip bioreactor for the treatment of subsurface drainage with dynamic flows under pastoral agriculture

Aldrin Rivas ^a, Greg Barkle ^b, Roland Stenger ^a, Brian Moorhead ^a, Juliet Clague ^a

89 – 92%
DRP-removal (yrs 2-3)

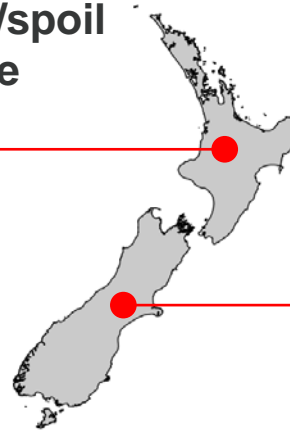
0.65 – 2.0 log-reduction
(over 75 m)



Woodchip denitrification wall trials (n =2)



Sand w/ silt & clay
 $K_{aquifer} \sim 65$ m/d
 Velocity < 0.5 m/d
 NO₃-N 5-16 mg/L
 30/70 sawdust/spoil
 Wall 1.5 m wide



Woodchip denitrification wall technology trialled in a shallow alluvial gravel aquifer
 Lee Burbery^a, Theo Sarris^a, Richard Mellis^a, Phil Abraham^a, Richard Sutton^a, Mike Finnenore^a, Murray Close^a



Evaluation of pollution swapping phenomena from a woodchip denitrification wall targeting removal of nitrate in a shallow gravel aquifer
 Lee Burbery^a, Phil Abraham^a, Richard Sutton^a, Murray Close^a



Gravel w/ sand
 $K_{aquifer} \sim 1330$ m/d
 Velocity > 5 m/d
 NO₃-N ~ 7 mg/L
 50/50 woodchip/gravel
 Wall 5 m wide



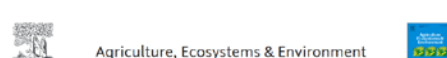
Technical Report
Nitrate Removal from Groundwater Using a Denitrification Wall Amended with Sawdust: Field Trial
 Louis Schipper^a, M. Vojvodić-Vuković^a
 First published: 01 May 1998



Nitrate removal from groundwater and denitrification rates in a porous treatment wall amended with sawdust
 Louis A. Schipper^a, Maja Vojvodić-Vuković^a



Five years of nitrate removal, denitrification and carbon dynamics in a denitrification wall
 Louis A Schipper^a, Maja Vojvodić-Vuković^a



Long-term nitrate removal in a denitrification wall
 Lauren M. Long^a, Louis A. Schipper^a, Denise A. Bruesewitz^b

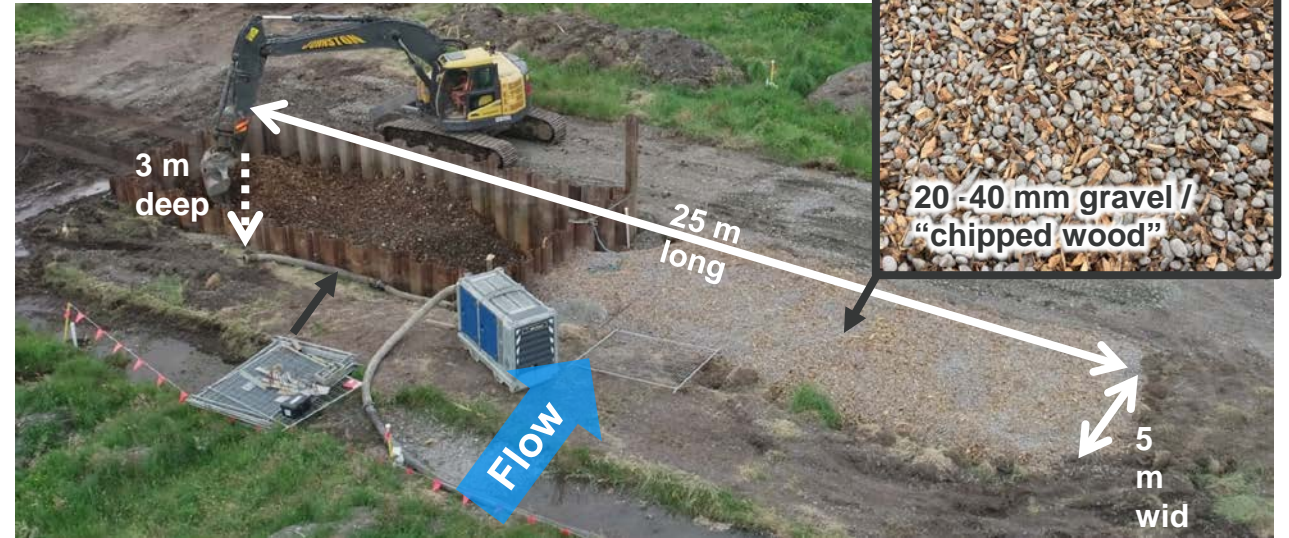
Wall performance (medians):

Treatment flow: 1.6 L/s

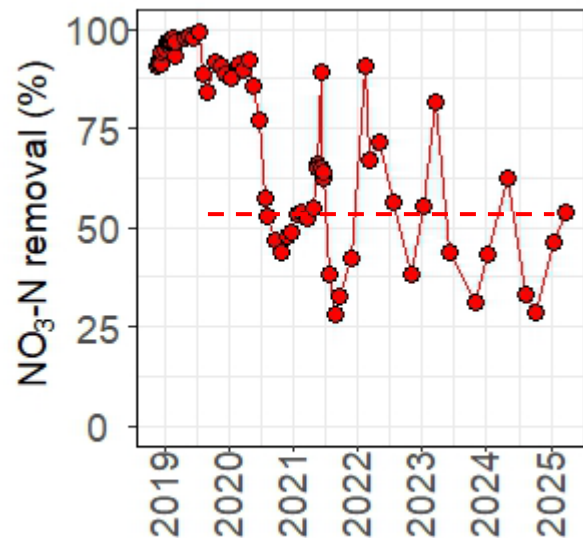
$[NO_3-N]_{in} = 7 \text{ mg/L}$

N-reduction: $\sim 4 \text{ mg/L}$

205 kg N-removed/year

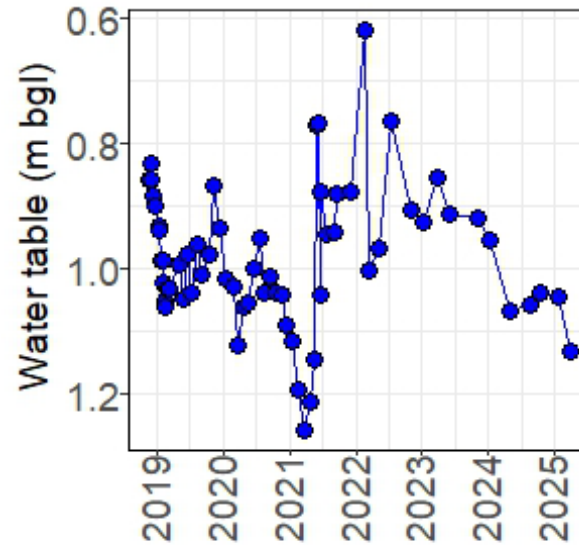


N-removal efficiency

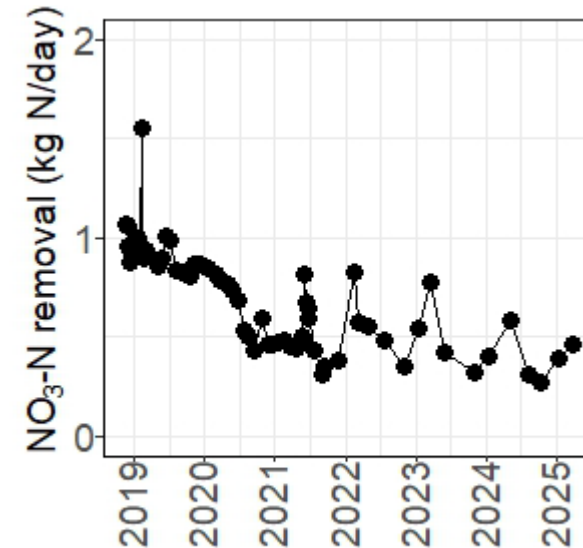


Median
54%

Water level



N-removal rate



Cost-effectiveness



NZ\$/kg N-removed (10-year life; discount rate 8%)

NEW ZEALAND JOURNAL OF AGRICULTURAL RESEARCH
<https://doi.org/10.1080/00288233.2023.2245789>

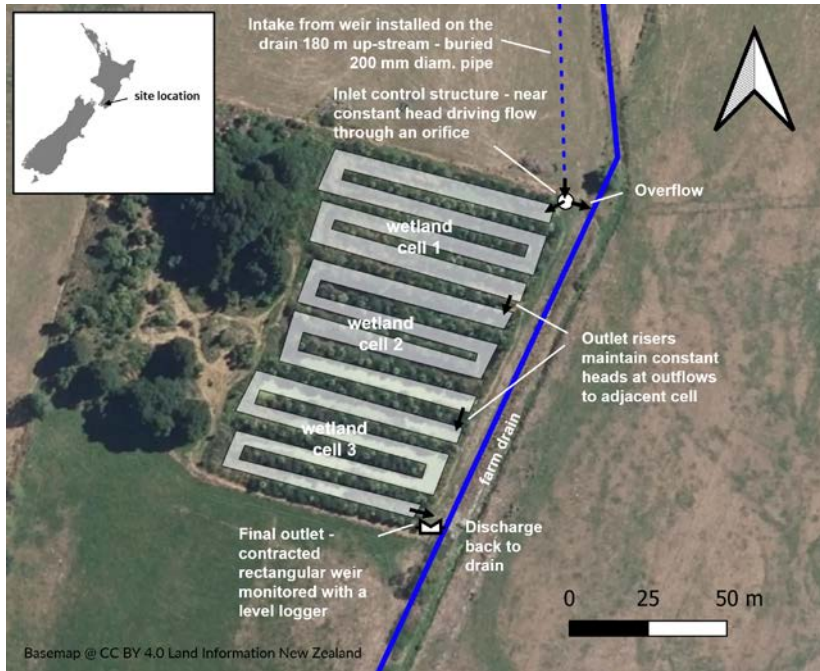


RESEARCH ARTICLE

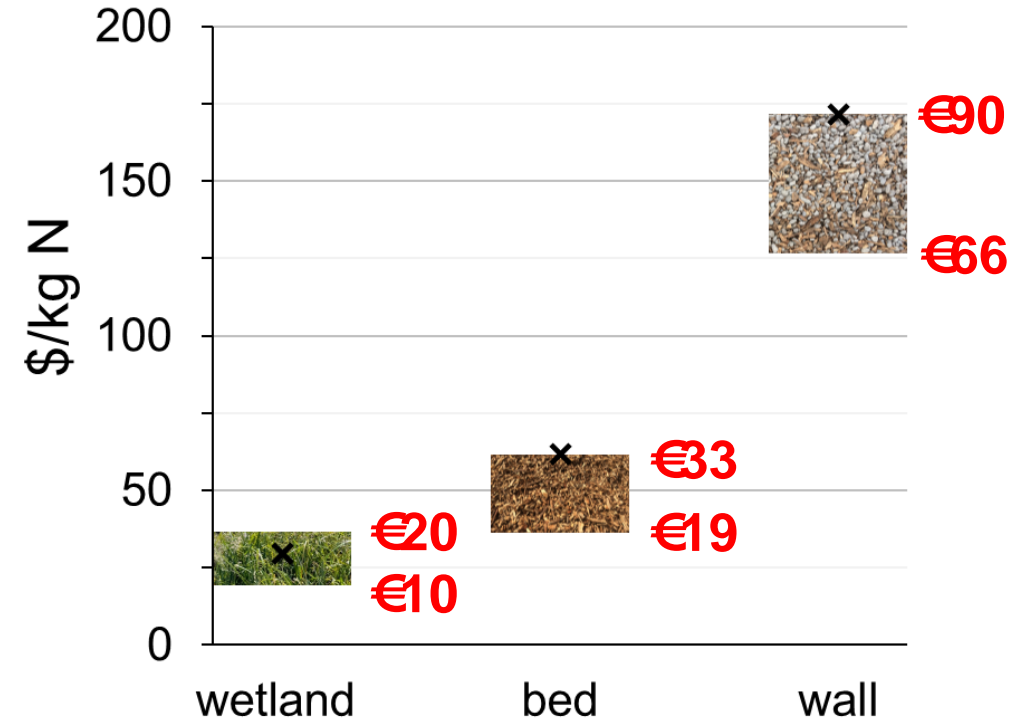


Efficacy of an off-line constructed wetland for mitigating nitrogen loss from a pastoral catchment

Lee Burbery^a, Katrina A. Macintosh^a, John-Paul Praat^b, Vern Brasell^c and Aidan Bichan^c



Load removal 834 kg N/ha/year



Burbery, L.F., Abraham, P., Pratt, J.P., Brasell, V., Bichan, A., Close, M.E. 2023. A comparison of three different edge-of-field nitrate mitigation practices, as realised from field trials. In: *Diverse solutions for efficient land, water and nutrient use*. (Eds. C.L. Christensen, D.J. Horne and R. Singh). <http://flrc.massey.ac.nz/publications.html>.

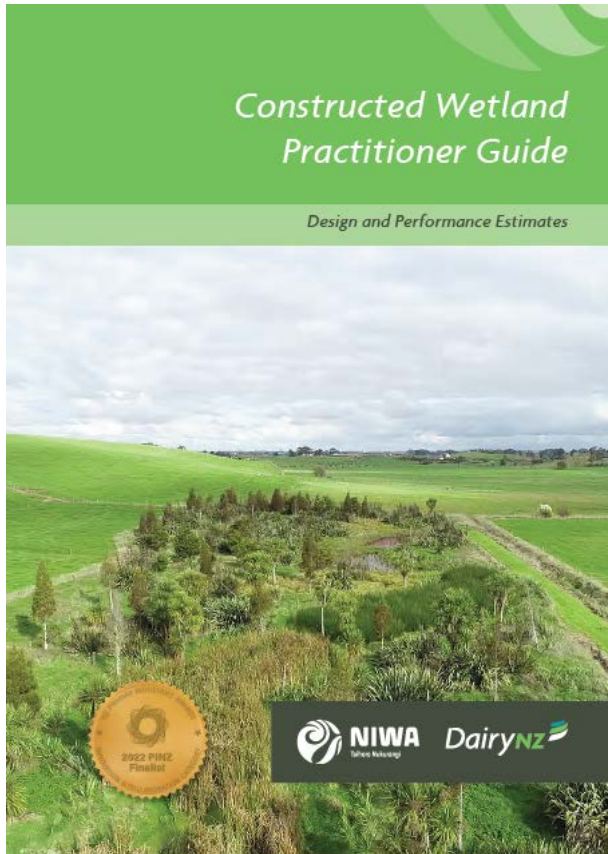
Future outlook



DairyNZ 

Constructed wetlands

Published 2022



Load reduction ~1,300 kg N/ha/yr



Ministry for the
Environment
Manatū Mō Te Taiao

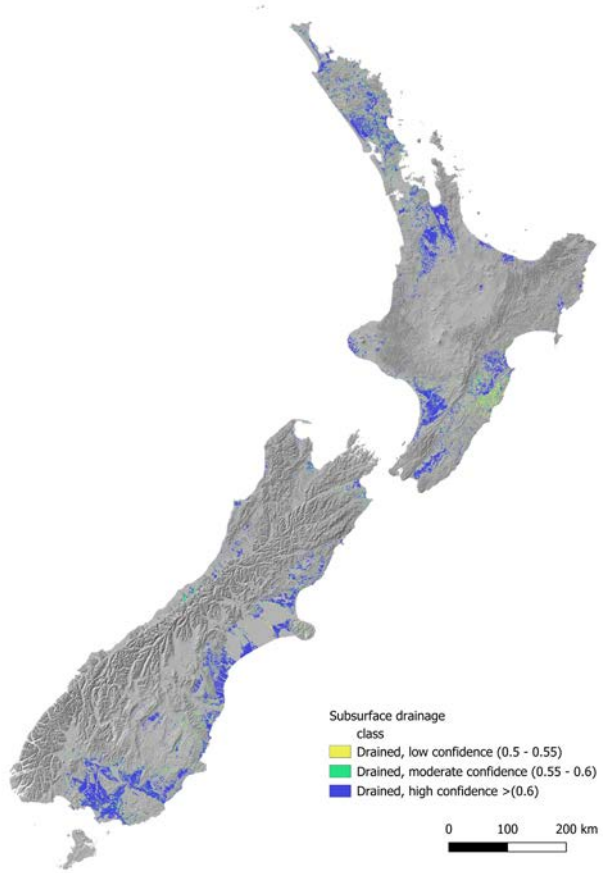
The Government has committed to:

- reviewing the definition of 'natural inland wetland' in the NPS-FM to exclude, among other things, artificial wetlands created by burst pipes
- amending the NES-F to make the creation and maintenance of wetlands a permitted activity.



Woodchip bioreactors

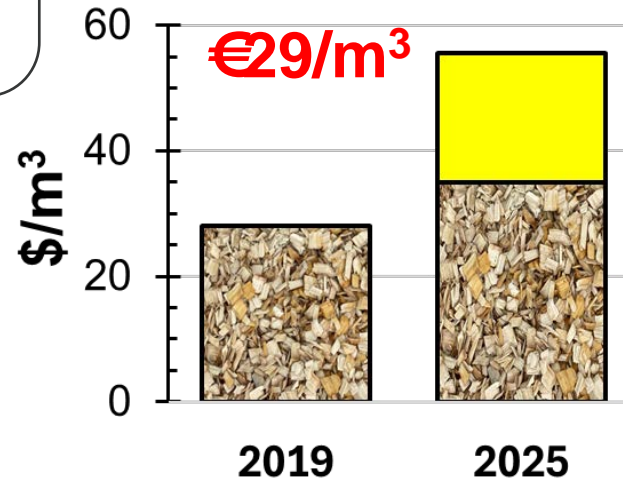
~10% NZ artificially drained



Data: Manderson (2018)



Woodchip becoming expensive - tracking 60% above inflation



Otago Daily Times

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Woodchips cleaning up Uni heating

WAIKATO TIMES

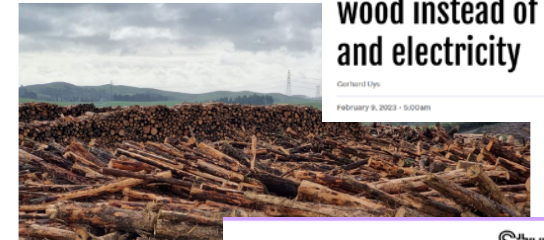
TE REO O WAIKATO

OPINION BUSINESS SPORT PUZZLES SUNDAY STAR-TIMES

Forest waste fuelling milk production

Bethwyn Littler | WAIKATO TIMES

January 23, 2024



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Fonterra and Genesis want to use wood instead of coal for heating and electricity

Garland Igo

February 9, 2023 - 5:00am

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New biomass boilers help slash Canterbury's reliance on coal for hospitals

Doreen Williams

March 28, 2023 - 6:08pm

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Acknowledgements:



Ngā mihi nui
Thank you
Tak

