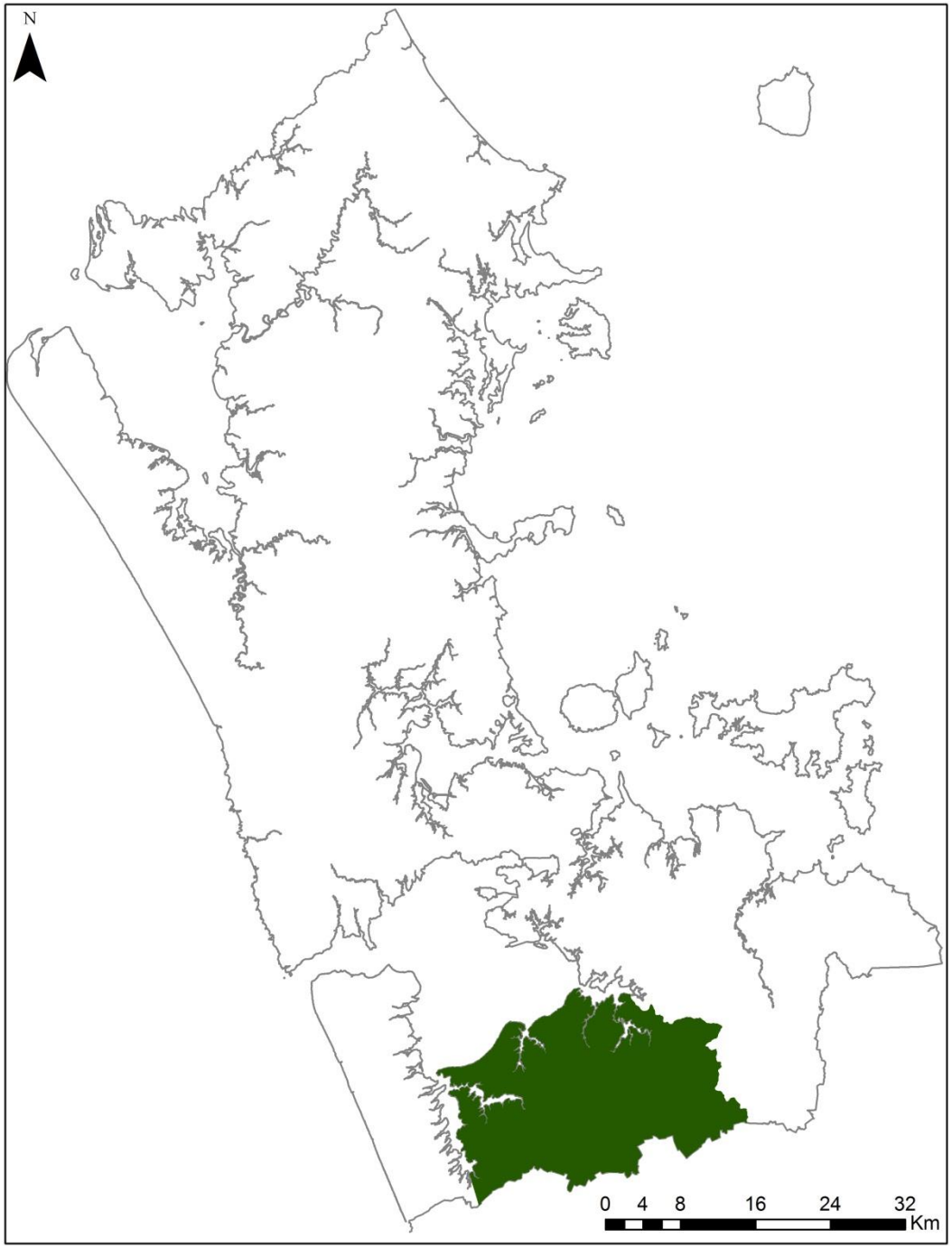
Sources of nitrate in Franklin surface and groundwater

Laura Buckthought
Kirsten Meijer
Research & Evaluation Unit (RIMU)

Auckland Region

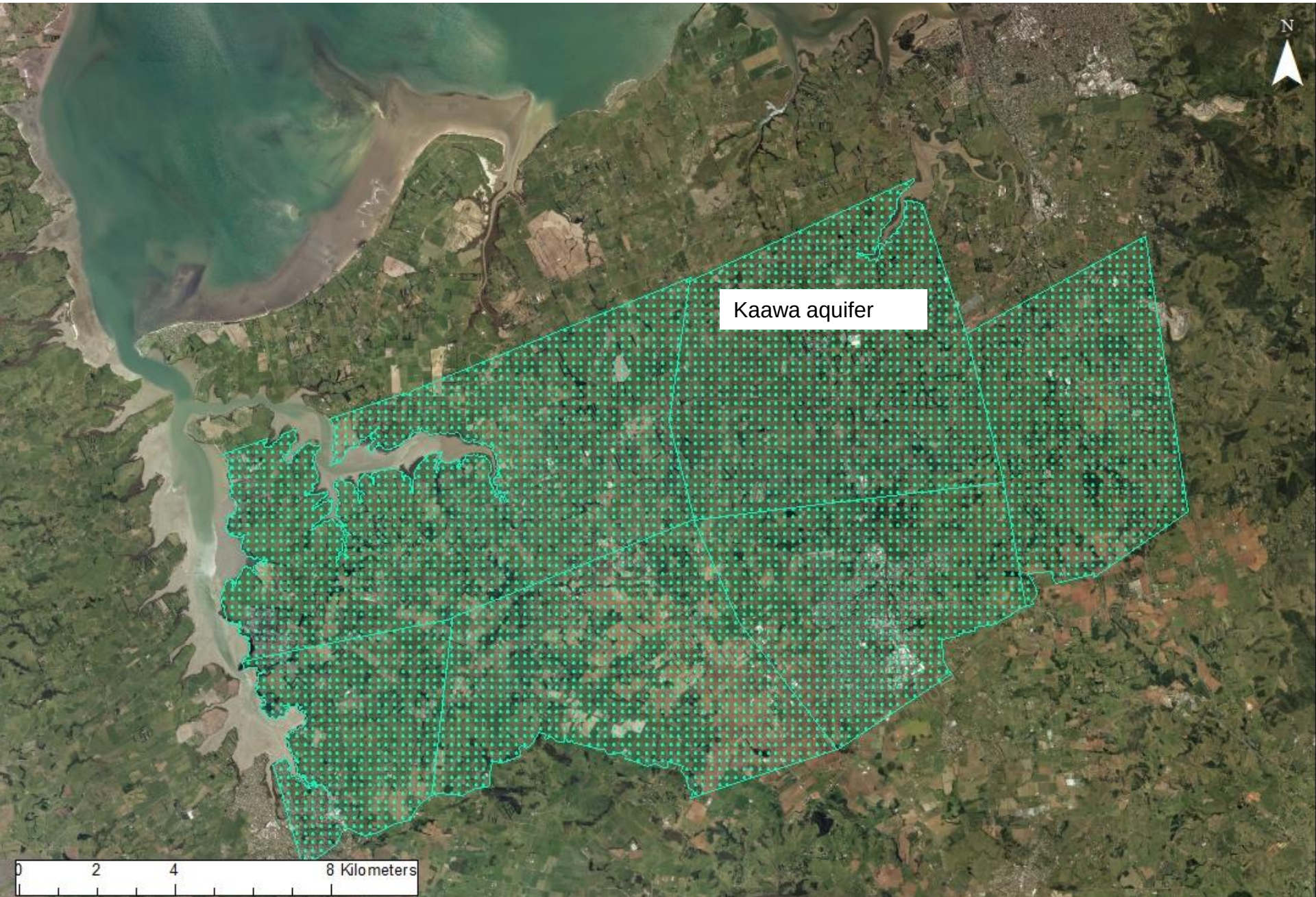
New Zealand



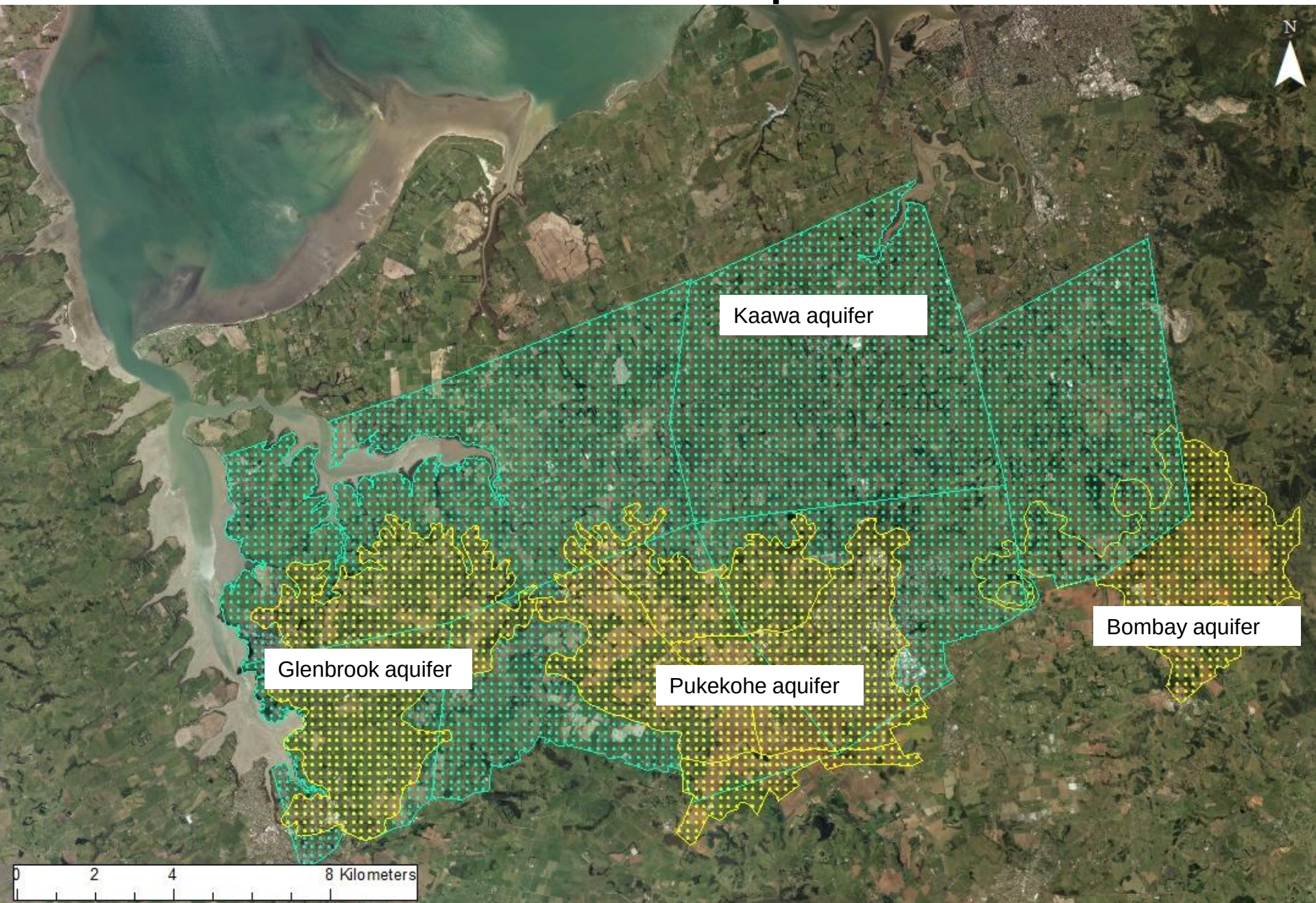
Franklin

- Pastoral land (73%)
- Short rotation cropland (14%)
- Native bush(4%)
- Urbanised area (4%)

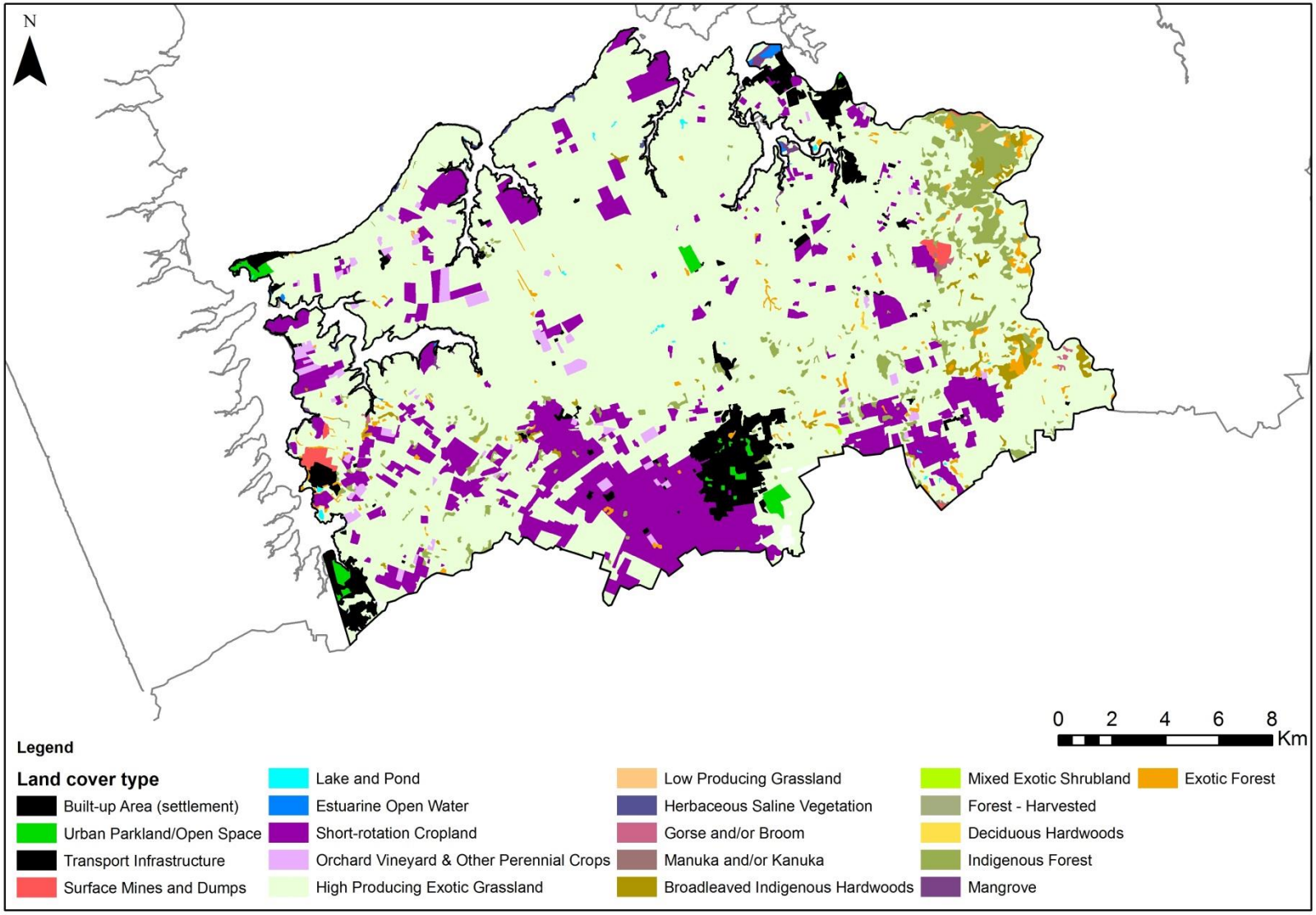
Franklin Kaawa Aquifer



Franklin basalt volcanic aquifers



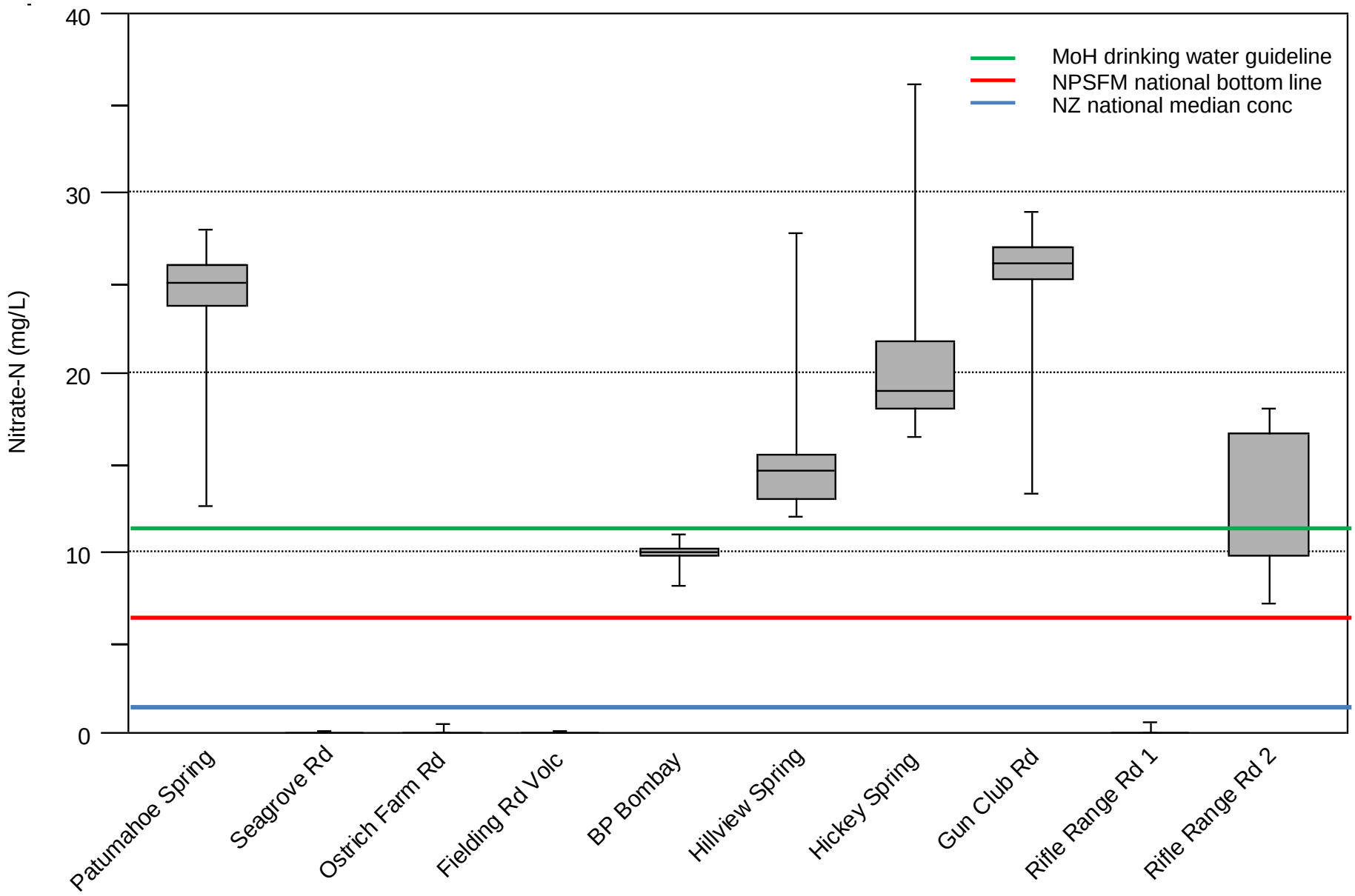
Franklin Land Use (LCD v 3)



Franklin land cover type (LCDBIII)

Map Produced by
Research, Investigations
and Monitoring Unit
Auckland Council

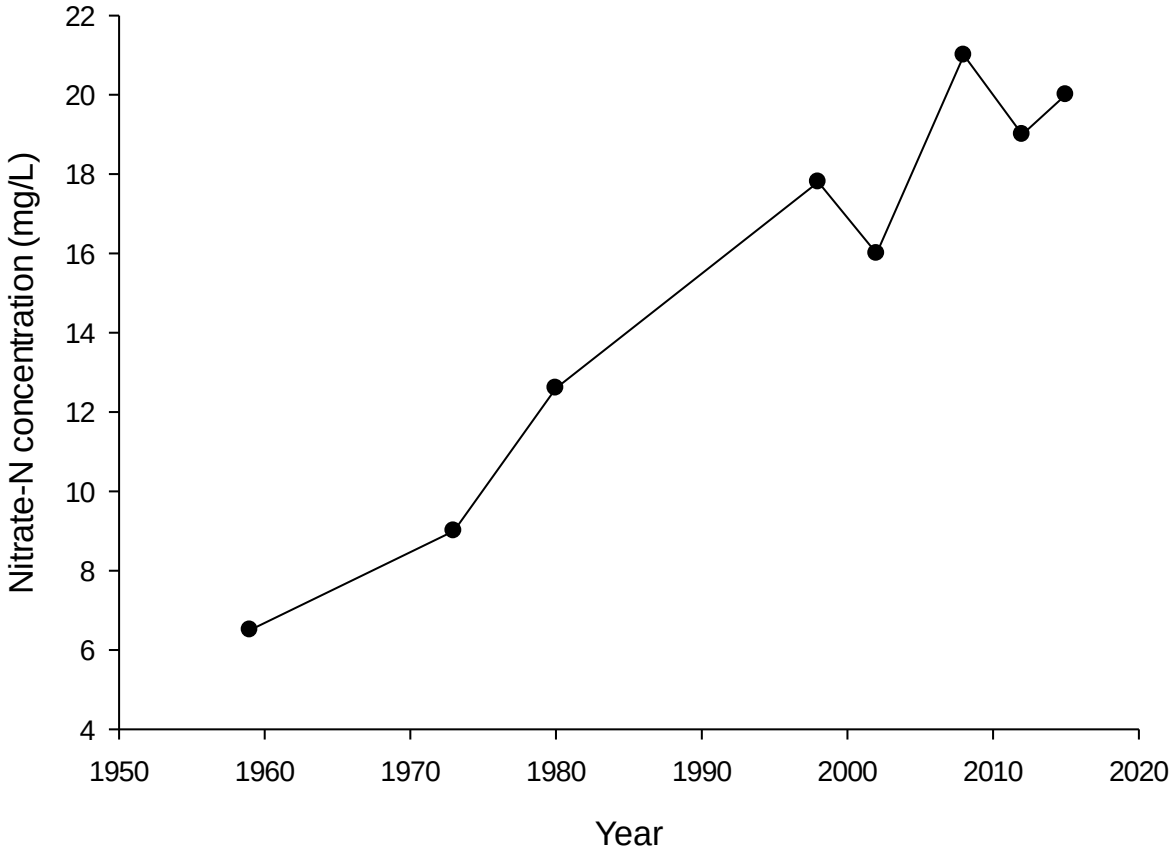
Groundwater: Nitrate-N concentrations



Hickey's Spring, Pukekohe aquifer: 1959-2015

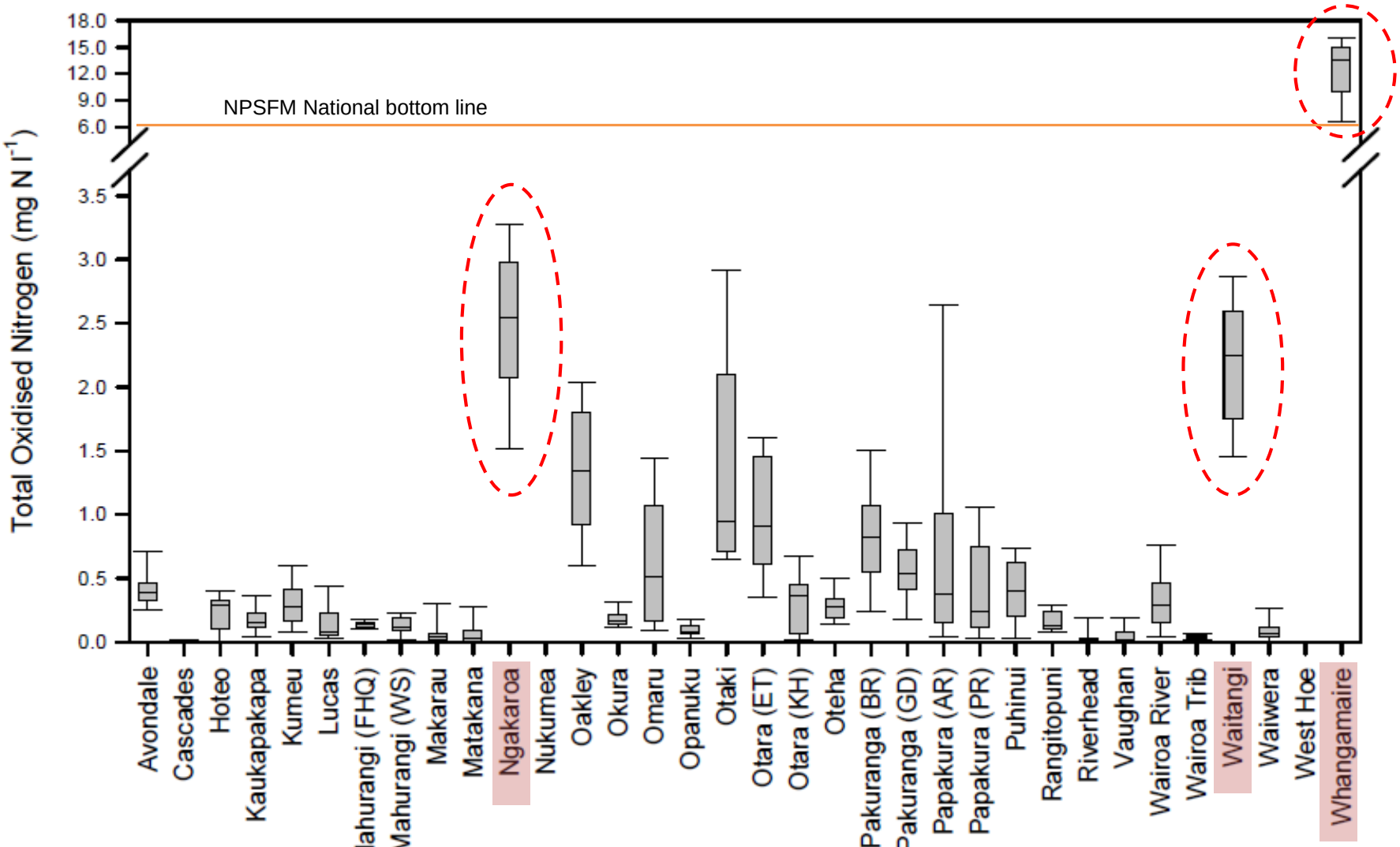
Year	Nitrate conc (mg NO_3-N/L)
1959*	6.5
1973*	9.0
1980*	12.6
1998	17.8
2002	16.0
2008	21.0
2012	19.0
2015	20.0

Rate of increase 1959-2015
= 0.24 mg NO_3-N per year



* Burden, R. J. 1982. Nitrate contamination of New Zealand Aquifers. Water and soil science centre, Christchurch, New Zealand.

Surface water: Nitrate-N concentrations



Lockie, S. and Neale, M.W. (2012). State of the Environment Monitoring: River Water Quality Annual Report 2011. Auckland Council Technical Report 2012/013.

Context:

- **Environmental Impacts**

Macrophyte growth, DO fluctuations, ecological health

- **National Policy Statement for Freshwater Management**

Nitrate toxicity in rivers:

National bottom line = 6.9 mg/L

- **Ministry of Health**

Drinking water guidelines:

Max acceptable value= 11.3 mg/L

Potential sources

Intensive Market Gardening

→ Multiple crops per year

→ N fertiliser anecdotally up to 1000 kg N/ha per crop!

→ Soil tillage encourages further accumulation of nitrate

→ Irrigation: nitrate-rich water

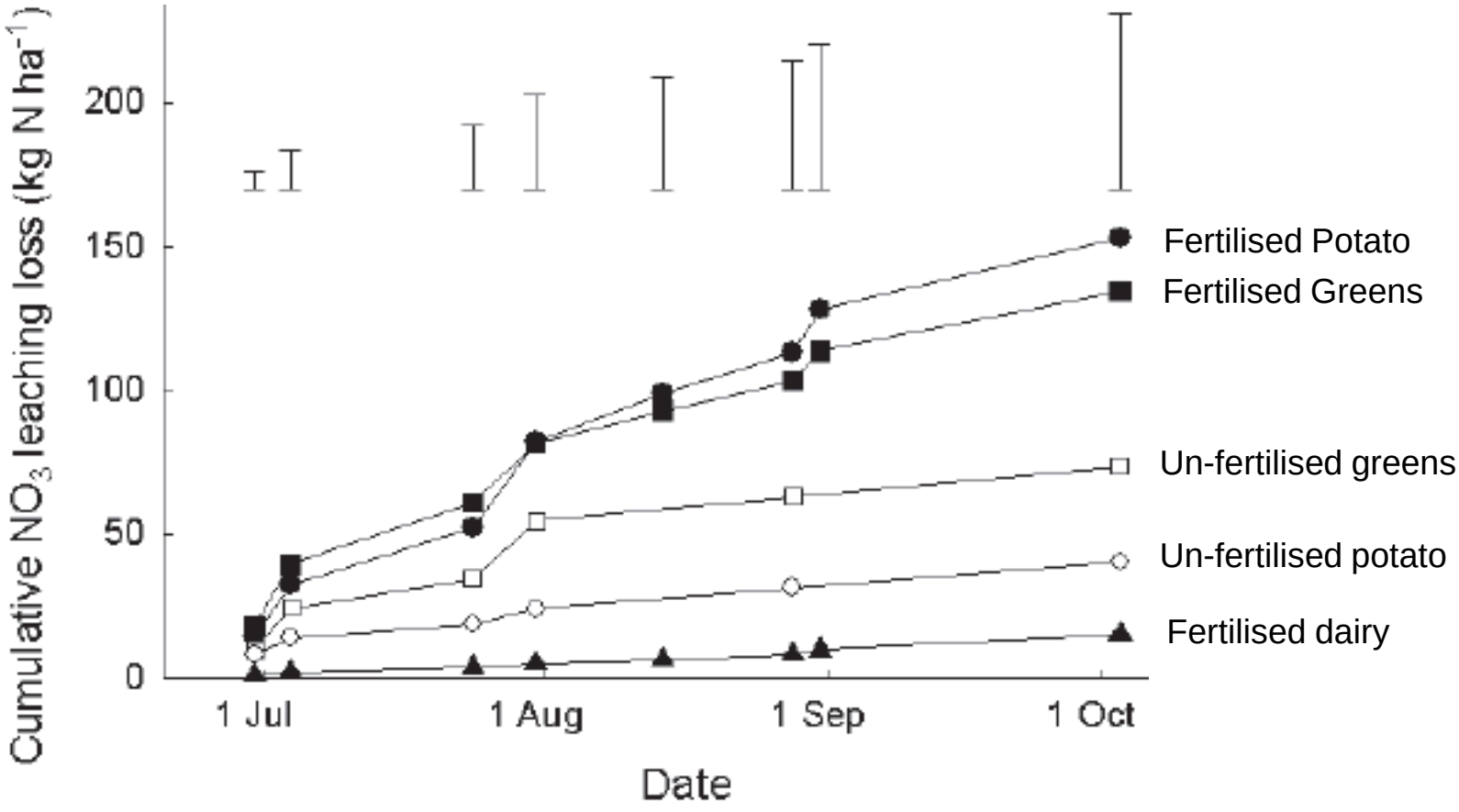
N transfer from land to water:

- Leaching: high soil nitrate concentrations + drainage
  - N cycling rates e.g. Mineralisation
  - Fertiliser application rates & timing
  - Management e.g. tillage & irrigation
  - Free draining soils

- Subsurface drainage pipes
  - Transfer of nitrate directly to surface water?

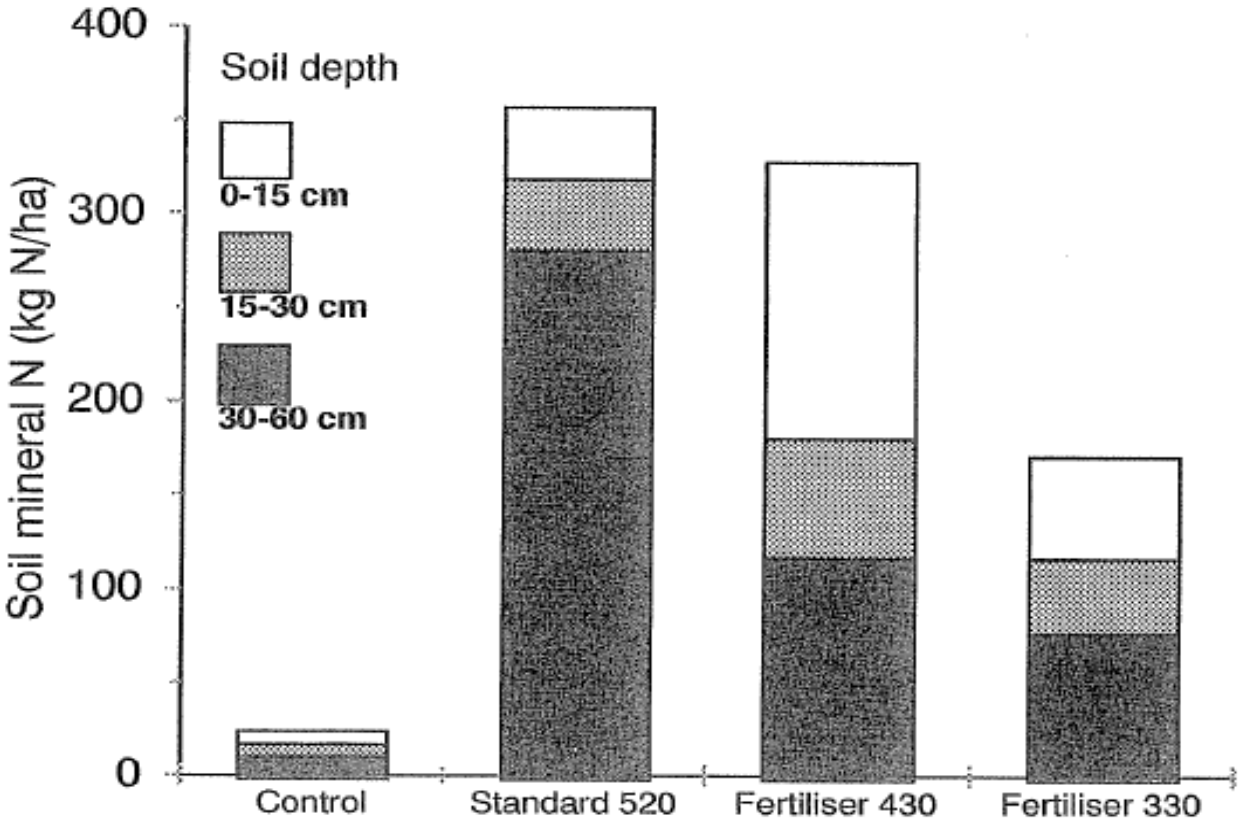
- Sediment traps/ponds
  - Hotspots of nitrate leaching?

Research: Current knowledge



Francis et al. 2003

Research: Current knowledge



Williams et al. 2003

1. Groundwater ageing study

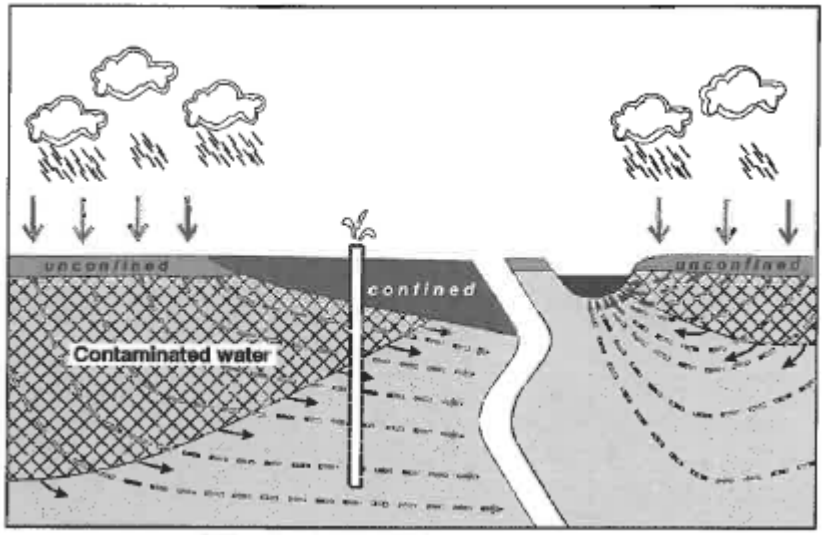
Objective: Determine groundwater mean residence time (MRT) and ultimately, use its relationship to groundwater chemistry to estimate groundwater age in Bombay and Pukekohe aquifers

- Age tracer samples (tritium, CFCs, SF_6) were collected and analysed;
- Distribution of groundwater residence time estimated using the exponential piston flow model (EPM)

1. Groundwater ageing study

Results:

- Groundwater MRT ranges from 16 and 99 years
- Groundwater age increases with direction of flow and depth.

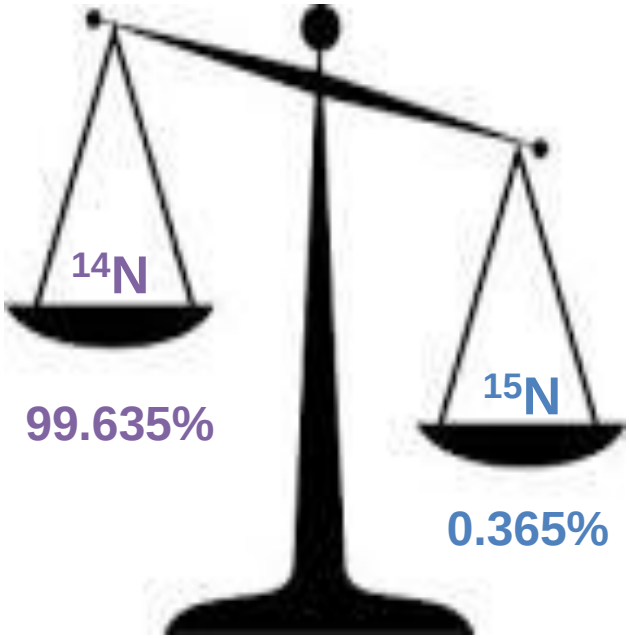


- Assuming constant land use contributions of nitrate to the system, the proportion of post 1950's recharge is expected to increase, which will result in increasing nitrate concentrations

2. Stable isotope abundance

Objective:

Use Dual Stable Isotope Abundance Technique (^{15}N & ^{18}O) for nitrate source determination and to characterise in-stream N cycling dynamics.



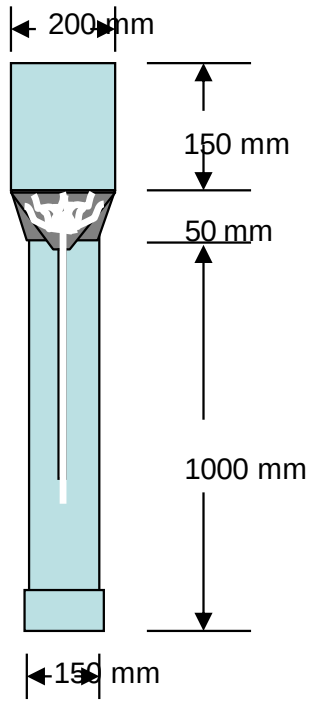
2. Stable isotope abundance

- Took water samples (streams, spring and groundwater).
- Expecting high $\delta^{18}O$ signal, characteristic of nitrate fertiliser.
- Other studies suggest high rates of mineralisation & nitrification from soil OM pool, dominate the $\delta^{18}O$ signal.
  Even under excess N application.

3. Root zone reality study

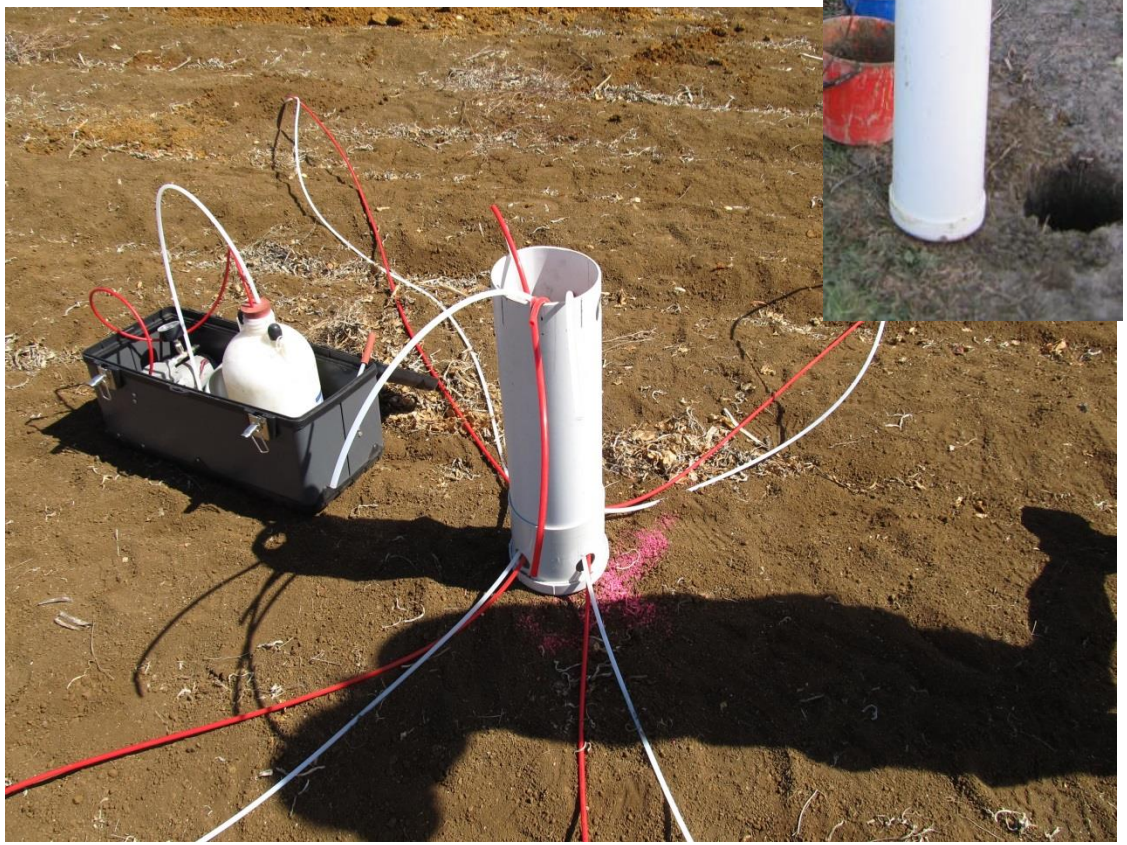
Field study to directly measure nitrate leaching under rotation cropping land use (potatoes and onions) using “Fluxmeters”

- Joint study by Plant & Food, Horticulture NZ and Regional Councils.
- Two sites in Franklin: Fluxmeters installed below crop root zones and capture leachate volume and concentrations.
- Leachate collected and analysed for NH_4N, NO_3-N, total N + range of other species



3. Root zone reality study

- No results yet.
- Opportunity to take fluxmeter subsamples and analyse for ^{15}N and ^{18}O.
- Characterise isotopic signatures of ‘freshly leached’ nitrate.



Future work :

- Spatial extent of high groundwater nitrate concentrations
- Aquifer recharge
- Groundwater-surface water connections
- Contribution of sub-surface drainage
- Contribution of sediment settling ponds


Thank-you