

Science to policy and back again: compliant land use practices still cause P leaching

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The Issue

In 2015, around 5% of surface water sites exhibited increasing DRP concentrations in baseflow that mirrored increases in DRP concentrations in groundwater.

Risks identified:

- P-rich soils
- Irrigation
- Soils and aquifers with low anion storage capacity (P retention)



Guidelines and Policy

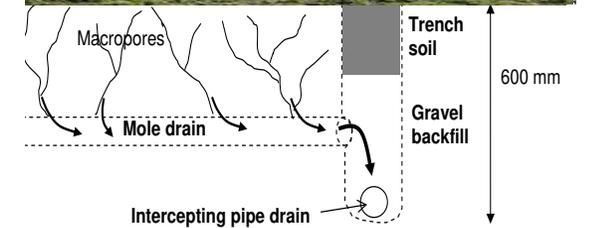
Industry good practice stipulates that:

- Soils are maintained at an agronomic optimum
- P is applied outside periods of likely runoff

Regional rules stipulate that farm dairy effluent is applied to avoid the FDE ponding on the soil surface and leaching to depth (i.e. $< 10\text{mm}$ at a time).



Too much effluent applied at too high a rate



Lincoln University Dairy Farm

- 3.5 cows/ha, top 2% for profit
- 160 ha irrigated (500 mm/yr)
- Soil Olsen P (40 mg/L) maintained by fertilizer or effluent
- Low anion storage capacity soils (15-25%)
- Rapid and moderate draining soils. *The 'rapid' soil is representative of 143,000ha of shallow stony soils under dairying in Canterbury.*

40-50 mm/yr effluent spread across 20 ha via drip line



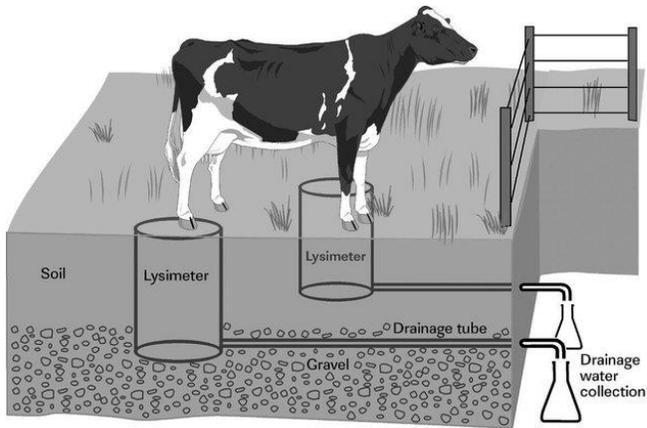
The question

The LUDF has all the risk factors for P leaching

- Irrigation
- Low ASC soils
- High permeability
- **Effluent**

Are guidelines and policy sufficient to prevent P leaching across these risk factors?





Field lysimeters in free draining soils.

20 Templeton (moderate) soil lysimeters

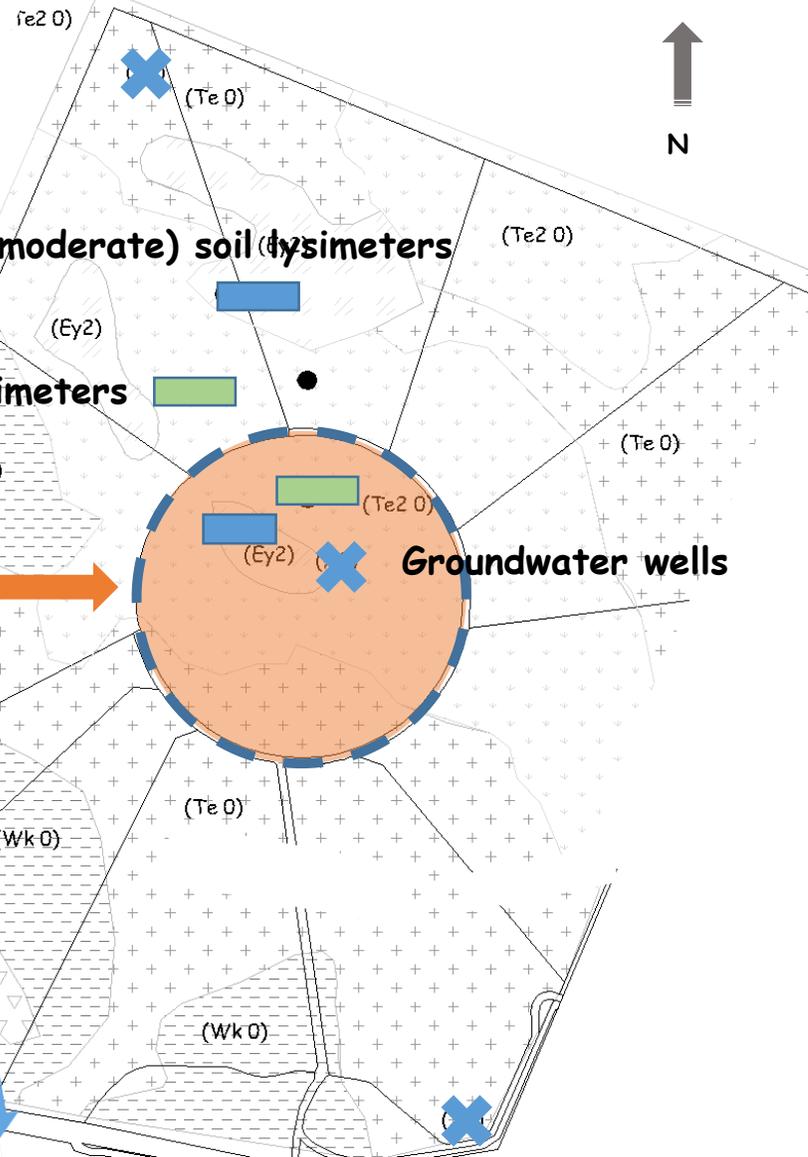
20 Eyre (rapid) soil lysimeters

Effluent application area



Groundwater wells

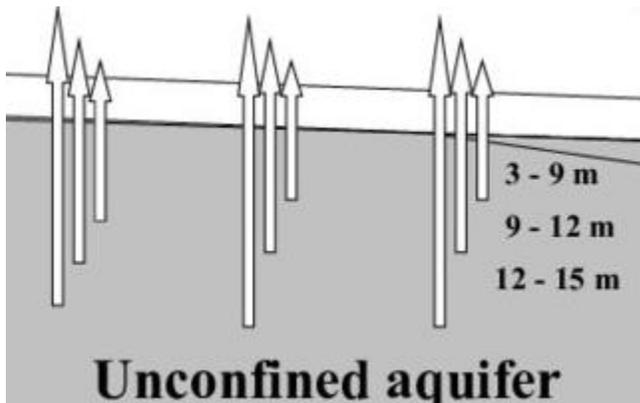
Direction of groundwater flow



2001-2015

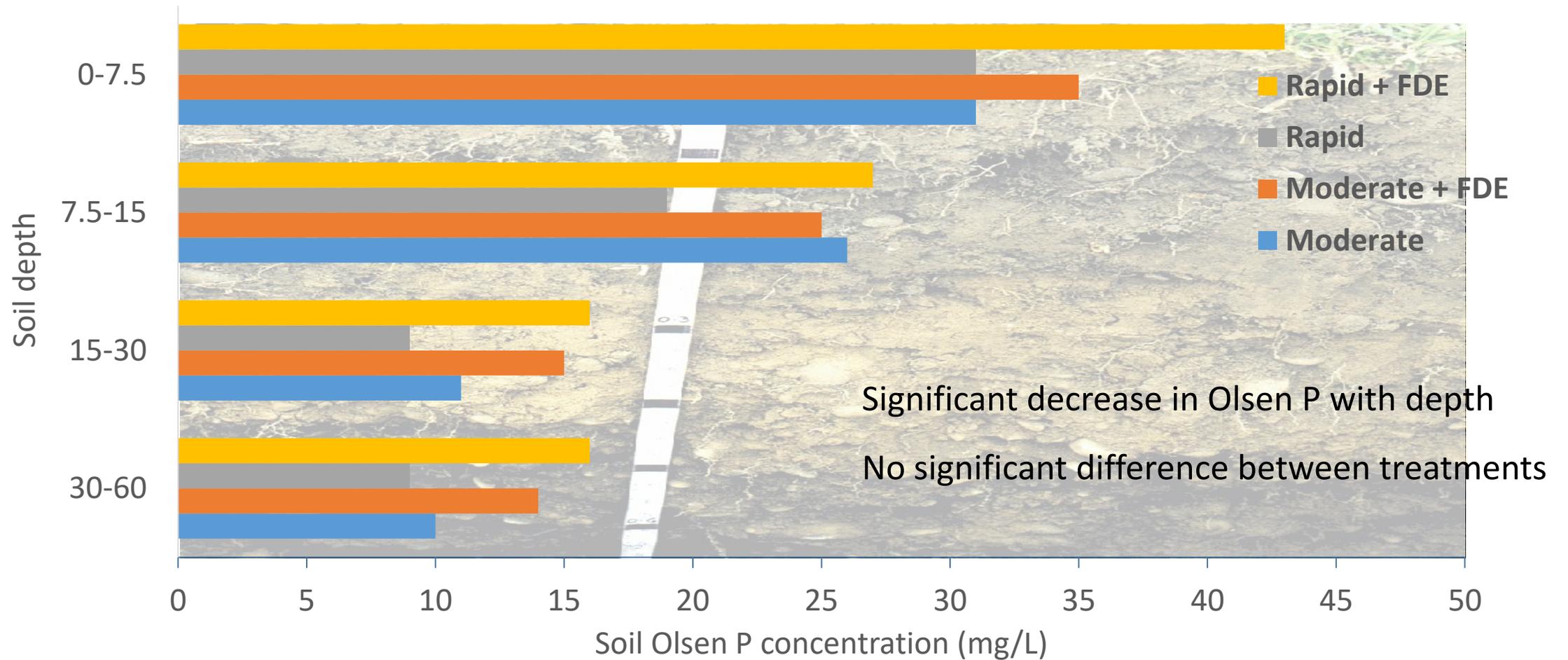
305 rainfall events have been collected (c. 8000 samples)

Groundwater samples collected quarterly

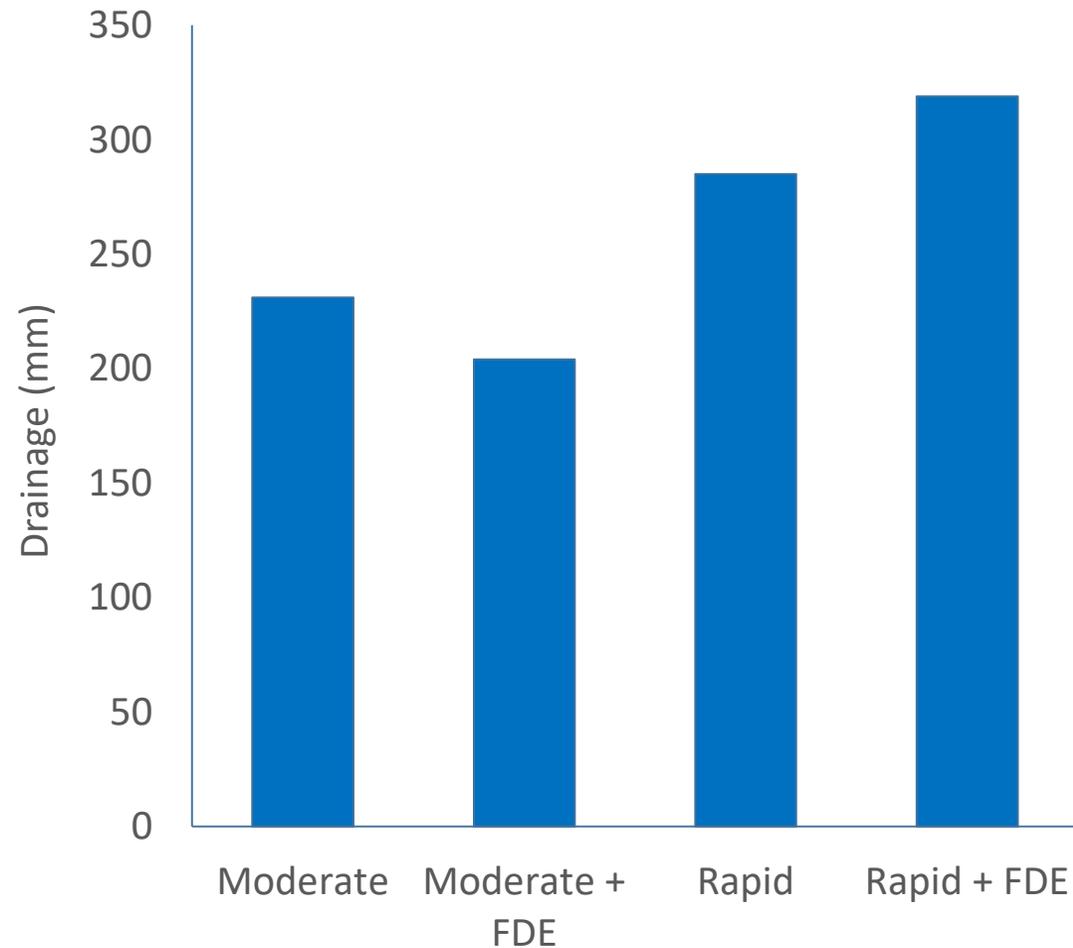


Unconfined aquifer

Soil P enrichment



Mean annual drainage

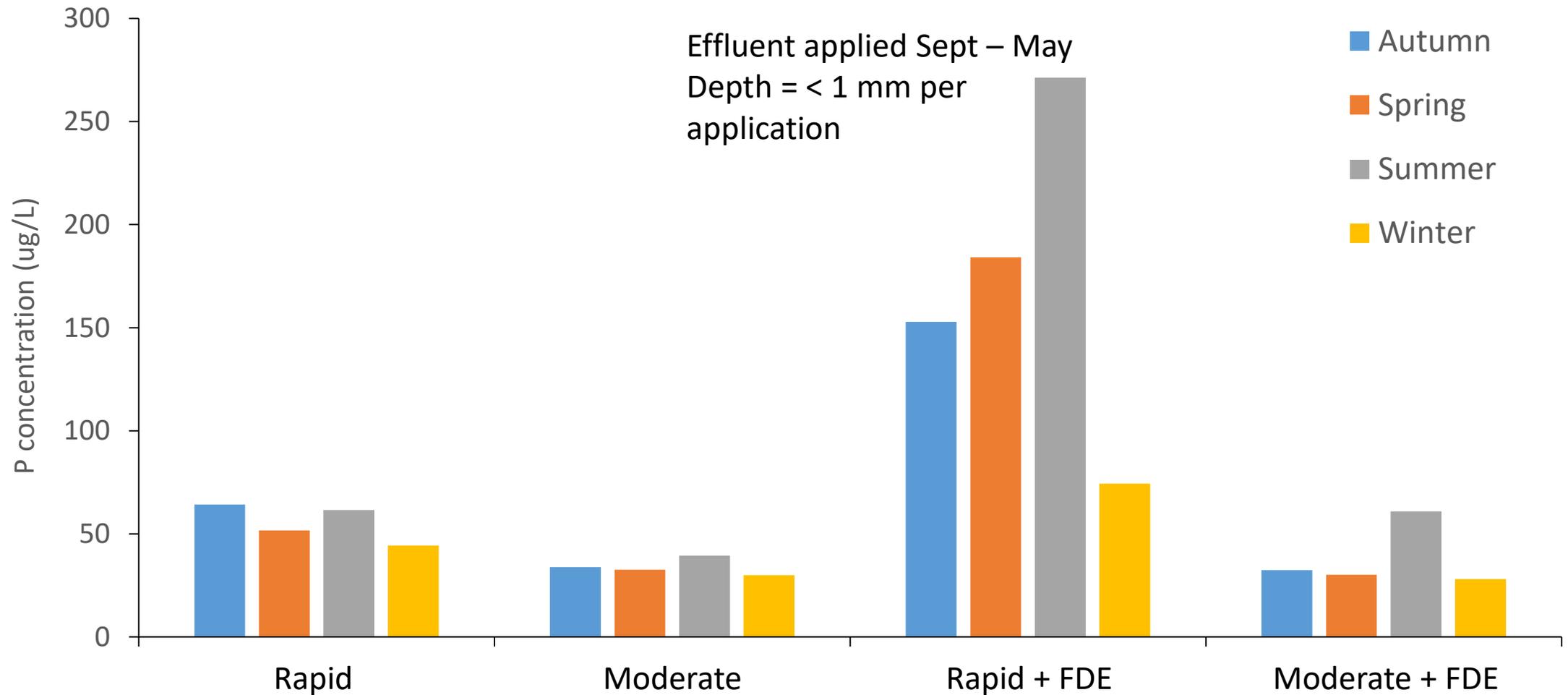


Drainage facilitated by soil conditions

Rapid $K_{sat} = 390$ mm/hr

Moderate $K_{sat} = 90$ mm/hr

Seasonal total P losses



Mean annual yield (kg/ha/yr)

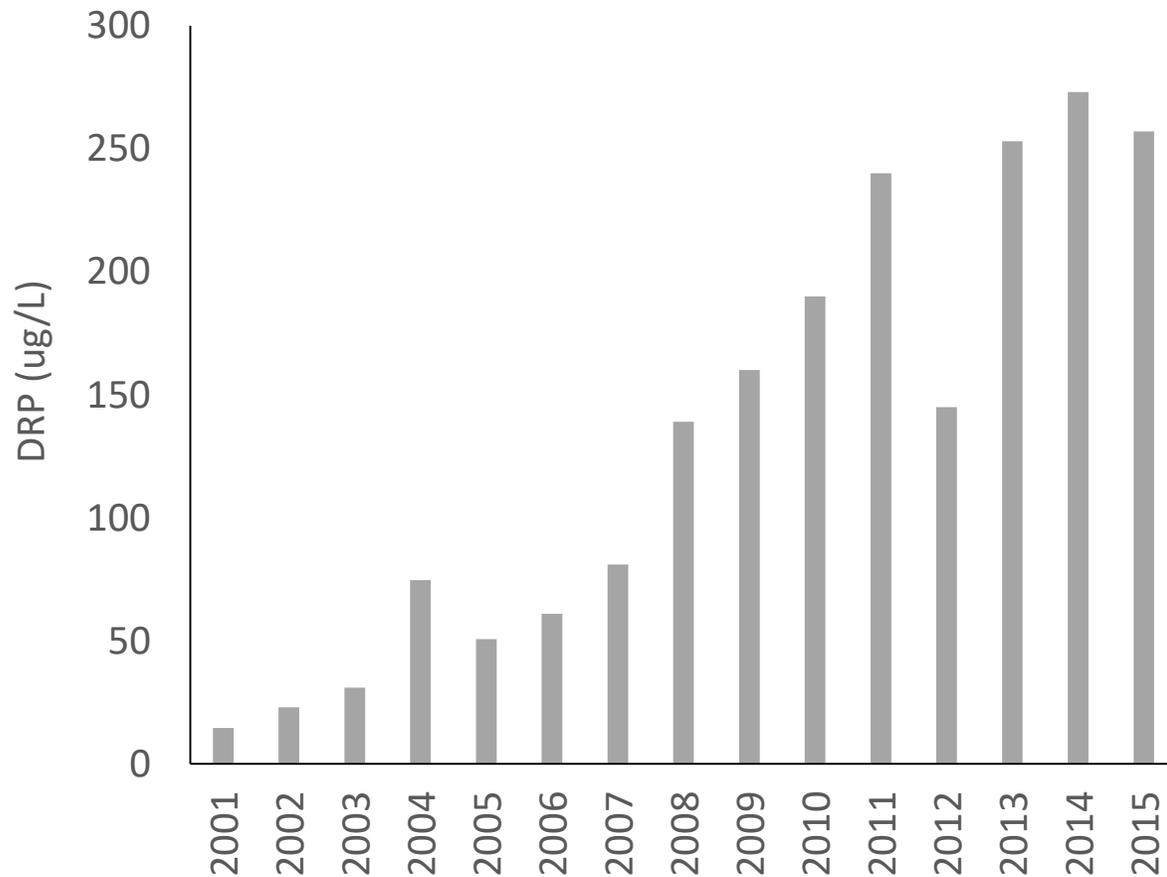
Mean TP yield in leachate from grazed dairy pastures = 0.30 (n = 4)

Mean TP yield in runoff from dairy pastures = 1.9 (n = 10)

Mean TP yield in dairy dominated catchments = 1.5 (n = 11)

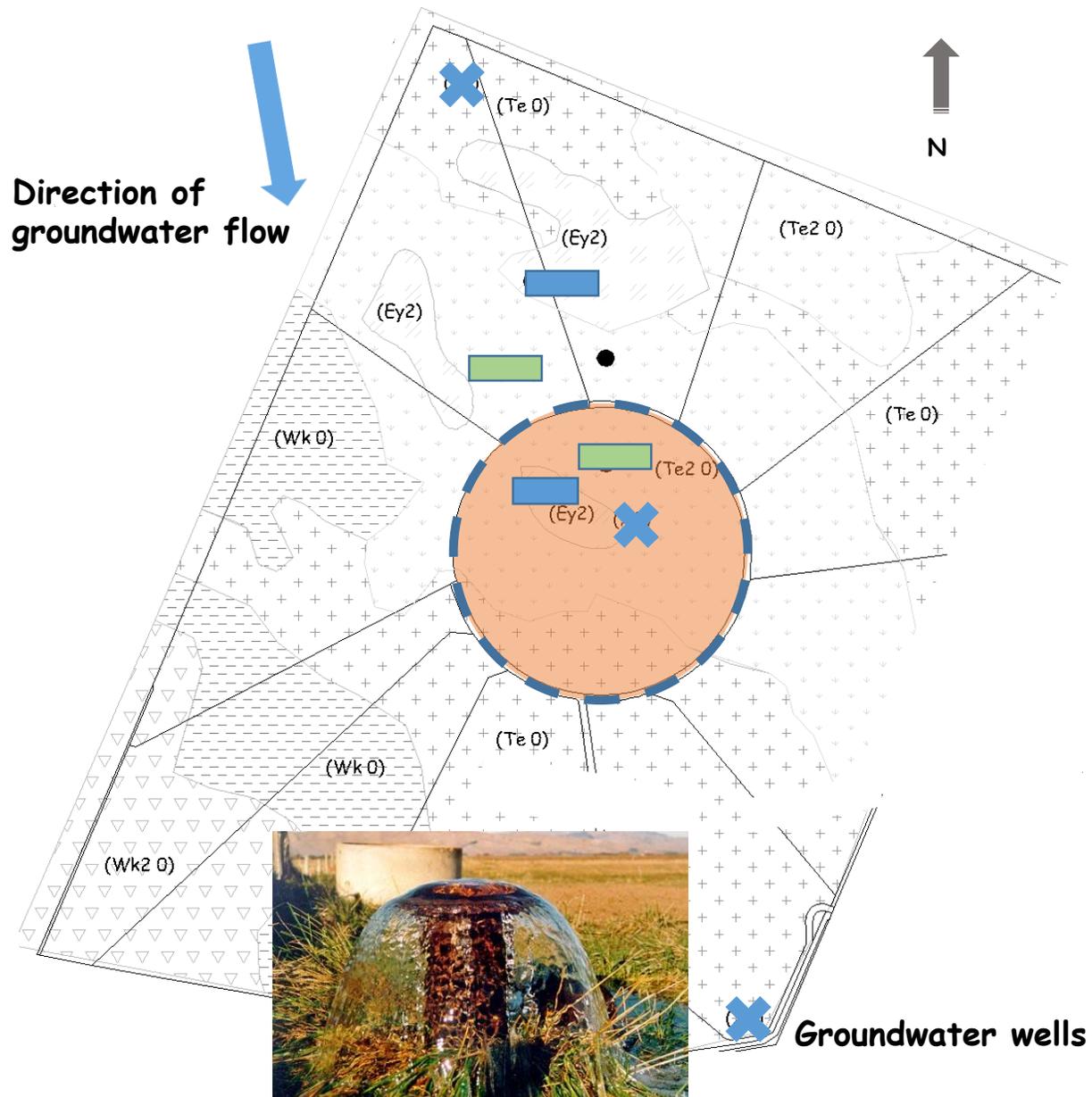
	DRP	Total P
Rapid + FDE	0.33	1.46
Rapid	0.07	0.25
Moderate + FDE	0.05	0.12
Moderate	0.05	0.11

Enrichment over time



Mean annual enrichment for P fractions

	DRP	DURP	PP
Rapid + FDE	5	8	7
Rapid	-	5	6
Moderate + FDE	-	5	-
Moderate	-	4	-



	Total P (ug/L)
Up-gradient (n=3)	5
Mid-point (n=2)	4
Down-gradient (n=3)	7

Two wells had samples for all 15 years

Mean DRP at down-gradient well (5 ug/L) was > up-gradient well (2 ug/L) and increased over the 15 years by 8% p.a.

But unclear if due to P leaching from rapid + FDE soil

Conclusions

- Considerable P leaching to 70-cm depth over 15 years.
- Characteristics of rapid soil enhanced P leaching and exacerbated by FDE application over time.
- Some suggestion of detection in down-gradient groundwater.
- Guidelines for P fertilisation minimised P leaching.
- Effluent application rules did not prevent P leaching on rapid soil representative of 143,000 ha in Canterbury.
- Therefore, less FDE-P must be applied (**possible?**), made less available for loss, or **FDE not applied** to these freely draining, shallow and stony soils.