

# Predicting Changes in Nitrogen Concentration in Groundwater Using Water Age

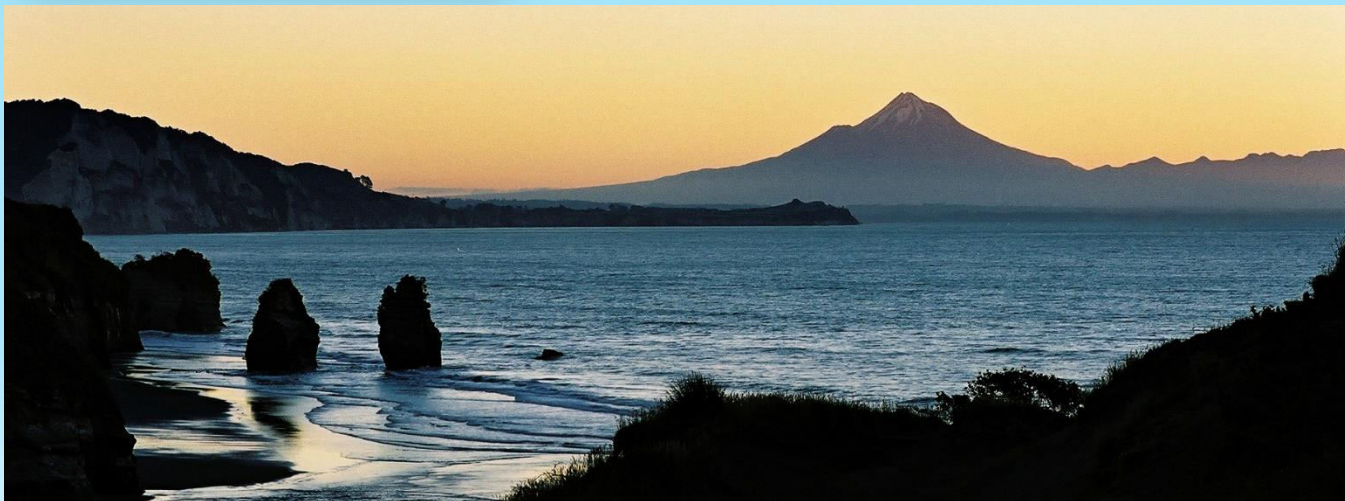
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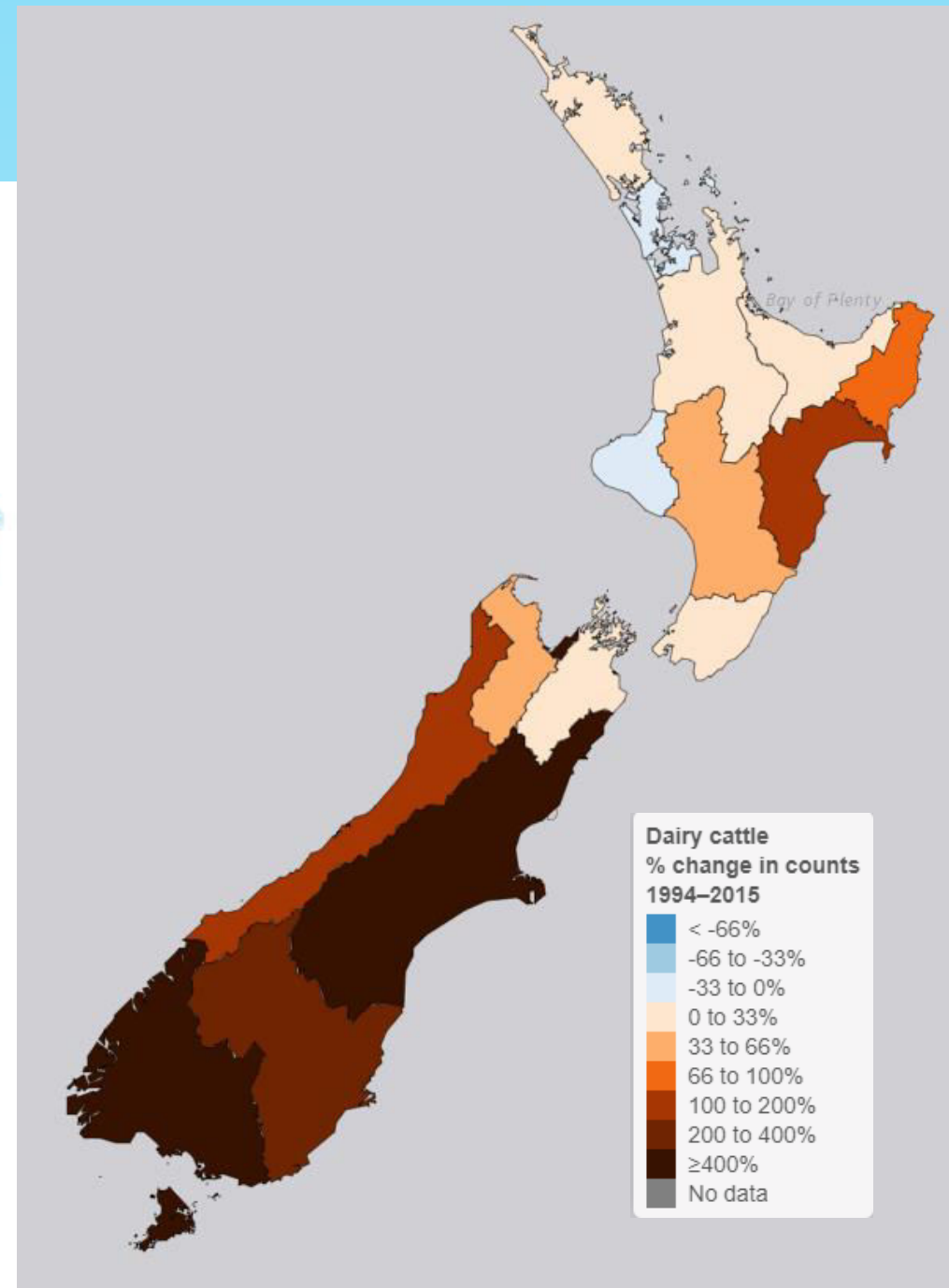
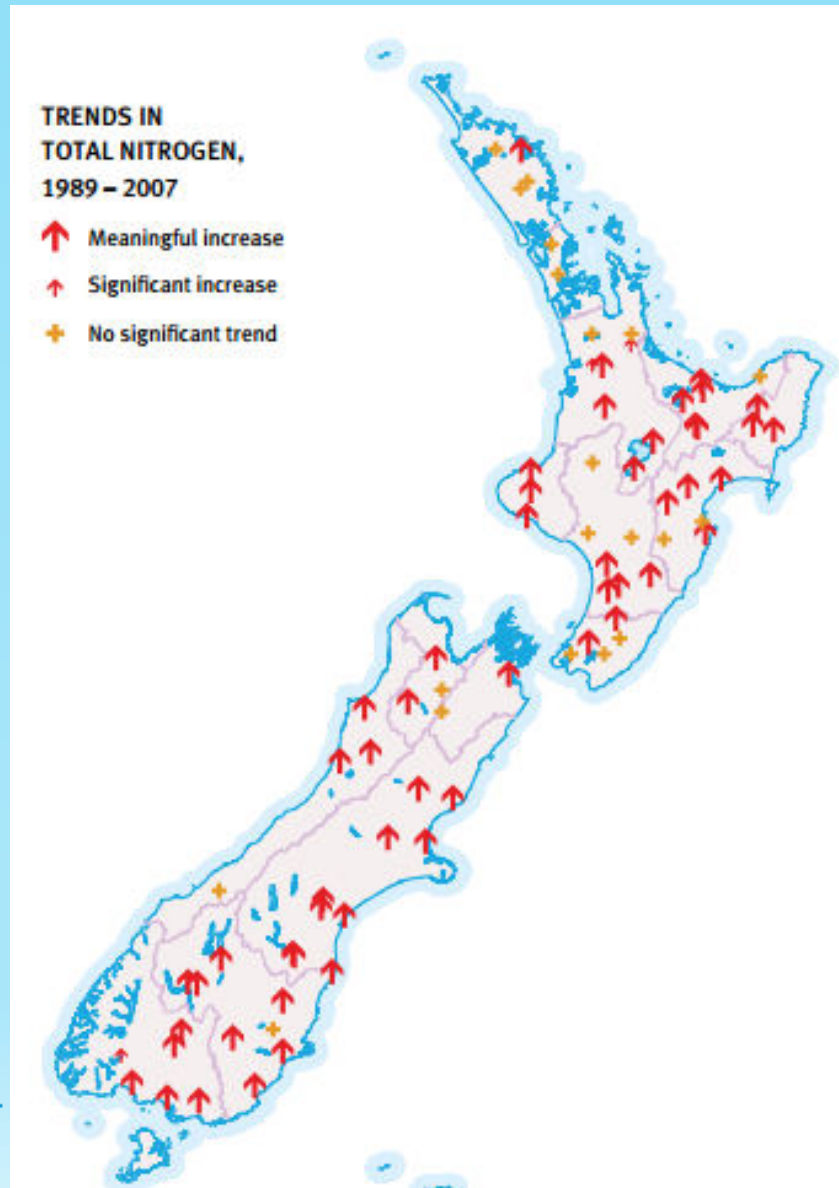
# New Zealand - Water



Curtesy of NIWA Photo Library & Tourism Waikato



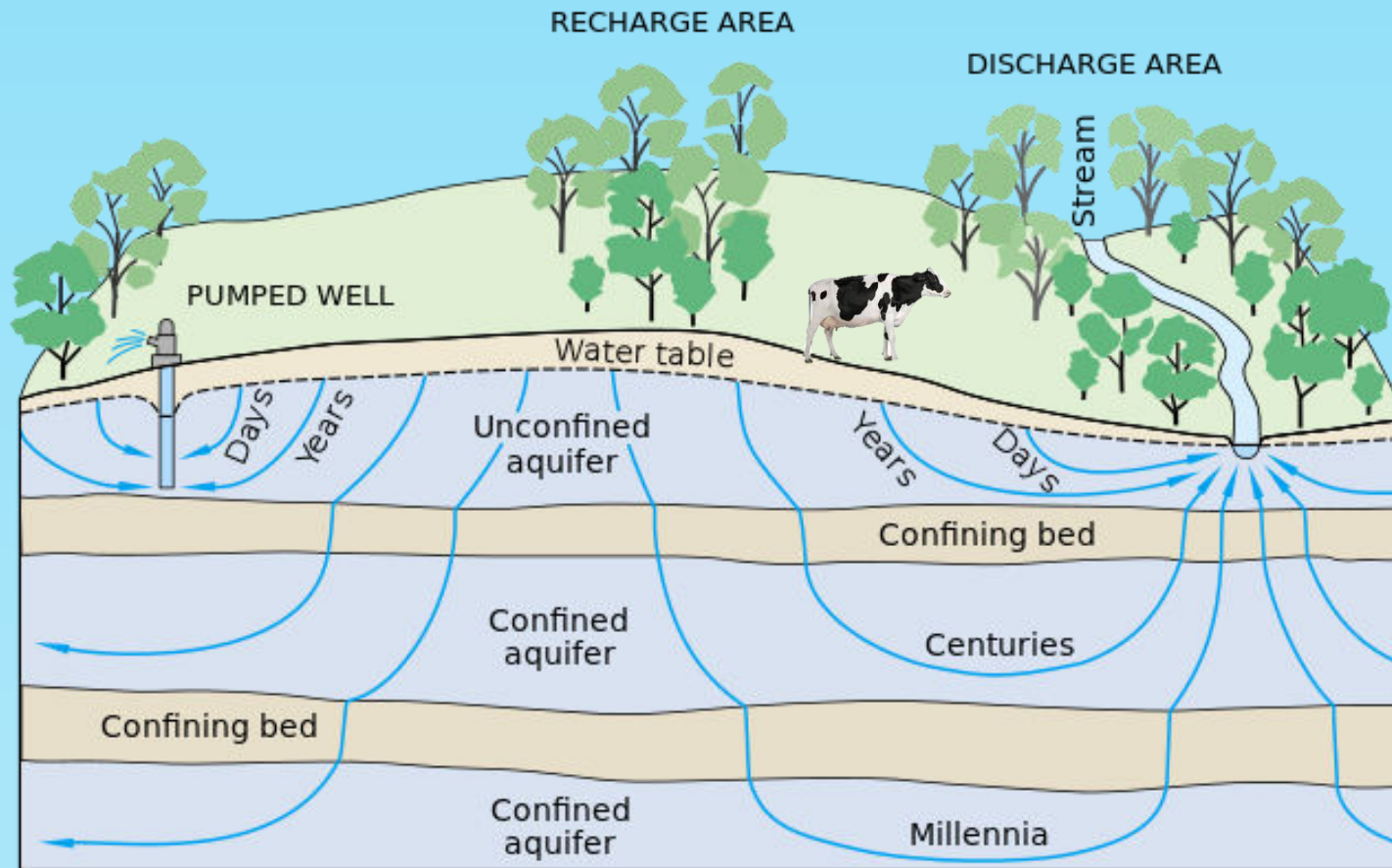
# Nitrogen in water



# Groundwater Lag Time

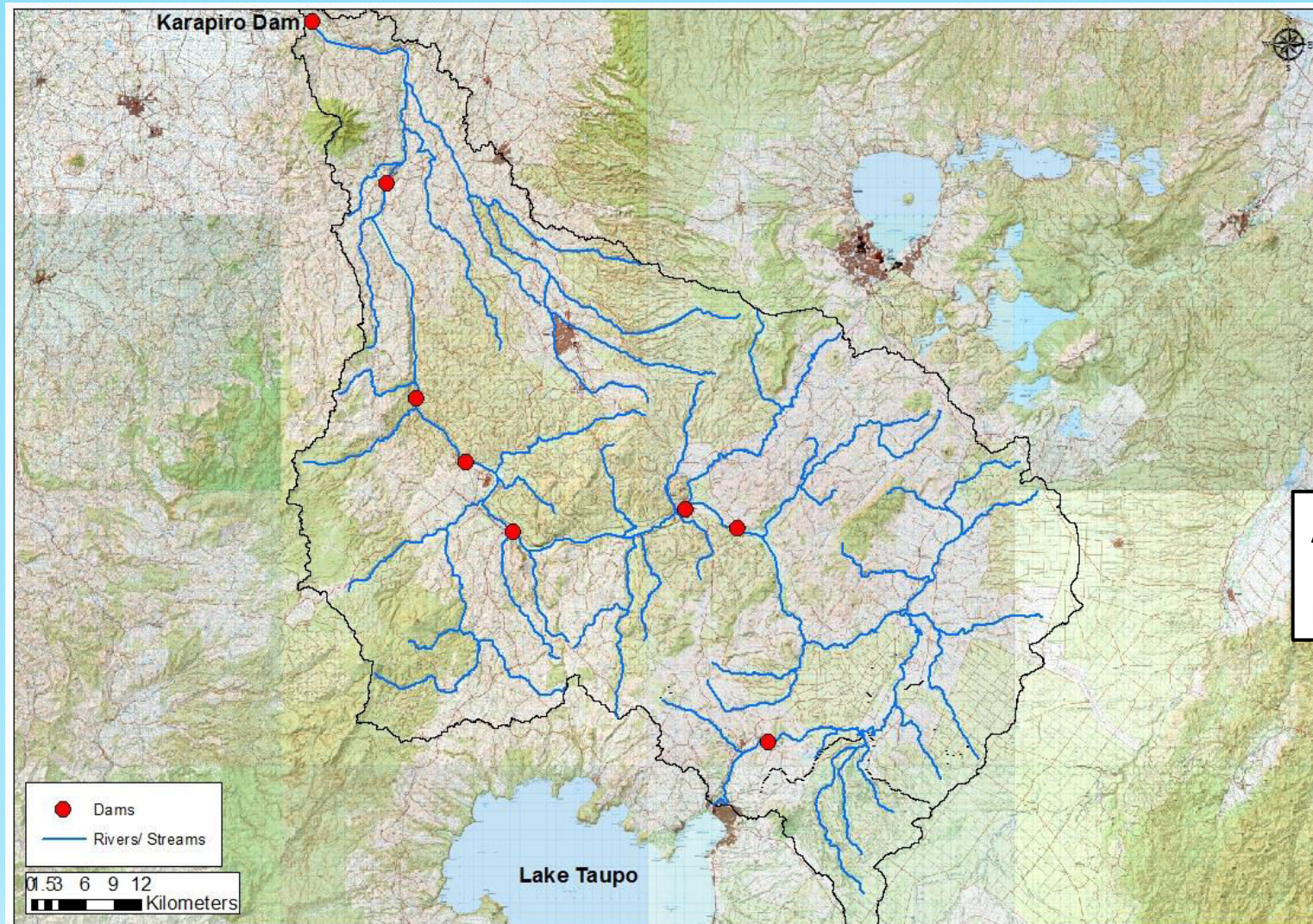
- The time from which a water drop hits the ground to the time it works its way through the groundwater and to the surface water is called "lag time."
- The lag time is dependent on the different geologic settings and topography.

# Why it is important to know about the GW lags?





# Model Area - Upper Waikato Catchment

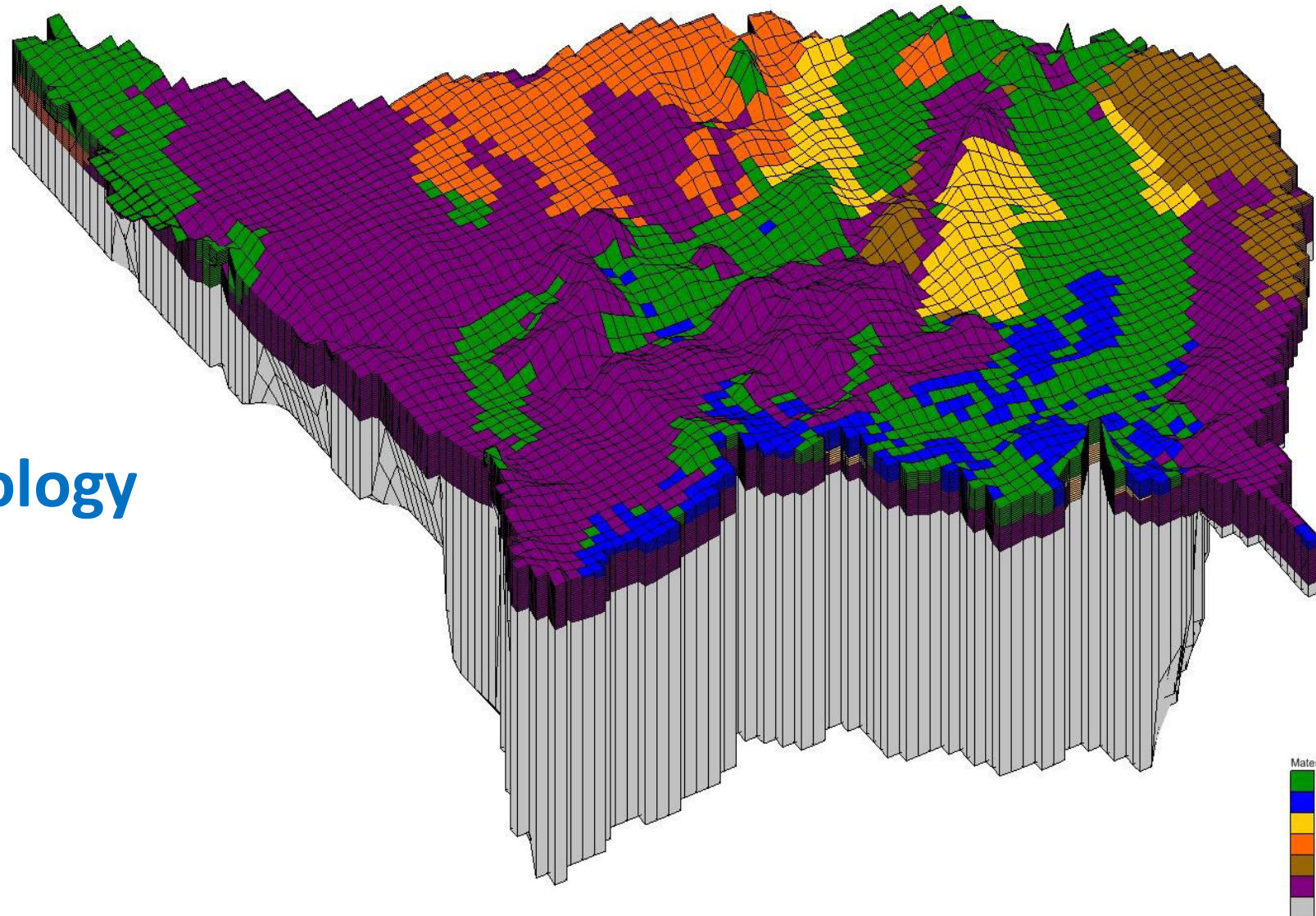


Area = 440,000 ha

MODFLOW/MT3D model

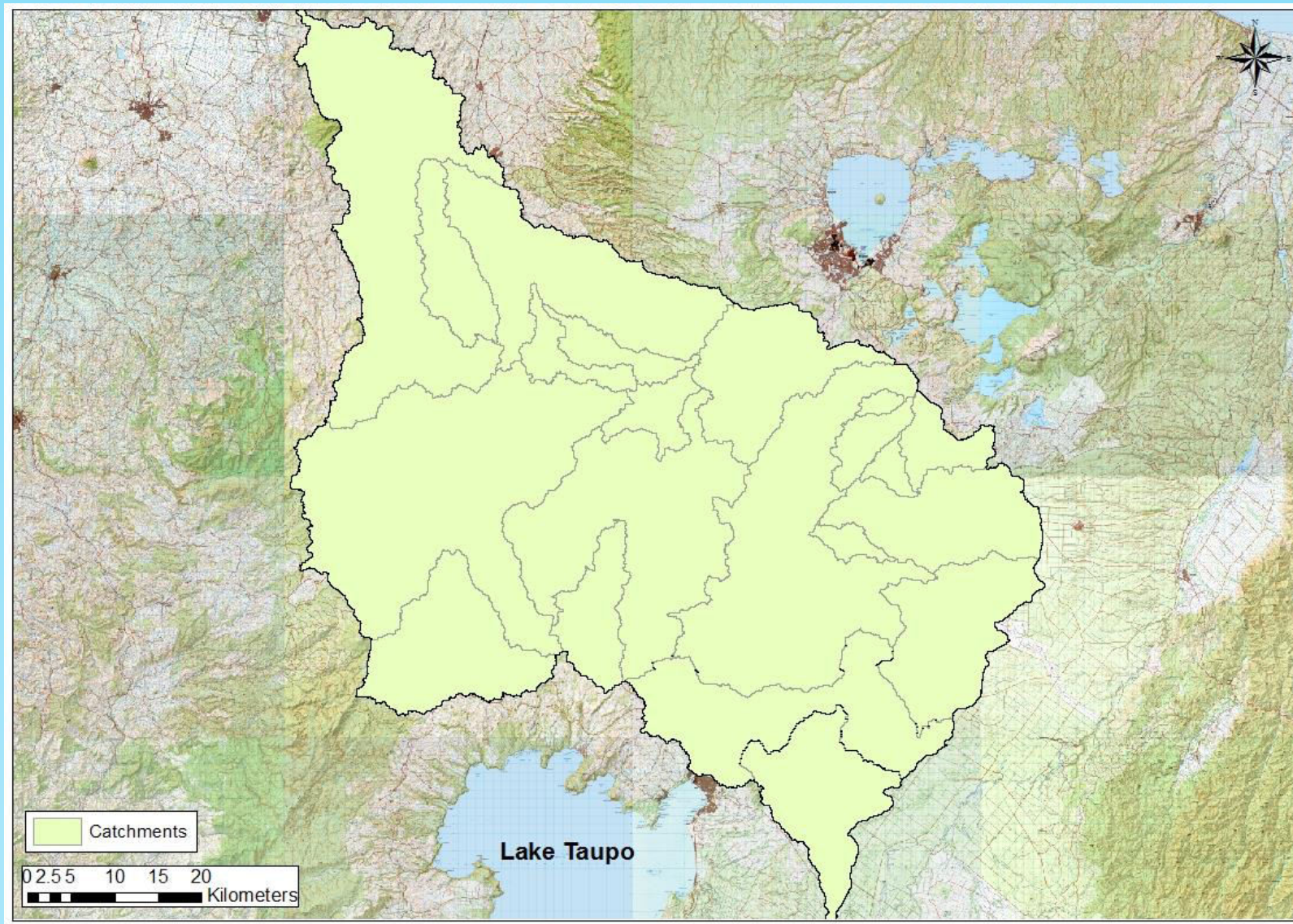


# Geology



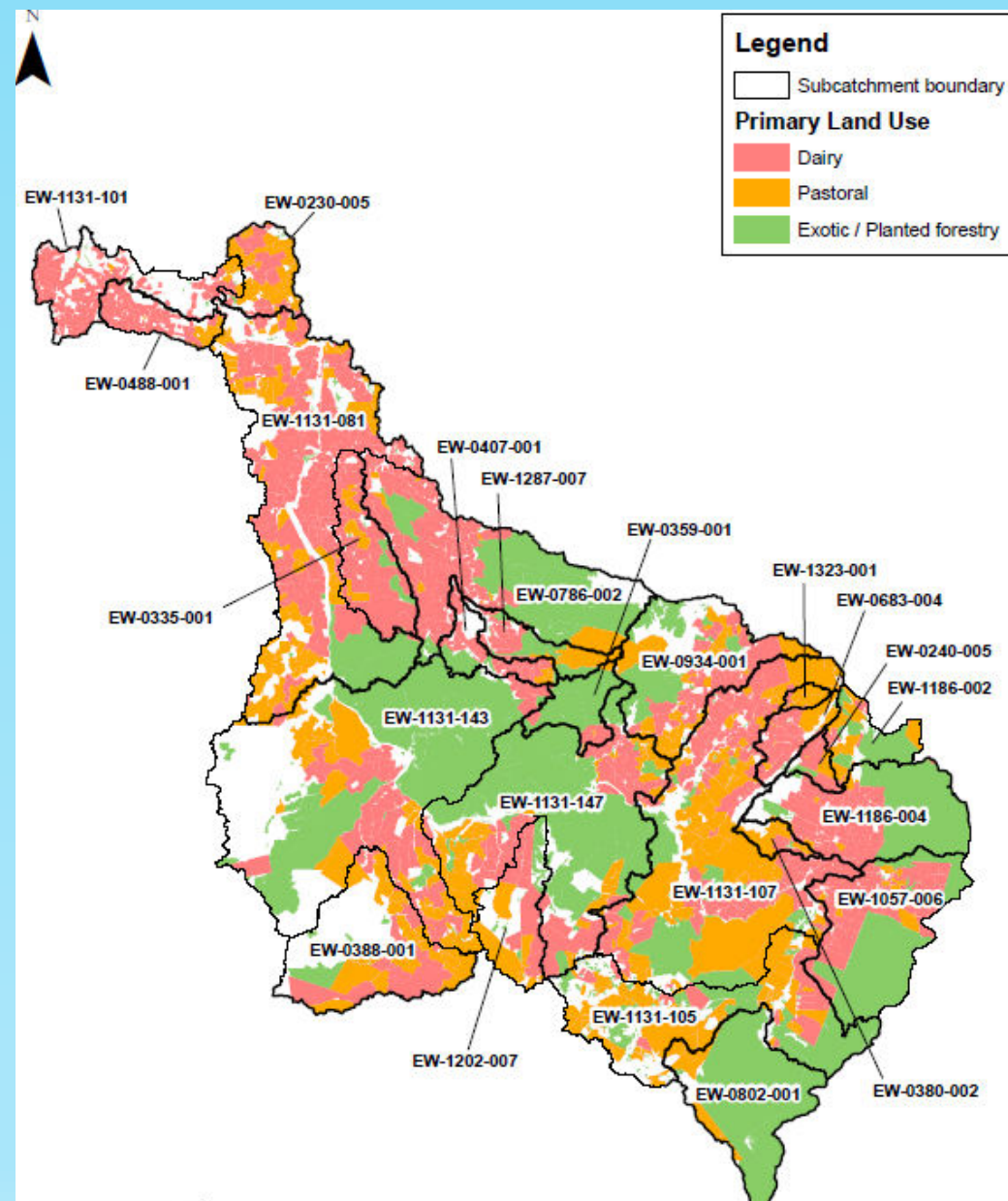
Data supplied by GNS



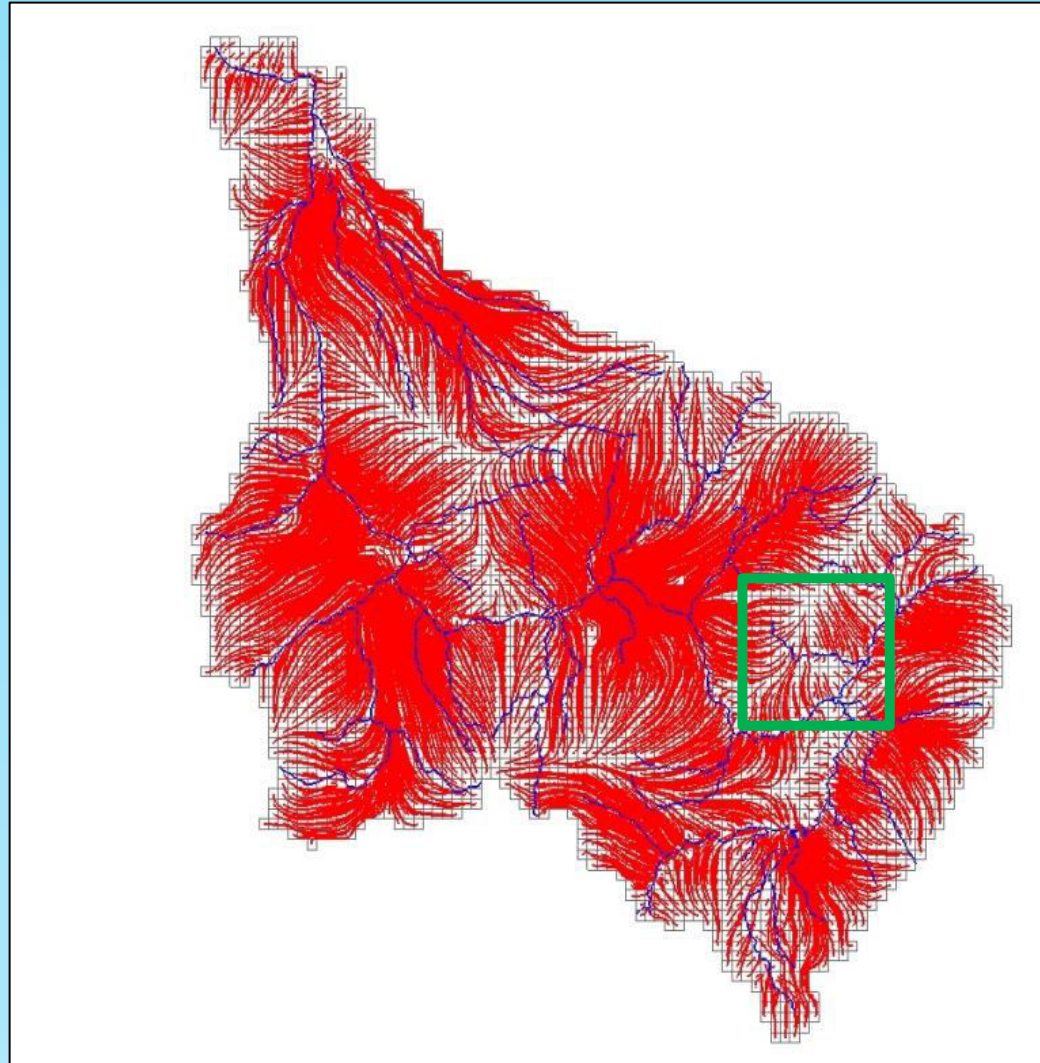




Water quality is a  
function of land use

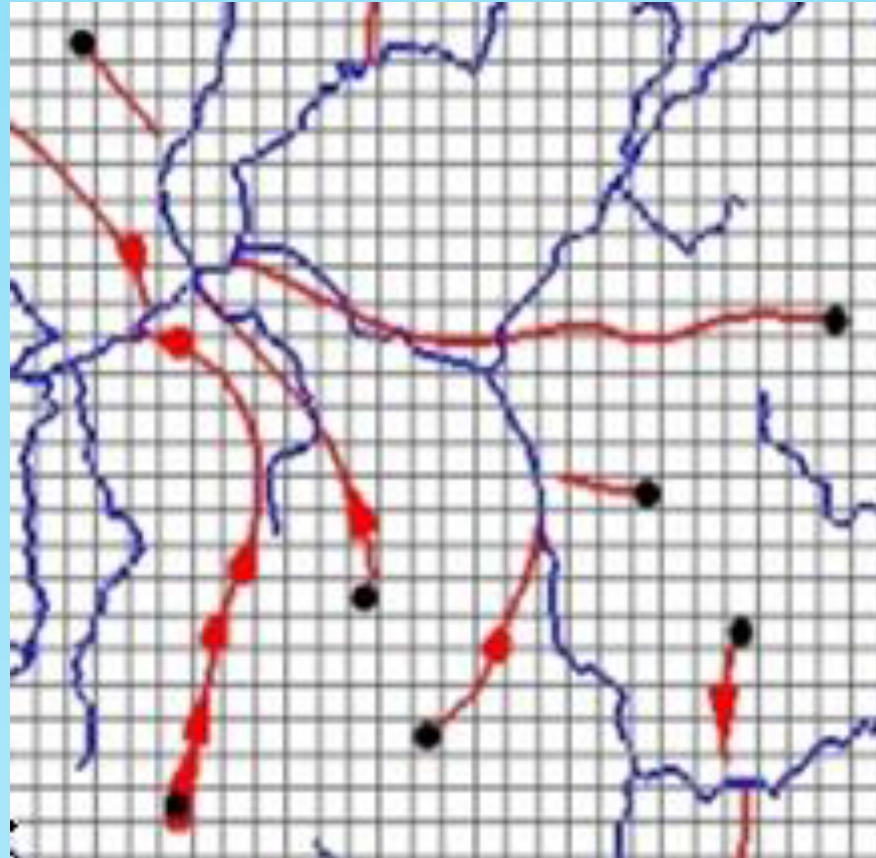


# Particle Tracking





# Particle Tracking

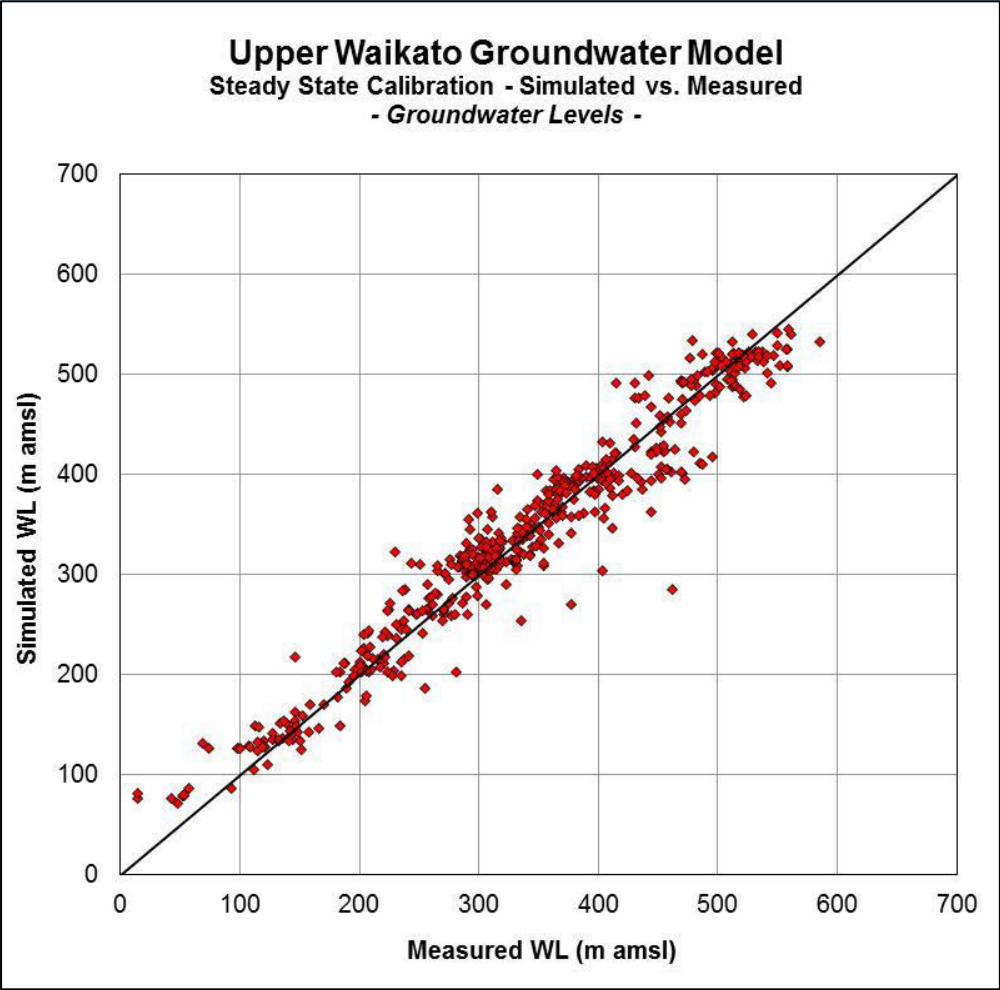


# Model Calibration

- Groundwater level
- River flow gains and losses
- Nitrate-N Concentrations
- Groundwater age
- Surface water age

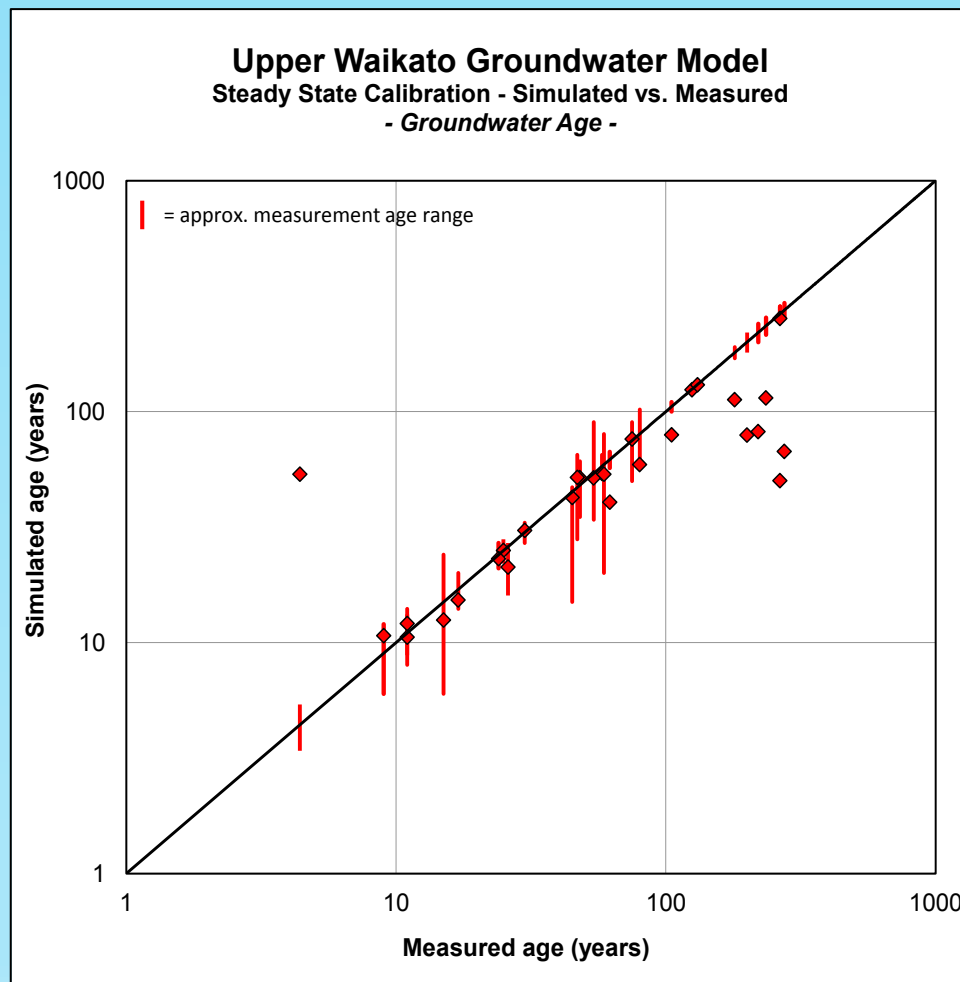


# GW Level calibration



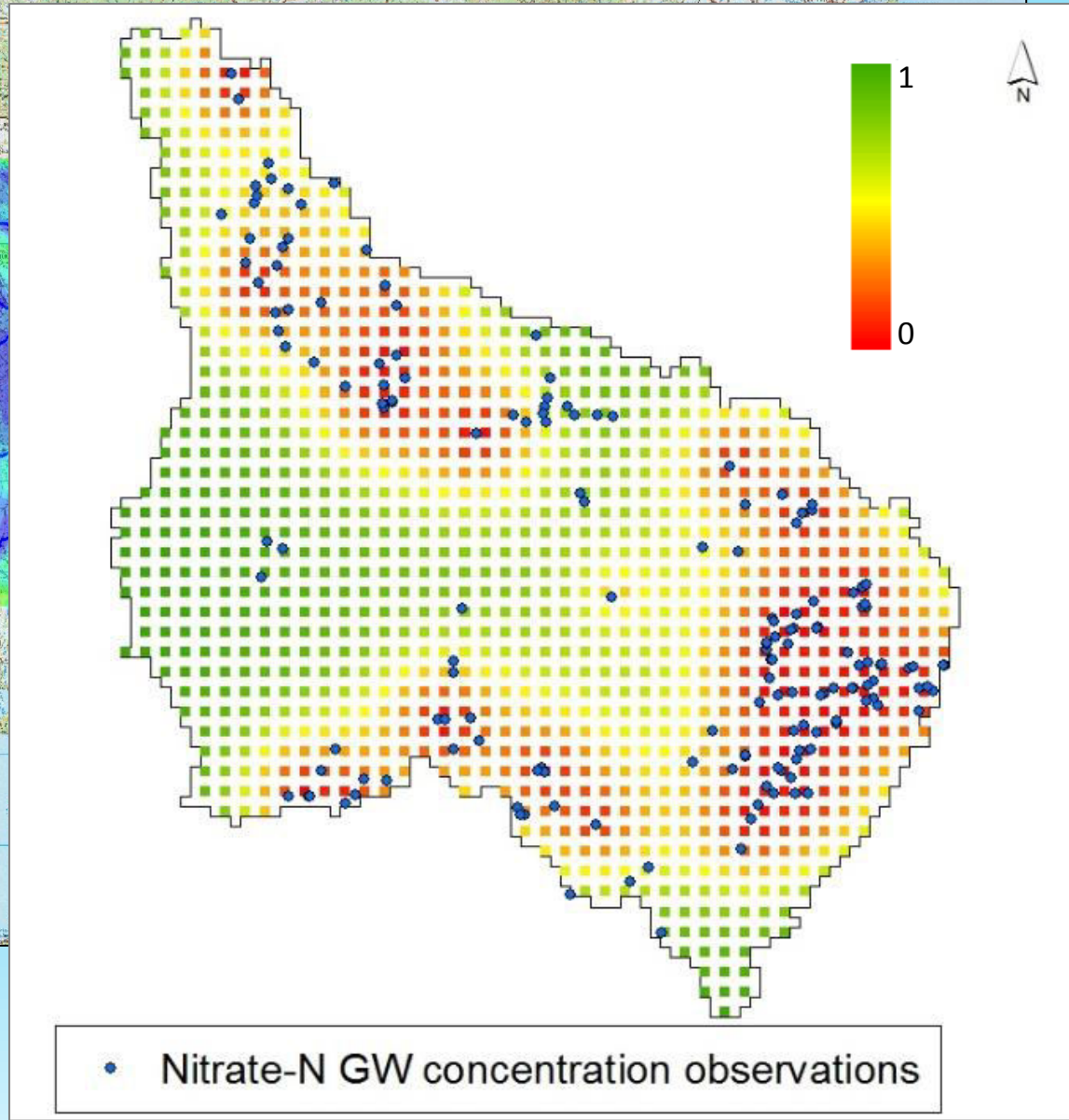
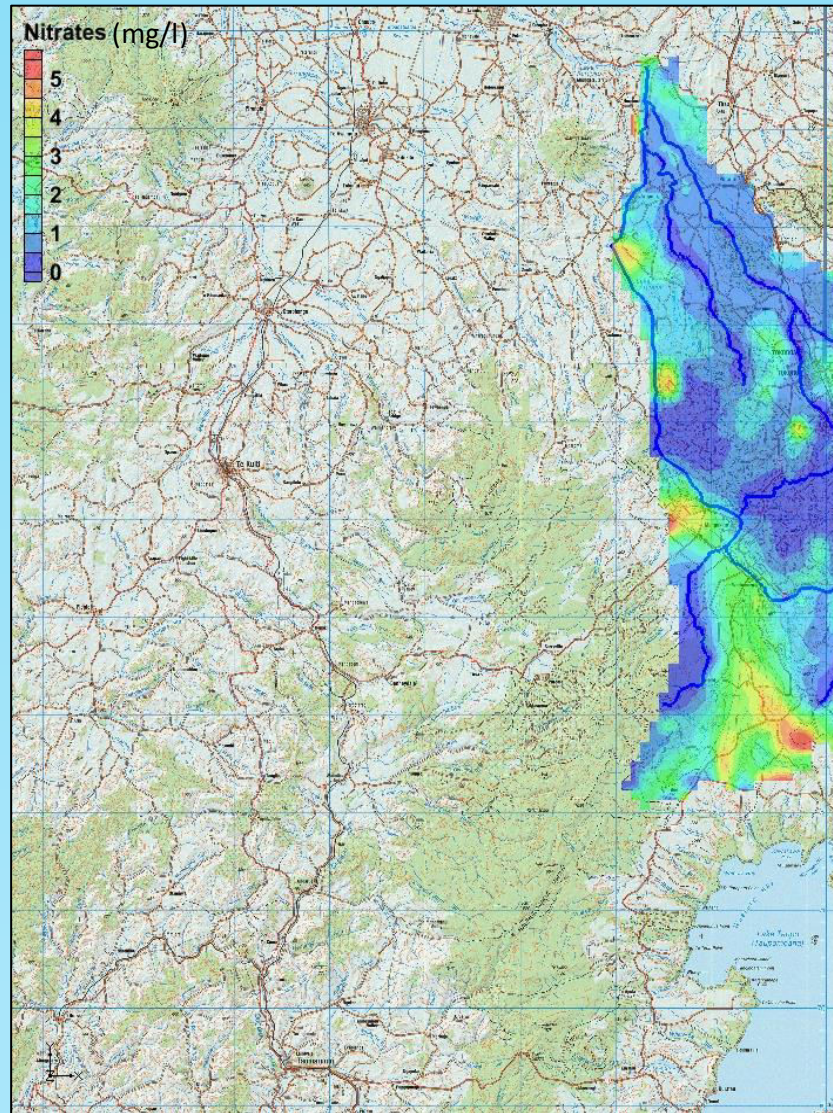
Normalised RMSE	4.8%
R <sup>2</sup>	0.95

# GW Age calibration





## Relative Parameter Uncertainty



# Surface Water Age Calibration

## Tritium results and age interpretations (GNS, 2007)

Water Quality Site	Date sampled	Tritium Ratio	MRT (years)
Waipapa Stream @ Tirohanga Rd	28/9/06	0.862	48
Little Waipa Stream @ Arapuni-Putaruru Rd.	21/02/07	0.795	51

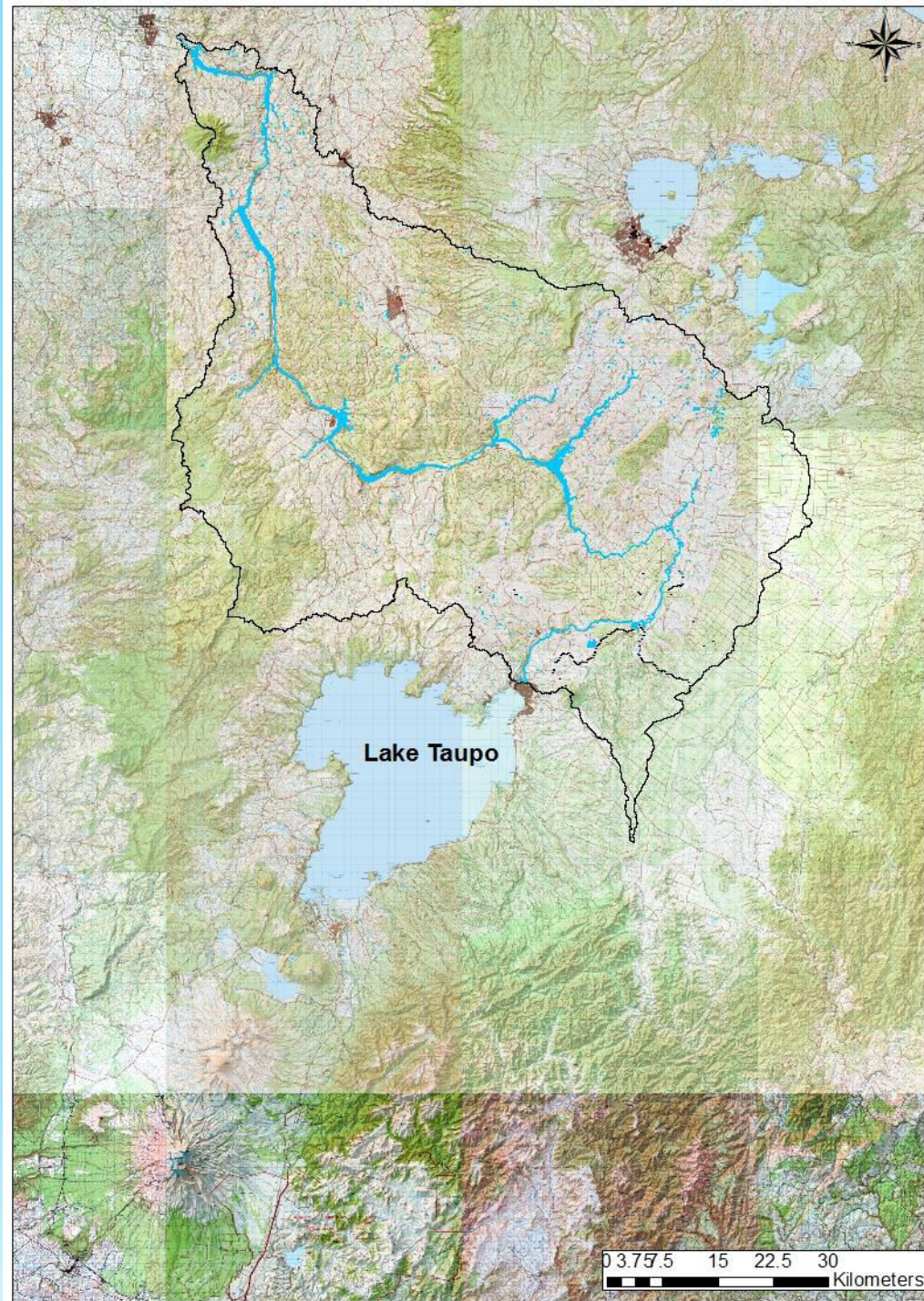
MRT = Mean Resident Time





# Approach

Geological composition of Lake Taupo & top part of Upper Waikato catchments are similar

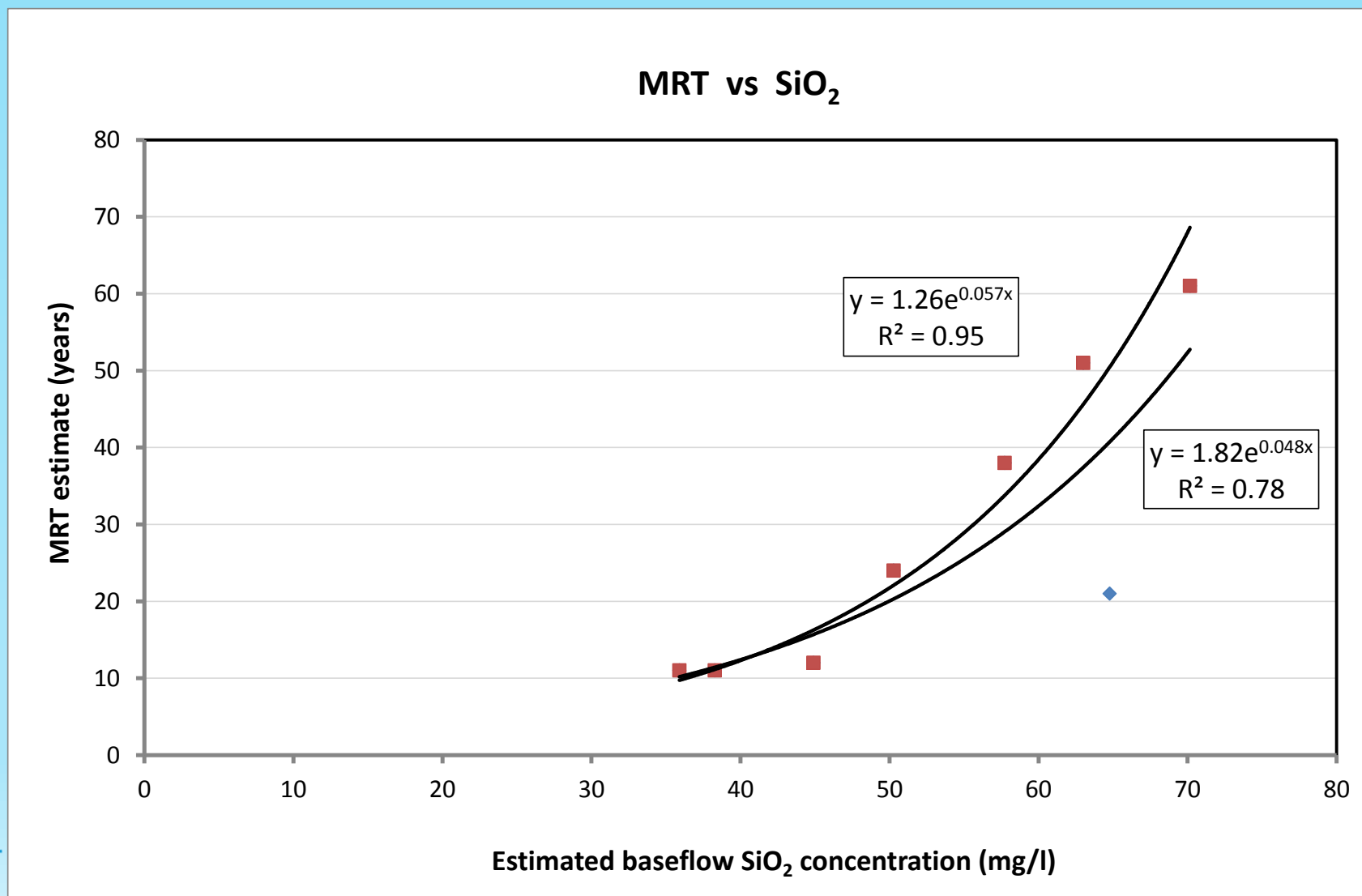


# SiO<sub>2</sub> and MRT

Site (Catchment)	MRT determined from tritium (years)	SiO <sub>2</sub> concentration (mg/L)
Mapara Stream (L. Taupo)	61	70.1
Waihaha Stream (L. Taupo)	11	35.9
Whanganui Stream (L. Taupo)	11	38.2
Whareroa Stream (L. Taupo)	24	50.3
Waitahanui River (L. Taupo)	38	57.7
Kuratau River (L. Taupo)	12	44.9
Little Waipa Stream (Upper Waikato)	51	63.0
Oraka Stream (Hauraki)	21	64.7

- MRT estimates (GNS, 2007; GNS, 2012)
- SiO<sub>2</sub> measurements (WRC, 2012)

# SiO<sub>2</sub> and MRT





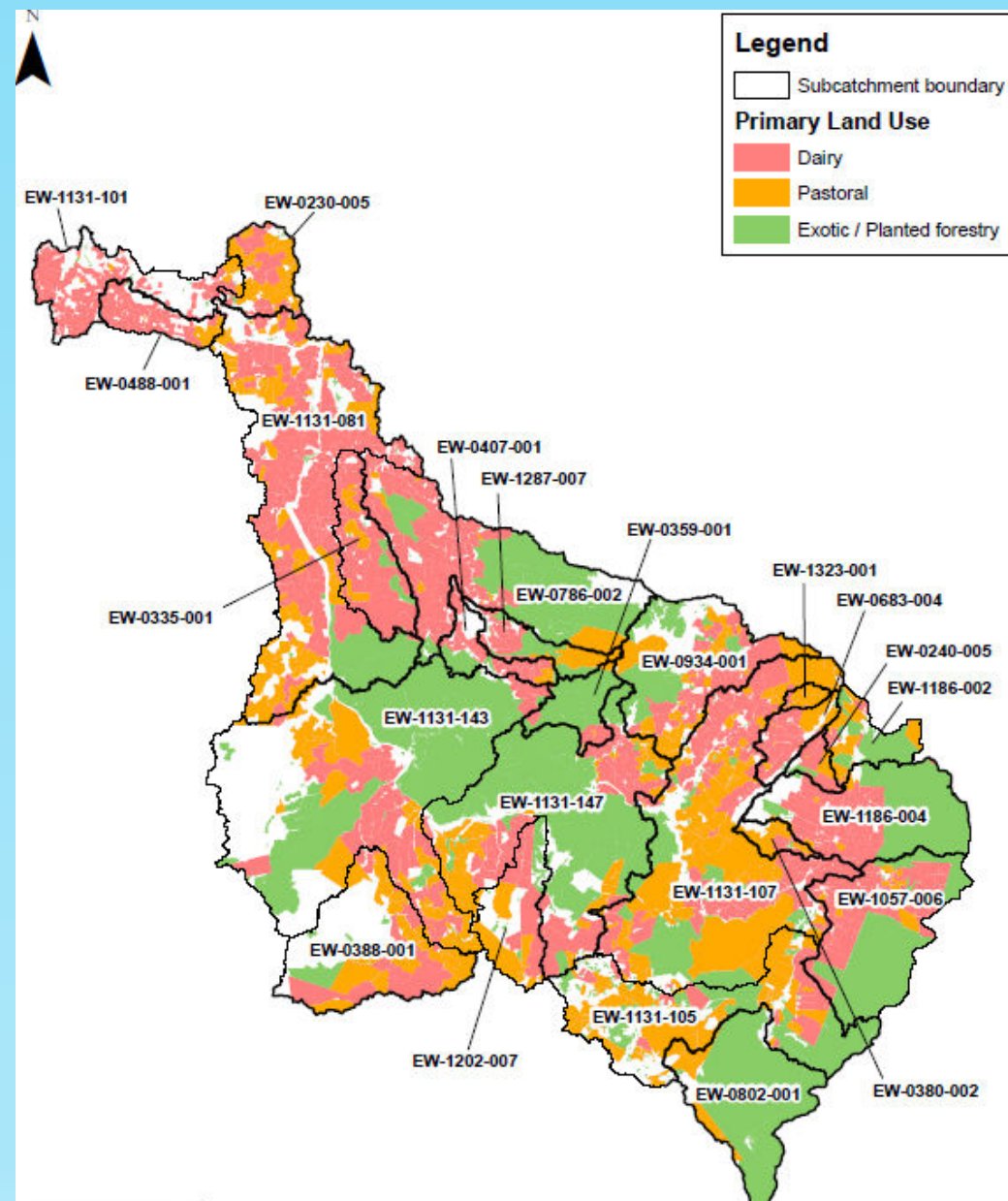
# Mean Residence Time (MRT)

**Mean age of water at tributary water quality sites at average flow**

Site	Age of water (years)	
	Tritium results* or estimated using SiO <sub>2</sub> data	Estimated using particle tracking
Pueto	48	56
Torepatutahi Stm @ Vaile Rd Bridge	68	91
Waiotapu Stm @ Campbell Rd Bridge	55	47
Kawaunui Stm @ SH5 Bridge	75	78
Waitapu Stm @ Homeestead Rd Bridge	75	67
Mangakara Stm (Reporoa) at SH5	55	50
Otamakokore Stm @ Hossack Rd	62	101
Whirinaki Stm@ Corbett Rd (WAI/A)	62	49
Tahunaatara Stm @ Ohakuri Rd	44	49
Mangaharakeke	65	60
Mangakino River (Whakamaru) @ Sandel Rd	16	17
Waipapa Stm (Mokai)	48	44
Little Waipa Stm @ Arapuni - Putaruru Rd	51	51

\* GNS Estimates

Water quality is a  
function of land use

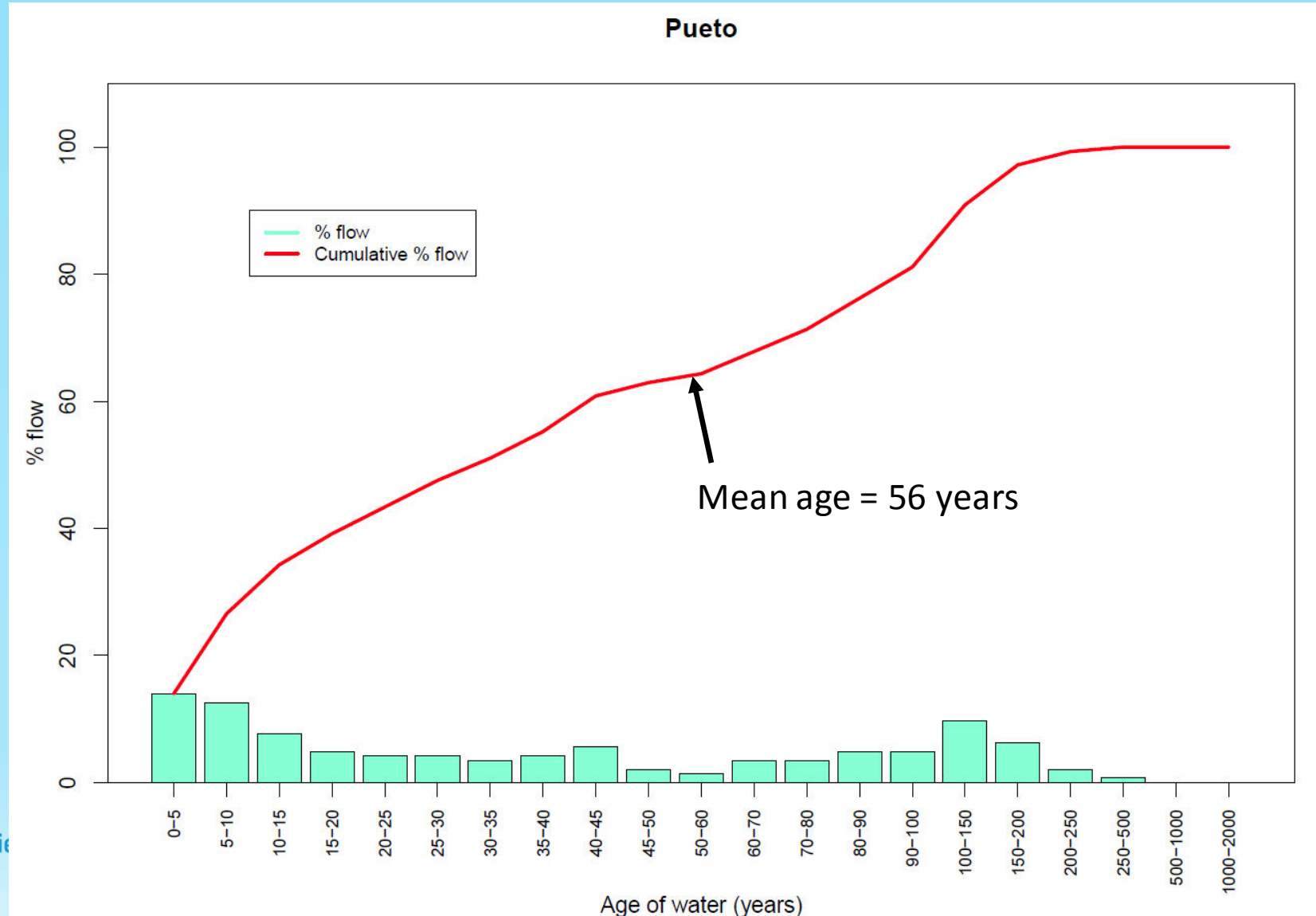


# MRT from High-Producing Lands

Site	Age of water (years)	
	From all lands	From high-producing lands
Pueto	56	29
Torepatutahi Stm @ Vaile Rd Bridge	91	67
Waiotapu Stm @ Campbell Rd Bridge	47	5
Kawaunui Stm @ SH5 Bridge	78	48
Waitapu Stm @ Homeestead Rd Bridge	67	40
Mangakara Stm (Reporoa) at SH5	50	60
Otamakokore Stm @ Hossack Rd	101	112
Whirinaki Stm @ Corbett Rd (WAI/A)	49	49
Tahunaatara Stm @ Ohakuri Rd	49	47
Mangaharakeke	60	76
Waipapa Stm (Mokai)	44	3
Mangakino River (Whakamaru) @ Sandel Rd	17	18
Little Waipa Stm @ Arapuni - Putaruru Rd	51	53

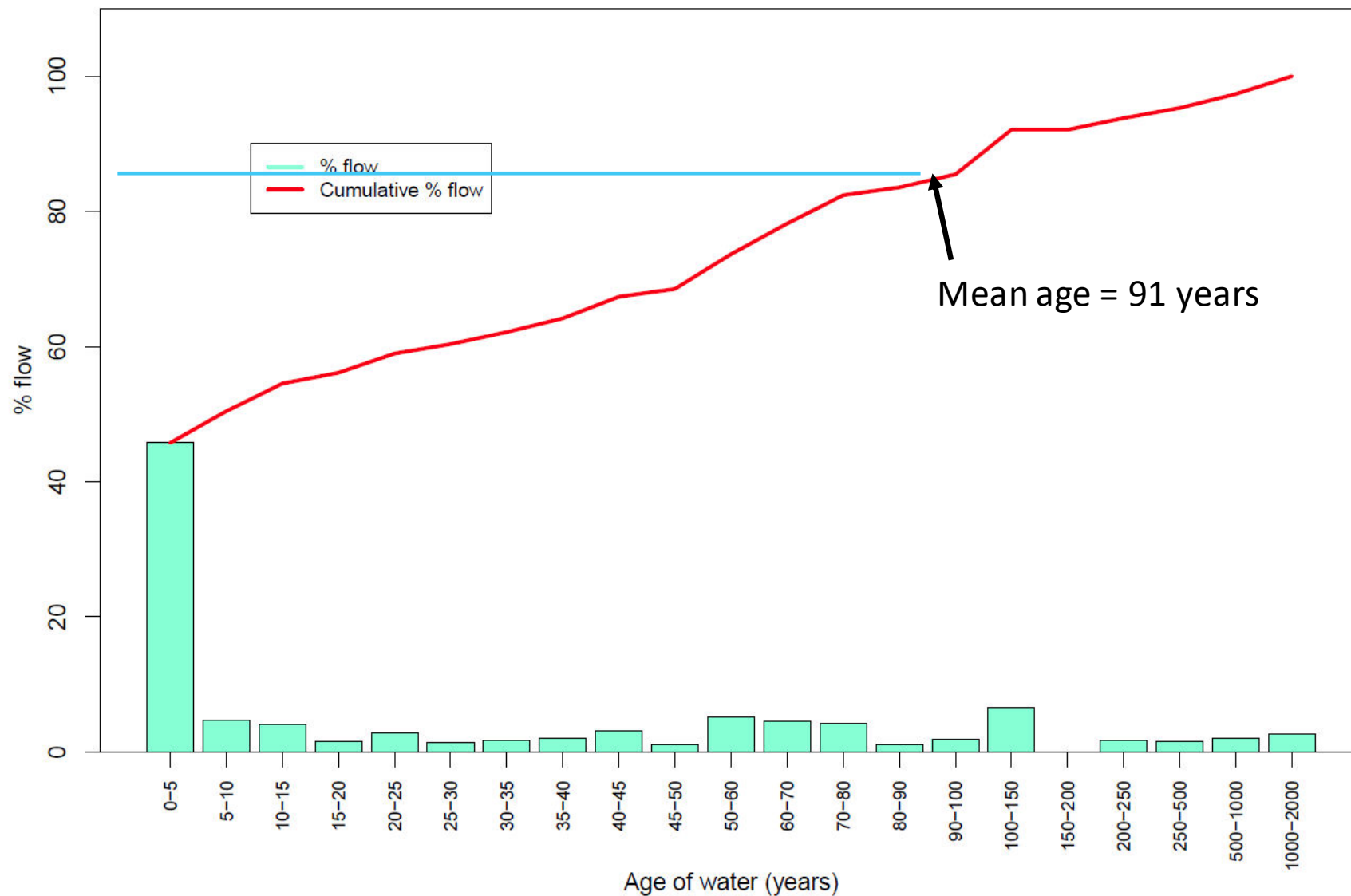


# MRT vs Age Distribution

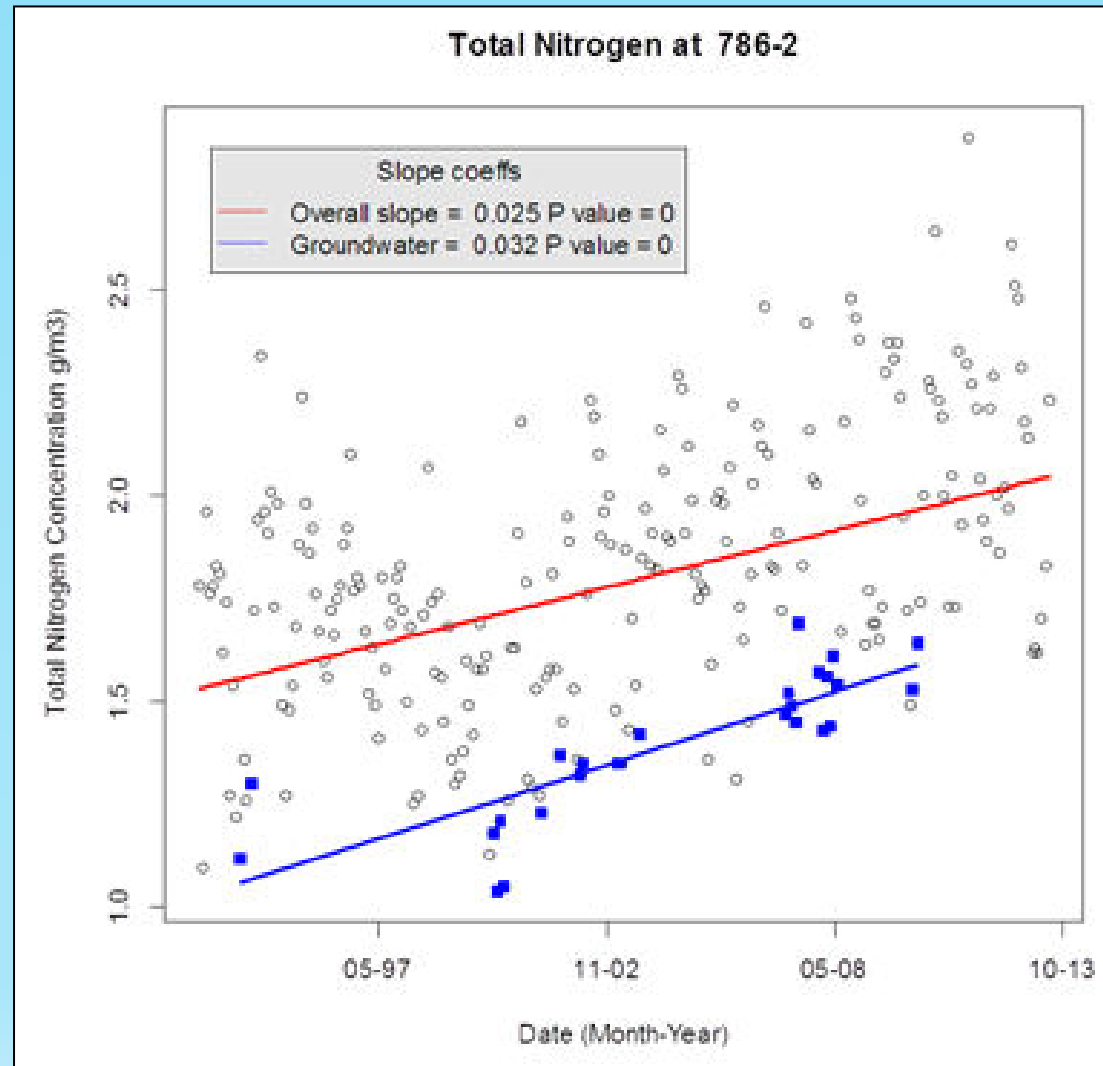


# MRT vs Age Distribution

Torepatutahi Stm @ Vaile Rd Bridge



# Trends in Groundwater Nitrogen



Linear regression

- All the data
- Lowest 10% of flows



# Conclusions

- Because of the lag, the full effect of current land use may not be realised for many years
- Particle tracking is an effective tool to approximate
  - Mean residence time
  - Distribution of water age
  - Age distribution by land use types
- The link between spatially diffused sources and point destinations in catchments cannot be reliably described using a single mean residence time
- Mean residence times can sometimes be misleading
- It is therefore important to develop a distribution of water age.

# Thanks to

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# Thank you

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