Te Waikoropupu Springs Water Quality Modelling

AQUALINC

LANDCARE RESEARCH
MANAAKI WHENUA

Modelling Recap

- Thomas & Harvey (2013)
- Eigen models set up using:
  - Geology
  - Climate (rainfall and PET)
  - Soils
  - Land use
  - Consents and irrigated areas
  - Monitoring data (groundwater levels; river flows; quality)

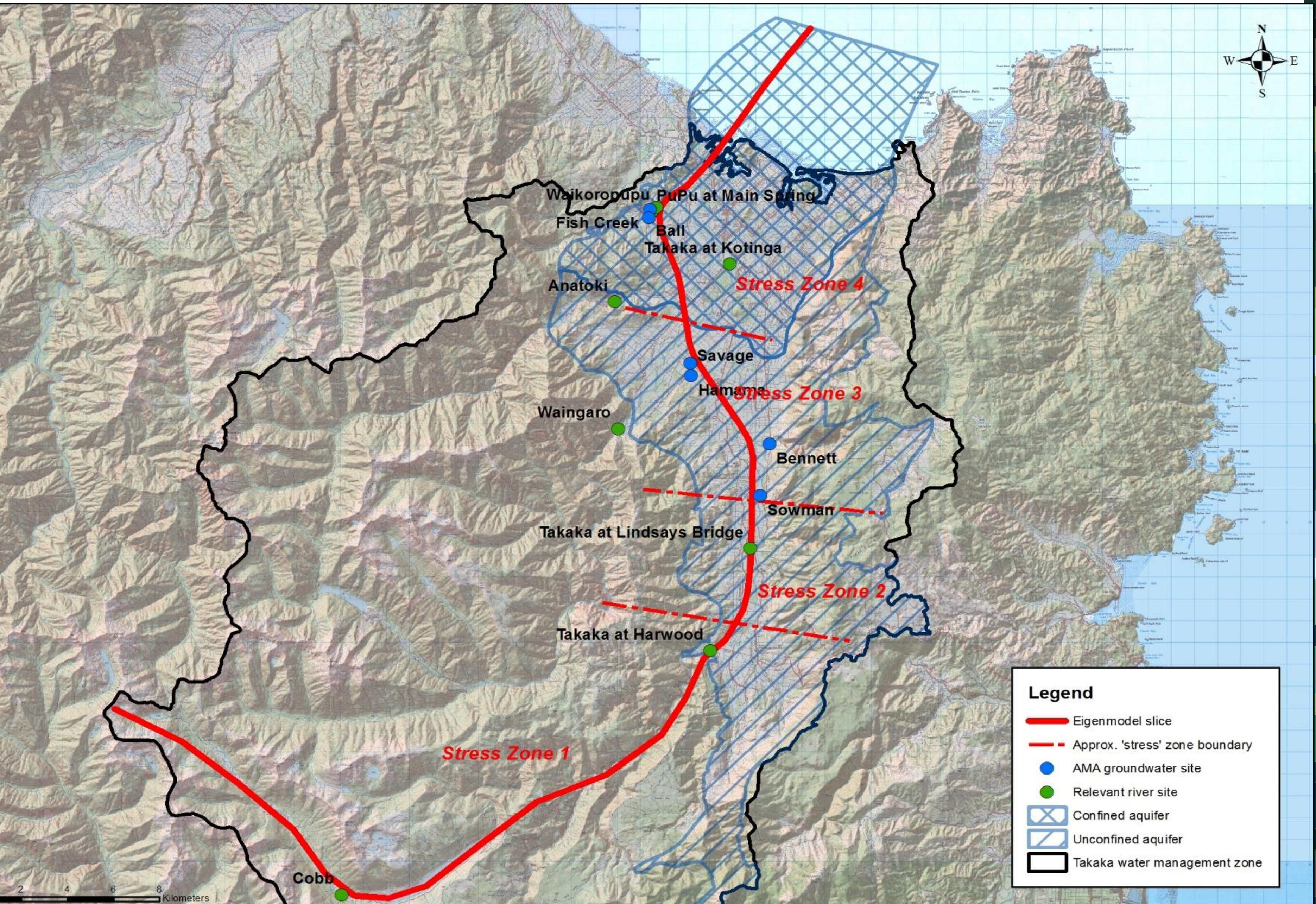
Modelling Approach

- FLOW: Eigen-modelling for river flow and groundwater levels by ‘stress zone’
- WATER QUALITY: Fully mixed mass balance without attenuation for nitrate concentrations

Calibration

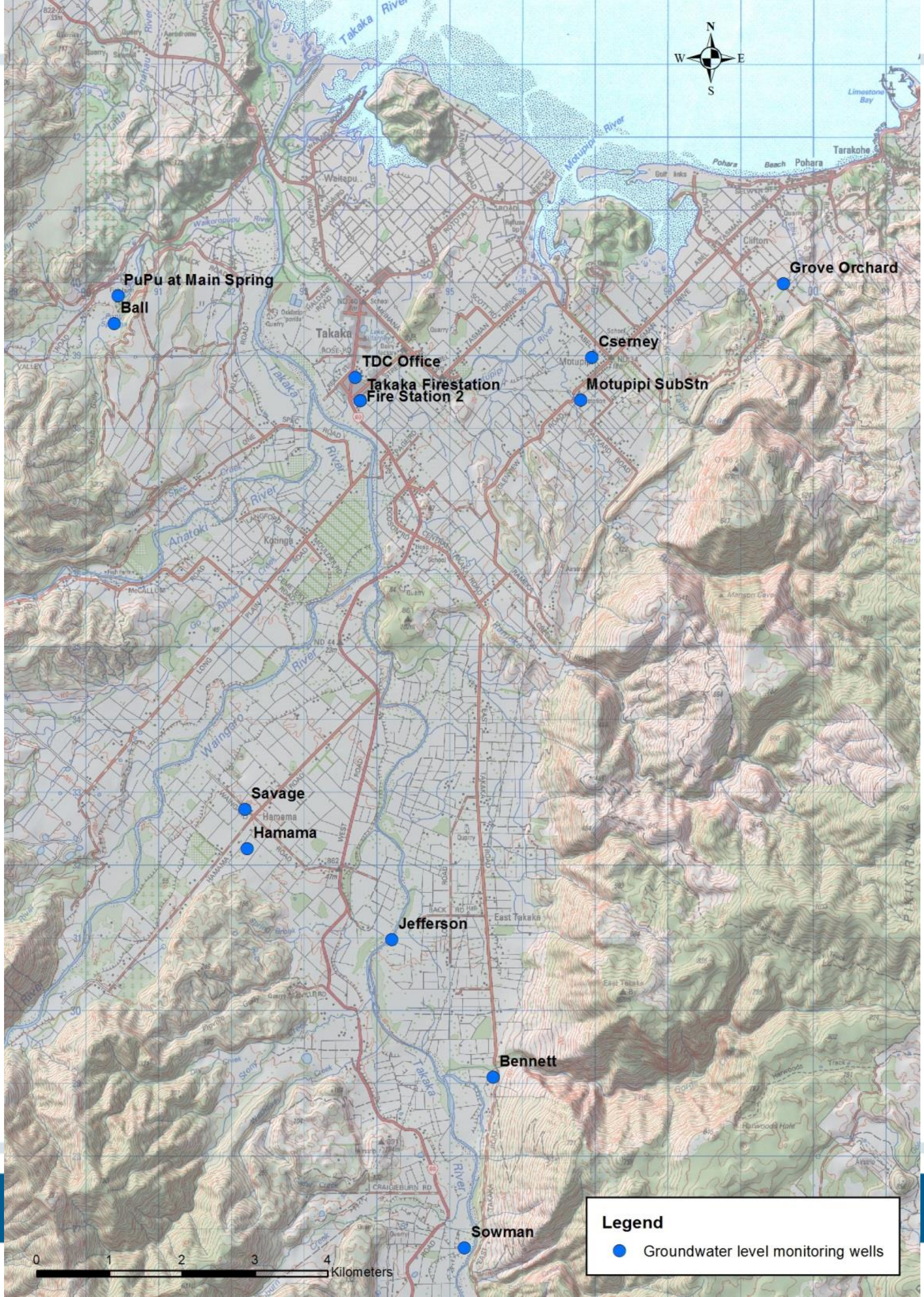
- Measured groundwater levels
- Measured river flows
- Existing nitrate-nitrogen concentrations

AMA Eigen-Model Domain



Modelling Assumptions & Uncertainties

- Water in = water out (water balance)
- Nitrate in = nitrate out (no attenuation)
- Nitrate fully mixed with flow reaching Te Waikoropupu
- Marble aquifer ‘plumbing’ largely as expressed in Stewart & Thomas (2008)
- Dairy farm N-leaching rates from OVERSEER™ ver 6.1.2 (probably ±30%); rates for other land uses from literature
- We consider there is no better approach with the time and resources available



Groundwater level calibration sites

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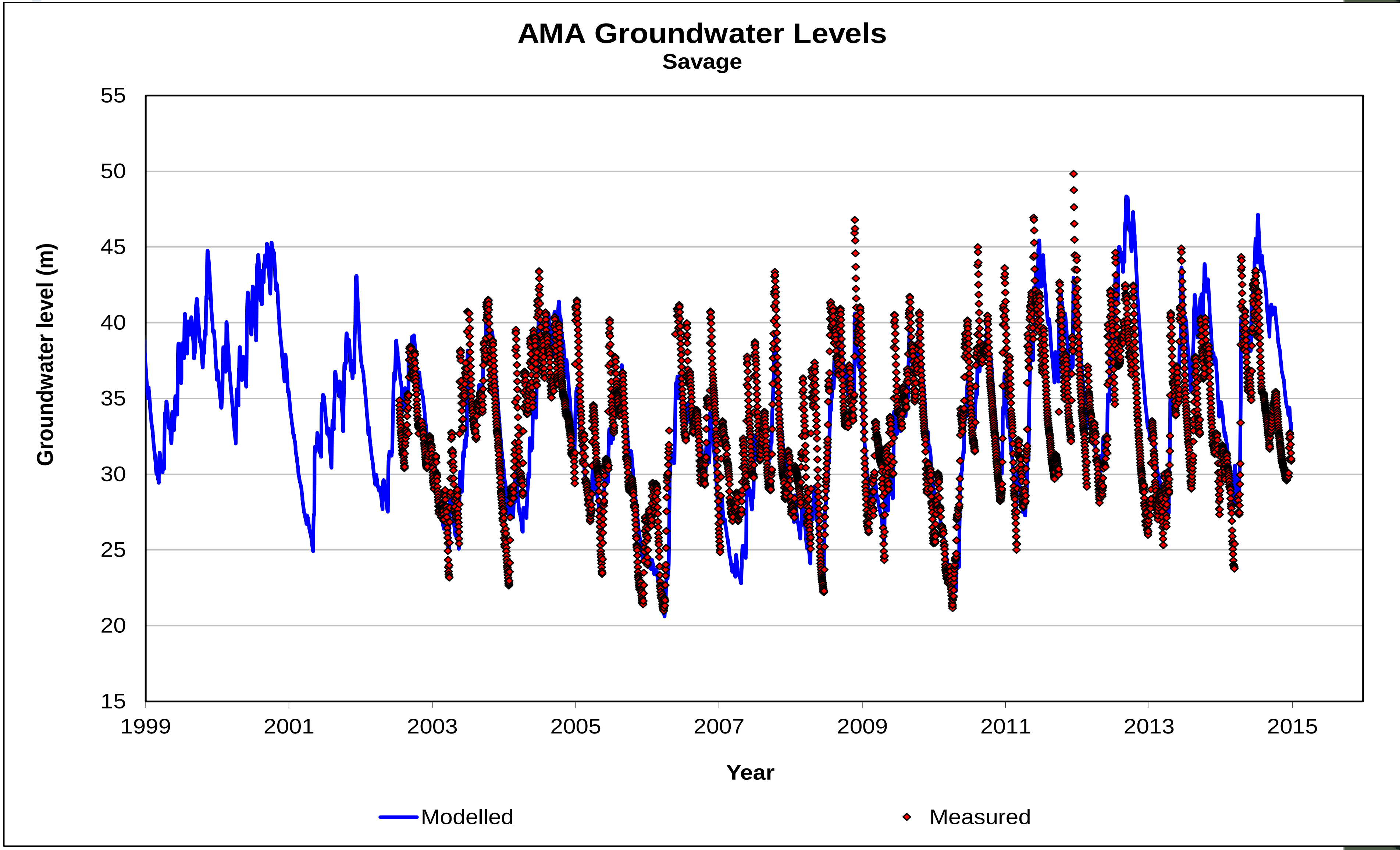
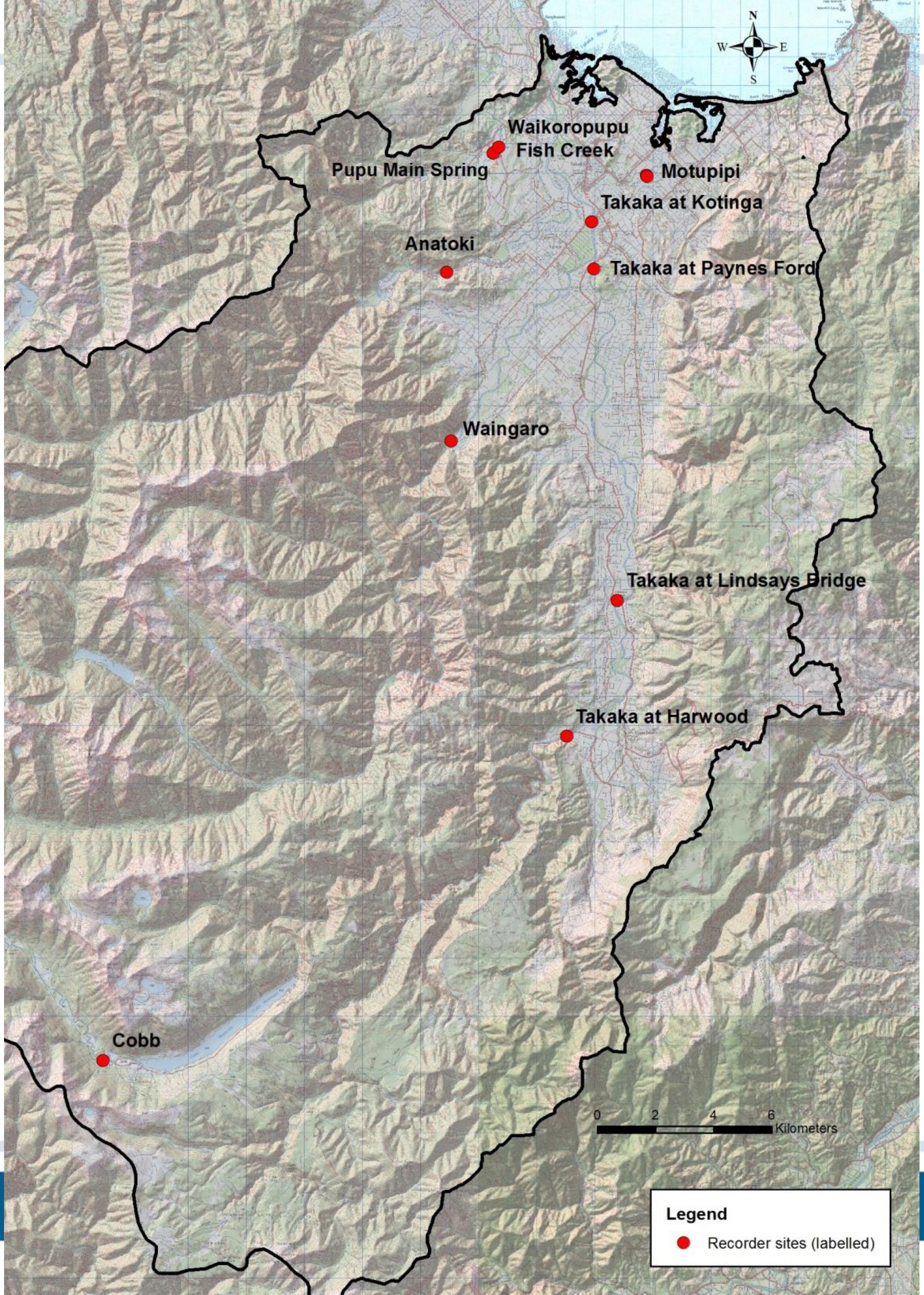
Groundwater level calibrations





River flow sites

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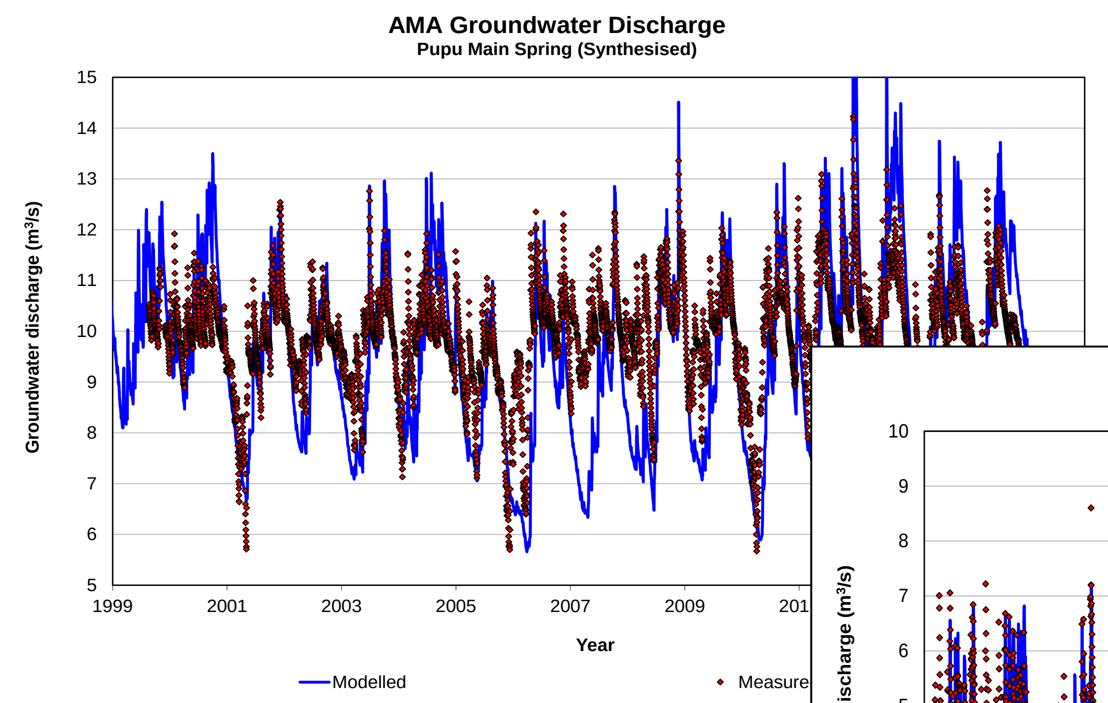
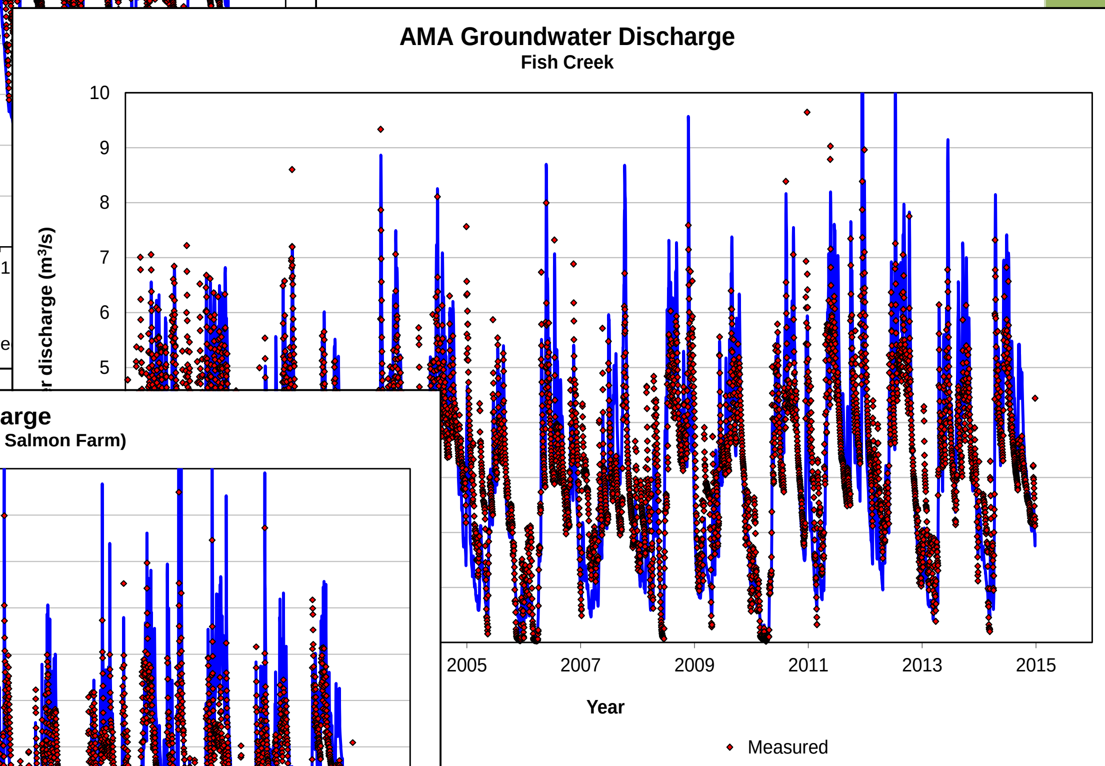
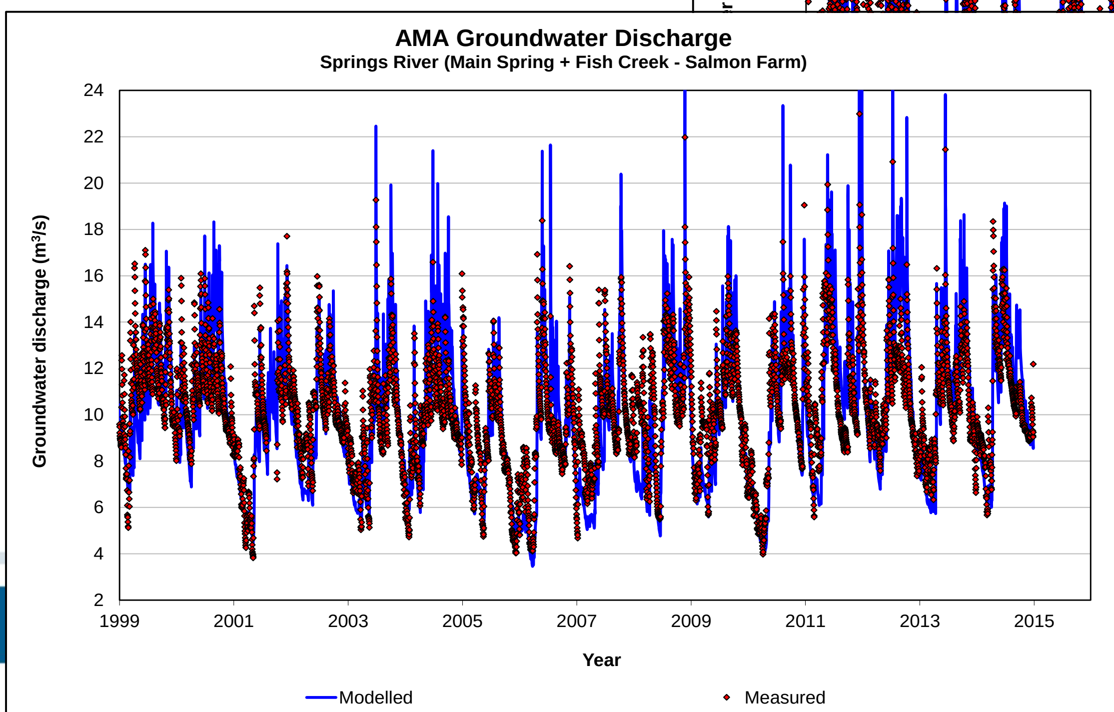
Modelled River/spring flows







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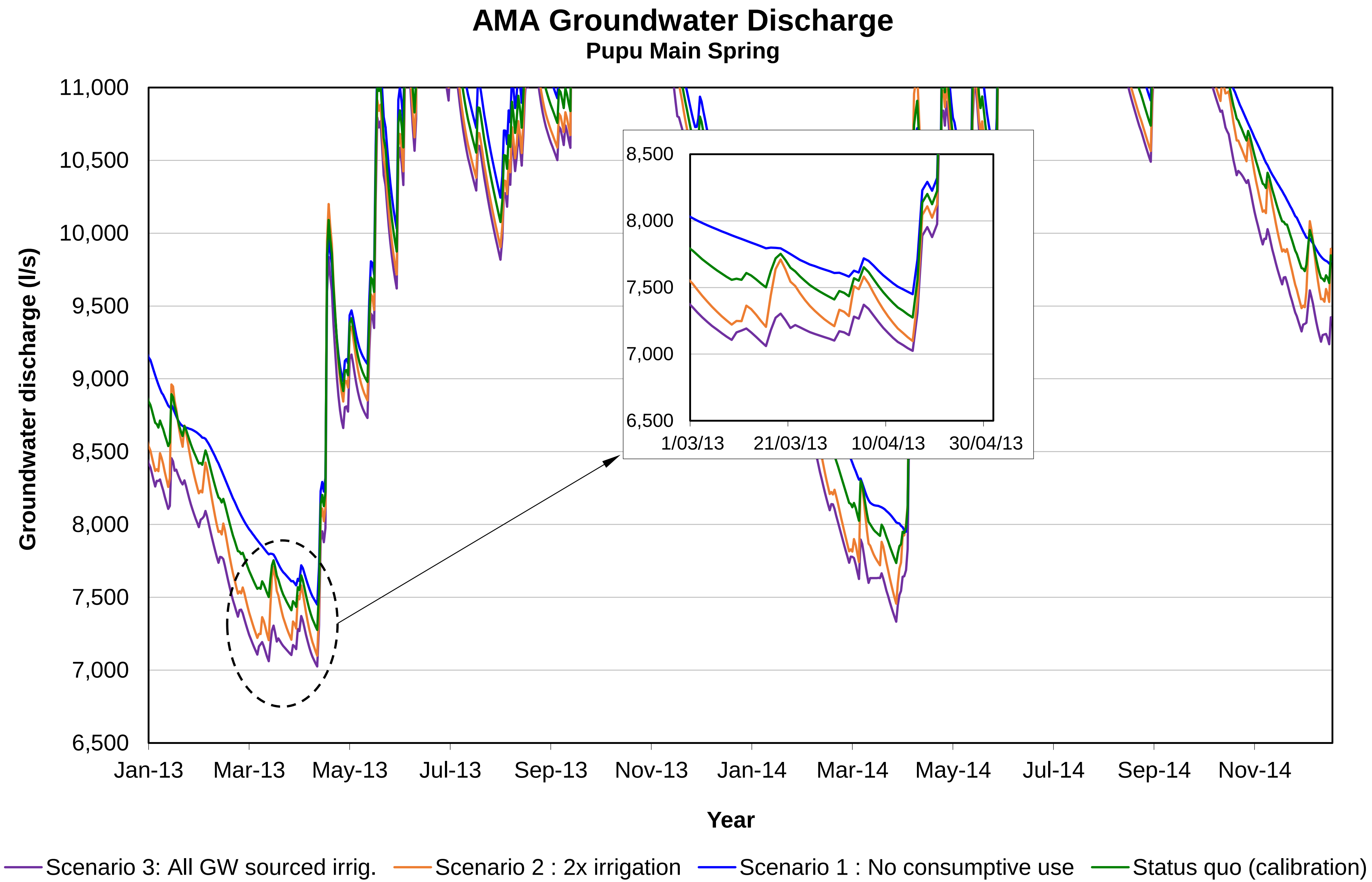
Previous Scenarios

- Status quo (calibration)
- Scenario 1: No consumptive use
- Scenario 2: Double irrigation
- Scenario 3: Surface water irrigation taken instead from g/water
- Scenario 4: No Cobb Dam – upper Takaka river flows are 'natural' flows
- Scenario 5: No Waingaro River recharge (sensitivity test)
- Scenario 6: Natural State
- Scenario 7: Likely irrigation 1 (+494ha)
- Scenario 8: Likely irrigation 2 (+674ha)
- Scenario 9: Likely irrigation 3 (+794ha)


AMA Groundwater Discharge
Pupu Main Spring
Groundwater discharge (l/s)
11,000
10,500
10,000
9,500
9,000
8,500
8,000
7,500
7,000
6,500
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jul-14
Sep-14
Nov-14
Year
8,500
8,000
7,500
7,000
6,500
1/03/13
21/03/13
10/04/13
30/04/13
Scenario 3: All GW sourced irrig.
Scenario 2 : 2x irrigation
Scenario 1 : No consumptive use
Status quo (calibration)

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Fish Creek Limits Simulator

Adjust settings

Update Scenario

Minimum Flows (% of the 7 day mean annual low flow)

0 — 0.8 — 1

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

Allocation Flows (% of the 7 day mean annual low flow)

0 — 1.7 — 5

0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

Indicators

Economic

- [ ] Irrigation Take (m3/s)
- [x] Minimum flow restrictions (% of time)
- [ ] Management flow restrictions (% of time)
- [ ] Irrigation Bulk Reliability
- [x] % of Irrigable area Irrigated
- [x] % of Allocation used

Recreational

- [x] Clarity
- [x] % Brown Trout habitat

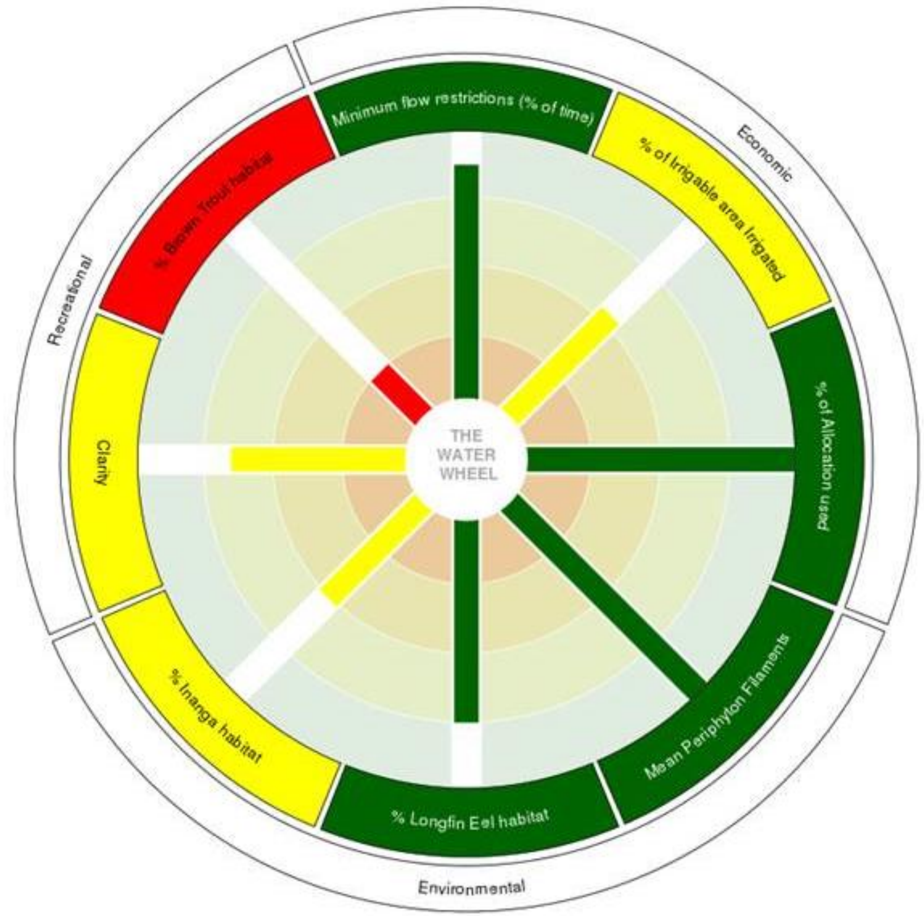
Environmental

- [ ] MCI
- [ ] % Reduction in river width
- [x] Mean Periphyton Filaments
- [ ] Max Periphyton Filament
- [ ] Mean Periphyton Mats
- [ ] Max Periphyton Mat
- [x] % Longfin Eel habitat
- [ ] % Shortfin Eel habitat
- [ ] % Brown Trout habitat
- [ ] % Bluegill Bully habitat
- [x] % Inanga habita
- [ ] % Torrent habitat
- [ ] % Kokopu habitat

This model was prepared as part of the Wheel of Water research project funded by the Ministry of Business, Innovation and Employment.

Interface design by Tim Kerr

Water Wheel Diagram | How it works



Revisiting the Nitrate Modelling

- Refined irrigable areas
- OVERSEER updated N-losses for dairy, with Mirka (Fonterra)

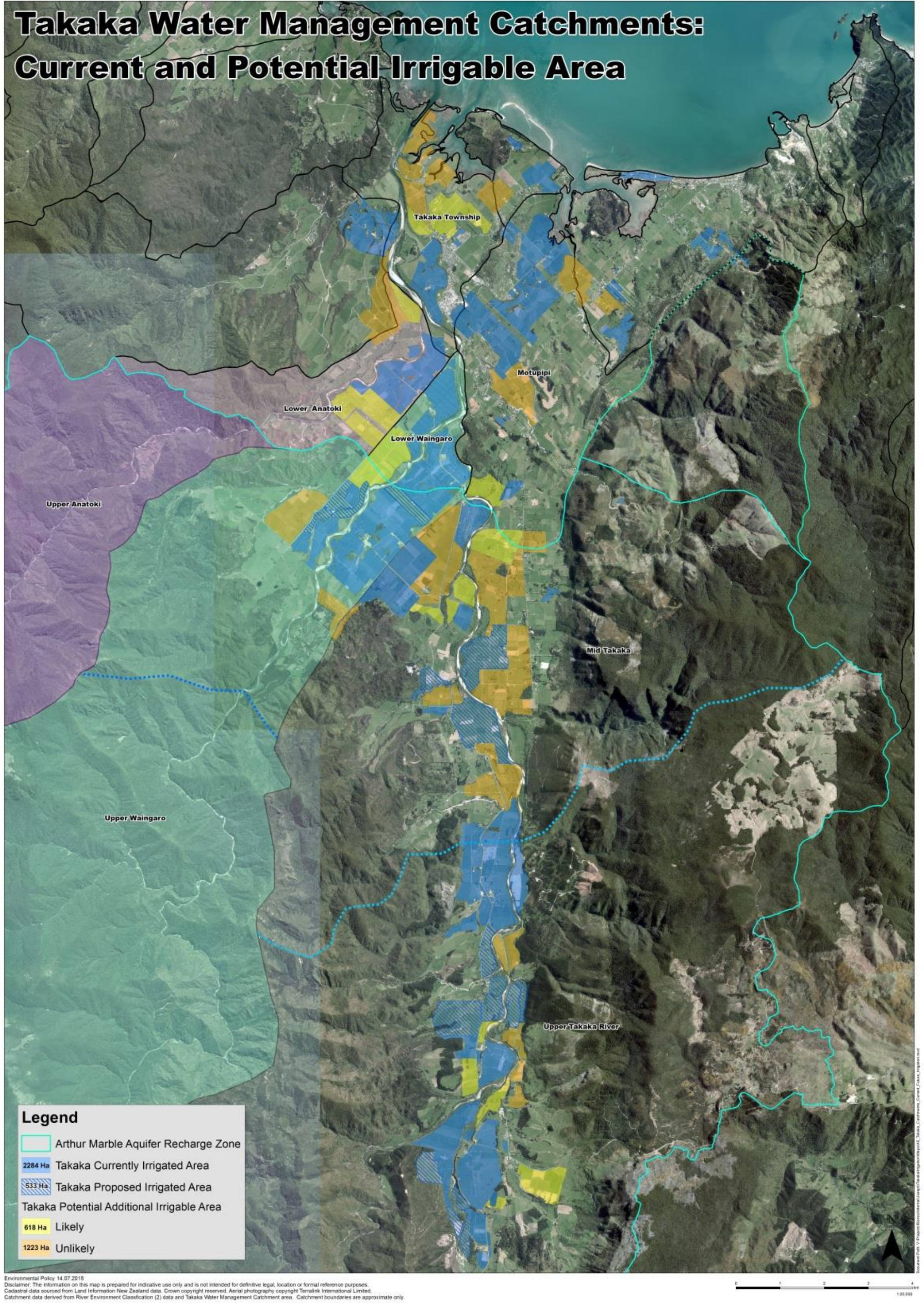
New scenarios:

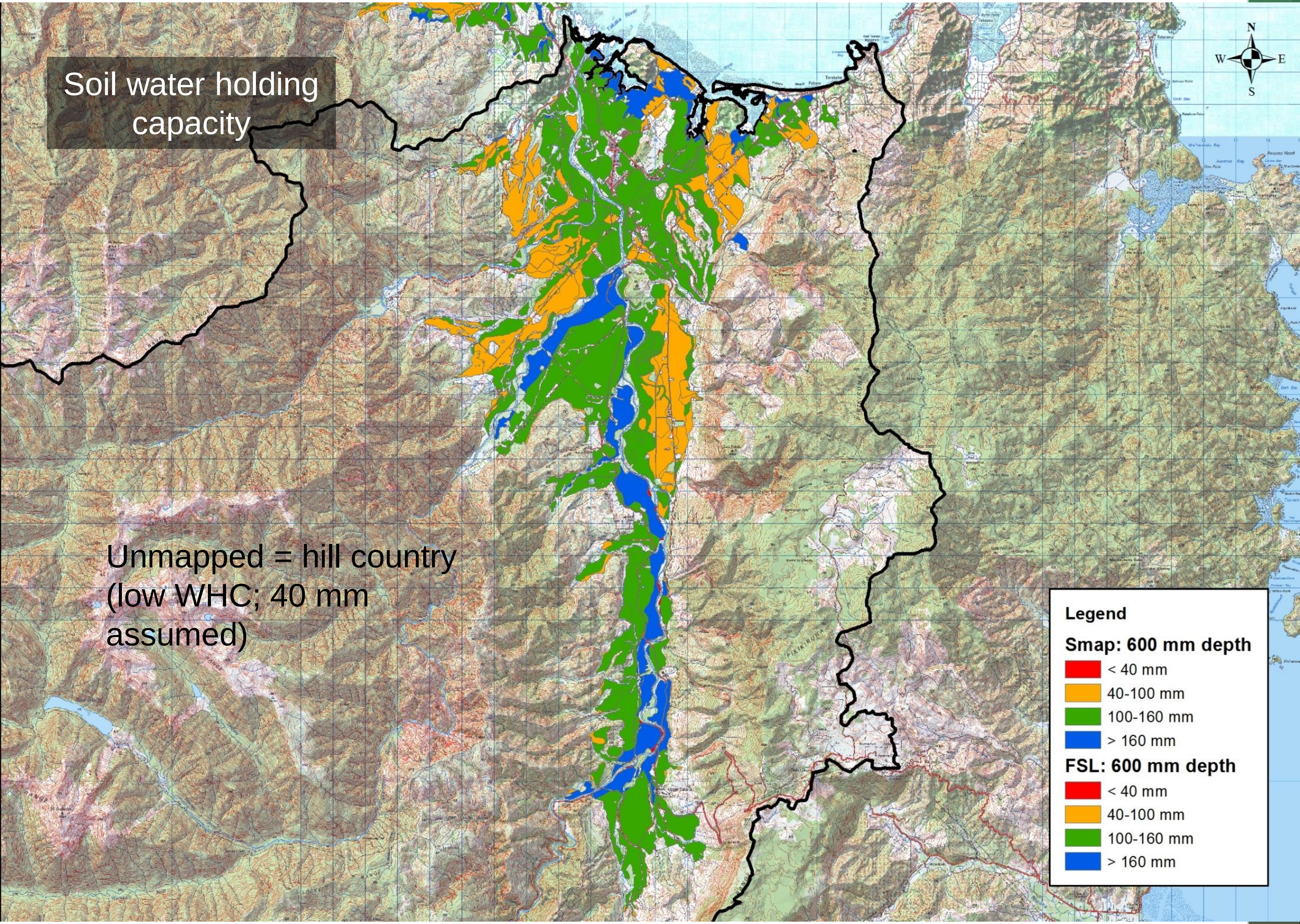
Current irrigation
993ha

Proposed Irrigation (waiting list)
Current + 469ha

Plausible Irrigation (for dairy with potential water nearby)
Current + 583ha

Unlikely Irrigation (for dairy but water may be difficult to access)
Current + 1011ha




Soil water holding capacity
Unmapped = hill country (low WHC; 40 mm assumed)
N
W
E
S
Legend
Smap: 600 mm depth
< 40 mm
40-100 mm
100-160 mm
> 160 mm
FSL: 600 mm depth
< 40 mm
40-100 mm
100-160 mm
> 160 mm

N Loss Rates by Soil Water Retention aggregated from OVERSEER™ 6.1.2 (courtesy Mirka Langford, Fonterra)

Soil group (Plant Available Water, mm)	**Dryland kgN/ha/yr**	**Irrigated kgN/ha/yr**
PAW 40-100	55	109
PAW 100-160	81	115
PAW >160	71	92

Irrigation Scenarios and N Loads

SUMMARY N LOADS	N loading (tonnes/yr)	Ha irrigated dairy	Ha dryland dairy
Current Dairy	**260**	993	2063
Current+Proposed	**275**	1462	1594
Current +Proposed+Plausible	**298**	2045	1011
Current+Proposed+Plausible+Unlikely	**336**	3056	0
766 l/sec allocation limit from FLAG	**278**	1544	1512
Double current irrigation (Scenario 2)	**294**	1986	1070

Sub Catchment Nitrate Budgets

Land cover	Area (ha)	Average NO_3-N (kg/ha/year)	Loading reference	Mass of NO_3-N (tonnes/year)
Forestry	67,400	0.65	Aqualinc (2014) Table 9, and further calibrated	44
Intensive pasture/dairying	2,275 (1)	106	Mirka Langford (Fonterra), estimated average for Takaka valley	241
Dryland/low intensity pasture	5,465 (2)	68	Mirka Langford (Fonterra), estimated average for Takaka valley	372
Native grassland / hill scrubland	16,860	2.5	Hanson (2010) Tables 1-4, and further calibrated	42
		Total		**699**

(1) Existing irrigated area.
(2) Estimated based on remaining unirrigated area on valley floor.

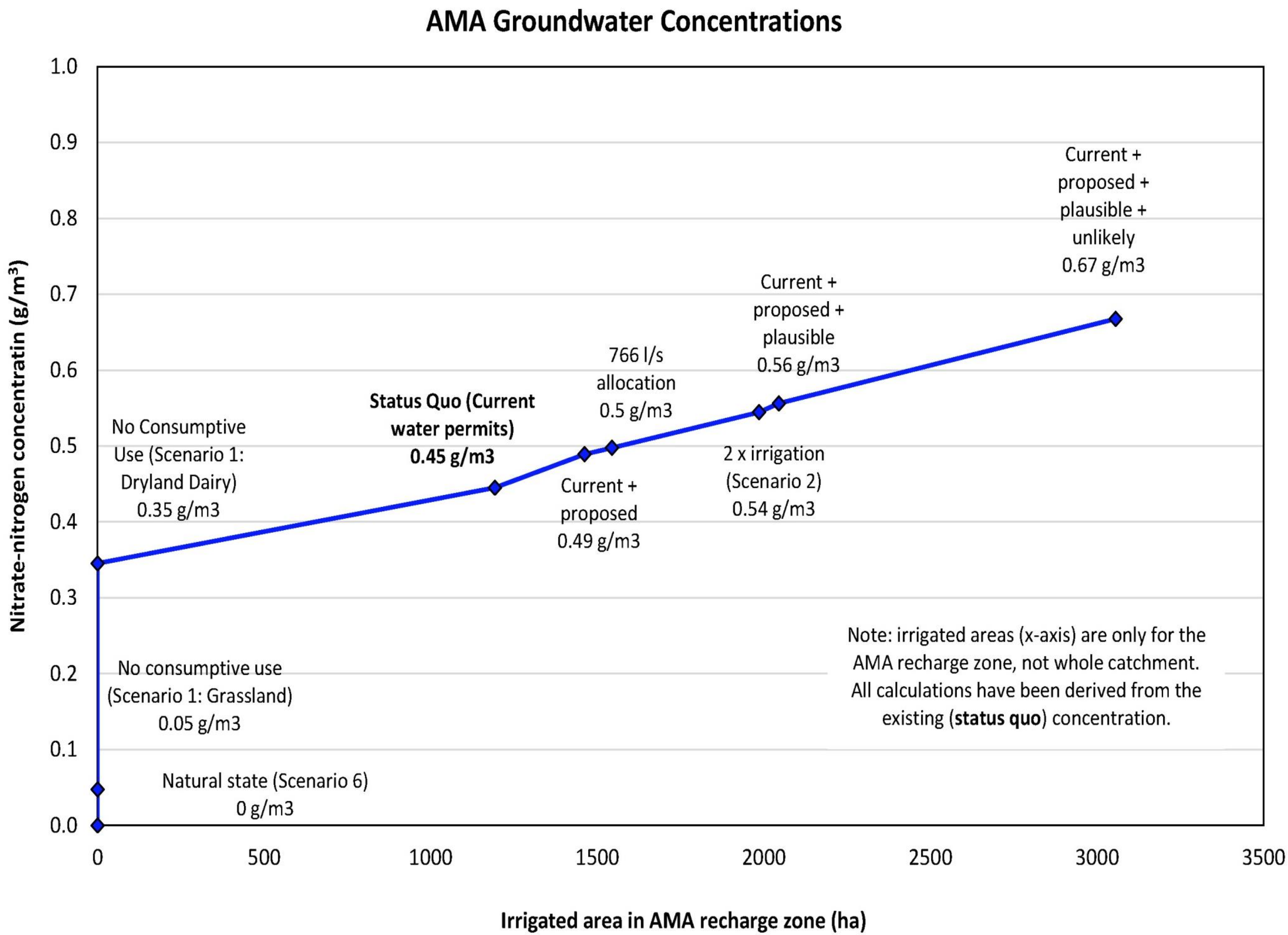
Sub Catchment Nitrate Budgets

Flow component	Nitrate-nitrogen (tonnes/year)			
Aquifer	***AMA***	***TLA***	***TUGA***	***Combined***
		Input		
Land surface [1]	**152**	**190**	**167**	**509**
		Output		
Surface water (groundwater component)	115 [2]	12 [3]	96 [4]	223
Groundwater (off shore) [5]	37	178	71	286
Total out	**152**	**190**	**167**	**509**

(1) Calculated for surface areas overlaying individual aquifer systems.
(2) Calculated as the product of the groundwater component to Pupu Main spring and Fish Creek (7.4 m^3/s + 0.8 m^3/s, based on Figure 21 of Thomas & Harvey, 2013), and nitrate-nitrogen concentration in Waikoropupu main spring (0.445 g/m).
(3) Calculated as the product of Motupipi River flow (0.47 m^3/s) and Motupipi Spring concentration (2.5 g/m^3).
(4) Calculated as the sum of individual products of the TUGA groundwater flow component and concentration, estimated at various surface water sites.
(5) Individually calculated for each aquifer system as the product of calculated off-shore flow and representative groundwater concentration.

Discussion Process

- Critical values needing management √
- Nitrate as management attribute √
- Threshold(s)/limits for management to achieve that value √
- Which is the most acceptable scenario for achieving that water quality limit?
- Is it consistent with FLAG's draft AMA allocation limit?
- If not, review both to reach a consensus.


AMA Groundwater Concentrations
Nitrate-nitrogen concentratin (g/m³)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Current + proposed + plausible + unlikely 0.67 g/m3
Current + proposed + plausible 0.56 g/m3
766 l/s allocation 0.5 g/m3
Status Quo (Current water permits) 0.45 g/m3
No Consumptive Use (Scenario 1: Dryland Dairy) 0.35 g/m3
Current + proposed 0.49 g/m3
2 x irrigation (Scenario 2) 0.54 g/m3
Note: irrigated areas (x-axis) are only for the AMA recharge zone, not whole catchment. All calculations have been derived from the existing (**status quo**) concentration.
No consumptive use (Scenario 1: Grassland) 0.05 g/m3
Natural state (Scenario 6) 0 g/m3
0
500
1000
1500
2000
2500
3000
3500
Irrigated area in AMA recharge zone (ha)