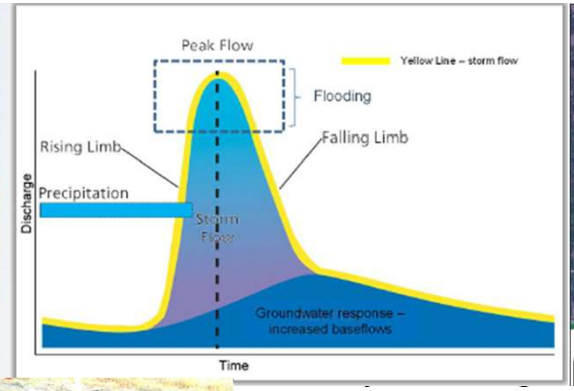
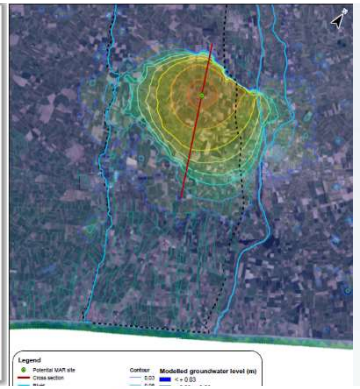
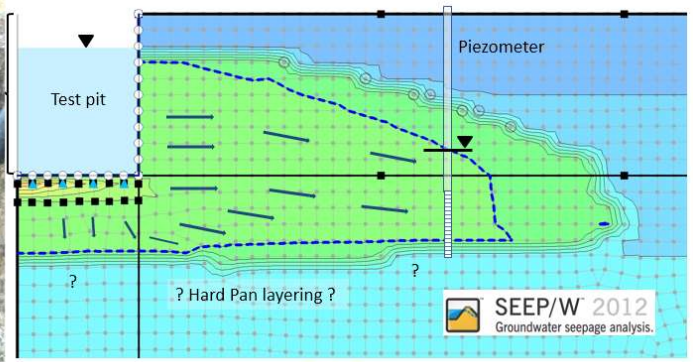
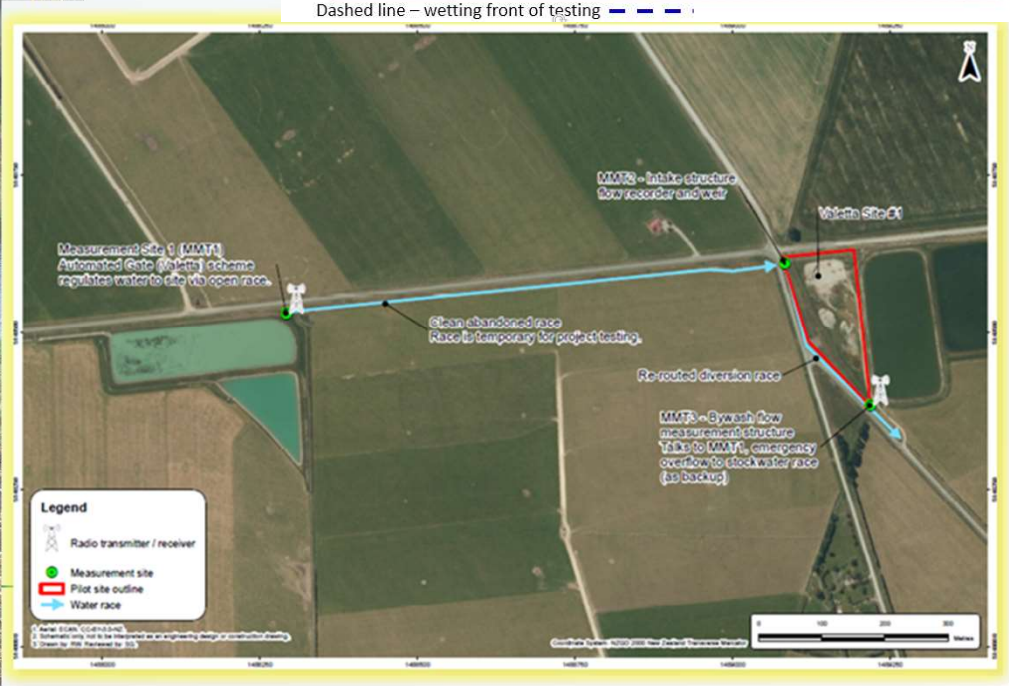
Groundwater Replenishment on the Canterbury Plains using the Tools of Managed Aquifer Recharge (MAR): Overview of Hinds MAR Pilot Project







Dashed line – wetting front of testing



IAH presentation – 8th March 2016,
Golder Associates Christchurch office,
New Zealand

Bob Bower, Principal Hydrologist (Golder)
Patrick Durney, Senior Hydrogeologist, (CRC)

Golder Associates

Environment Canterbury Regional Council

Introduction – 2 Part Presentation

Overview – MAR and Sustainable Groundwater Management

The tools of MAR

Hinds Catchment Drivers

MAR pilot project

Why we modelled?

What we have done (modelling)

What we found

Discussion session

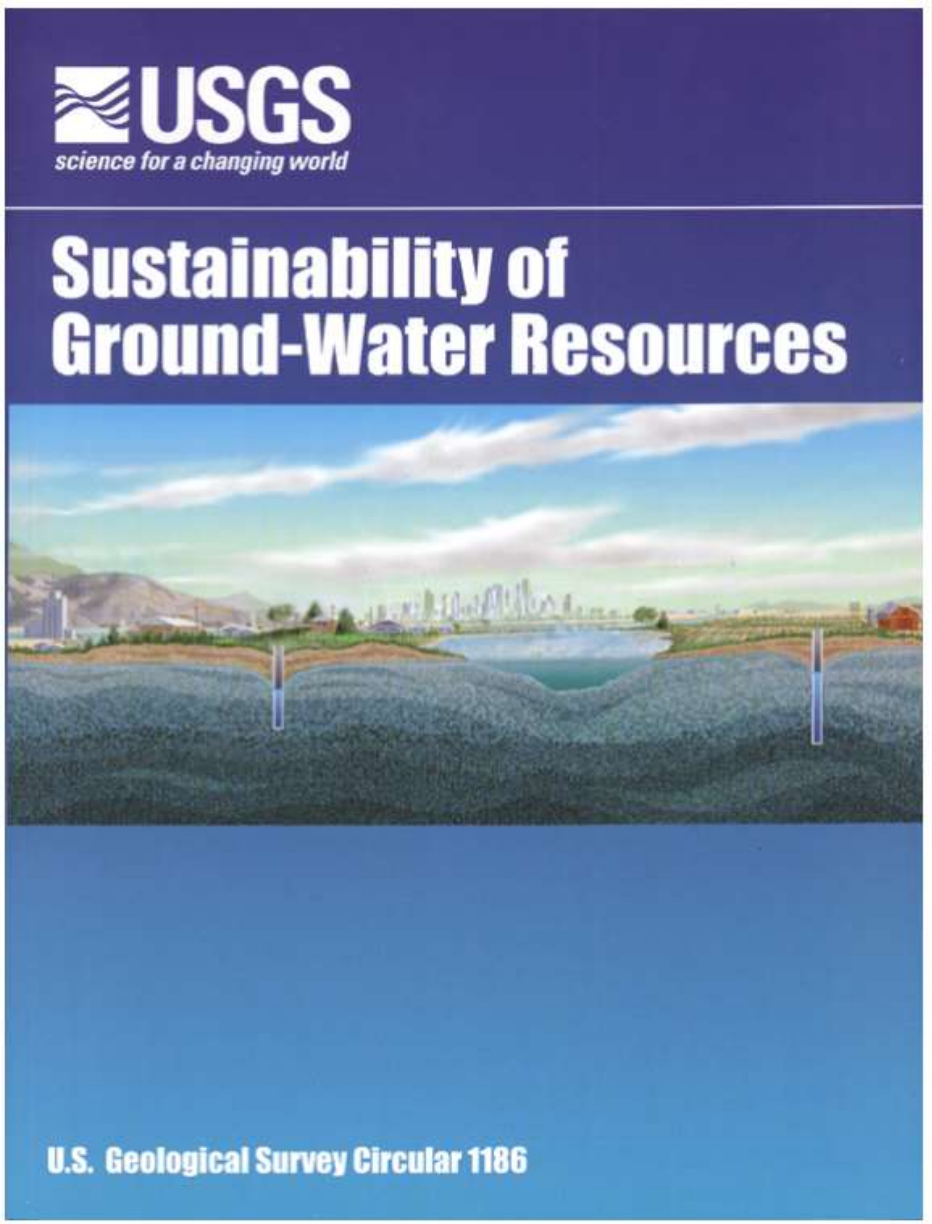
Sustainable Groundwater Management

USGS – 1999 Sustainability of Groundwater Resources

Basic Principles:

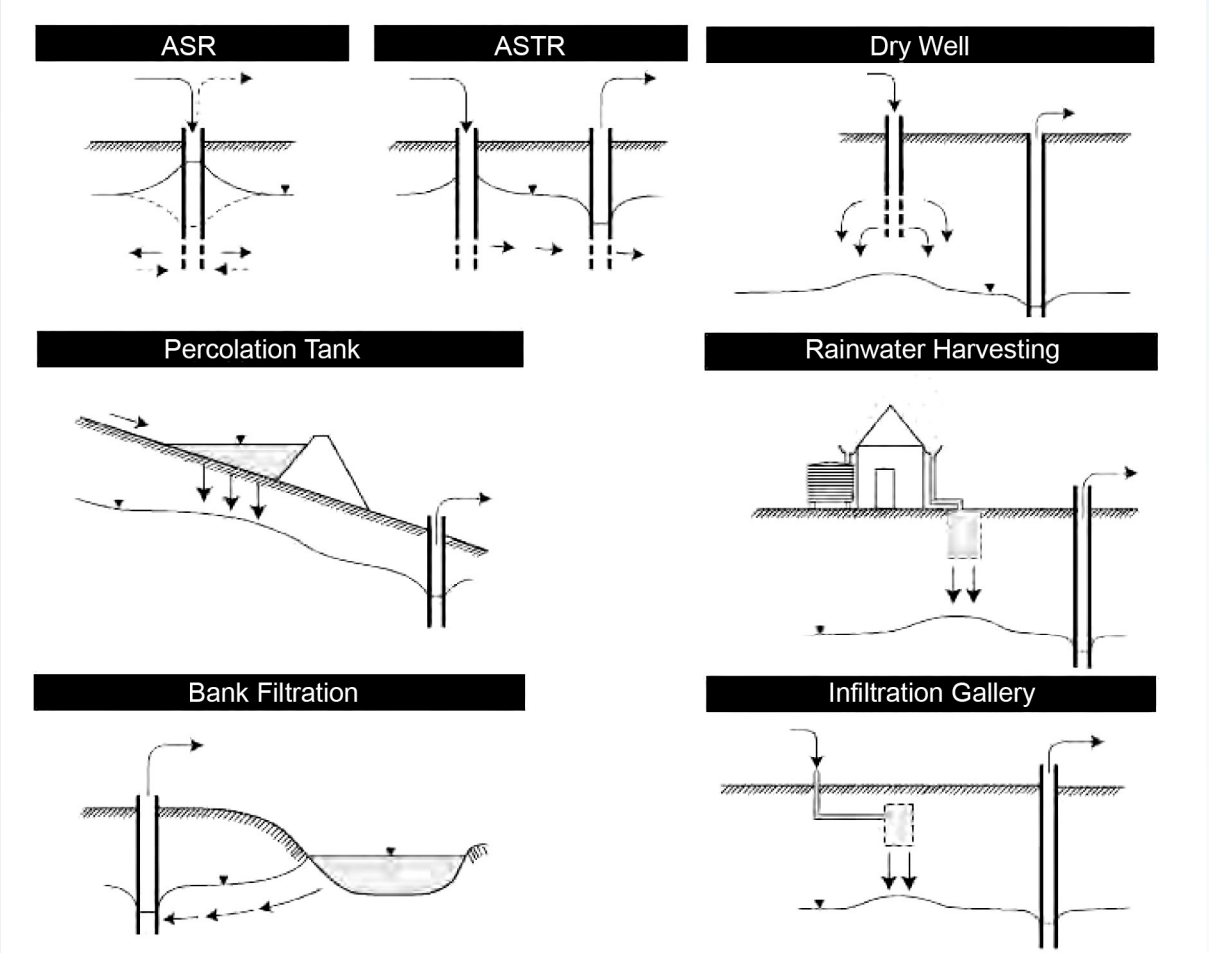
- Water Budgets - balance
- Catchment – scale
- Conjunctive management

http://pubs.usgs.gov/circ/circ1186/pdf/circ1186.pdf

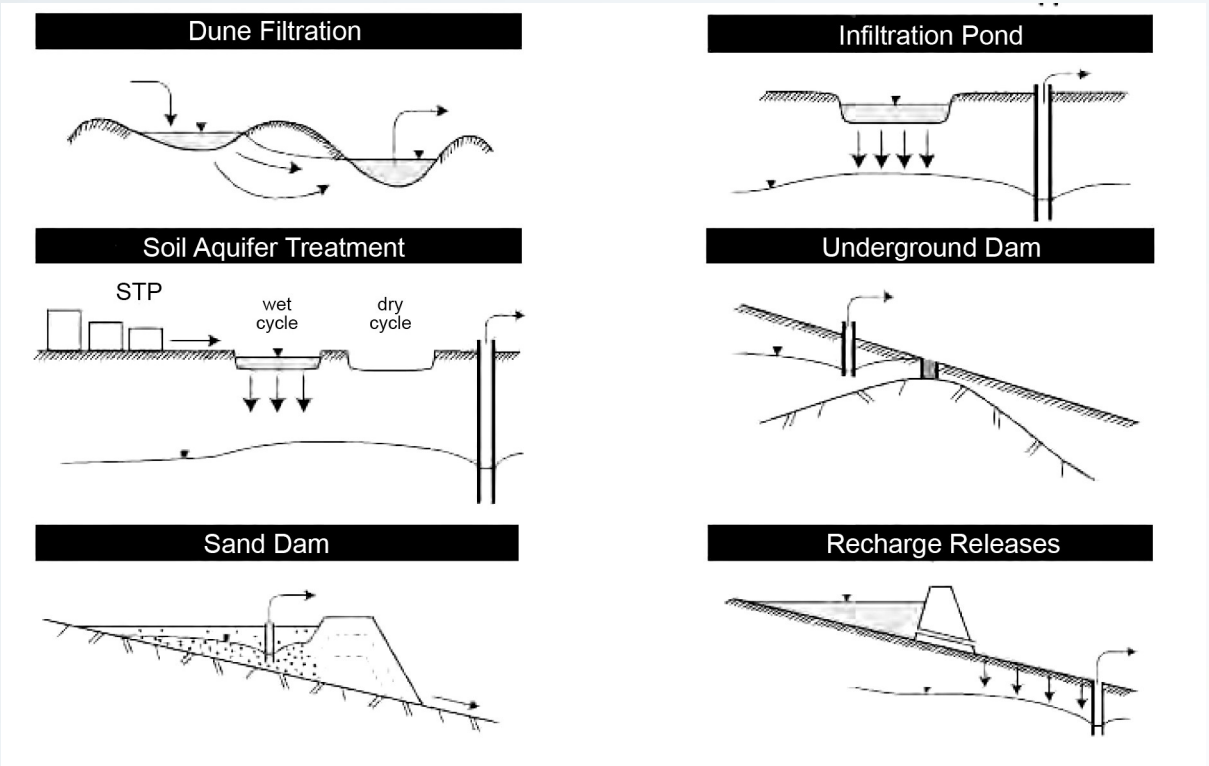



A TOOLS OF MAR

Various tools

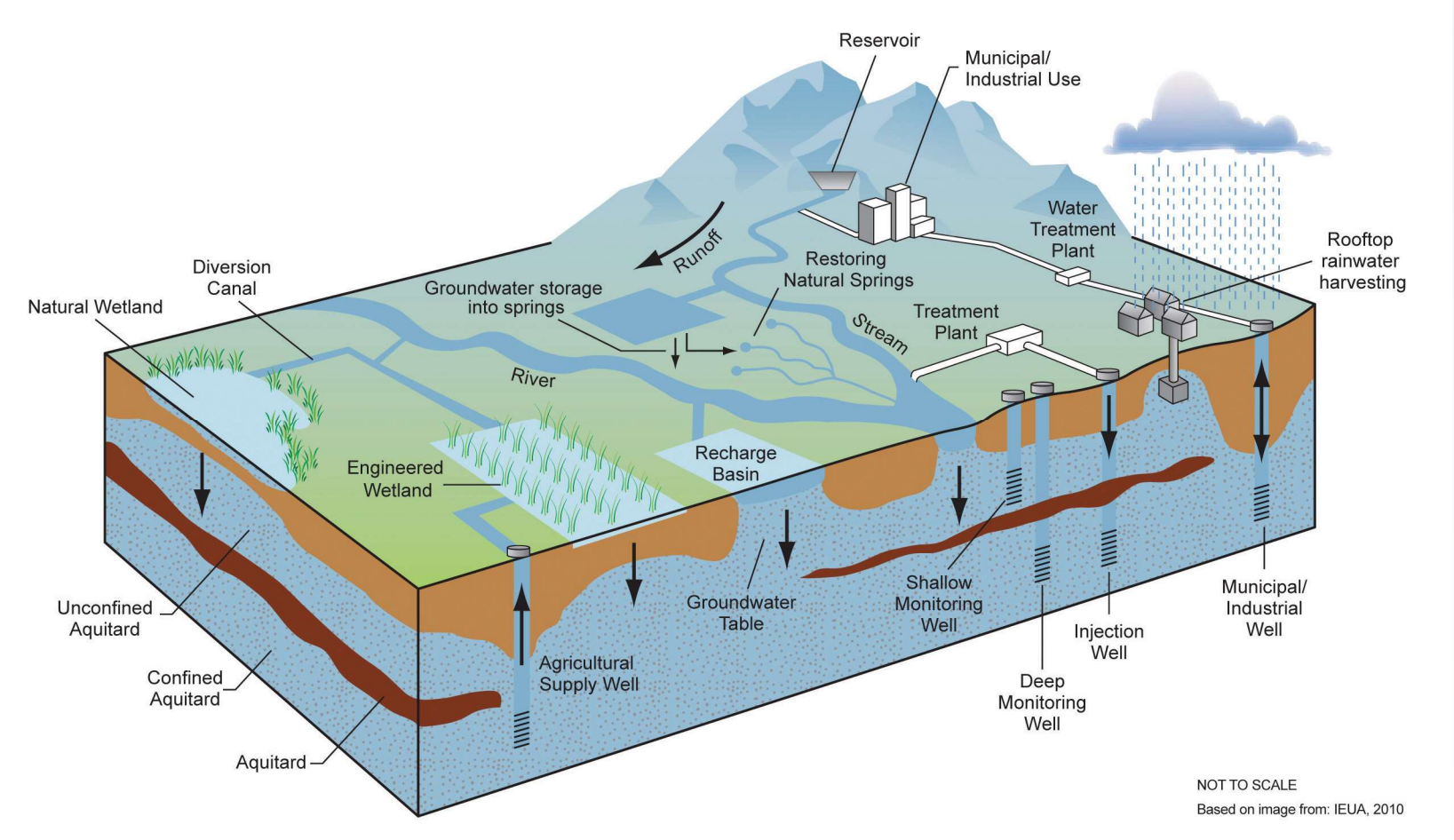


More tools


Dune Filtration
Infiltration Pond
Soil Aquifer Treatment
STP
wet cycle
dry cycle
Underground Dam
Sand Dam
Recharge Releases


The Tools
of MAR

Managed Aquifer Recharge (MAR)



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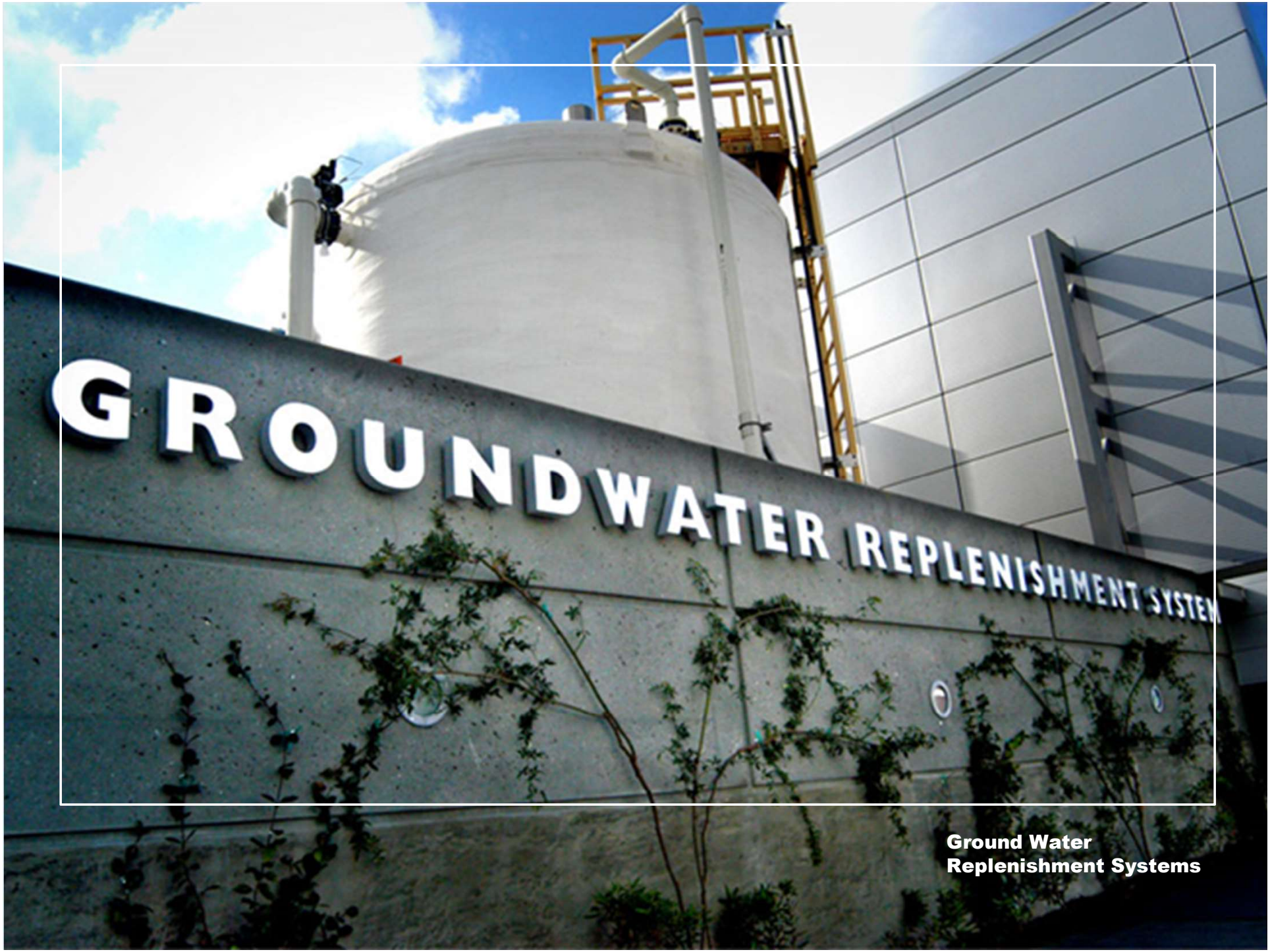
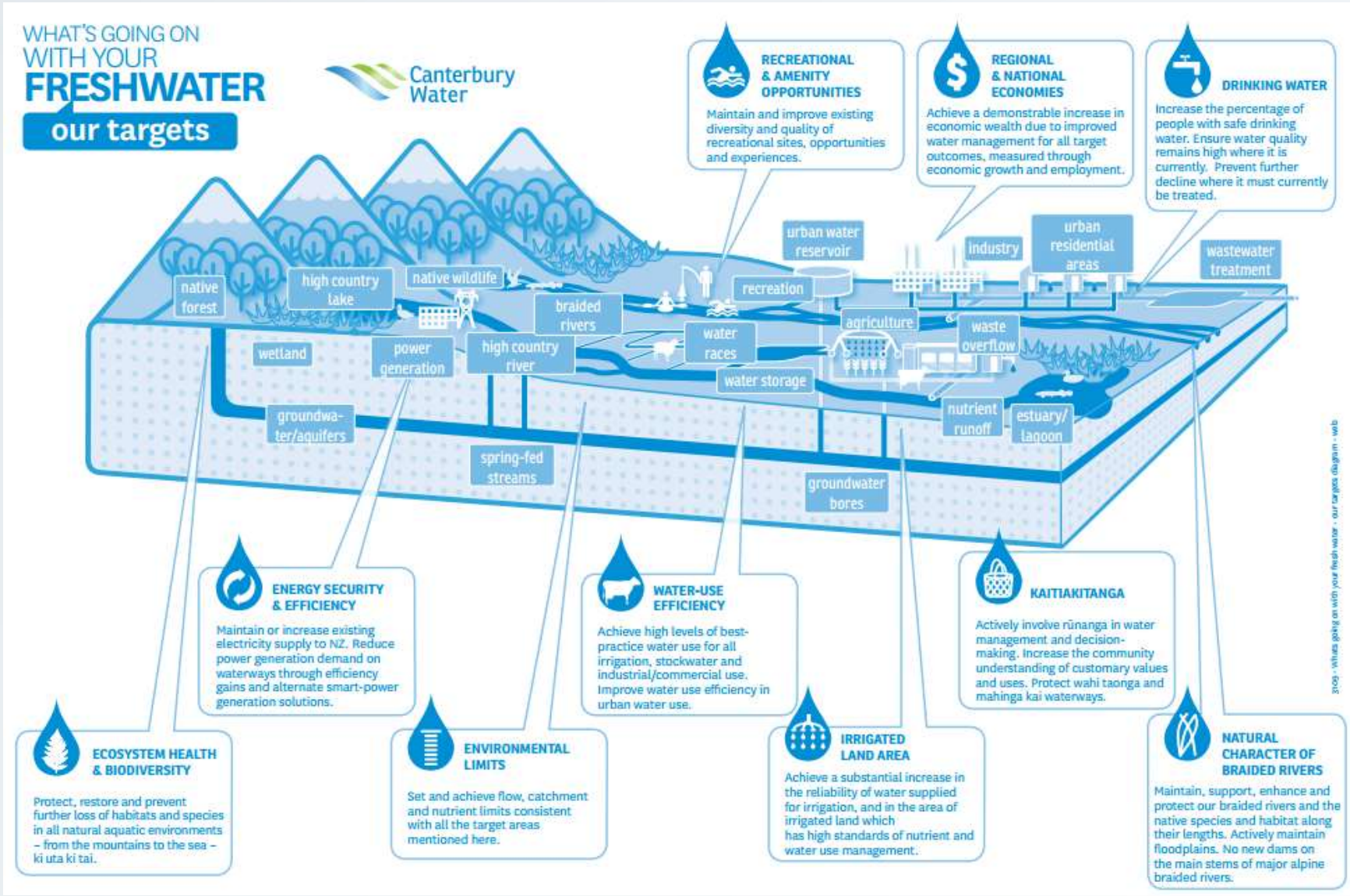


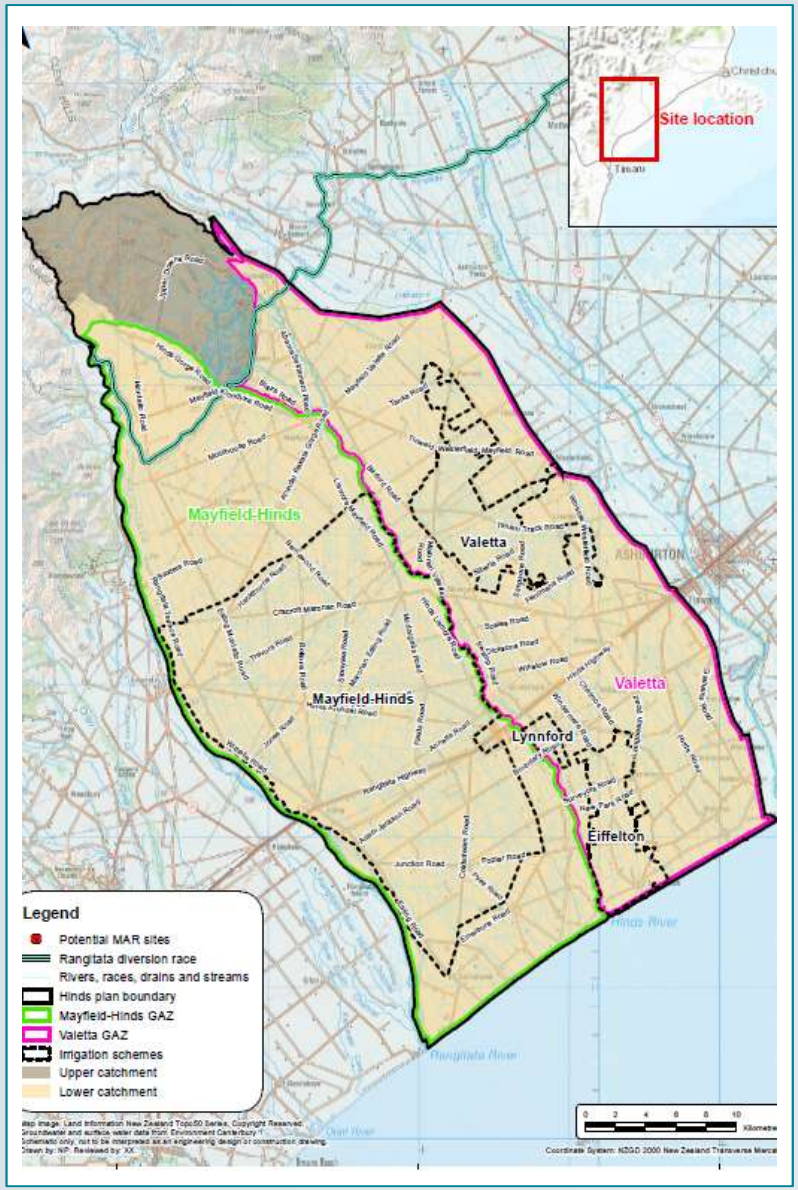
Ground Water Replenishment Systems

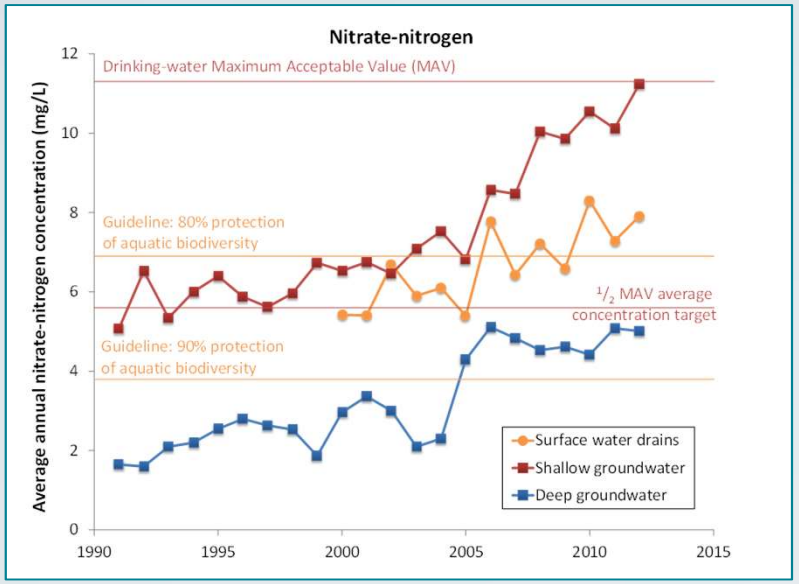

CAP Recharge Program, Arizona

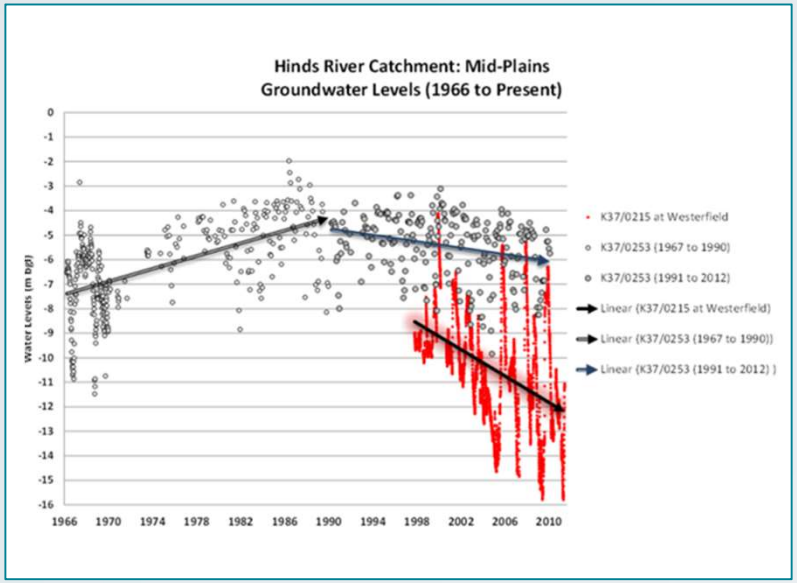
HINDS Plains
Canterbury



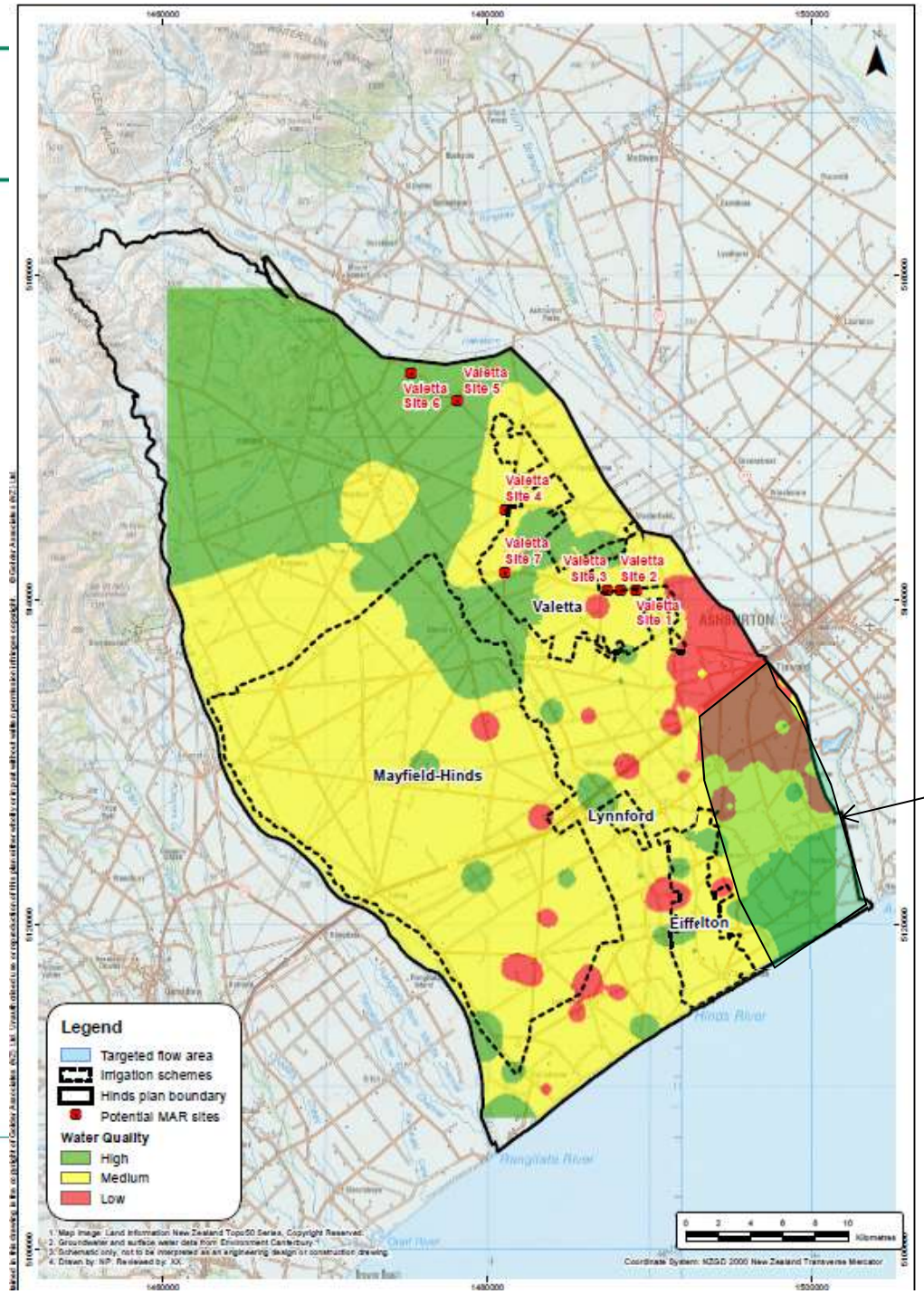
Golder Associates


Site location
Mayfield-Hinds
Valetta
Mayfield-Hinds
Valetta
Lynnford
Eiffelton
Legend
Potential MAR sites
Rangitata diversion race
Rivers, races, drains and streams
Hinds plan boundary
Mayfield-Hinds GAZ
Valetta GAZ
Irrigation schemes
Upper catchment
Lower catchment


Nitrate-nitrogen
Drinking-water Maximum Acceptable Value (MAV)
Guideline: 80% protection of aquatic biodiversity
½ MAV average concentration target
Guideline: 90% protection of aquatic biodiversity
Average annual nitrate-nitrogen concentration (mg/L)
Surface water drains
Shallow groundwater
Deep groundwater


Hinds River Catchment: Mid-Plains
Groundwater Levels (1966 to Present)
Water Levels (m bgl)
K37/0215 at Westerfield
K37/0253 (1967 to 1990)
K37/0253 (1991 to 2012)
Linear (K37/0215 at Westerfield)
Linear (K37/0253 (1967 to 1990))
Linear (K37/0253 (1991 to 2012))

Nitrates



Area were baseflows need most support

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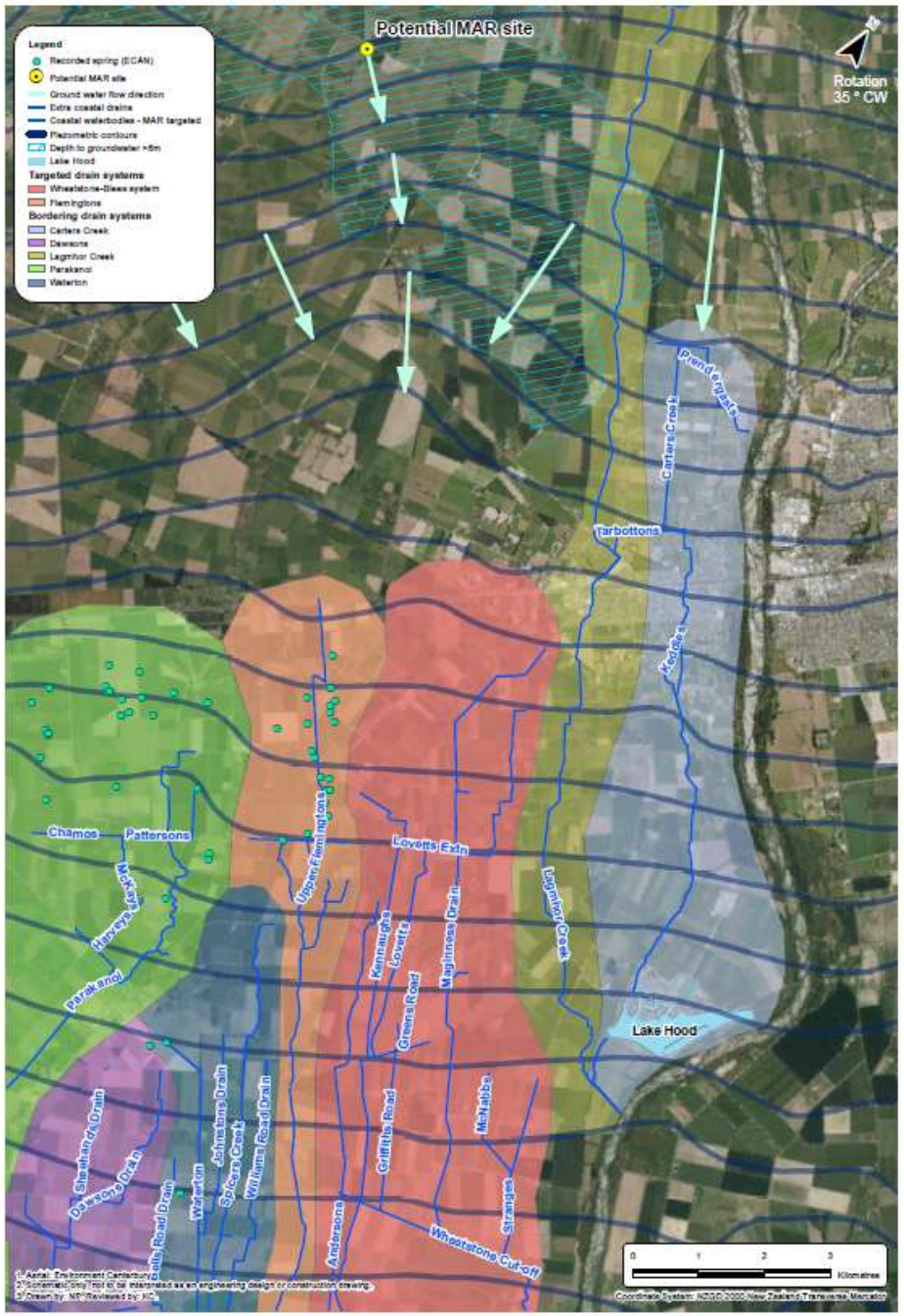

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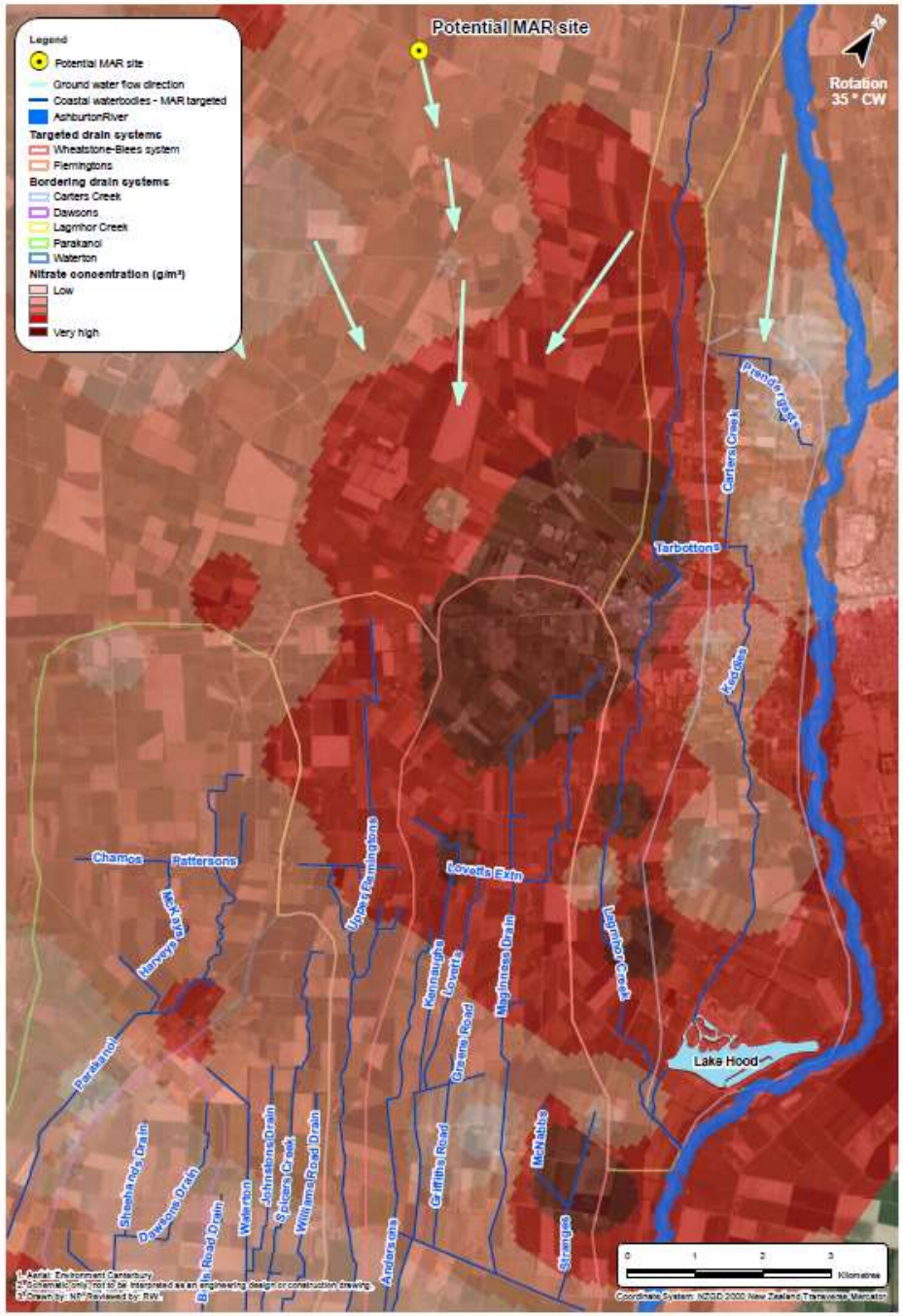
MAR QUANTITY TARGETING
DRAINS SYSTEMS

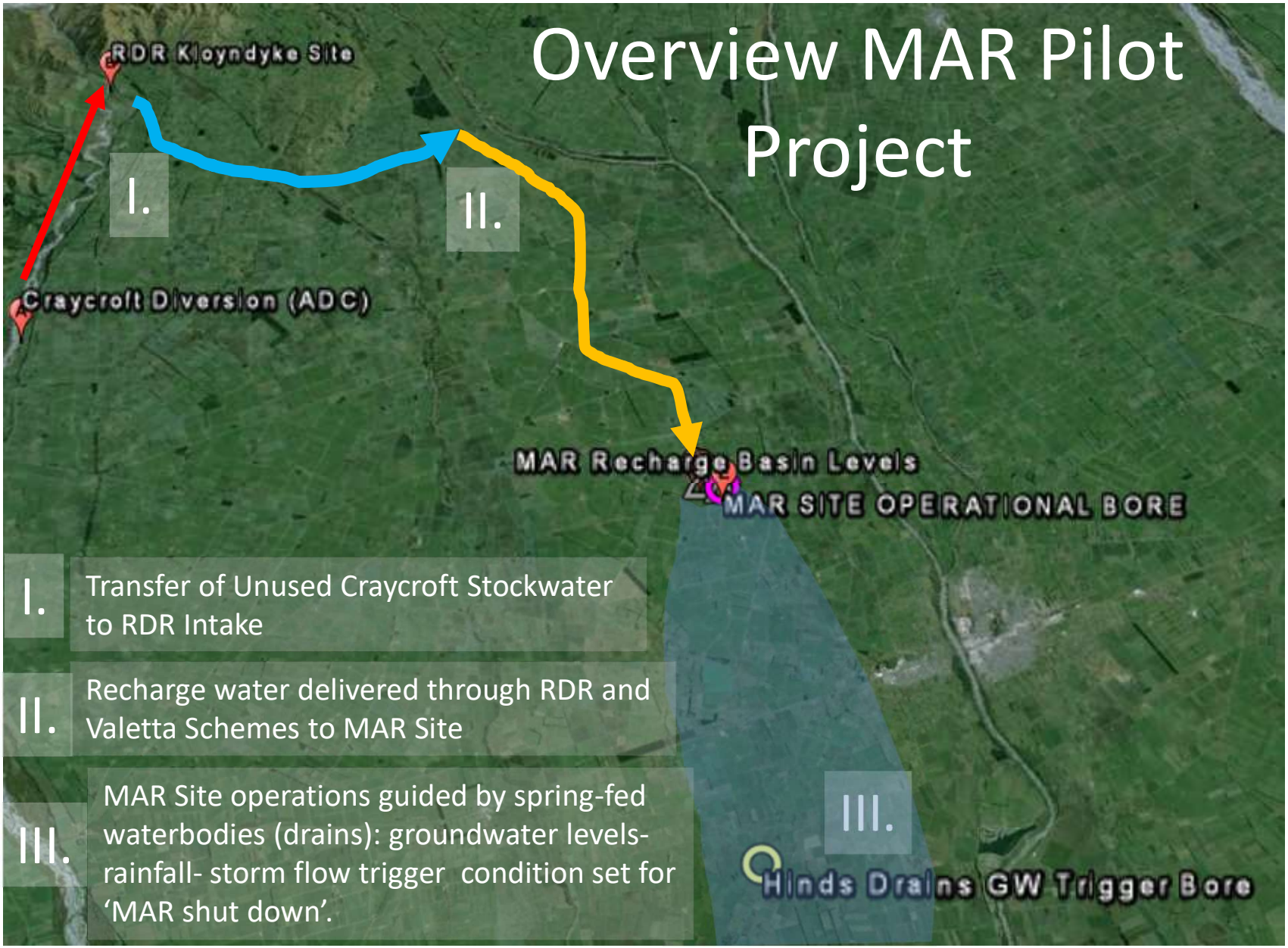
FEBRUARY 2015

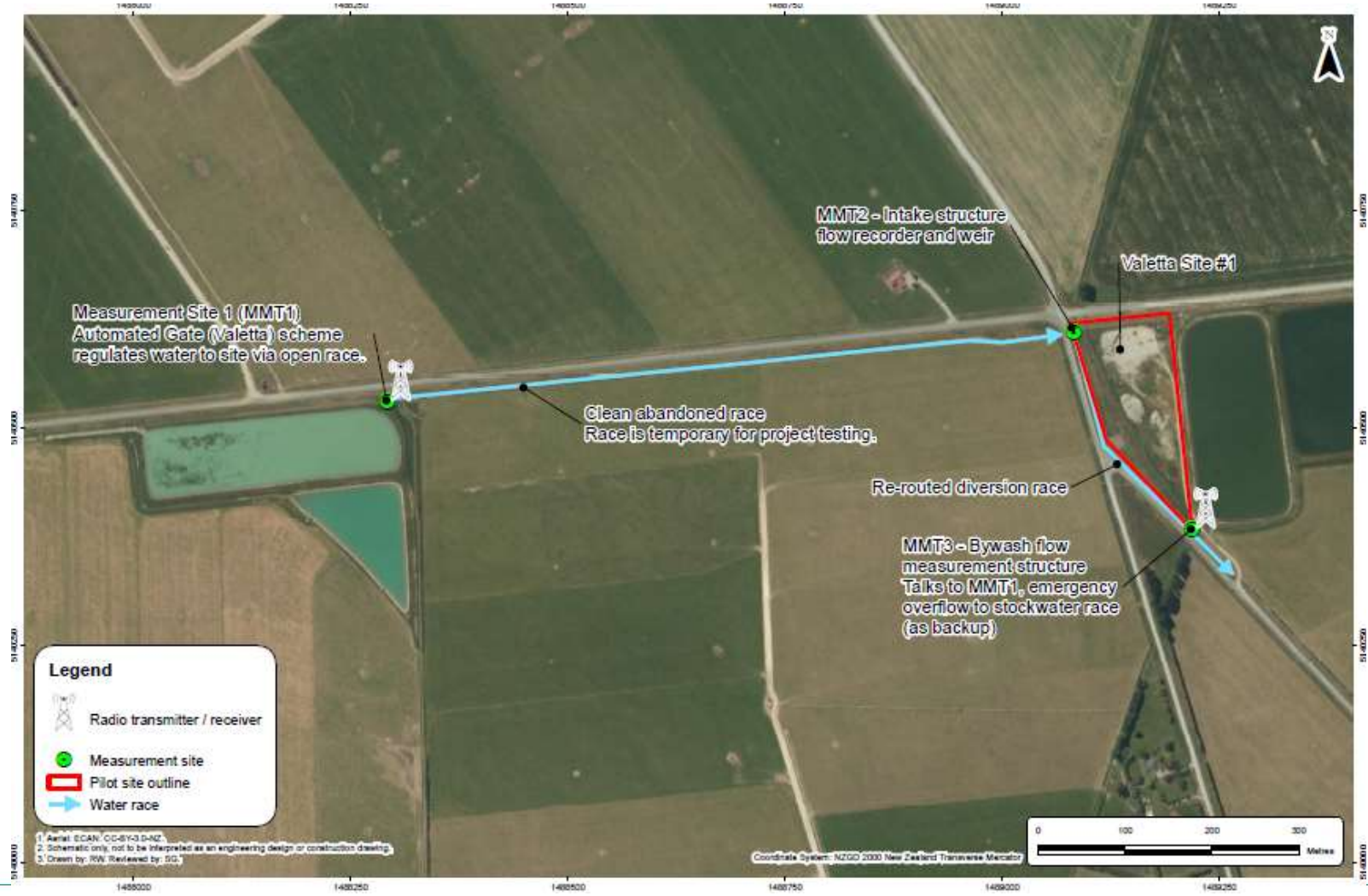
1478110257

9

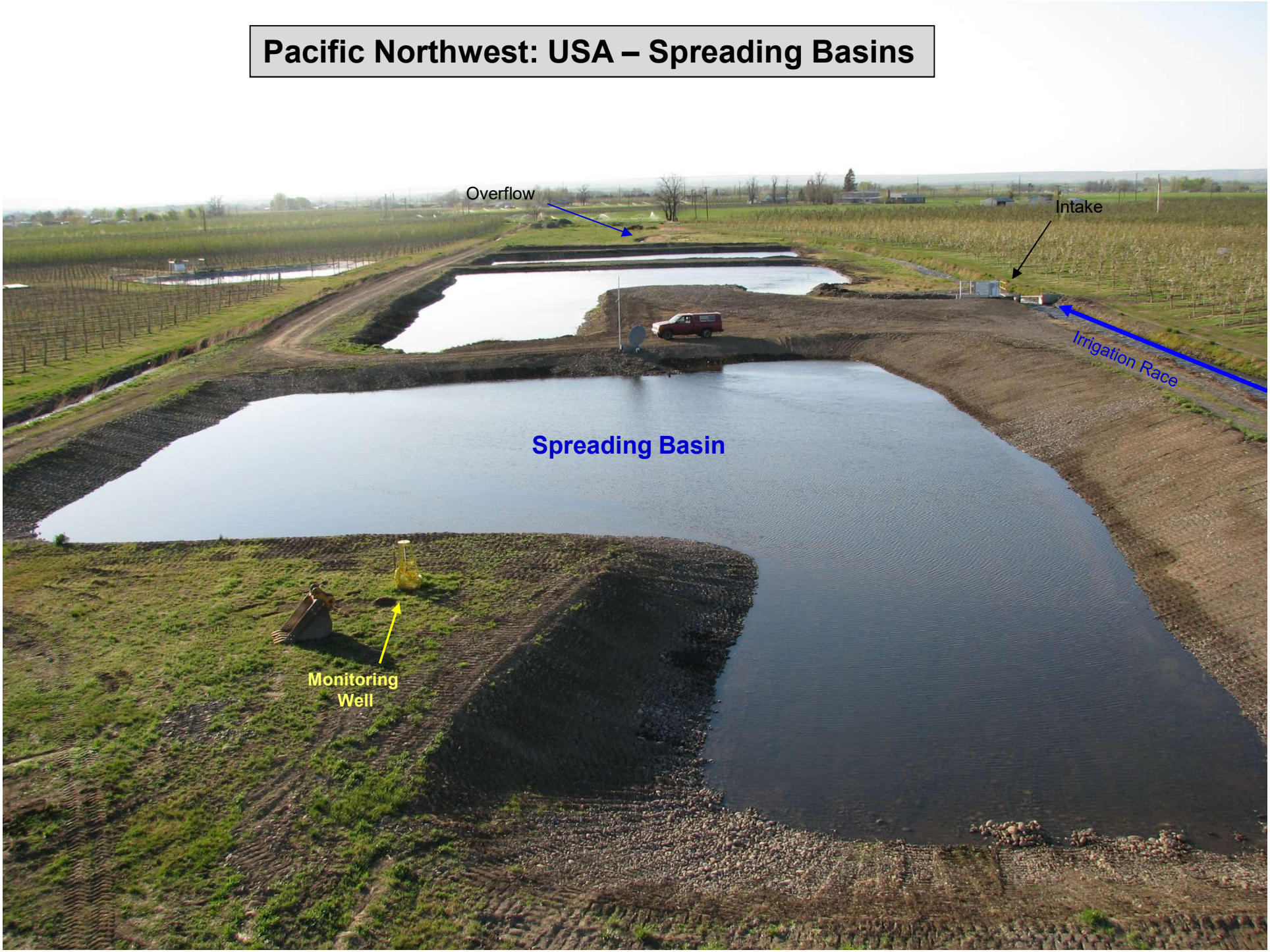
S:\GIS\Projects-Numbered\2014\1478110\10\1478110_257_Ecan_Hinde\MAR\PilotProject\MapDocuments\MAR_Pilot-Hinde\Fig09_MarTrialArea_A4P_GIS.mxd

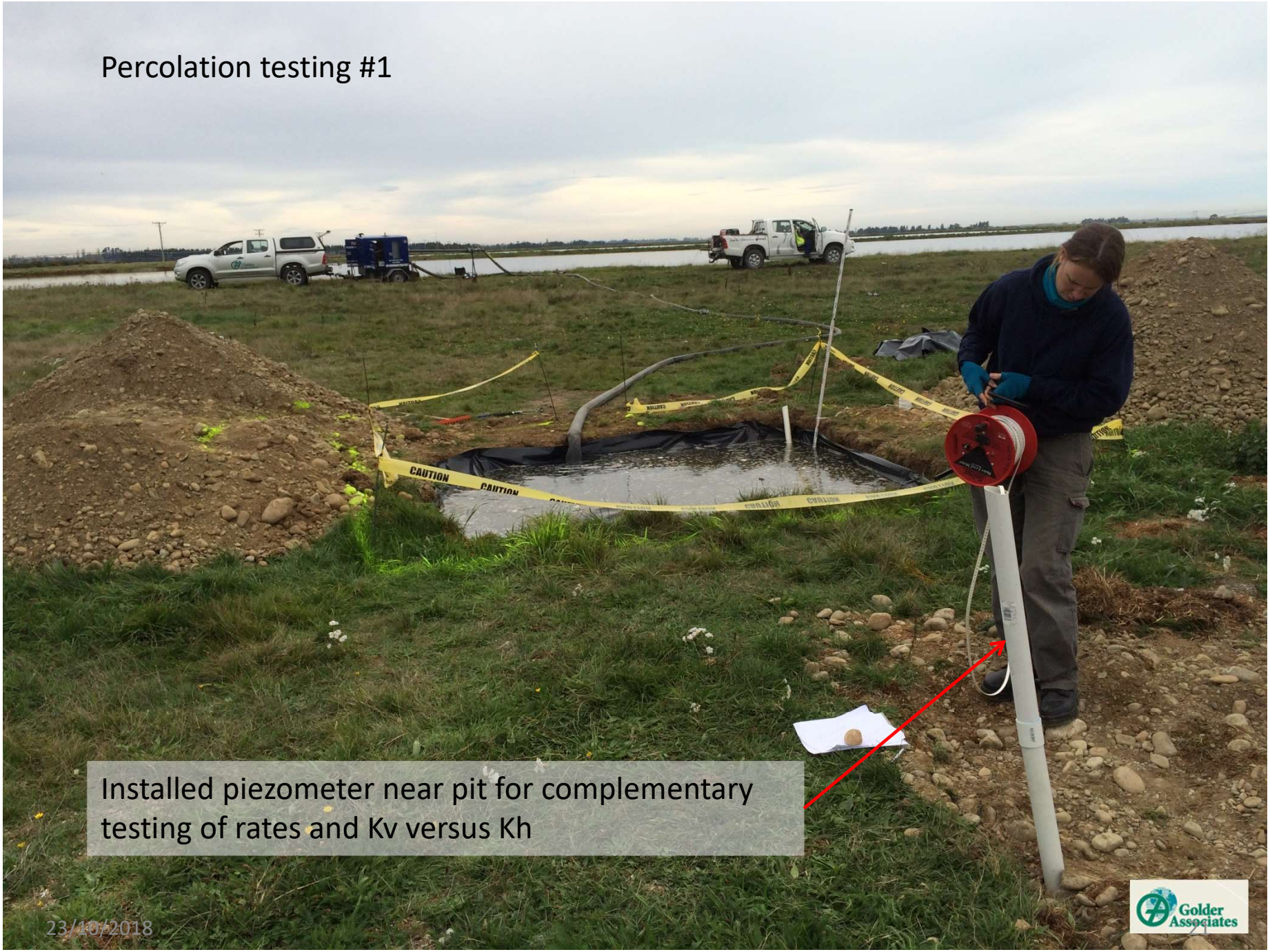

Potential MAR site
Legend
Potential MAR site
Ground water flow direction
Coastal waterbodies - MAR targeted
AshburtonRiver
Targeted drain systems
Wheatstone-Blees system
Flemingtons
Bordering drain systems
Carters Creek
Dawsons
Lagmhor Creek
Parakanoi
Waterton
Nitrate concentration (g/m³)
Low
Very high
Rotation 35 ° CW
Tarbottons
Carters Creek
Prendergasts
Keddies
Chamos
Pattersons
Lovetts Extn
Upper Flemingtons
Harveys Extn
Kennaughs
Lovetts
Maginness Drain
Lagmhor Creek
Graeme Road
Parakanoi
Lake Hood
Griffiths Road
McNabbs
Strenges
Sheehands Drain
Dawsons Drain
Johnstons Drain
Spicers Creek
Williams Road Drain
Waterton
B Road Drain
Andersons
0 1 2 3 Kilometres
Coordinate System: NZGD 2000 New Zealand Transverse Mercator


Overview MAR Pilot Project
RDR Kloyndyke Site
Craycroft Diversion (ADC)
I.
II.
MAR Recharge Basin Levels
MAR SITE OPERATIONAL BORE
I. Transfer of Unused Craycroft Stockwater to RDR Intake
II. Recharge water delivered through RDR and Valetta Schemes to MAR Site
III. MAR Site operations guided by spring-fed waterbodies (drains): groundwater levels- rainfall- storm flow trigger condition set for 'MAR shut down'.
III.
Hinds Drains GW Trigger Bore


MMT2 - Intake structure
flow recorder and weir
Valetta Site #1
Measurement Site 1 (MMT1)
Automated Gate (Valetta) scheme
regulates water to site via open race.
Clean abandoned race
Race is temporary for project testing.
Re-routed diversion race
MMT3 - Bywash flow
measurement structure
Talks to MMT1, emergency
overflow to stockwater race
(as backup)
Legend
Radio transmitter / receiver
Measurement site
Pilot site outline
Water race
Metres

Pacific Northwest: USA – Spreading Basins




Percolation testing #1
CAUTION
Installed piezometer near pit for complementary testing of rates and Kv versus Kh
23/10/2018
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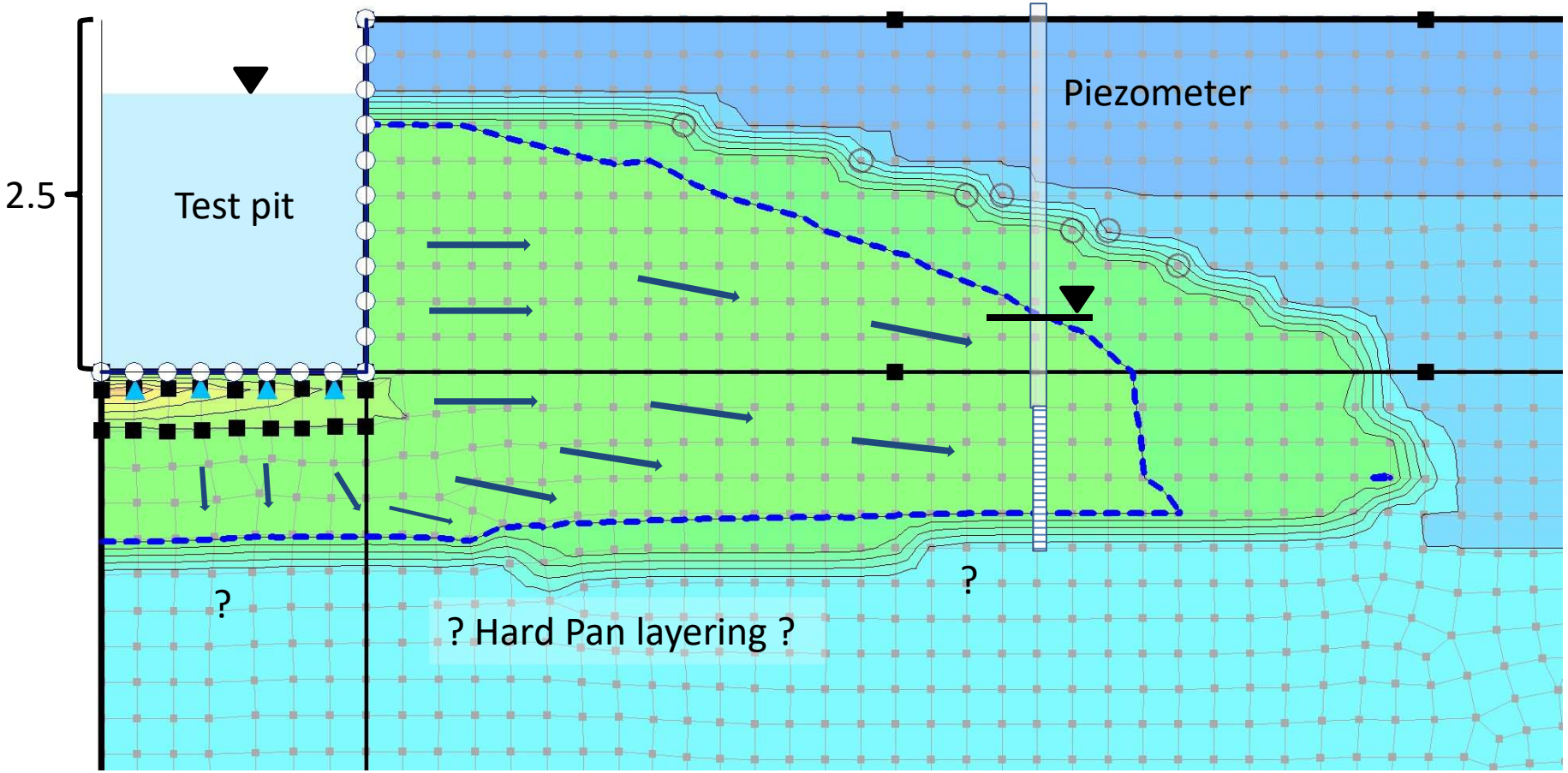
Golder Draft modelling results

SEEP/W 2012
Groundwater seepage analysis.



SEEP/W Hydraulic Modelling simulation of Hinds test pit infiltration trial indicates lateral seepage flows are significantly greater than vertical flows

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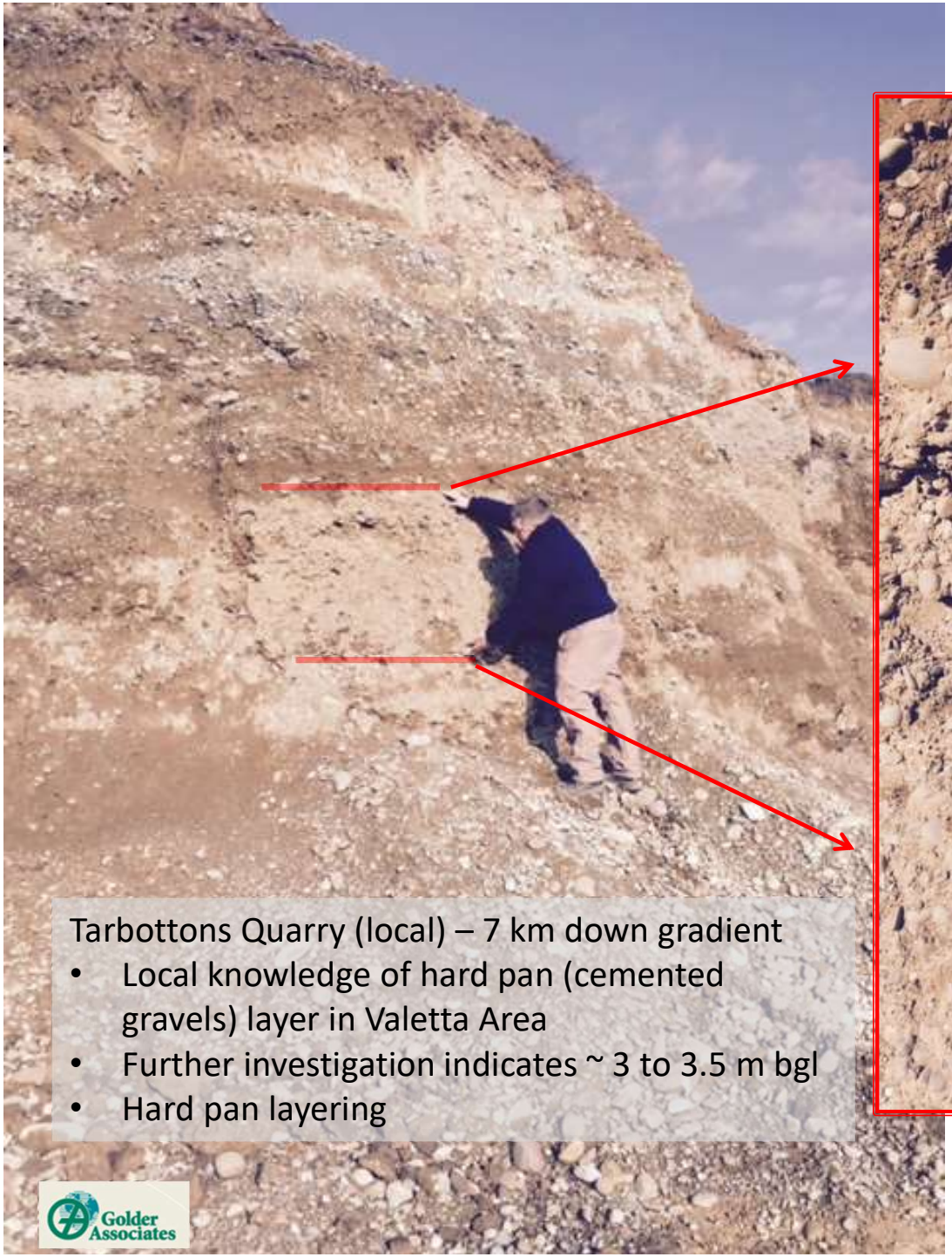
Taken today – 5-June-2015



Tarbottons Quarry (local) – 7 km down gradient

- Local knowledge of hard pan (cemented gravels) layer in Valetta Area
- Further investigation indicates ~ 3 to 3.5 m bgl
- Hard pan layering

Appears to be ~ 2 m below lip of quarry

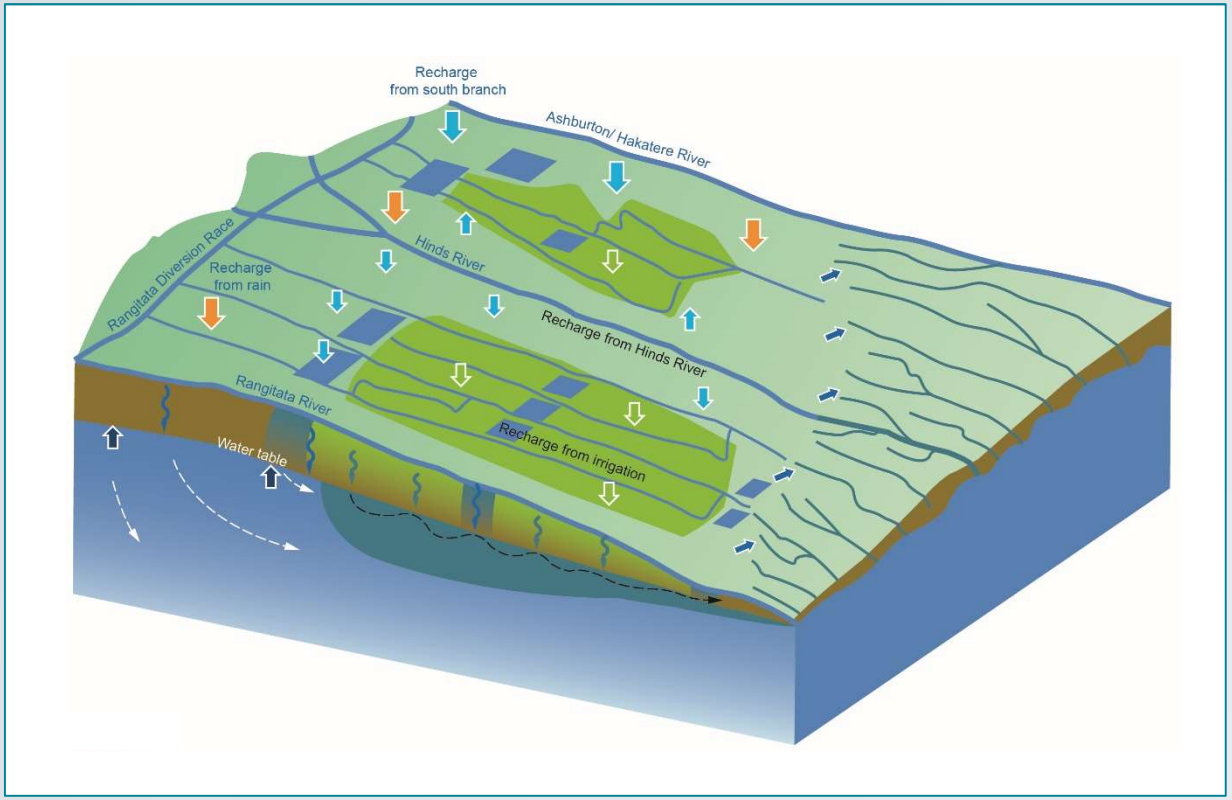
Percolation testing #2

Results

- Clamshell Holes (deeper)
  - Piezometer (6.5 metres)
  - Pit (~5.0 metres)
- Recovery curve indicates 500 L/s potential rate
- Modelled rate ~2,000 L/s
- Site variability will dictate actual final rate


DX140W

Conjunctive management conceptualisation



Outcomes:

- Offset lost incidental recharge (e.g. piping)
- Restore groundwater storage
- Increase baseflows
- Implement advanced on-farm practices to reduce leaching
- Dilution (nitrogen) with high quality alpine source water
- Build an integrated surface and groundwater storage systems

MAR Pilot – Next steps

- 1 year ‘trial’ focus (ADC)
- 5 year consents approved
- Funding (CRC, Community, IAF (pending)
- April construction
- Research Partnerships – Lincoln Agritech, Canterbury Health Board, Aqueon (Dillion)

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MARing the landscape

Managed Aquifer Recharge Modelling – Hinds Mid Canterbury

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This not this

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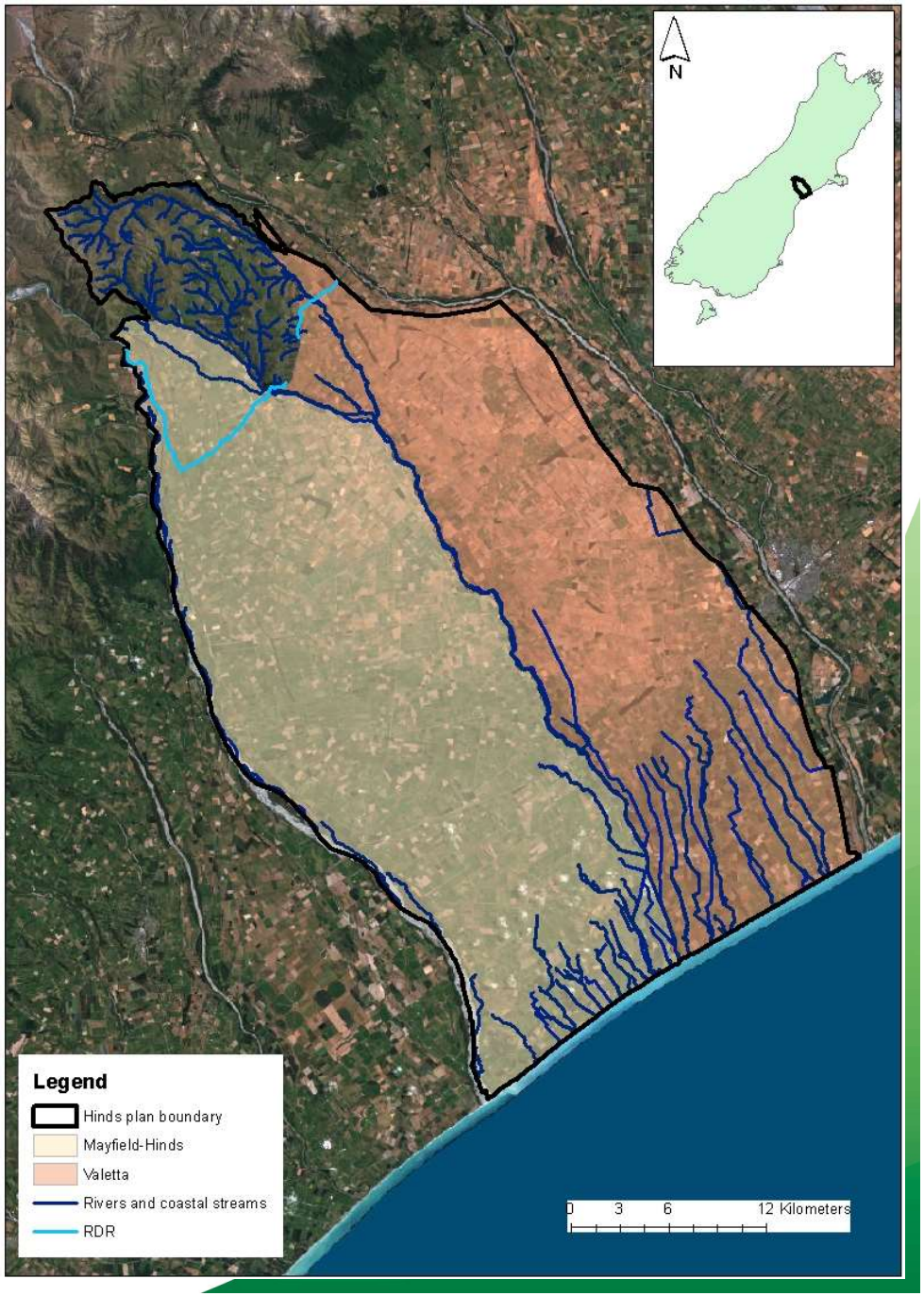
Study area and modelling

- Hinds - Plan change 2 area.
- 3 generations of model:
  1. Manually calibrated MIKE SHE model used in support of plan
  2. Expanded and refined, pilot point PEST calibrated MIKE SHE model
  3. In build probabilistic model



The problem: why model MAR

- Provide analysis for community discussion including a possible final MAR array design
- To aid in understanding likely impacts of MAR pilot including aiding the consenting process
- Assess the actual effects of the trial and the applicability to the rest of the catchment

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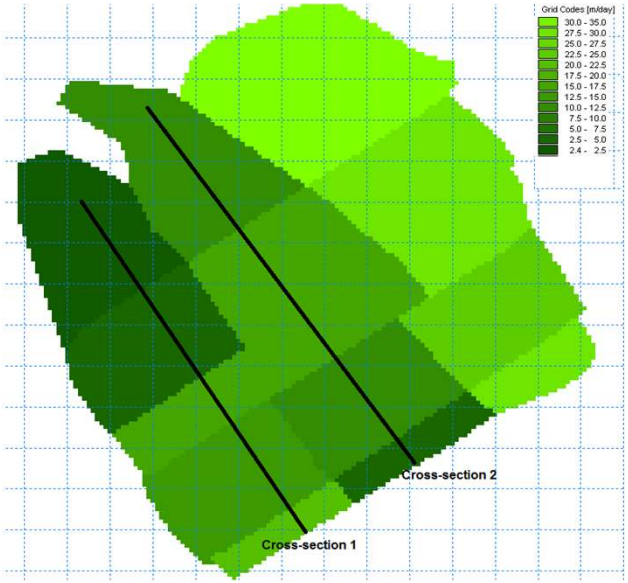
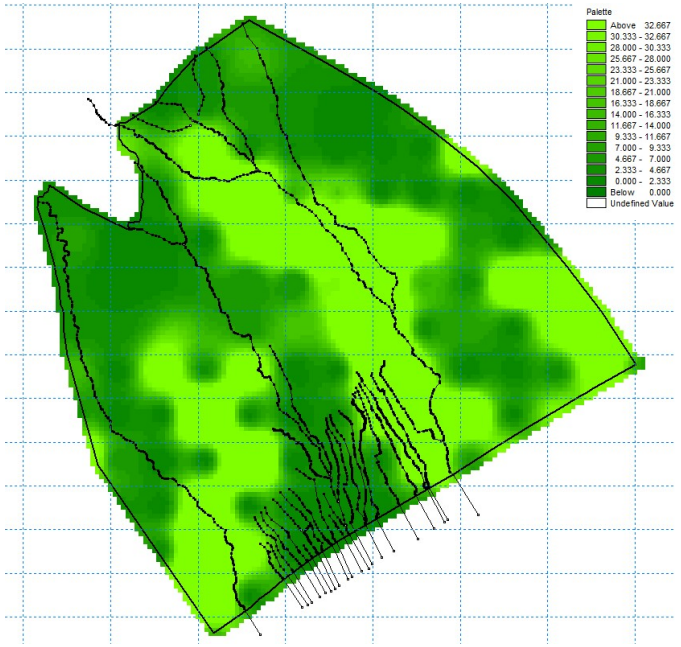
What we did and changes between models



- 2 numerical SZ layers
- manually calibrated SZ zones
- Coastal streams modelled as lumped drain codes



- Extended and corrected boundary
- 3 numerical SZ layers
- Pilot point PEST calibrated SZ
- Coastal streams modelled as rivers

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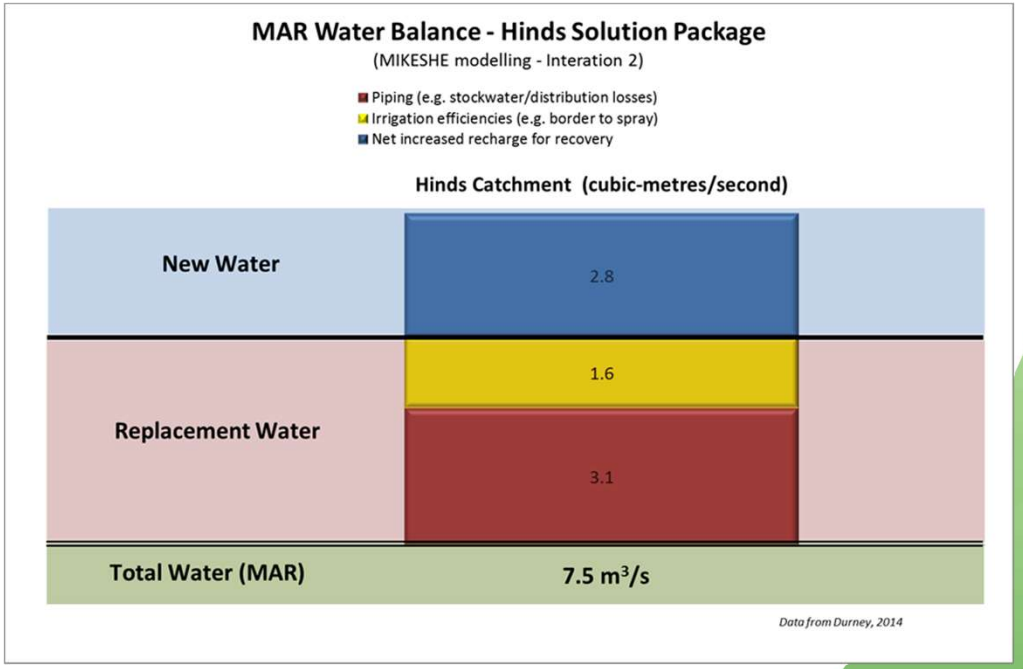
What we found

First model

- Large volumes required to off set declines in flow and groundwater level
- 3.1 m^3/s to offset lost incidental recharge
- 2.8 m^3/s to off set groundwater use



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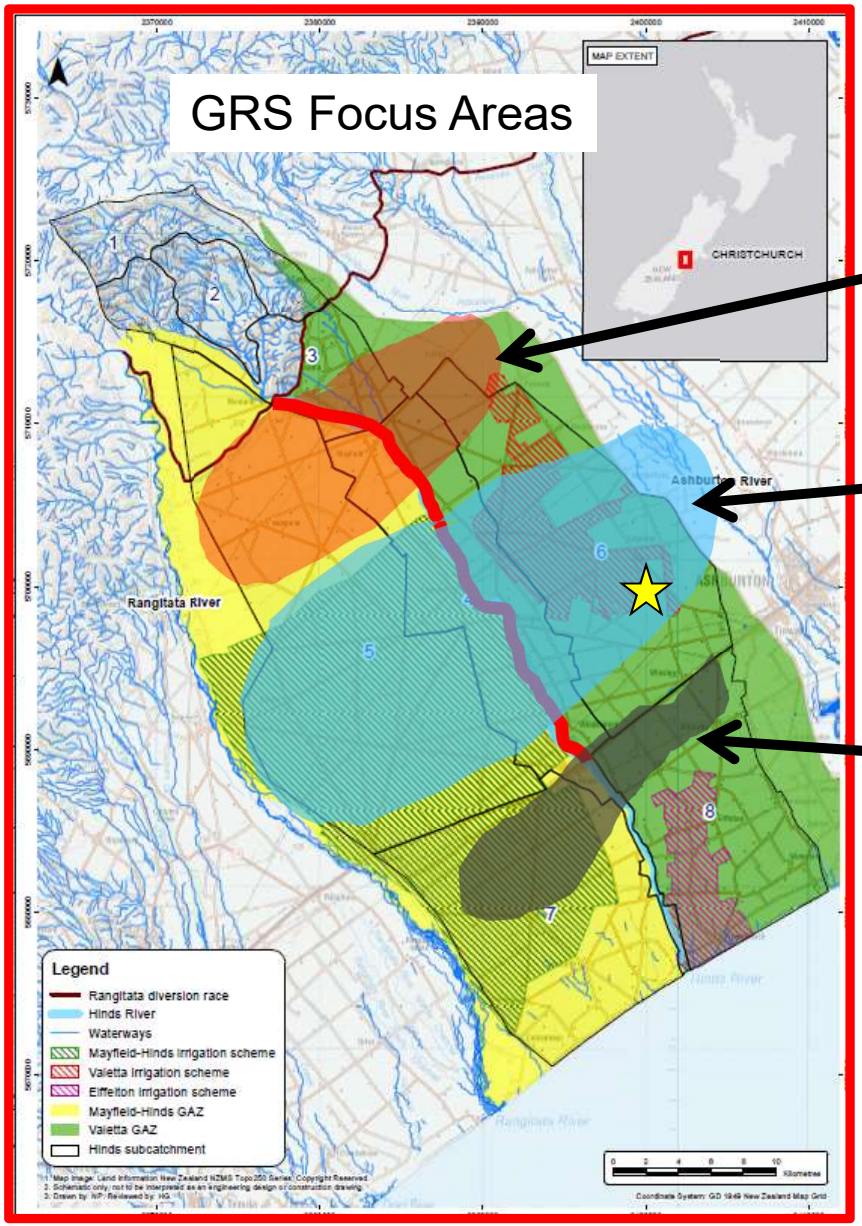
Hinds Catchment: Groundwater Replenishment Programme



Upper Plains – large infiltration basins (water banking)

Mid-Plains: 'on-farm' galleries or smaller basins (nitrogen mitigation and water banking)

Coastal springs: basins/galleries (targeted baseflows and offset pumping)

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Ground Water Replenishment Scheme Modelling

Model 0000

Legend

- MAR site
- River
- Coastal drains
- Valetta groundwater allocation zone

Modelled groundwater level (m)

- <+0.03
- +0.03 - +0.08
- +0.08 - +0.14
- +0.14 - +0.19
- +0.19 - +0.30
- +0.30 - +0.47
- +0.47 - +1.06
- +1.06 - +3
- +3 - +6
- >+6

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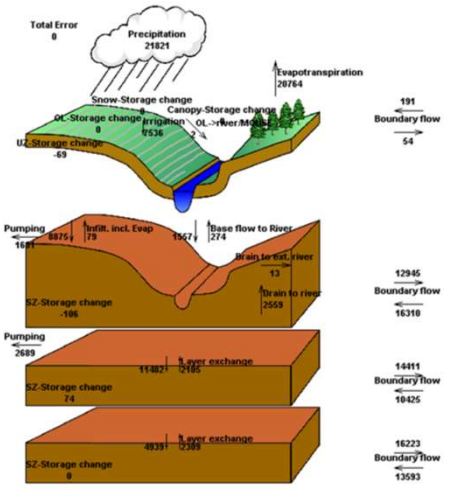
MIKE SHE (DHI) Model
Patrick Durney (2014, 2015)



0 2 4 6
Kilometres

Ground Water Replenishment Scheme Modelling

4th Year

Model 0120

Legend

- MAR site
- River
- Coastal drains
- Valetta groundwater allocation zone

Modelled groundwater level (m)

- <+0.03
- +0.03 - +0.08
- +0.08 - +0.14
- +0.14 - +0.19
- +0.19 - +0.30
- +0.30 - +0.47
- +0.47 - +1.06
- +1.06 - +3
- +3 - +6
- >+6

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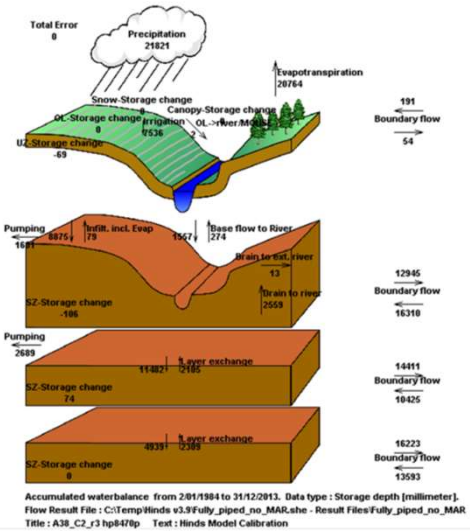
MIKE SHE (DHI) Model
Patrick Durney (2014, 2015)

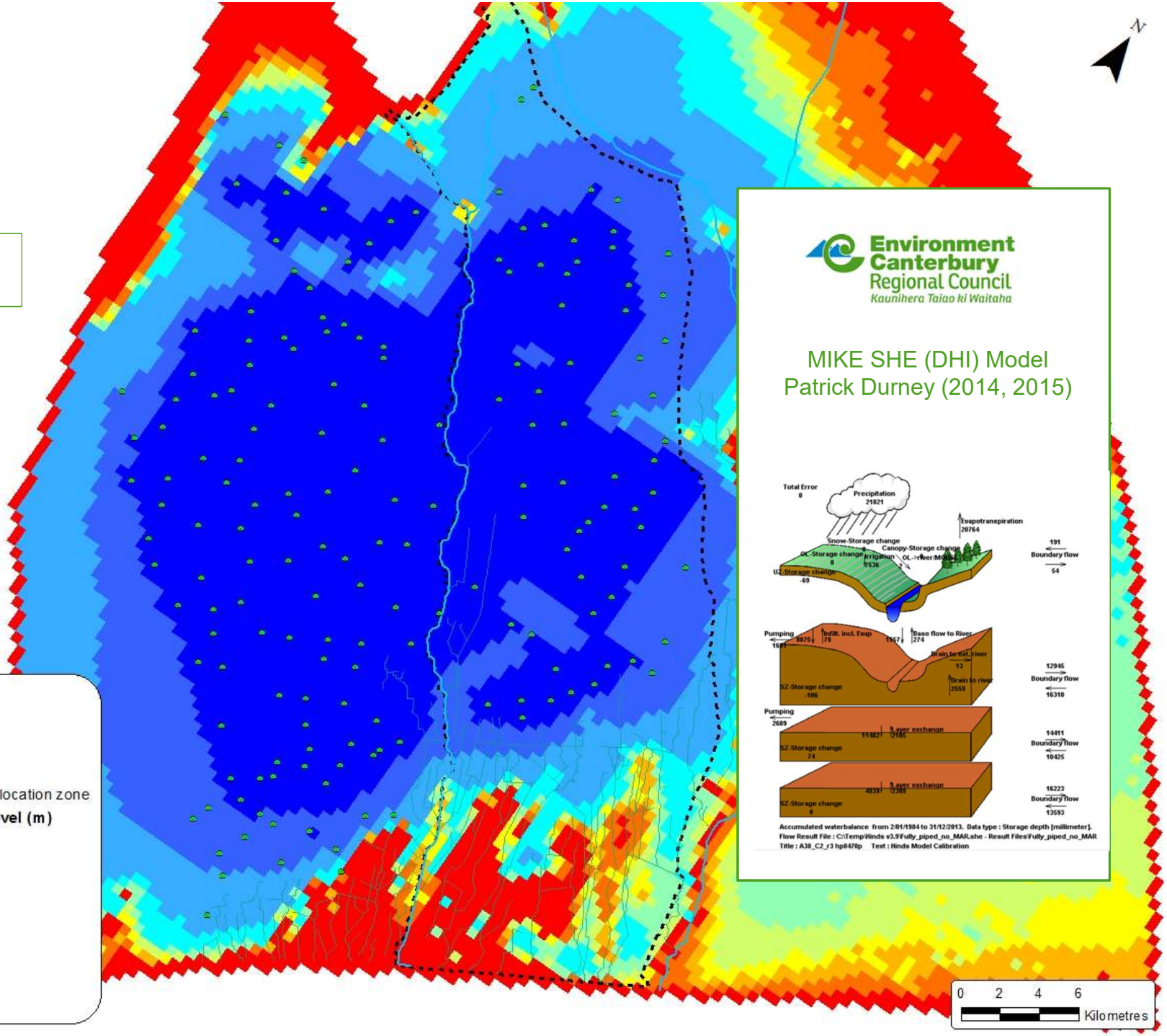


0 2 4 6 Kilometres

Ground Water Replenishment Scheme Modelling

10th Year

Model 1200



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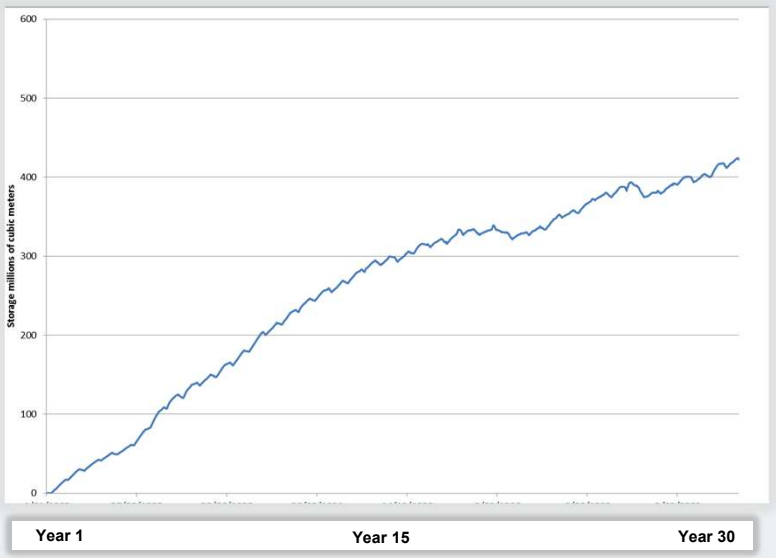
MIKE SHE (DHI) Model
Patrick Durney (2014, 2015)

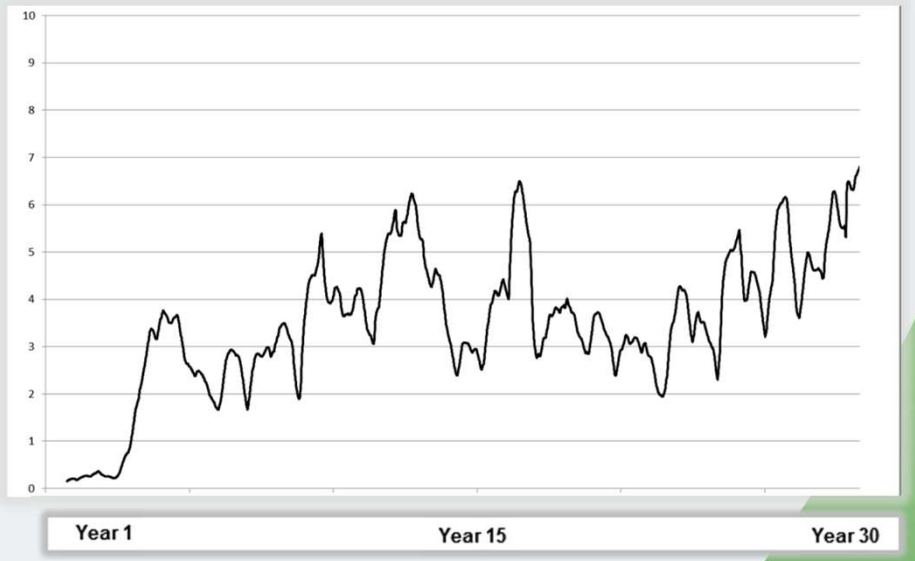
Ground Water Storage & Restored Baseflows

Groundwater storage and restored baseflows

Change in storage (million m^3)



Spring-fed streams baseflows (m^3/s)



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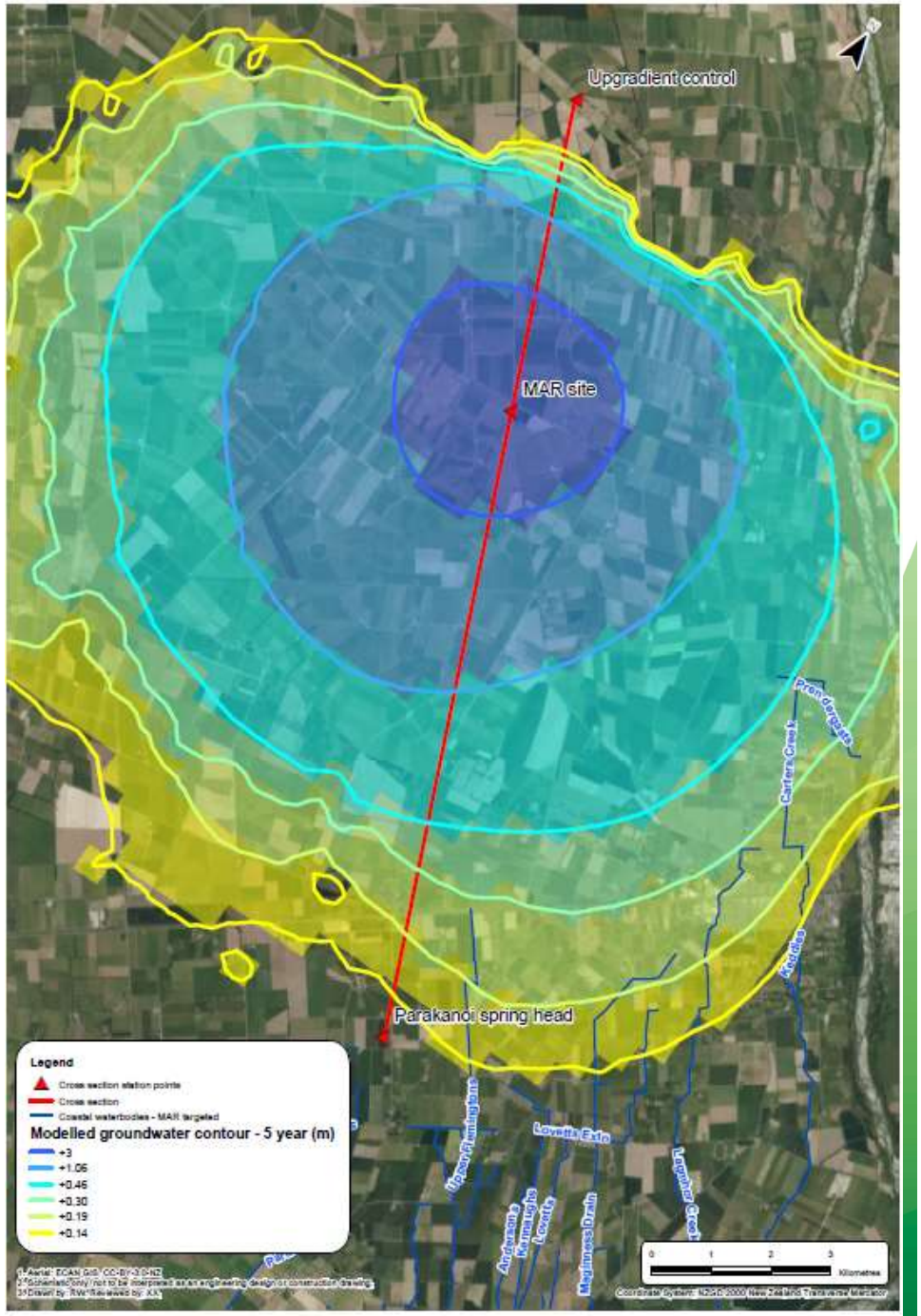
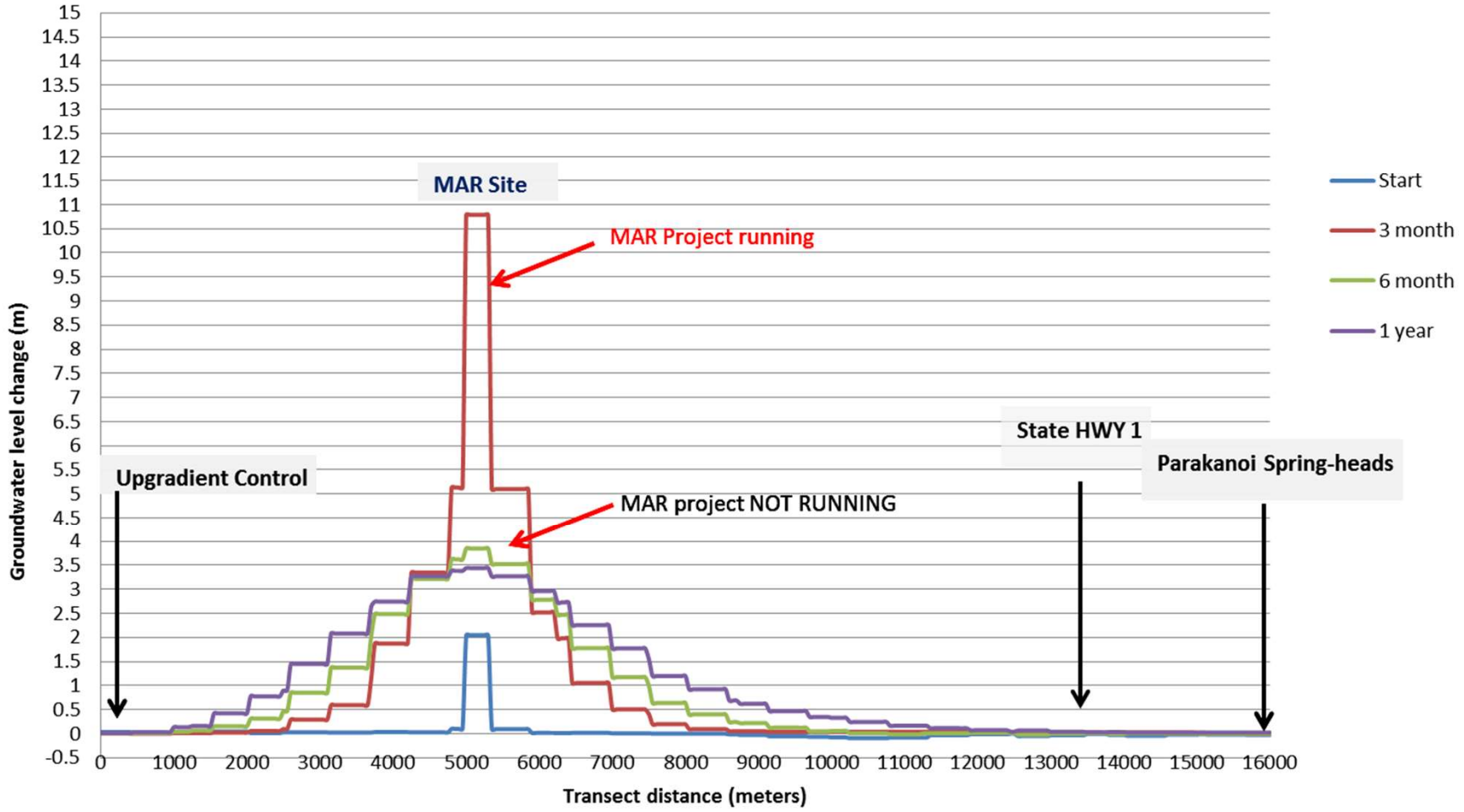
What about the trial then?

- The second model suggests….
- Up to 4.5 m head rise beneath trial site outside of operational season.
- Head will rise to just beneath recharge basin during operation
- Spring fed streams will pick up water and mute head rise down gradient
- There is low risk of groundwater flooding because of the spring fed streams and the managed nature of the trial



Year 1: MIKE SHE Modelling - Hind MAR Trial Transection: Upgradient control - MAR Site - Parakanoi Spring-heads



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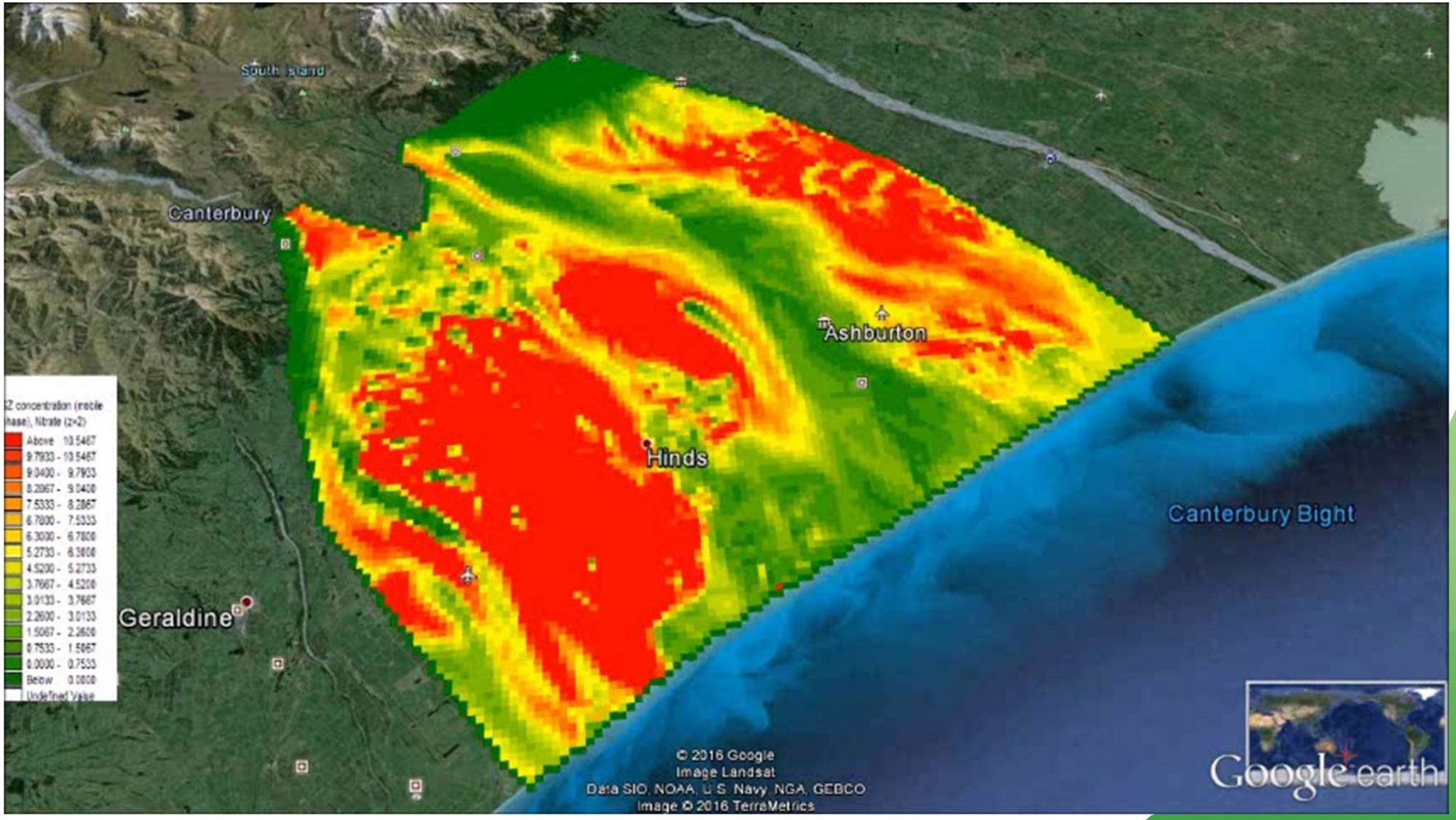

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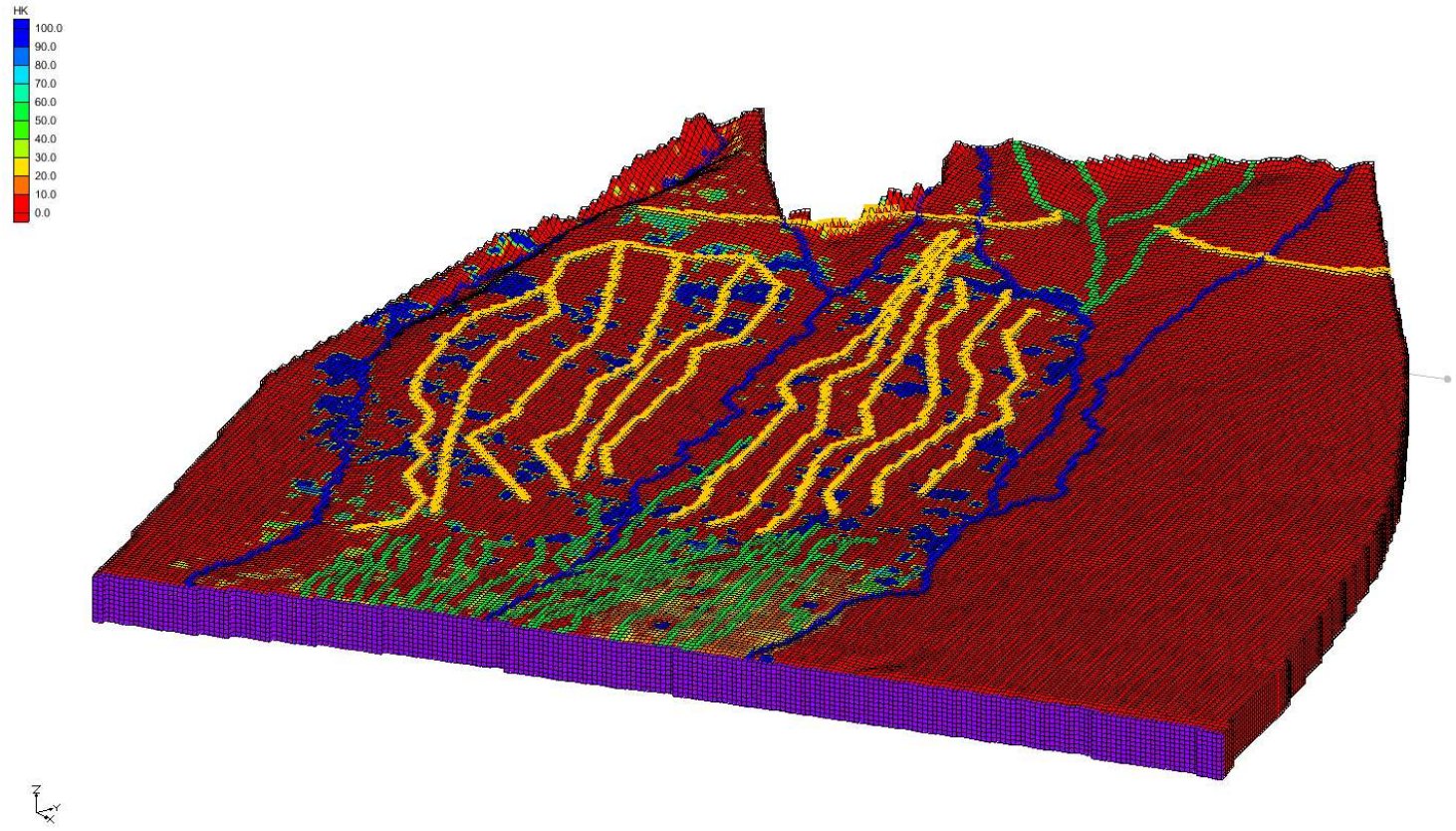
Generation 3



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This is the END!

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Discussion?

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Staff photos before and after modelling the Hinds

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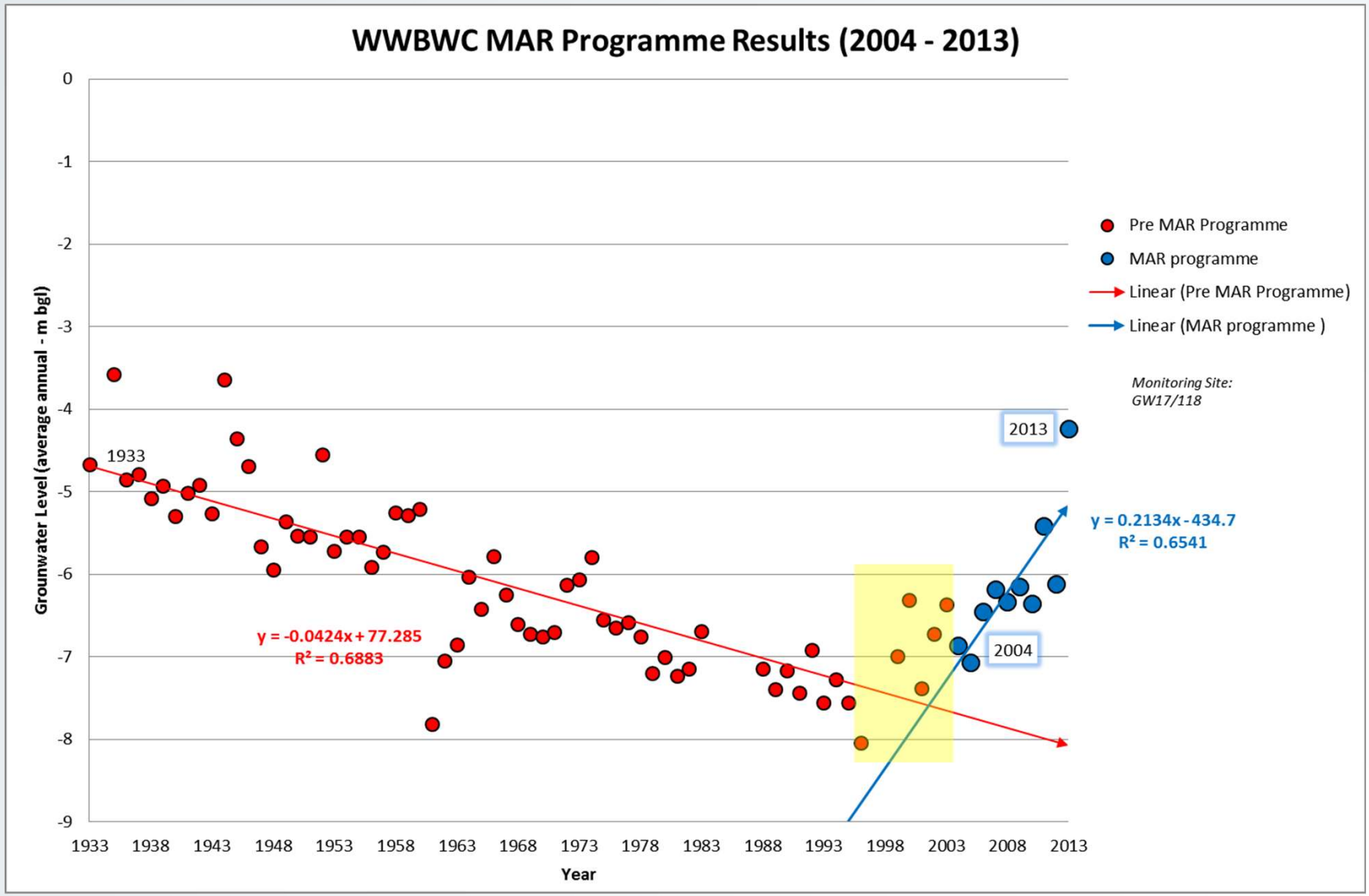
Discussion?


WWBWC MAR Programme Results (2004 - 2013)
Grounwater Level (average annual - m bgl)
Year
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
1933
1938
1943
1948
1953
1958
1963
1968
1973
1978
1983
1988
1993
1998
2003
2008
2013
Pre MAR Programme
MAR programme
Linear (Pre MAR Programme)
Linear (MAR programme)
Monitoring Site:
GW17/118
2013
2004
1933
y = -0.0424x + 77.285
R² = 0.6883
y = 0.2134x - 434.7
R² = 0.6541