

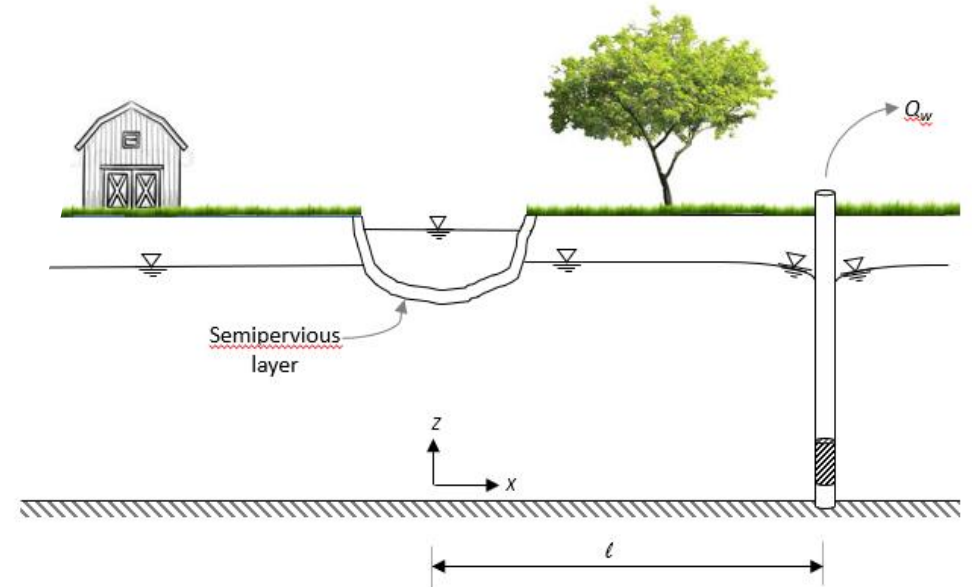
Estimating cumulative catchment streamflow depletion from abstractions

Channa Rajanayaka

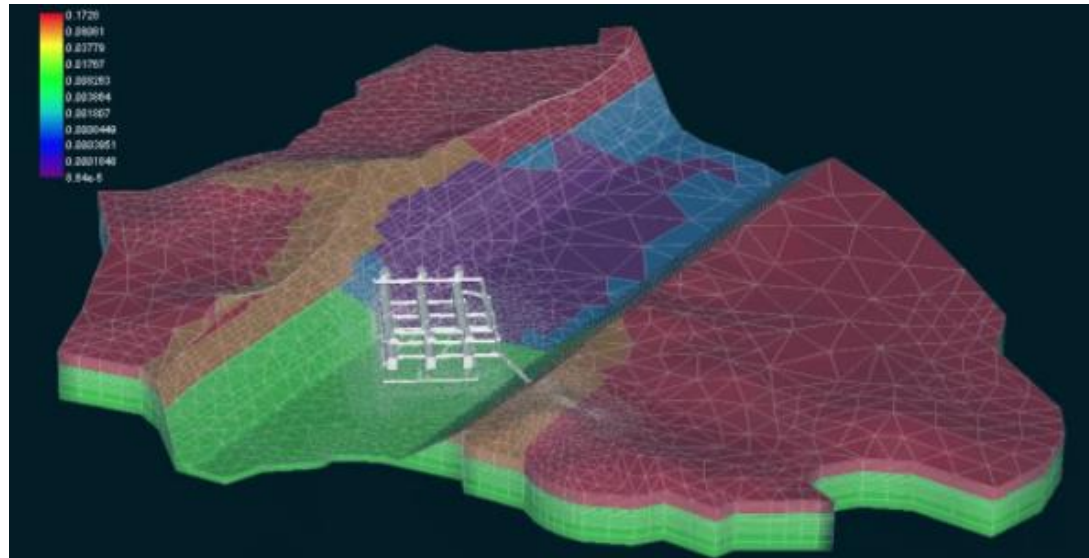
Doug Booker, Jing Yang

Background

- Abstractions alter flow regimes
- Impacts are often assessed in isolation
- Thereby fail to understand cumulative impacts
- New Zealand National Policy Statement for Freshwater management (NPS-FM) directs setting water abstraction limits by catchments



- Can use spatially distributed, high-resolution models (e.g. MODFLOW, FEFLOW)
- But, they are site specific models not transferrable
- They are also data hungry and expensive to develop for everywhere
- Need a nationally consistent methods

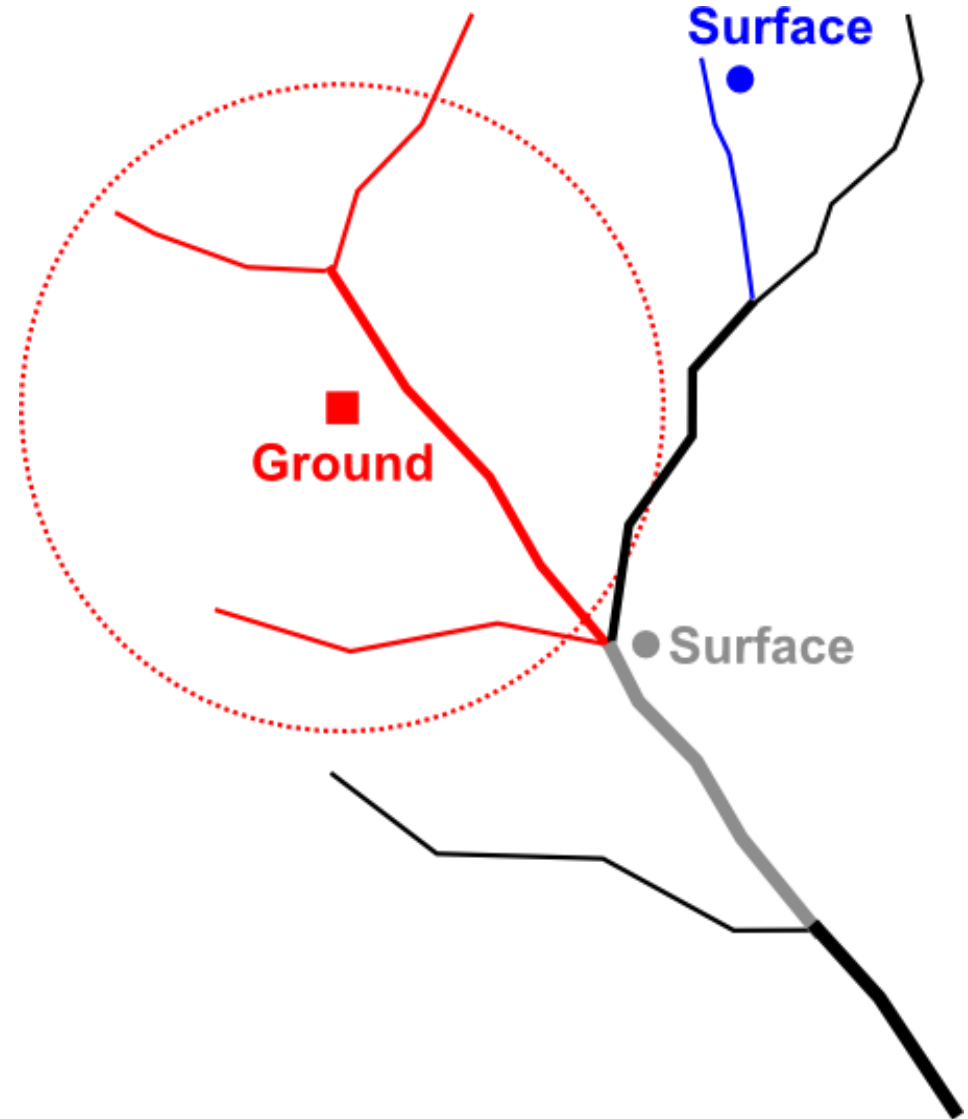


Method

- To estimate cumulative streamflow depletion at given locations of a stream network resulting from both **surface** and **groundwater** abstractions
- Flexible temporal scales (e.g., daily, monthly)
- Used the New Zealand River Environment Classification (REC) as the spatial framework
- Abstraction location - regional council consent information

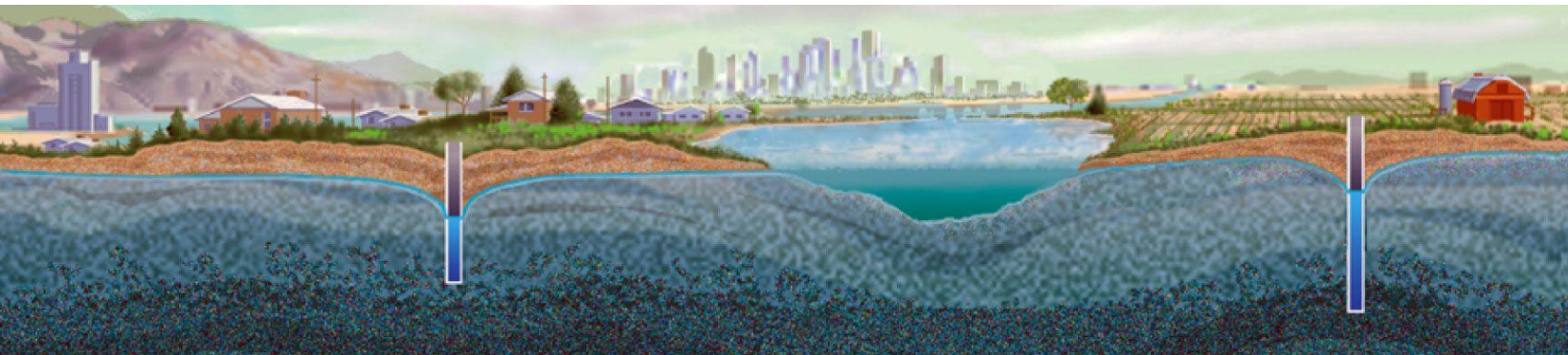
Streamflow Depletion Model

- **Surface water** - directly depletes the segment of the REC river network
- **Groundwater** – depletes all segments on the REC within a 2 km radius
 - distance between well and segment
 - flow - based on the naturalised 7-day MALF
 - length of the segment within 2 km radius



Depletion due to abstracting groundwater

- Depends on:
 - groundwater pumping rate
 - horizontal distance
 - depth
 - hydraulic properties of the aquifers
 - hydraulic properties of confining layers between the pumping aquifer and stream
 - streambed sediments
 - hydraulic gradient between the two water bodies





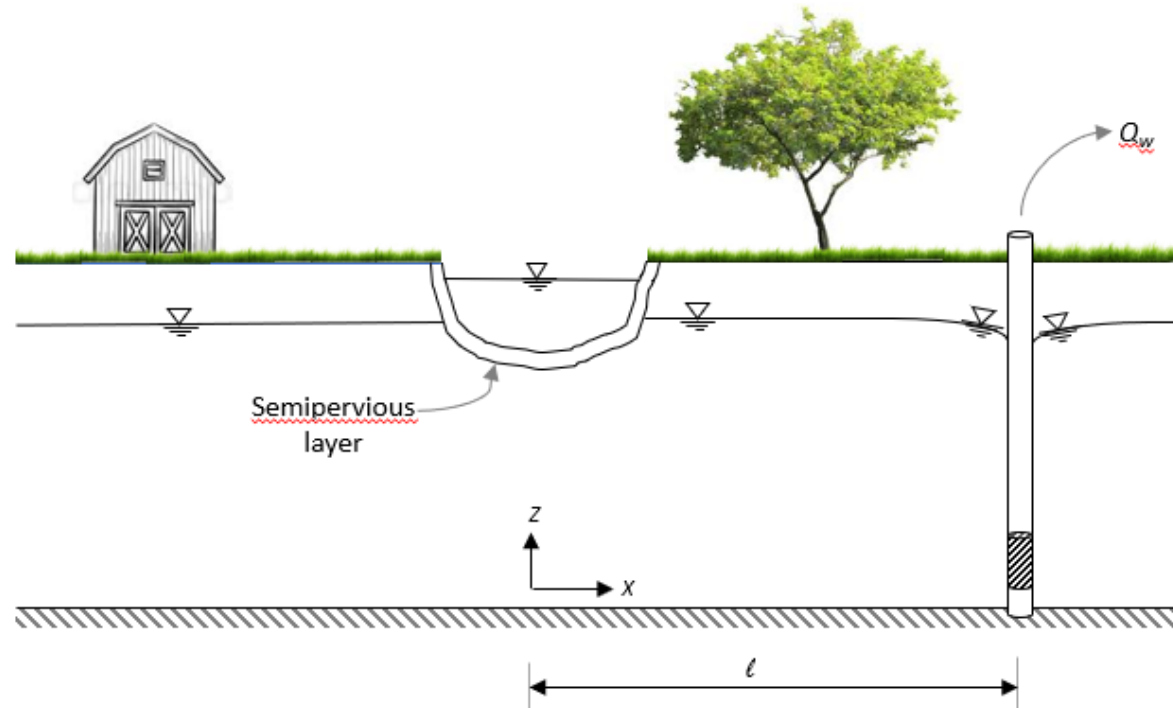
Streamflow depletion model

- Limitations
 - Available data/ info vary considerably
 - Data gaps → uncertainty
- Use two different approaches using two analytical solutions

Streamflow depletion model

One-layer model

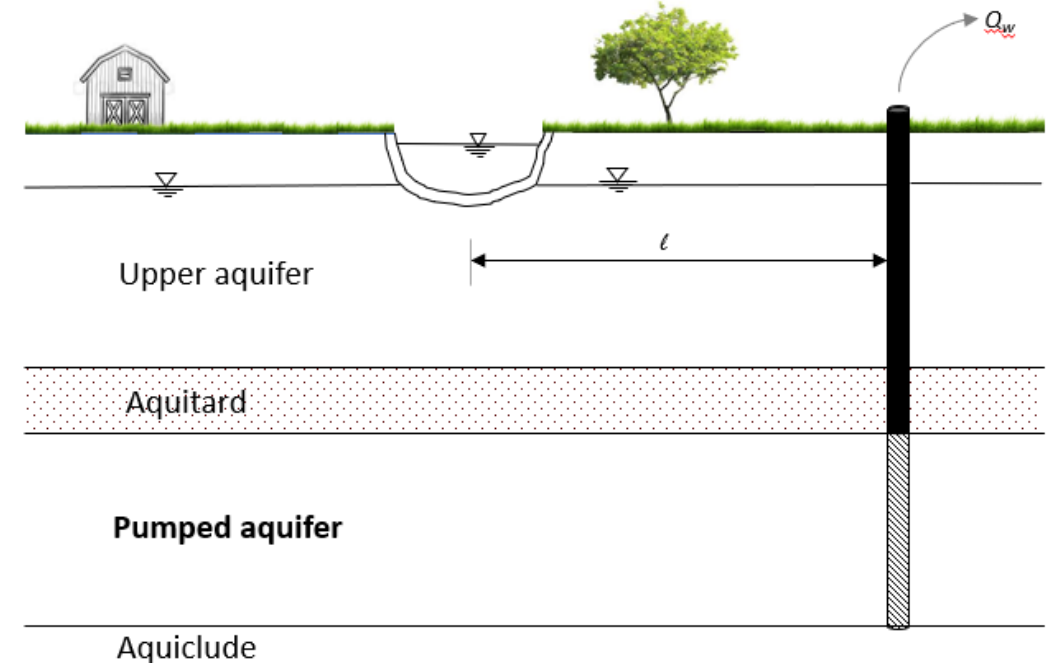
- a single unconfined aquifer
- the screen of the well is hydraulically connected homogeneously to the stream(s)
- Using Jenkins (1968)



Streamflow depletion model

Two-layer model

- based on the screen depth of the groundwater well
- If take is within 0-30 m: approach described in the One-layer model
- If take is below 30 m:
 - pumped from a semi-confined aquifer
 - aquifer overlain by an aquitard and an upper aquifer
 - pumping from the bottom aquifer uses an analytical model developed by Hunt (2009) and Ward and Lough (2011).



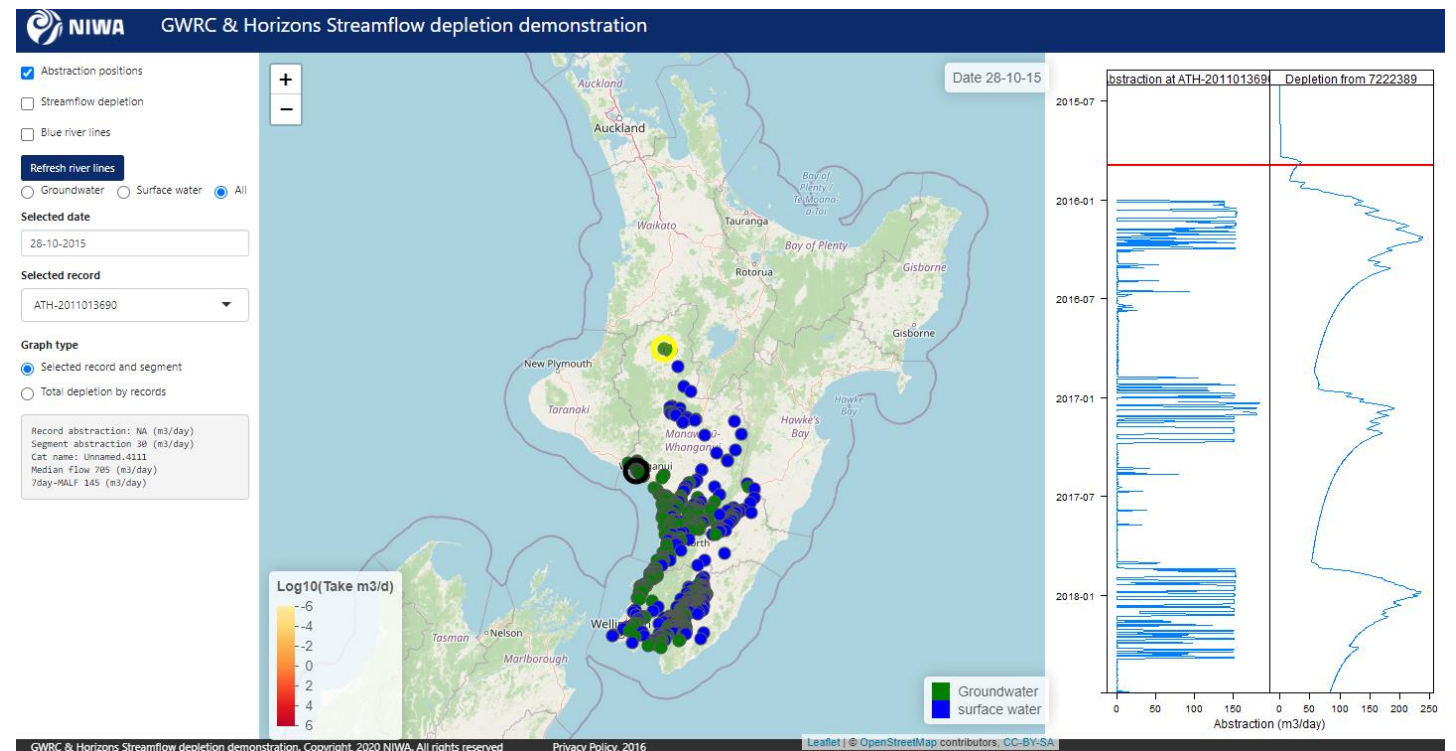
Aquifer parameters

- Use two parameters
 - Transmissivity (T)
 - Specific yield / storativity (S)
- Field test results are used
- But, enough test data are often not available
- Used Random Forest statistical technique to estimate the aquifer parameters at unmeasured locations

Results

- Time series outputs
 - Cumulative stream depletion at any location of the river network
- An interactive web app

Interactive web app



☒ Abstraction positions

☐ Streamflow depletion

☐ Blue river lines

Refresh river lines

☐ Groundwater ☐ Surface water ☒ All

Selected date

28-10-2015

Selected record

ATH-2011013690

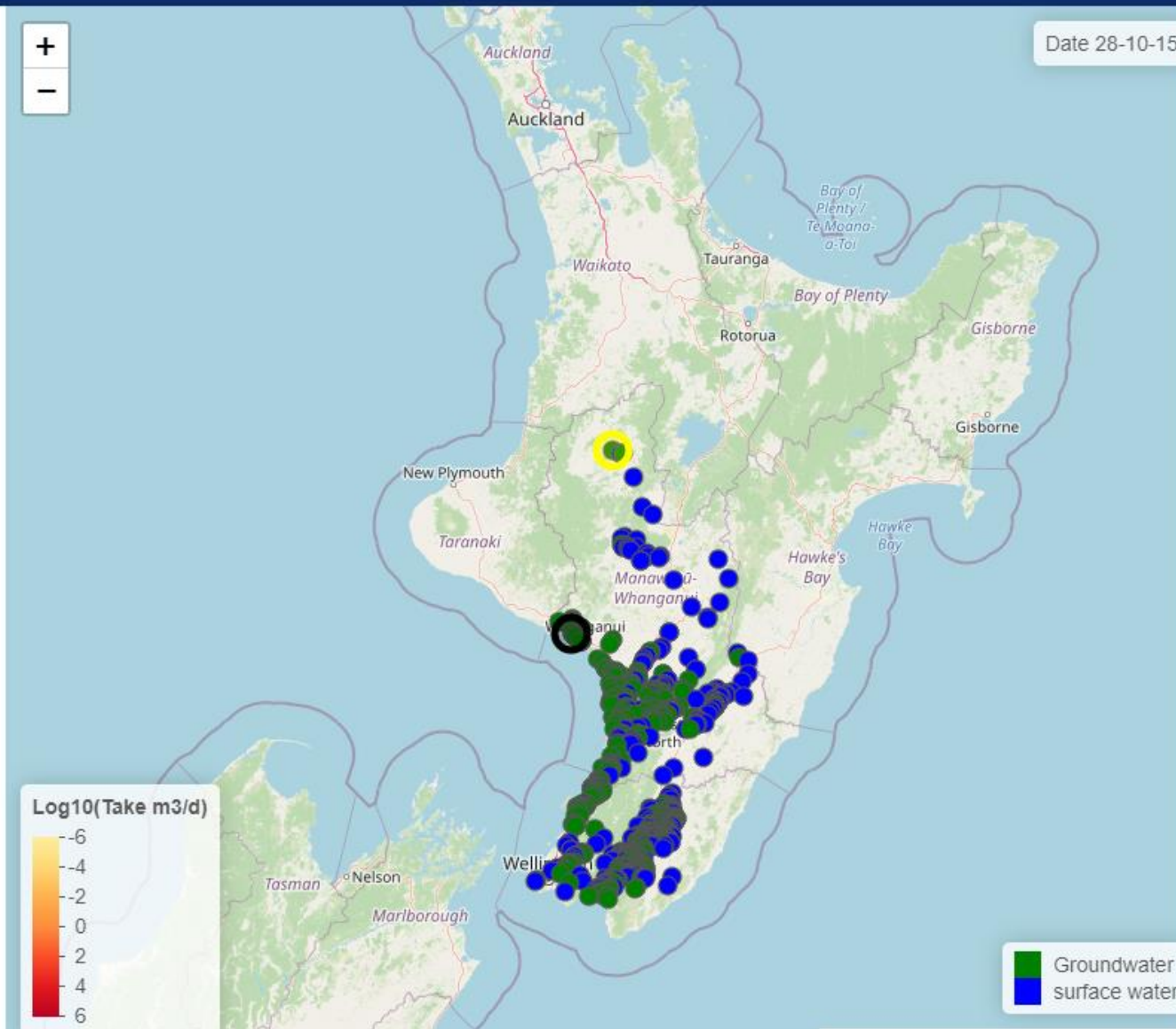
Graph type

☒ Selected record and segment

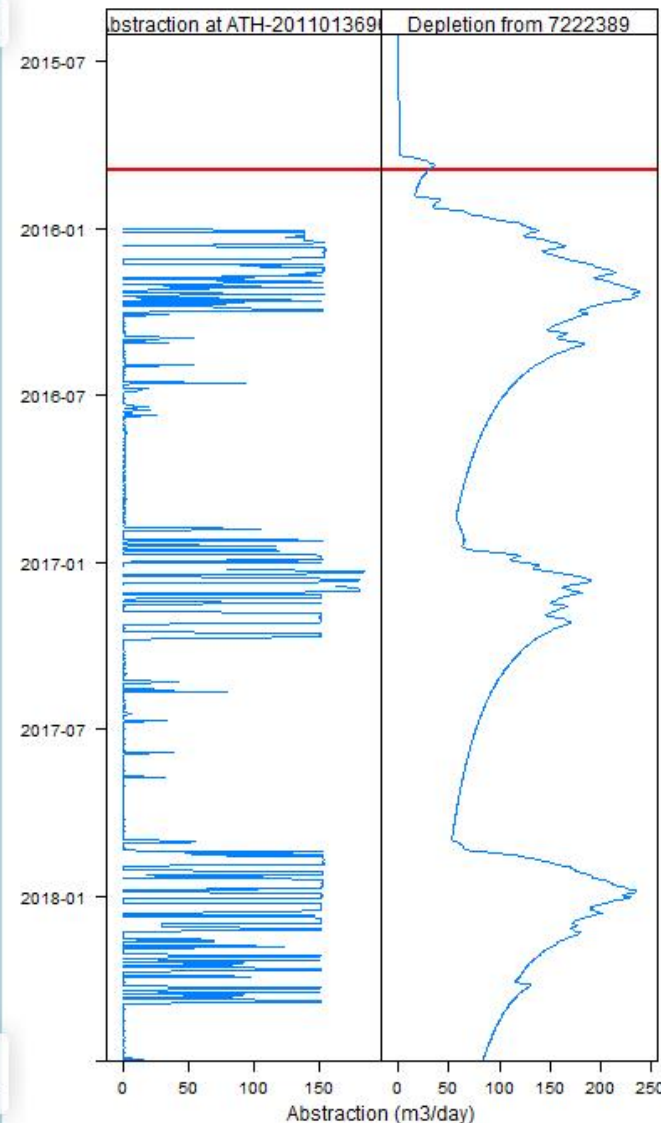
☐ Total depletion by records

Record abstraction: NA (m3/day)
Segment abstraction 30 (m3/day)
Cat name: Unnamed.4111
Median flow 705 (m3/day)
7day-MALF 145 (m3/day)

Log10(Take m3/d)



Date 28-10-15





GWRC & Horizons Streamflow depletion demonstration

☒ Abstraction positions

☐ Streamflow depletion

☒ Blue river lines

Refresh river lines

☒ Groundwater ☐ Surface water ☐ All

Selected date

28-10-2015

Selected record

BQ34/0002

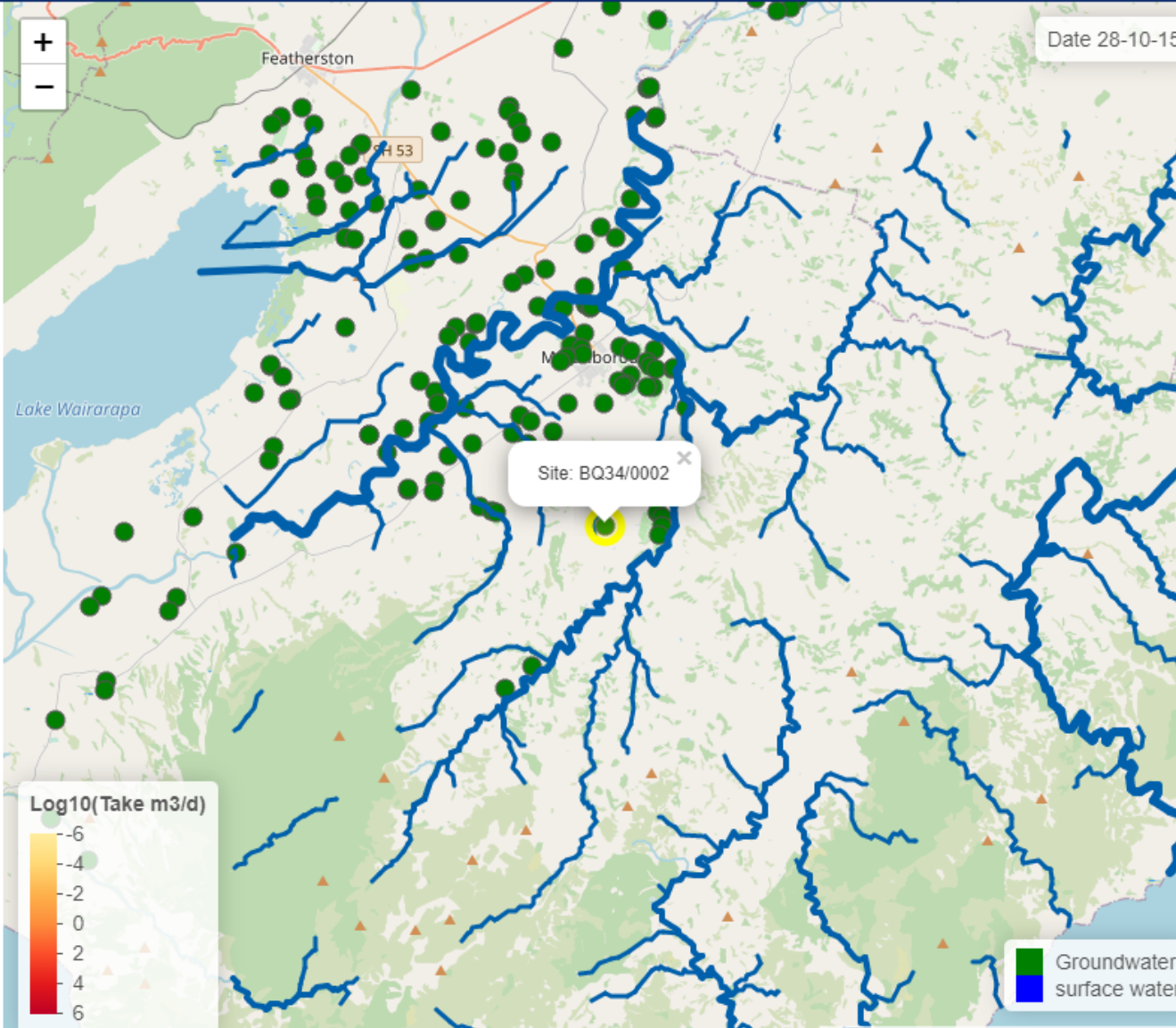
Graph type

☒ Selected record and segment

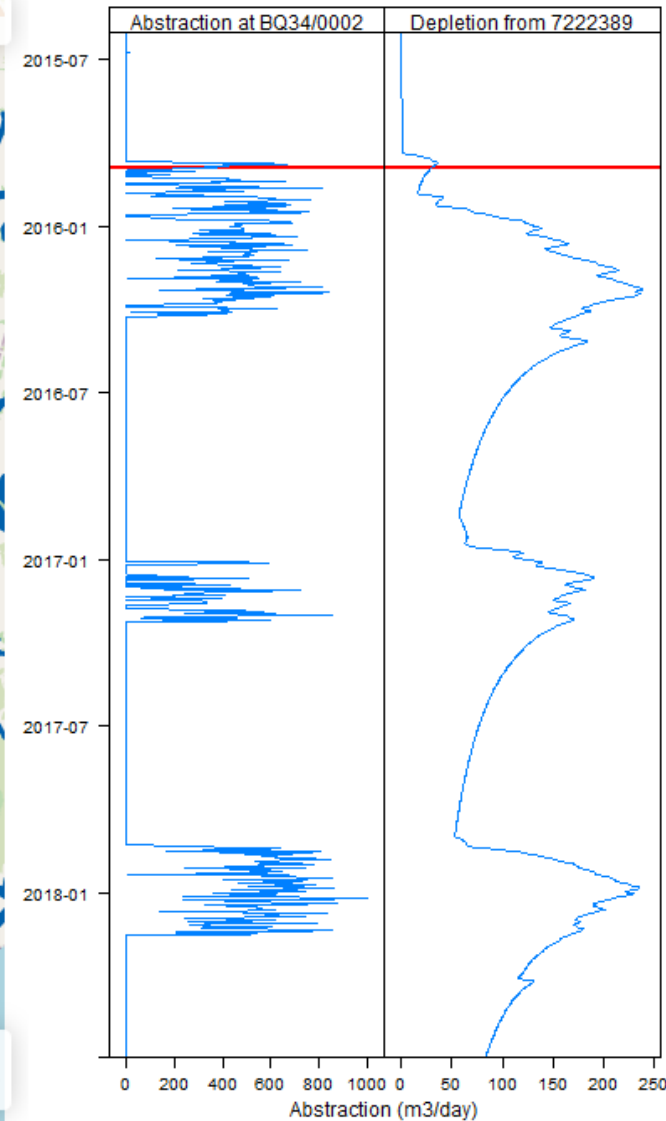
☐ Total depletion by records

Record abstraction: 227 (m3/day)
Segment abstraction 30 (m3/day)
Cat name: Unnamed.4111
Median flow 705 (m3/day)
7day-MALF 145 (m3/day)

Log10(Take m3/d)



Date 28-10-15



☒ Abstraction positions

☐ Streamflow depletion

☒ Blue river lines

Refresh river lines

☐ Groundwater ☒ Surface water ☐ All

Selected date

01-05-2012

Selected record

X1198

Graph type

☐ Selected record and segment

☒ Total depletion by records

Record abstraction: 0 (m3/day)
Segment abstraction 89 (m3/day)
Cat name: Tairua River
Median flow 340316 (m3/day)
7day-MALF 104080 (m3/day)

+

-

Date 01-05-12

Log10(Take m3/d)



Groundwater
surface water

3042631

50

100

150

200

Streamflow depletion (m3/day)

Upstream records

X1207
X1208
X1209
X1378
X1385
X1248
X1247

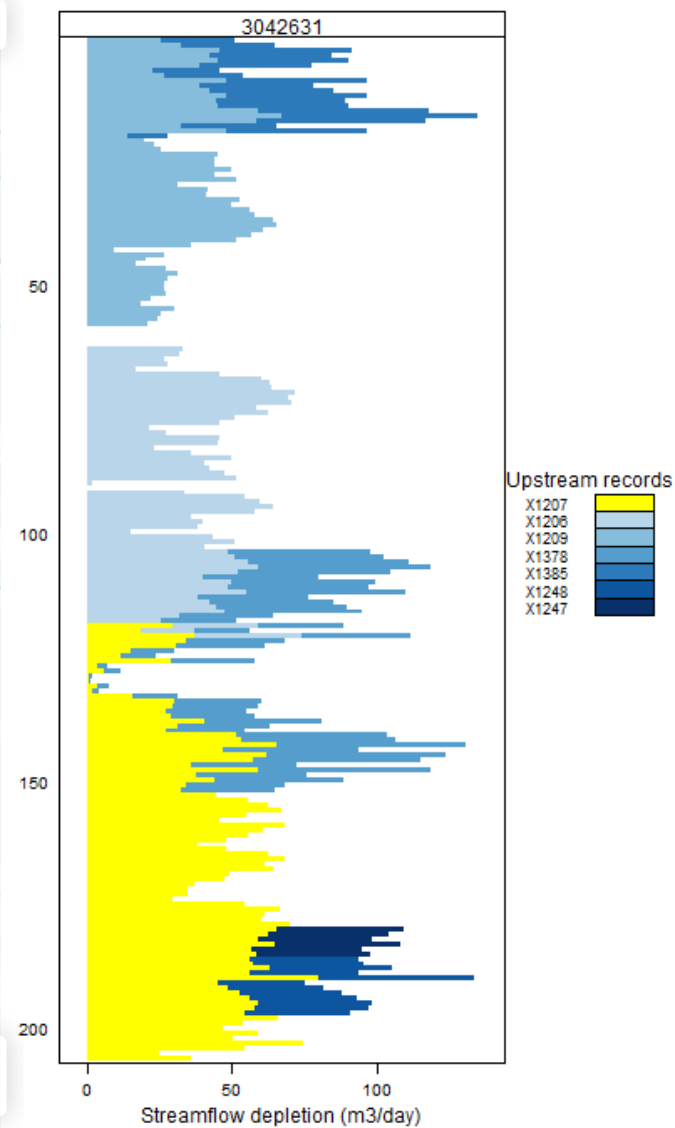
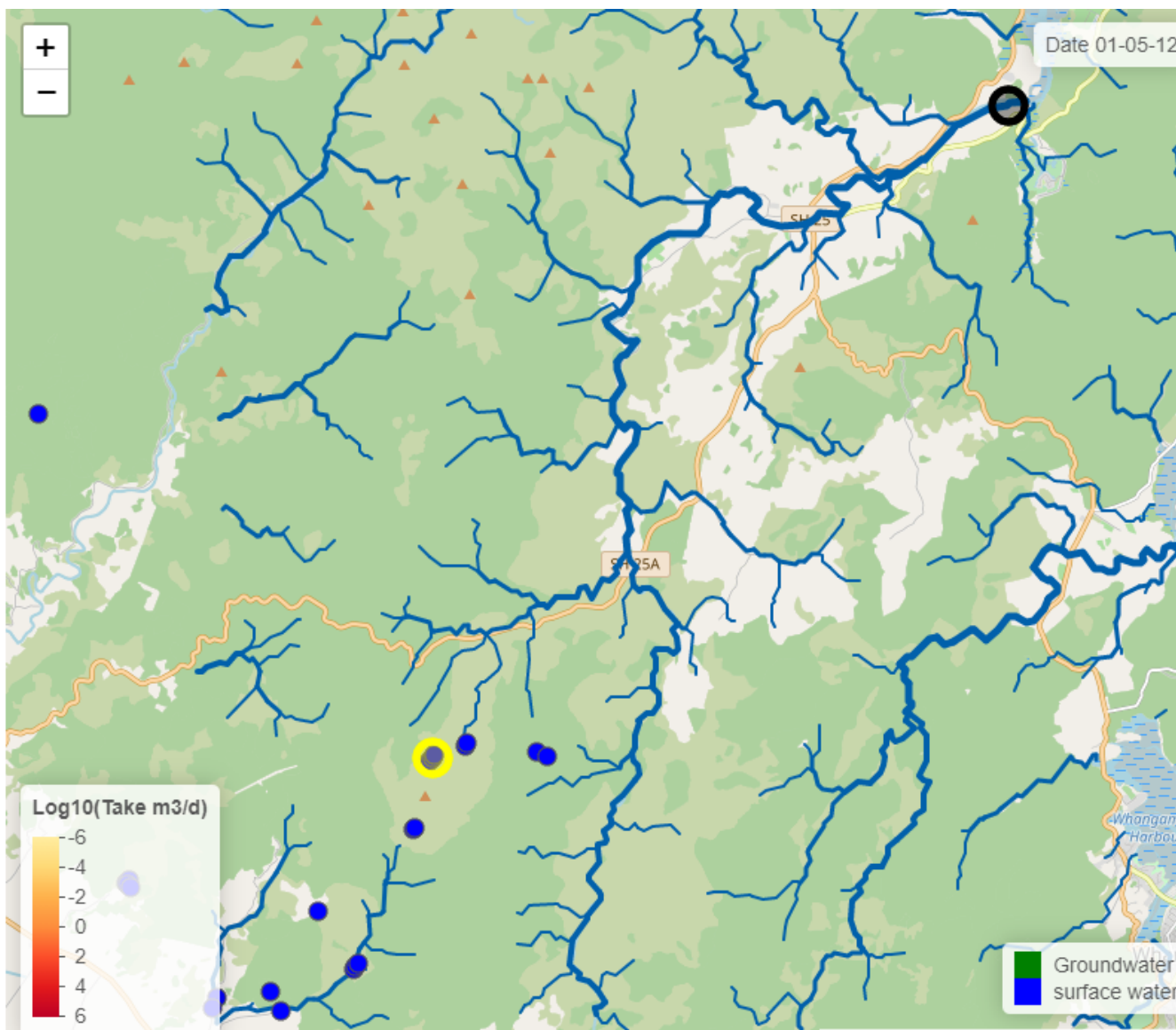
☒ Abstraction positions
☐ Streamflow depletion
☒ Blue river lines
 Refresh river lines
☐ Groundwater ☒ Surface water ☐ All

Selected date
 01-05-2012

Selected record
 X1207

Graph type
☐ Selected record and segment
☒ Total depletion by records

Record abstraction: 44 (m3/day)
 Segment abstraction 89 (m3/day)
 Cat name: Tairua River
 Median flow 340316 (m3/day)
 7day-MALF 104080 (m3/day)



Acknowledgement

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Thank you

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