NIWA
Taihoro Nukurangi

# Hydrological model for Ruamahanga

Christian Zammit, Jing Yang

# Surface Hydrological model

1. Aim of the model
2. Surface water model TopNet
3. Input data
4. Calibration/Validation
5. Regionalisation
6. Limitations

NIWA
Taihoro Nukurangi

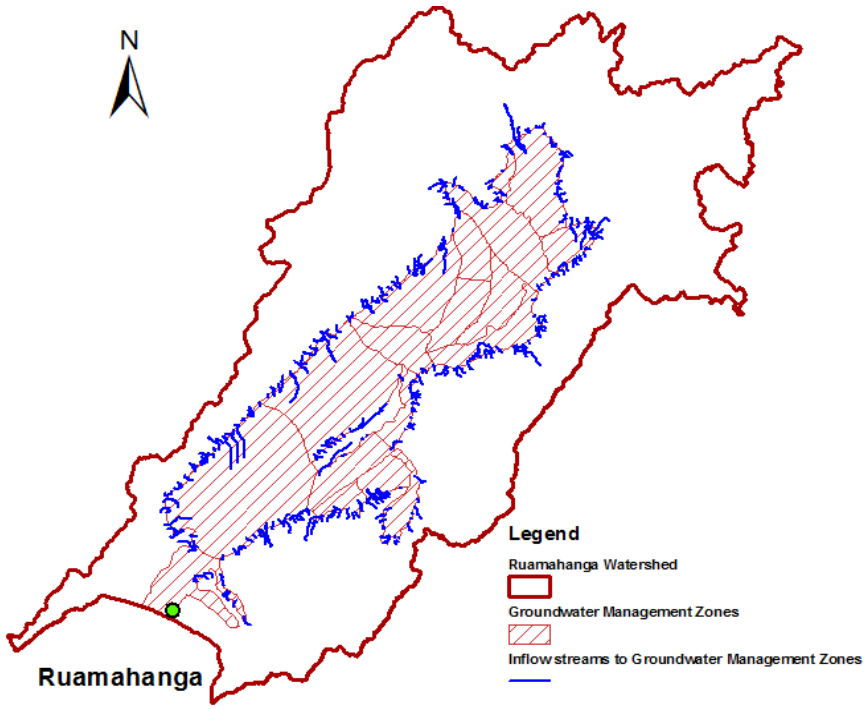
# Surface Hydrological model

1. Aim of the model
2. Surface water model TopNet
3. Input data
4. Calibration/Validation
5. Regionalisation
6. Limitations

NIWA
Taihoro Nukurangi

# Aim of surface water model

- To provide surface water inflows to the river system discharging to the Ruamahanga groundwater zone




297 discharge entry points
Daily time serie 1972-2014

Assumptions:

- Upstream catchment processes driven by surface water and snow
- Total flow little influenced by groundwater discharge

- Two steps process:
  - Calibration to existing gauging station
  - Parameter regionalisation to all catchments



NIWA
Taihoro Nukurangi

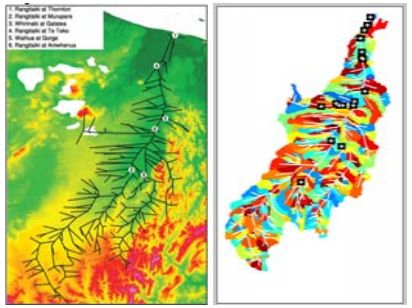
# Surface Hydrological model

1. Aim of the model
2. Surface water model TopNet
3. Input data
4. Calibration/Validation
5. Regionalisation
6. Limitations

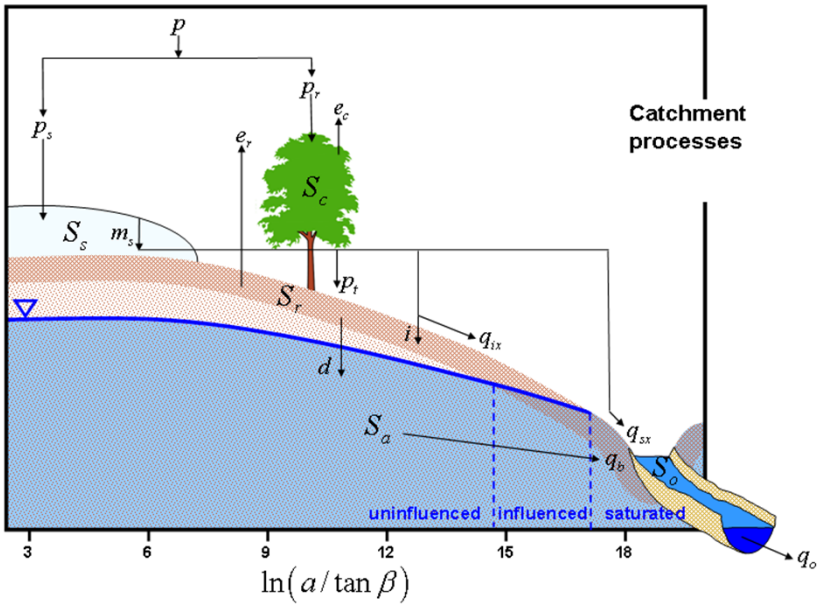
NIWA
Taihoro Nukurangi

# TopNet: Semi-distributed Hydrological Model

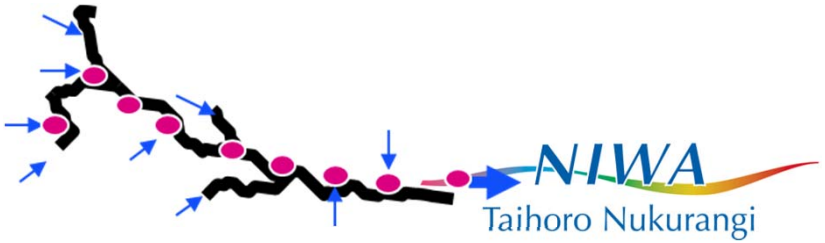
1. Define stream network and subcatchments



2. Water balance is simulated within each subcatchment (including snow, evapo-transpiration, surface and subsurface flows)




3. Flows from each subcatchment are routed through the river network

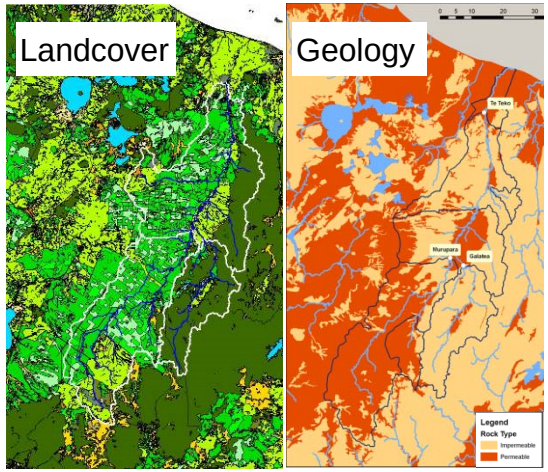


NIWA
Taihoro Nukurangi

# TopNet: Semi-distributed Hydrological Model

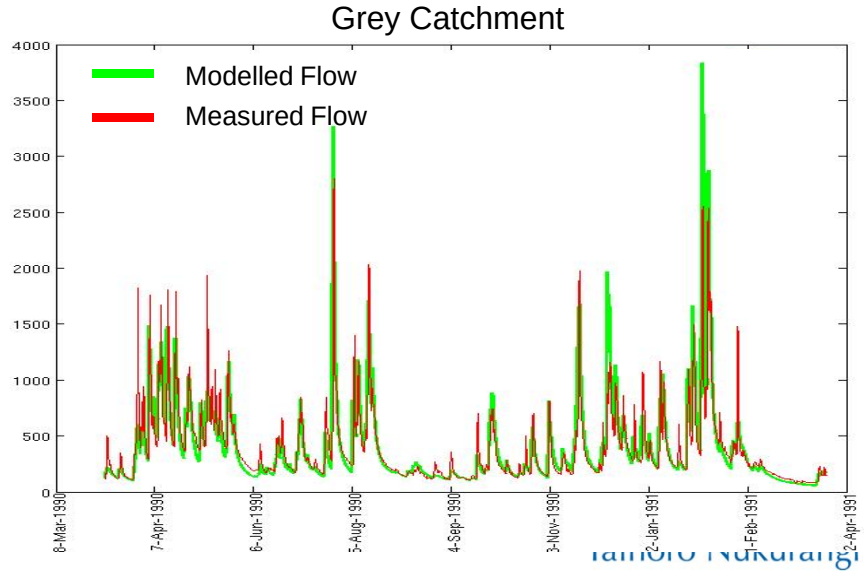
## Data Needs

- Time series of climate data (Rainfall, temperature, climate)
- GIS data (landcover, geology, soils, topography)
- Data is available nationally, can be updated using Regional Councils datasets (eg climate) etc..




## Outputs

- Integrated: Hourly river flow at every river reach
- “Catchment Production” : hourly time series of many hydrological variables (e.g. soil moisture)
- Naturalised discharge



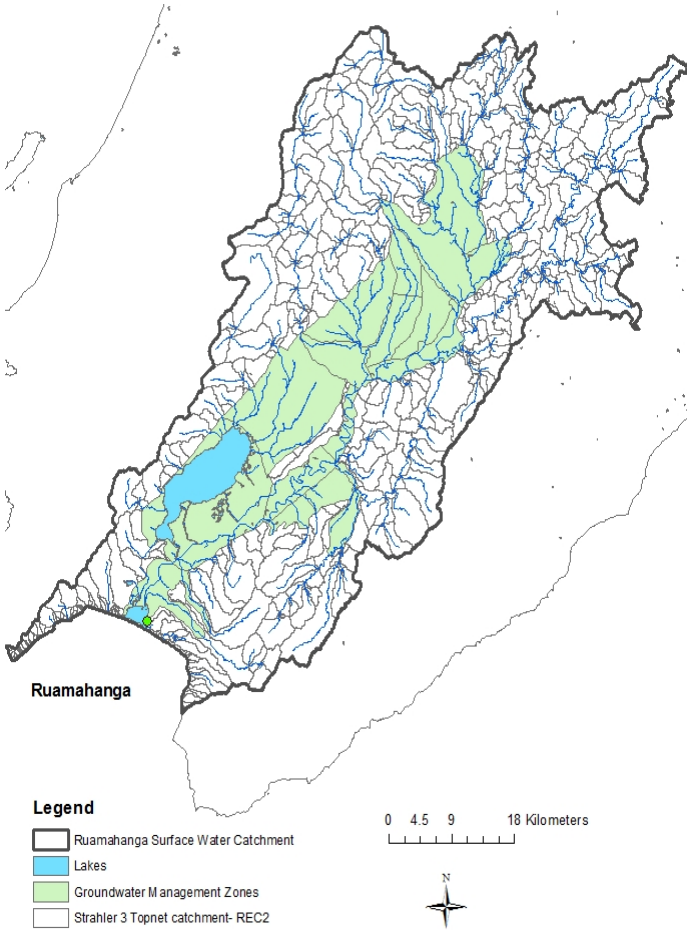
# Surface Hydrological model

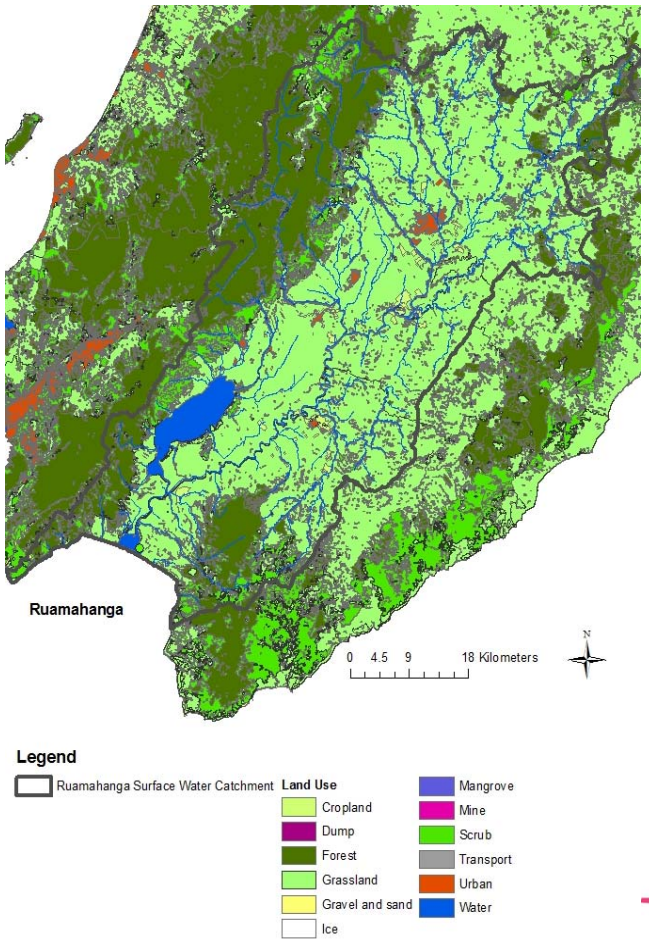
1. Aim of the model
2. Surface water model TopNet
3. Input Data
4. Calibration/Validation
5. Regionalisation
6. Limitations

NIWA
Taihoro Nukurangi

# Input Data

- Spatial
  - 30 m national DEM
  - Soil related information FSL, Land use LCDB v2

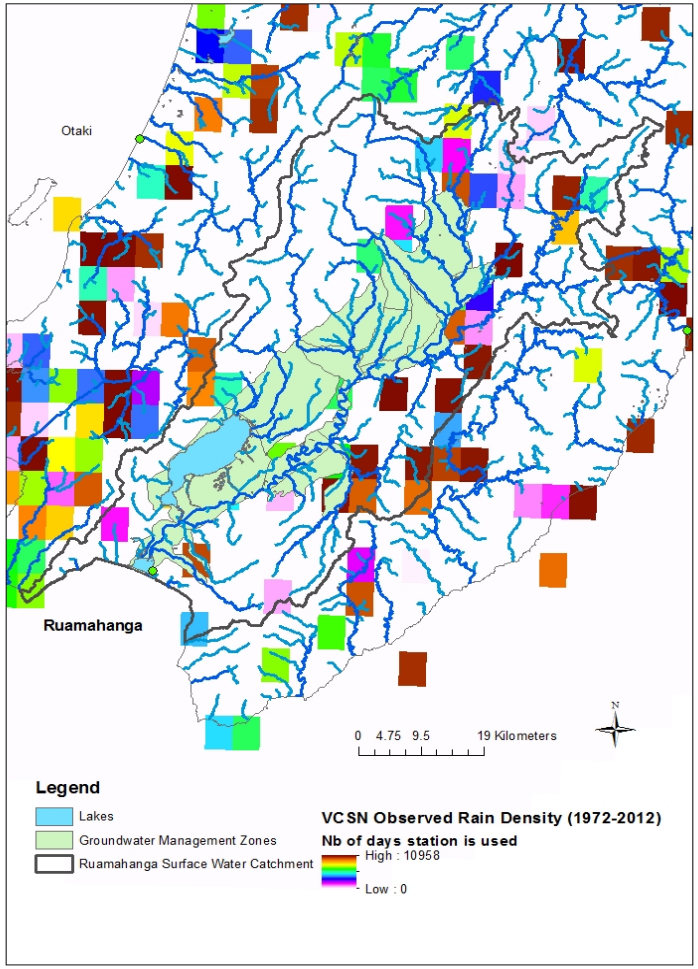


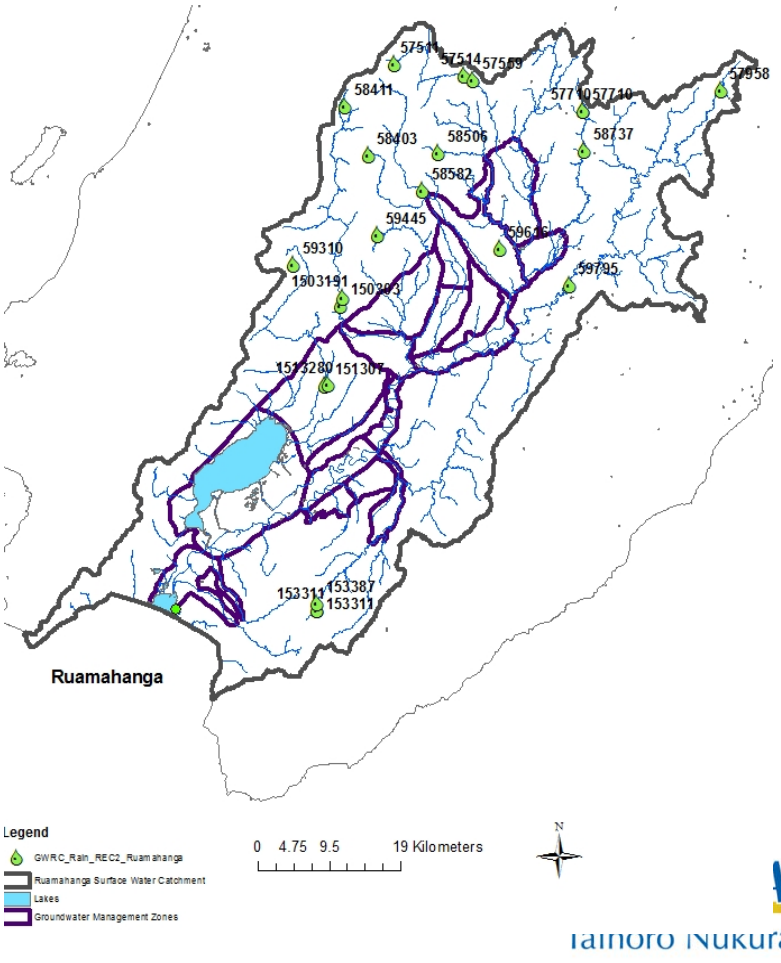




NIWA
Taihoro Nukurangi

# Input Data

- Climate
  - VCSN (based on CLIdB) daily grid climate information : 1972-2015
  - Does not use GWRC precipitation network



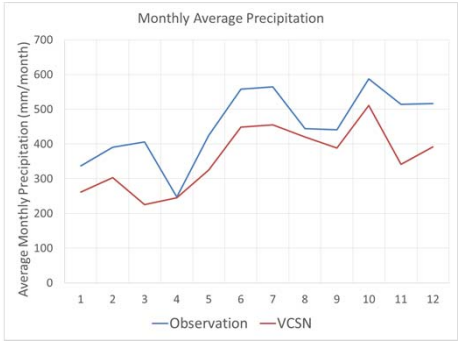



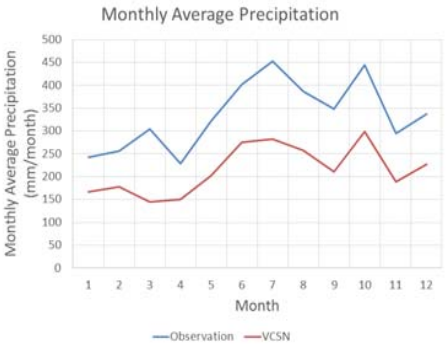

Tāngaroa Nukurangi

# Input data

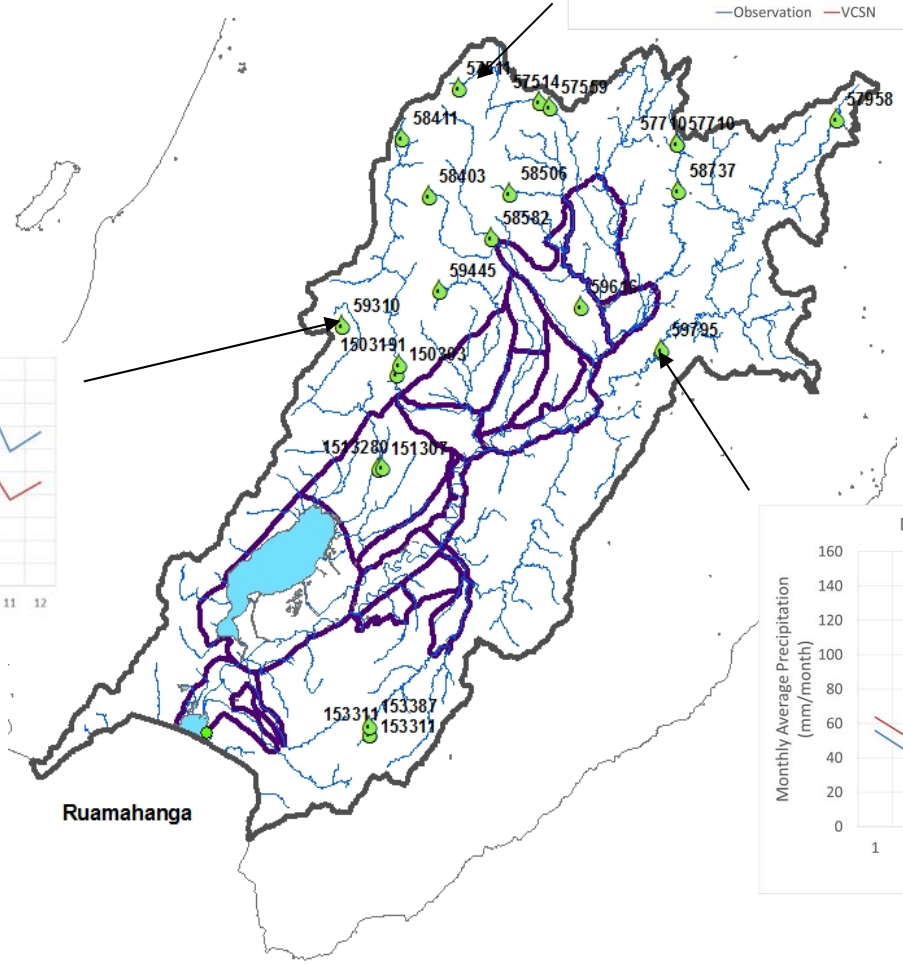
- Climate

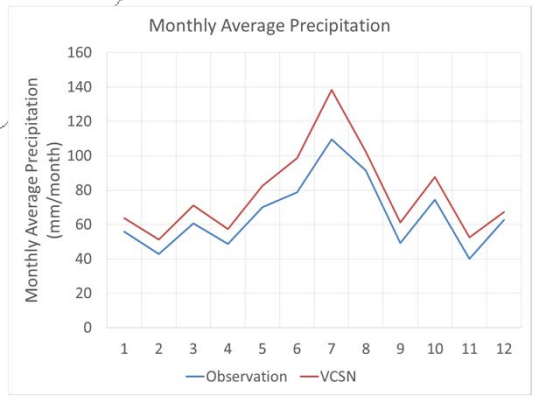
Ruamahanga




Tauherenikau



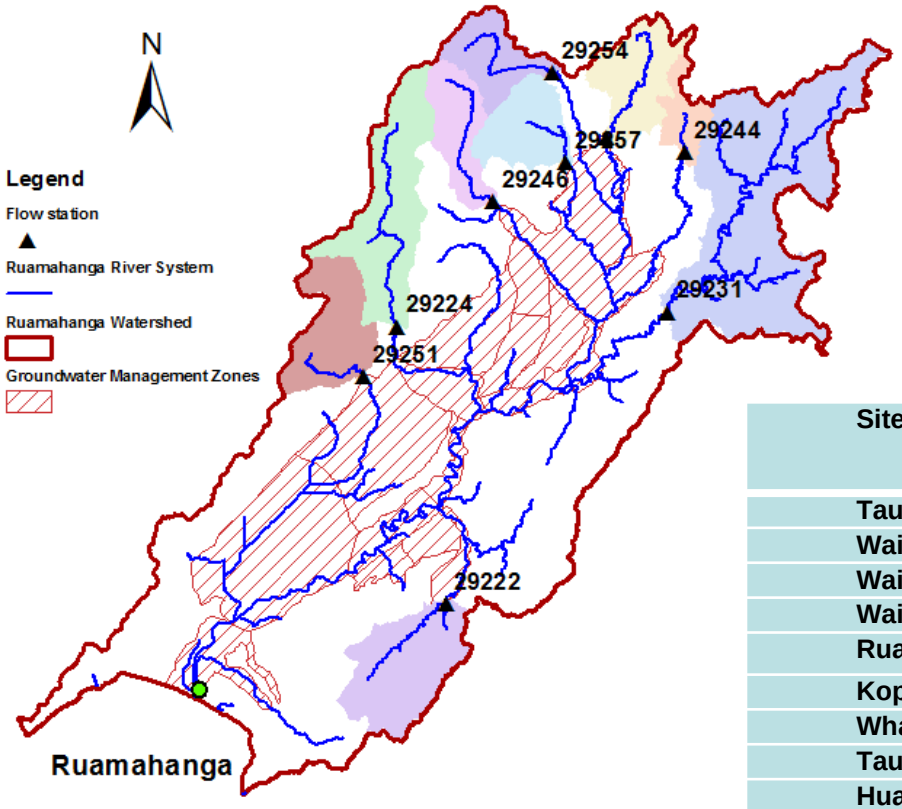

NIWA
Taihoro Nukurangi

# Surface Hydrological model

1. Aim of the model
2. Surface water model TopNet
3. Input Data
4. Calibration/Validation
5. Regionalisation
6. Limitations

NIWA
Taihoro Nukurangi

# Calibration-Validation




- 9 locations
- Strahler 1 (catch area ~0.5 km$^2$)
- Calibration 2001-2003
- Validation 2003-2010

| Site | Tideda ID | Area (km$^2$) |
|---|---|---|
| Tauherenikau | 29251 | 114.21 |
| Waiohine | 29224 | 177.89 |
| Waingawa | 29246 | 76.50 |
| Waipoua | 29257 | 79.84 |
| Ruamahanga | 29254 | 78.70 |
| Kopuaranga | 29230 | 100.63 |
| Whangaehu | 29244 | 36.80 |
| Taueru | 29231 | 391.19 |
| Huangarua | 29222 | 139.23 |

- Calibration for water resource ie reproduction of low flow conditions
- Non completed analysis

NIWA
Taihoro Nukurangi

# Calibration-Validation

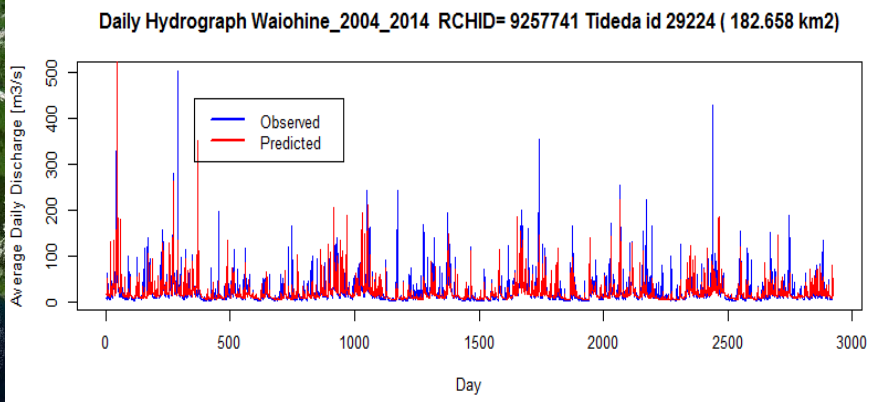
The accuracy of the calibration/validation process is estimated using the following hydrological criteria and statistics:

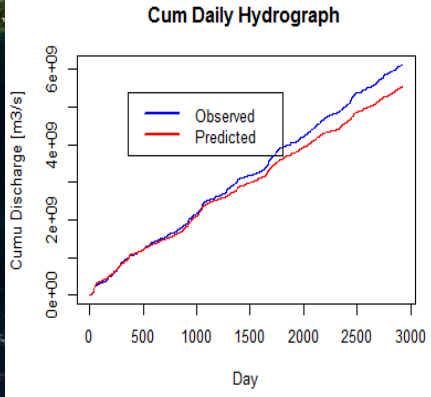
- NS efficiency calculated on discharge (NS- high flow) and **logarithm of the discharge** (NS Log- low flow- Jan to March).
- Total water balance of the upstream catchment
- Daily flow duration curve (FDC) (distribution of the flows) and cumulative flow (systematic bias)
- Average monthly flows (seasonality of the water balance)
- 7 days Mean Annual Low Flow (7days MALF) (low flow conditions)
- Monthly flow deciles (potential skewness towards specific flow conditions).

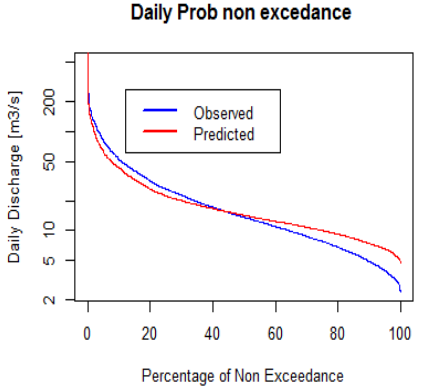
NIWA
Taihoro Nukurangi

# Calibration-Validation- West

## Waiohine catchment




## Efficiencies

| Location | Calibration (2001-2003) | | Validation (2004-2012) | |
|---|---|---|---|---|
| | NSlog | NS | NSlog | **NS** |
| **Waiohine at Gorge** | 0. 554 | 0.372 | 0.784 | 0.501 |

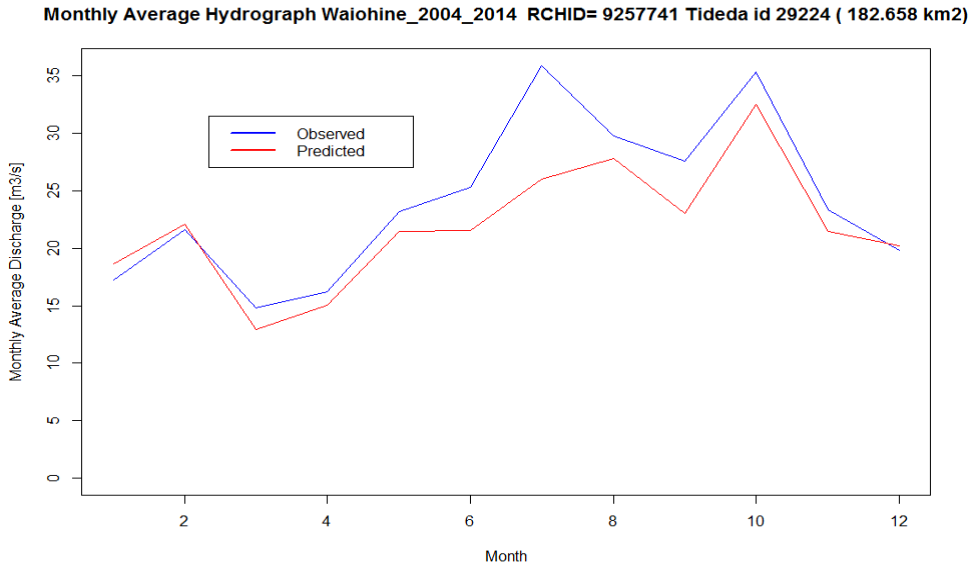
## Water Balance

| Annual Average Flux | TopNet (2004-2012) (mm/yr) | GWRC (2004-2012) (mm/yr) |
|---|---|---|
| **Mean annual precipitation** | 4297 | NA |
| **Mean annual evaporation** | 249 | NA |
| **Mean annual runoff** | 4009 | 4158 |

NIWA
Taihoro Nukurangi

# Calibration-Validation- West

Waiohine catchment



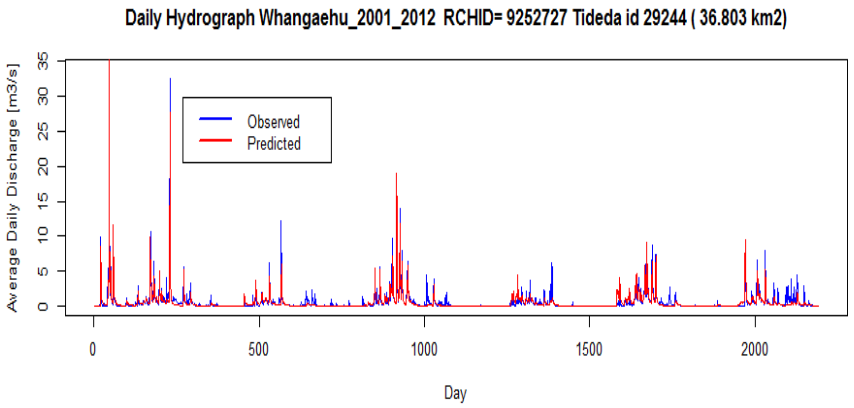

| Annual Average hydrological characteristics | TopNet (2004-2012) (m3/s) | GWRC (2004-2012) ($m^3/s$) | GWRC (1954-2015) ($m^3/s$) |
|---|---|---|---|
| **Mean Annual Flow** | 21.592 | 23.439 | 24.510 |
| **7 days Mean Annual Low Flow** | 6.000 | 3.603 | 7.601 |

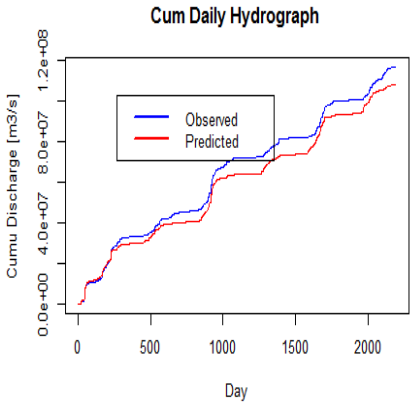
- Hydrological processes and characteristics simulated
- Lower than expected evaporation
- Low flows overpredicted- Underestimation of peaks
- Underprediction discharge during winter months

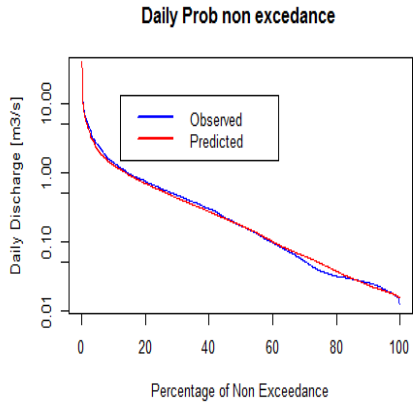
NIWA
Taihoro Nukurangi

# Calibration-Validation- East

## Whangaehu catchment




### Efficiencies

| Location | Calibration (2001-2003) | | Validation (2004-2012) | |
|---|---|---|---|---|
| | NSlog | NS | NSlog | **NS** |
| **Whageheu at Waihi** | 0.726 | 0.678 | 0.722 | 0.755 |

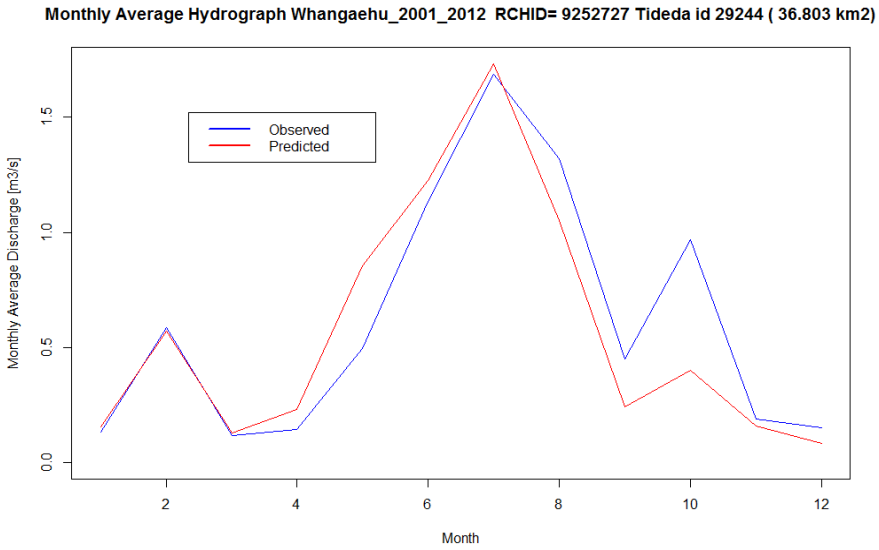
### Water Balance

| Annual Average Flux | TopNet (2004-2012) (mm/yr) | GWRC (2004-2012) (mm/yr) |
|---|---|---|
| **Mean annual precipitation** | 1410 | NA |
| **Mean annual evaporation** | 734 | NA |
| **Mean annual runoff** | 636 | 509 |

NIWA
Taihoro Nukurangi

# Calibration-Validation- West

Whangaheu catchment




| Annual Average hydrological characteristics | TopNet (2004-2012) (m3/s) | GWRC (2004-2012) ($m^3/s$) | GWRC (1954-2015) ($m^3/s$) |
|---|---|---|---|
| **Mean Annual Flow** | 0.571 | 0.617 | 0.526 |
| **7 days Mean Annual Low Flow** | 0.031 | 0.028 | 0.024 |

- Hydrological processes and characteristics simulated
- Low flows correctly reproduced
- Underestimation of spring flows

NIWA
Taihoro Nukurangi

# Calibration-Validation

Parameter Sensitivity

- Morris method- to main objective function (NSLog)
  - sensitivity across entire parameter space
  - Non linearity between parameters
- Carried out for each catchments outlet

Result

- Extreme sensitivity to precipitation correction (gucatch)
- 3 groups:
  - topmodf is the most sensitive parameter in the model (responsiveness of shallow subsurface flow)
  - swater2 (active soil depth) and dthetat (soil moisture)
  - hydraulic conductivity at saturation (hydrocon0) (surface water/groundwater interaction processes) and swater1 (plant available water).

NIWA
Taihoro Nukurangi

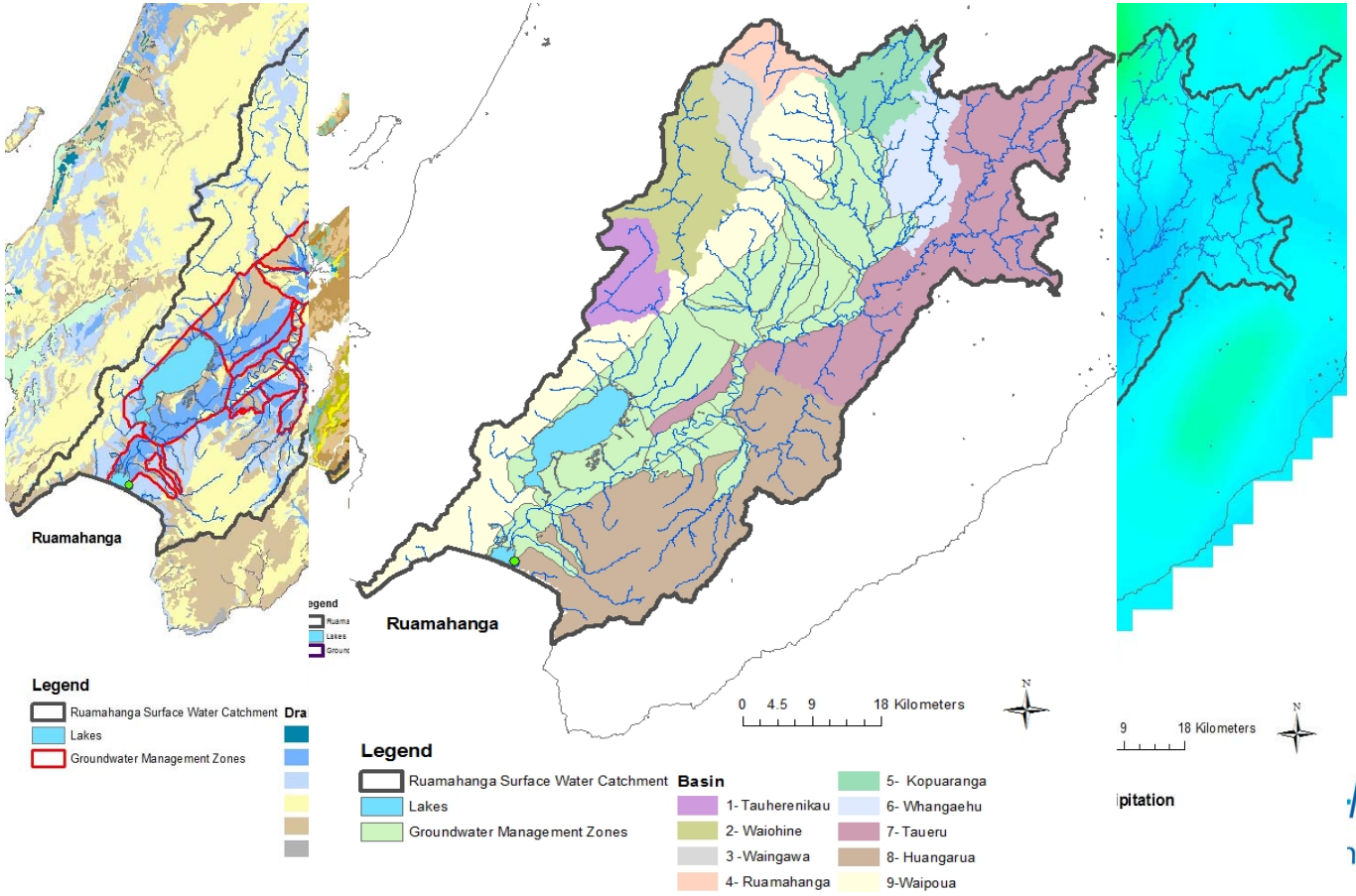
# Surface Hydrological model

1. Aim of the model
2. Surface water model TopNet
3. Input data
4. Calibration/Validation
5. Regionalisation
6. Limitations

NIWA
Taihoro Nukurangi

# Regionalisation

- Based on
  - Soil drainage similarity based on FSL
  - Soil type
  - Climate range input



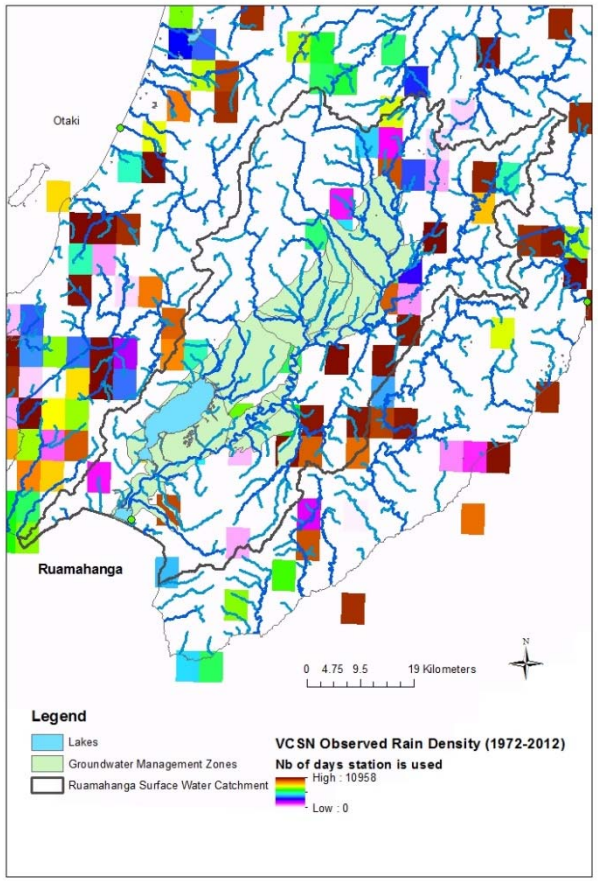
# Surface Hydrological model

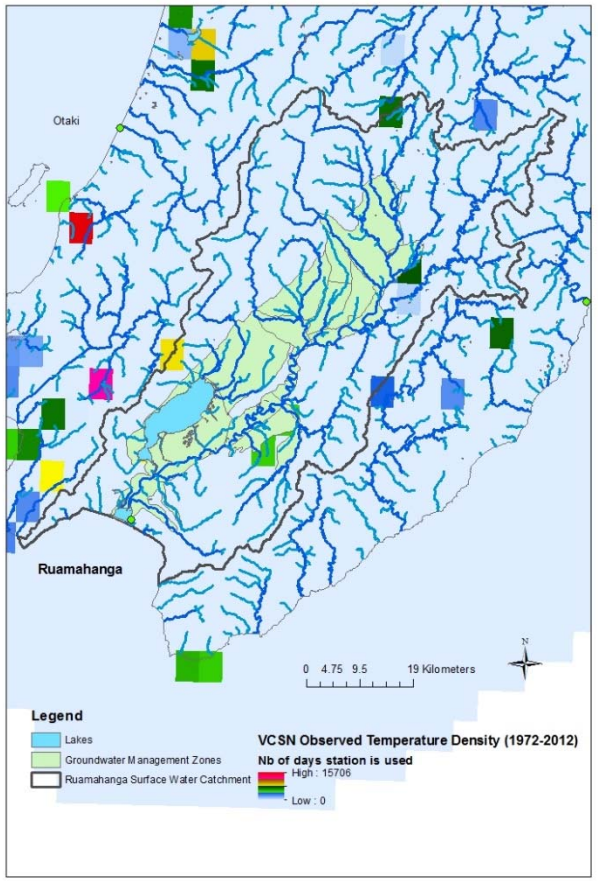
1. Aim of the model
2. Surface water model TopNet
3. Calibration/Validation
4. Input data
5. Regionalisation
6. Limitations

NIWA
Taihoro Nukurangi

# Spatial correction of climate inputs

- Reduce station network to drive VCSN interpolation
  - Potential increase uncertainties in Precipitation and Temperature

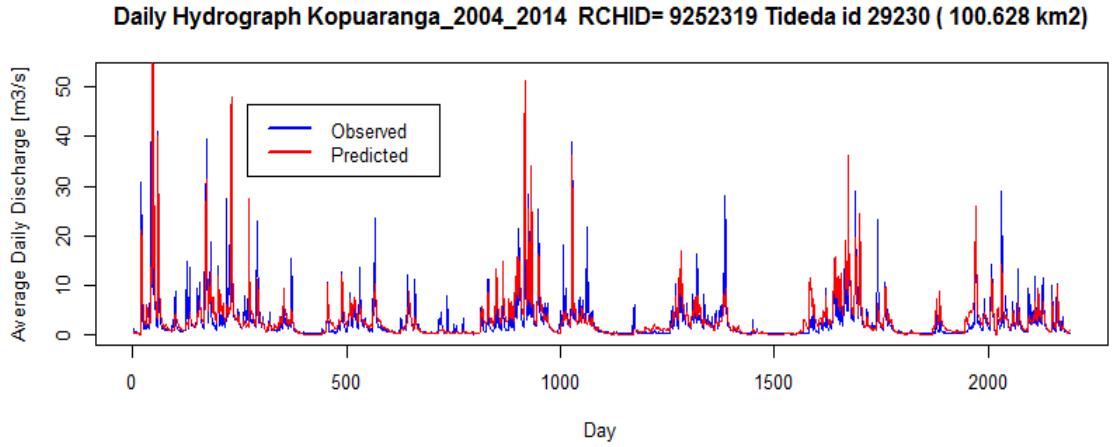


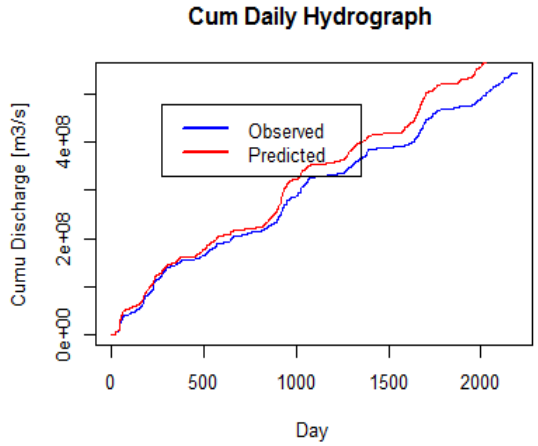



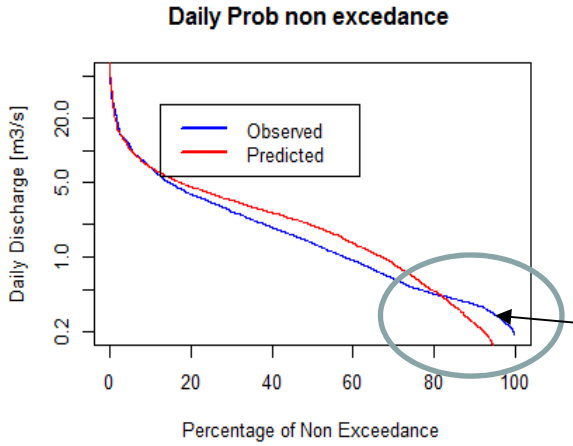

NIWA
Taihoro Nukurangi

# Groundwater inflows to GW zone

- Kopuaranga




Spring

NIWA
Taihoro Nukurangi

# Summary

1. Surface water model built and calibrated 9 upstream locations
2. Model provides inflows at 297 locations to GW Zone
3. Calibration/ Validation acceptable to good
4. Limitations due to climate inputs observations and potential non negligible GW inflows

NIWA
Taihoro Nukurangi

# Next step

- Complete analysis
- Completed uncertainty analysis
- Climate change impact on total water flows

NIWA
Taihoro Nukurangi