# *Modelling E. coli in lakes Onoke and Wairarapa*

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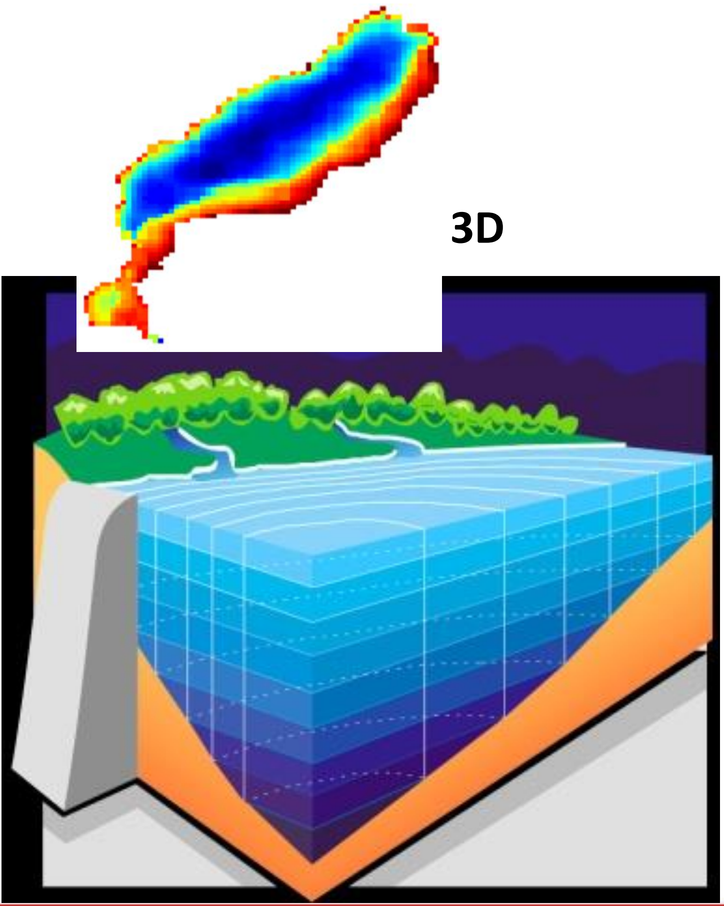
2017

# *Method: 3-D Numerical Hydrodynamic Model*

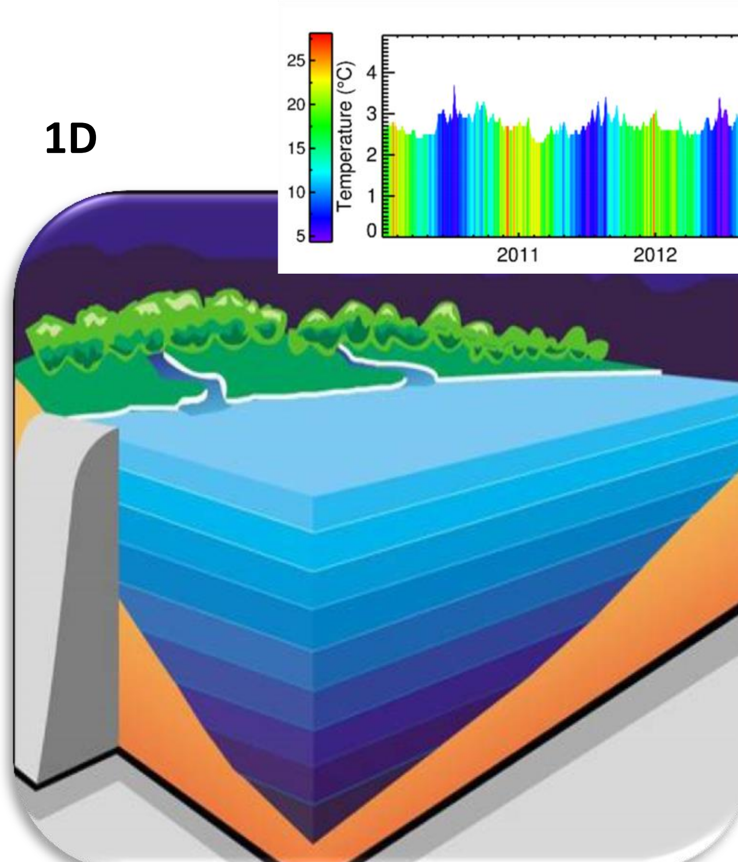


Hydrodynamic and thermodynamic models in order to predict velocity, salinity and temperature in waterbodies

**3D**



**1D**

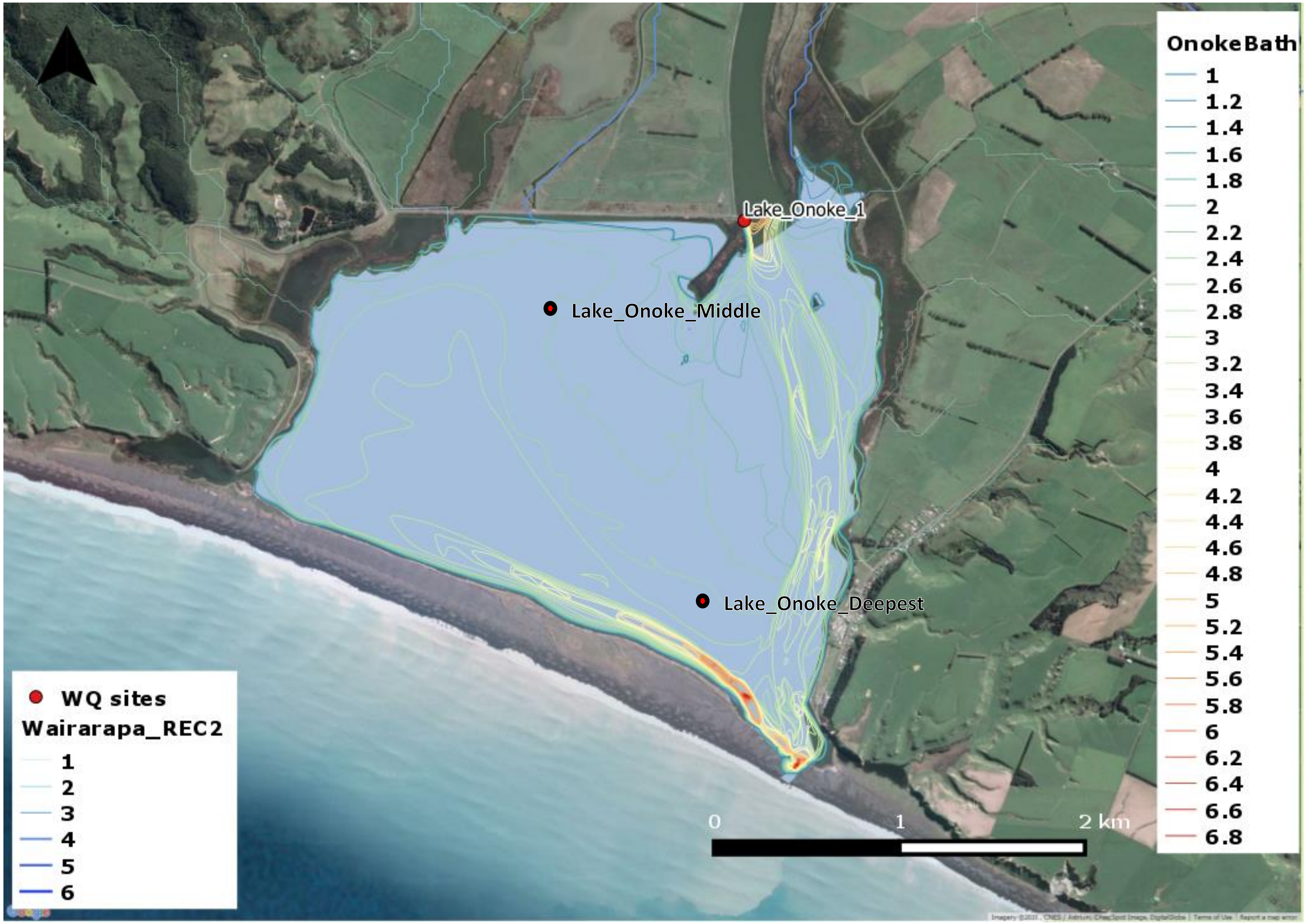


# 1-D vs. 3-D

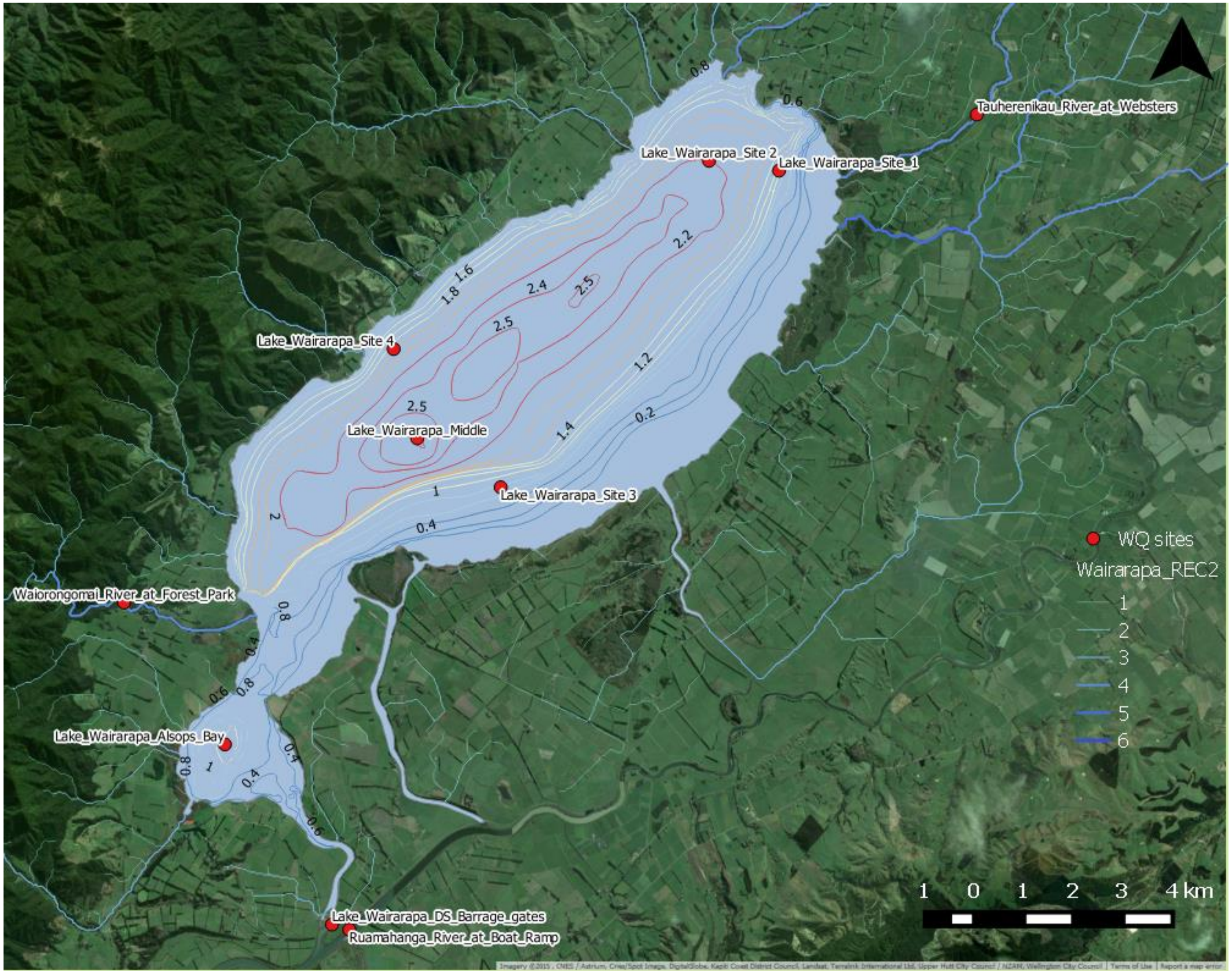


- Models should be no more complicated than necessary to provide the needed information with acceptable accuracy (Bower et al. 1977)
- Large spatial variation of water quality in lakes Onoke and Wairarapa
- 3-D modelling better represents scenarios that change the spatial variation

# Reporting points – Lake Onoke



# Reporting points – Lake Wairarapa

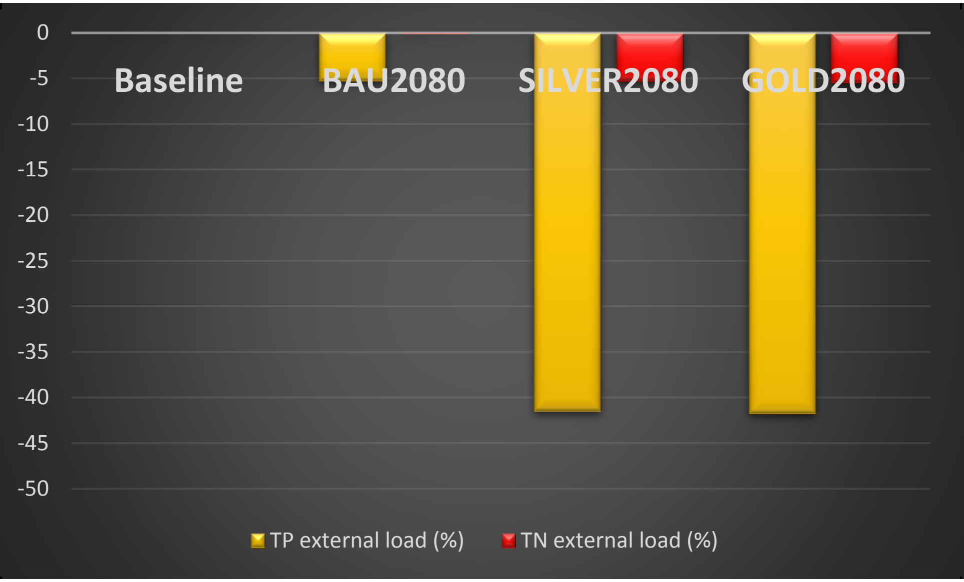


# Scenarios – Lake specific

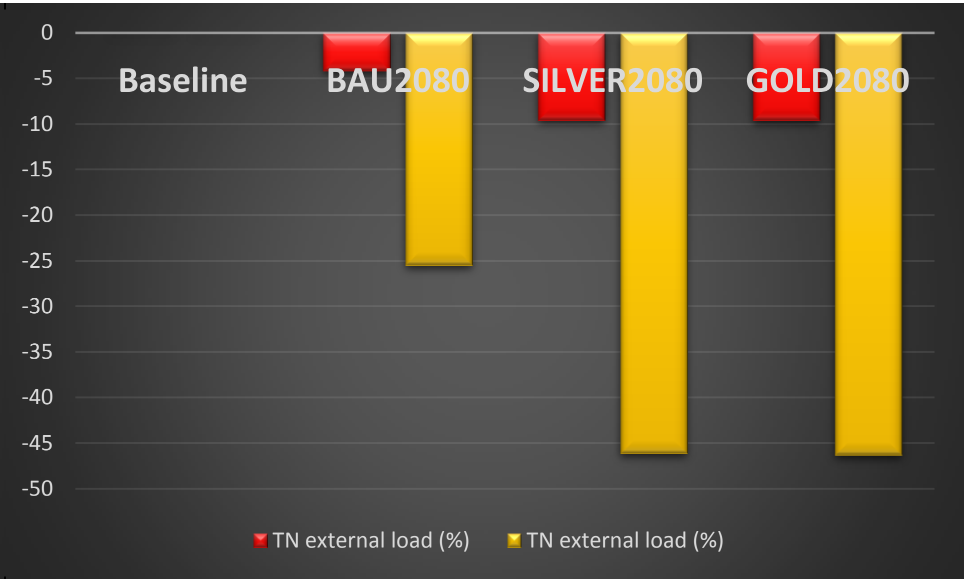
| Lake specific modelling scenarios were run in addition to catchment scenarios. The Lake Wairarapa specific scenarios included:<br>Modelling shorthand naming conventions | Description |
|---|---|
| ALL_RUA_SILVER2025/2040/2080<br>ALL_RUA GOLD2025/2040/2080 | All flows of the Ruamāhanga River entering Lake Wairarapa.<br>No flow by-passing via the diversion. |
| MEDIAN_RUA_SILVER2025/2040/2080 | Flows below median flow go into Lake Wairarapa, and flows above median flow are by-passed |
| Outlet_Close_SILVER2025/2040/2080,<br>Outlet_Close_Rua_All_SILVER2025/2040/2080 | Lake Onoke outlet closed January to March every year.<br>Lake Onoke outlet closed Jan to Mar, all Ruamahanga flows diverted into Lake Wairarrapa before entering Onoke |
| 1m_Inc_SILVER2025/2040/2080 | Deepening both lakes by 1m |

# Catchment nutrient load reduction

Wai




Onoke

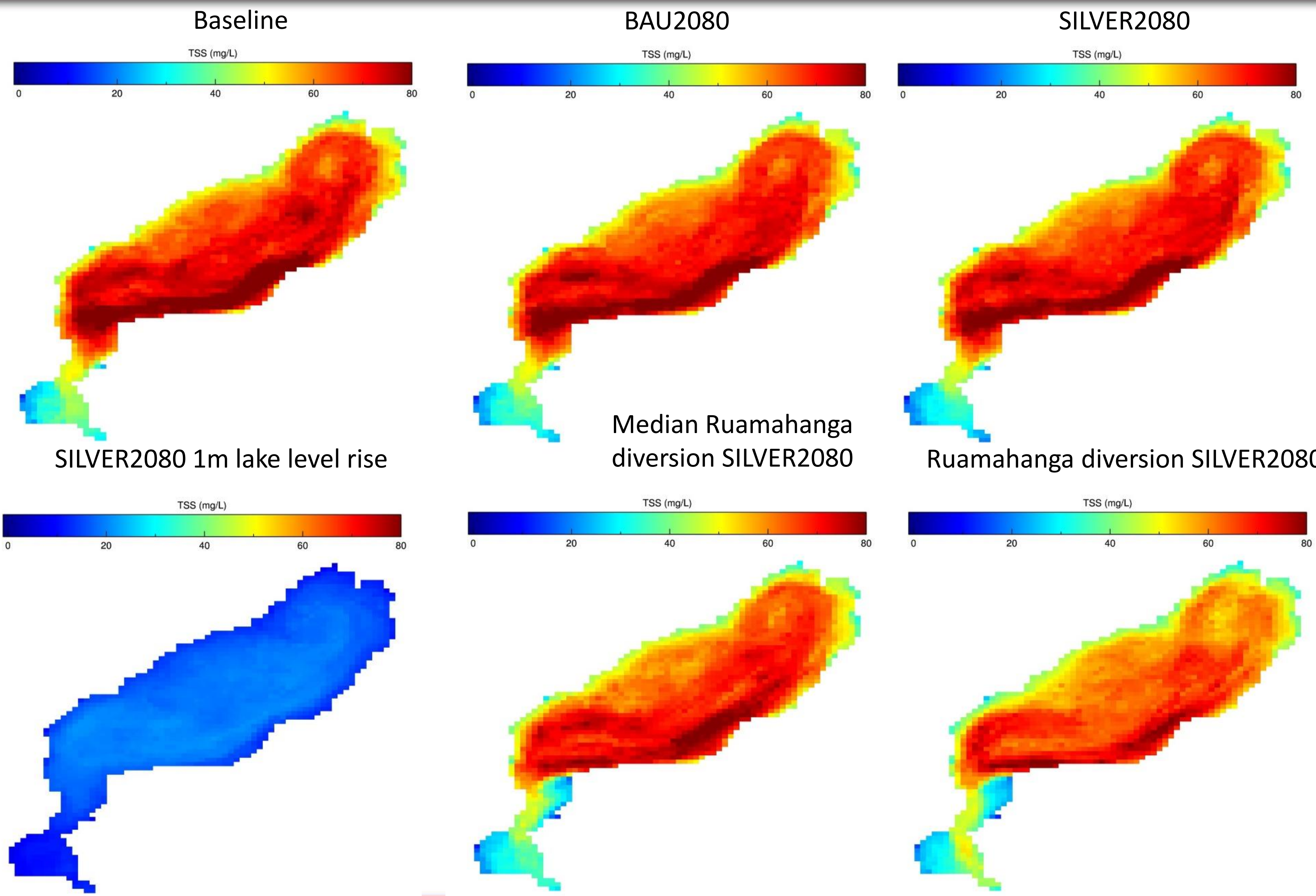


# Wairarapa Onoke 1-D outputs

| Lake Wairarapa | Modelling dataNo NOF band | Modelling dataNOF band | BAU | SILVER | GOLD | SILVER + 1 m deth | Silver + Onoke outlet closed | Silver + Onoke outlet closed + all flows of Ruamāhanga into Lake | Silver + all flows of Ruamāhanga into Lake Wairarapa | Silver + non-flood flows of Ruamāhanga into Lake Wairarapa |
|---|---|---|---|---|---|---|---|---|---|---|
| *E. coli* | | | | | | | | | | |
| Phytoplankton | | C | C | B | B | C | | | B | B |
| Total nitrogen | | B | B | B | B | B | | | C | B |
| Total phosphorus | | D | D | D | D | D | | | D | D |
| Trophic Level Index -TLI | 5.6 | | 5.5 | 5.3 | 5.3 | 5.2 | | | 5.2 | 5.1 |
| Total suspended sediment | 65 | | 64 | 63 | 63 | 46 | | | 60 | 58 |
| Ammonia toxicity | | A | A | A | A | A | | | A | A |
| Cyanobacteria (planktonic) | A | | A | A | A | A | | | A | A |
| Macrophytes (% cover) | 0.027 | | 3.93E-08 | 11 | 11 | 44 | | | 17 | 1.40E-05 |
| | | | | | | | | | | |
| **Lake Onoke** | | | | | | | | | | |
| *E. coli* | | | | | | | | | | |
| Phytoplankton | | C | C | B | B | C | B | B | | |
| Total nitrogen | | B | B | B | B | B | B | B | | |
| Total phosphorus | | D | D | C | C | C | C | C | | |
| TLI | 5.4 | | 5.2 | 5.0 | 5.0 | 4.9 | 4.8 | 5.0 | | |
| Total suspended sediment | 32 | | 31 | 30 | 30 | 23 | 22 | 33 | | |
| Ammonia toxicity | | A | A | A | A | A | A | A | | |
| Cyanobacteria (planktonic) | A | | A | A | A | A | A | A | | |
| Macrophytes (% cover) | 0.030 | | 0.0321501 | 0.0321057 | 0.032106 | 0.0373972 | 0.00646906 | 0.0128636 | | |

# 3-D simulation results –TSS Lake Wairarapa





# 3-D simulation results –chl a Lake Wairarapa

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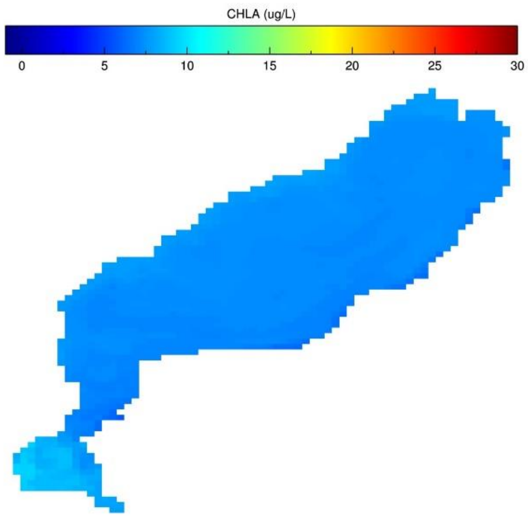
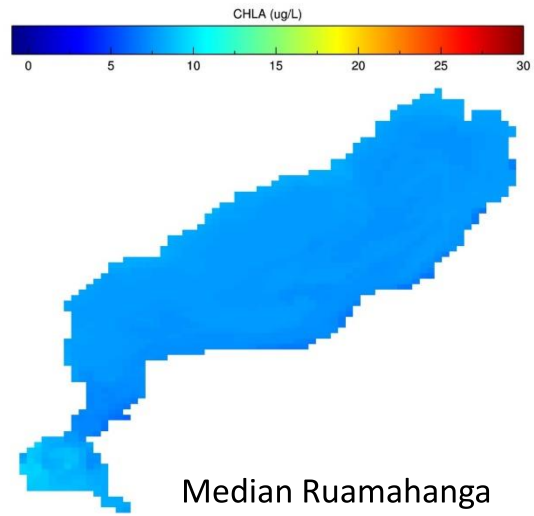
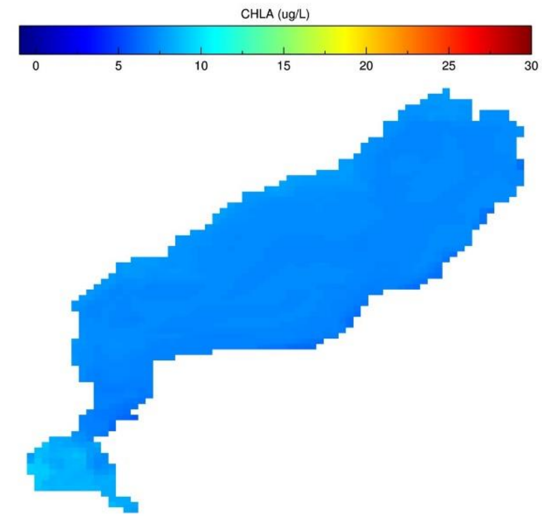
Baseline



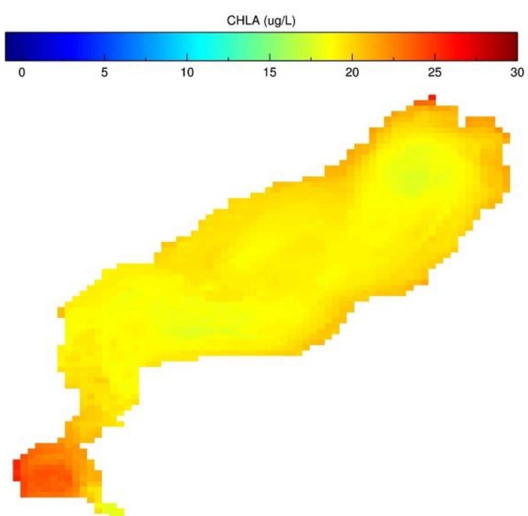

BAU2080



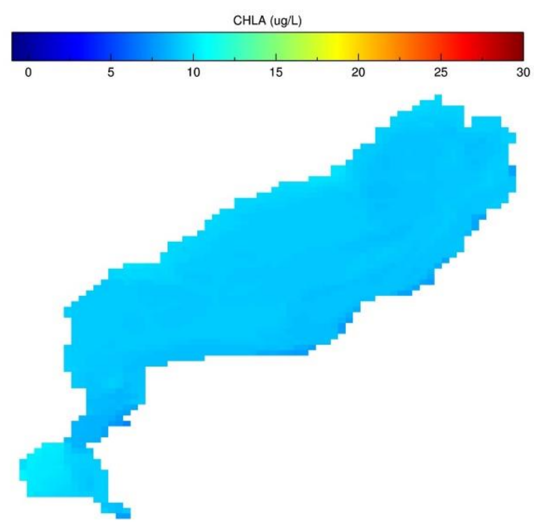

SILVER2080



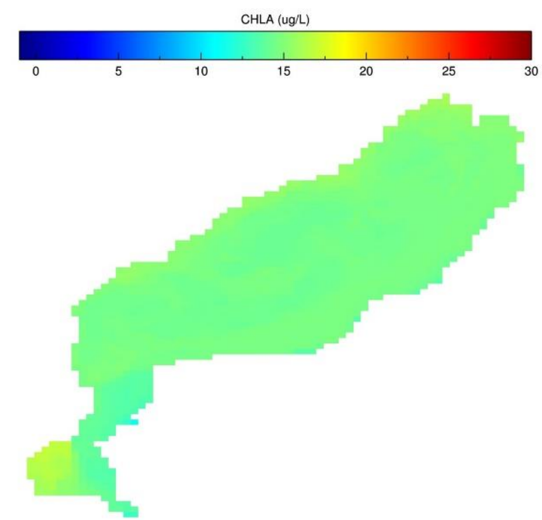

SILVER2080 1m lake level rise




Median Ruamahanga diversion SILVER2080



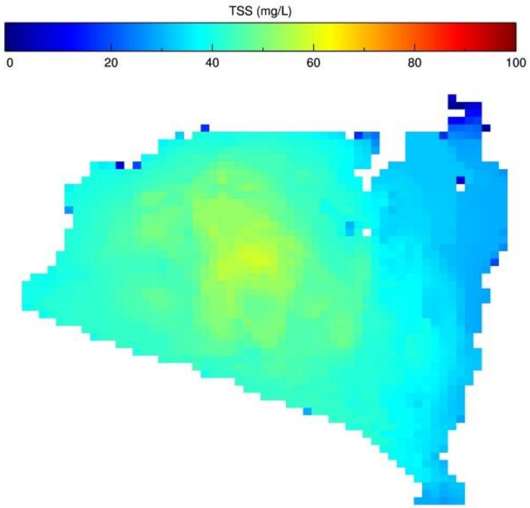

Ruamahanga diversion SILVER2080



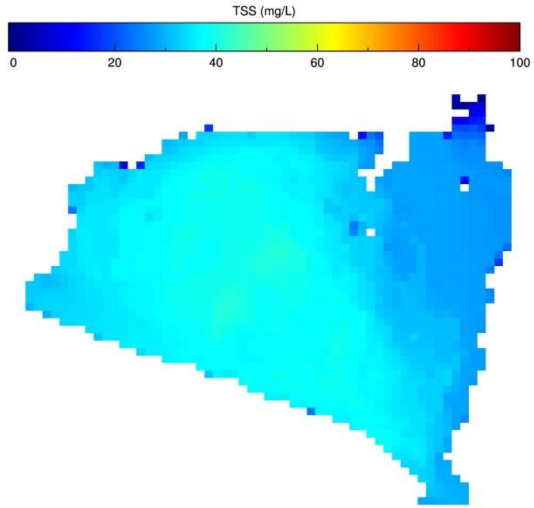
# 3-D simulation results –TSS Lake Onoke



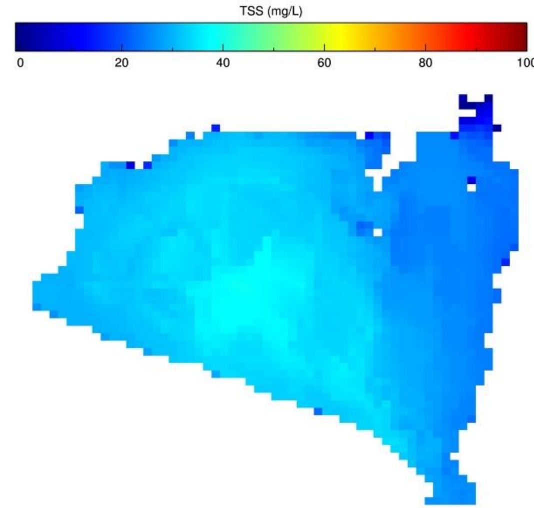
Baseline



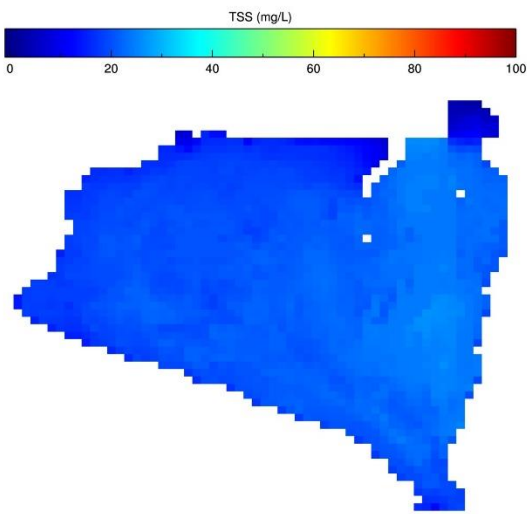

BAU2080



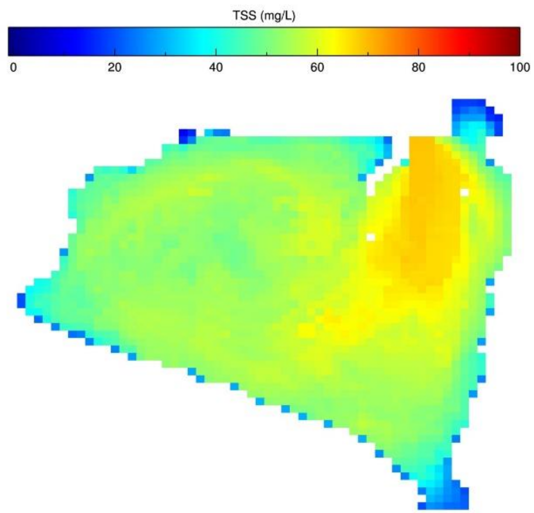

SILVER2080



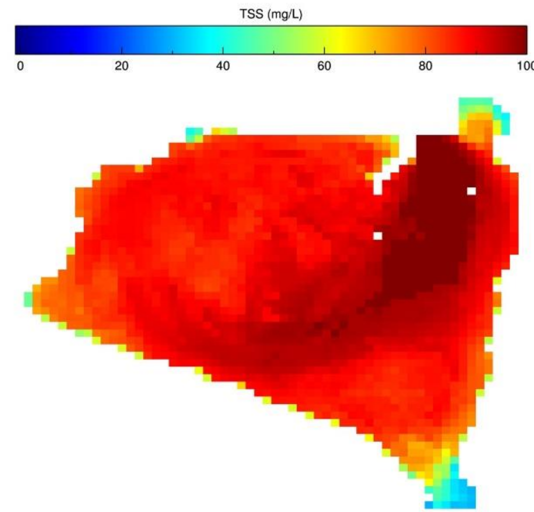

SILVER2080 1m increase




SILVER2080 outlet closed



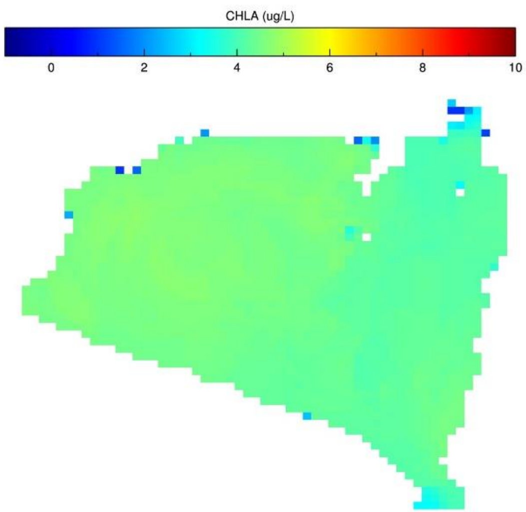

SILVER2080 outlet closed Rua. diversion



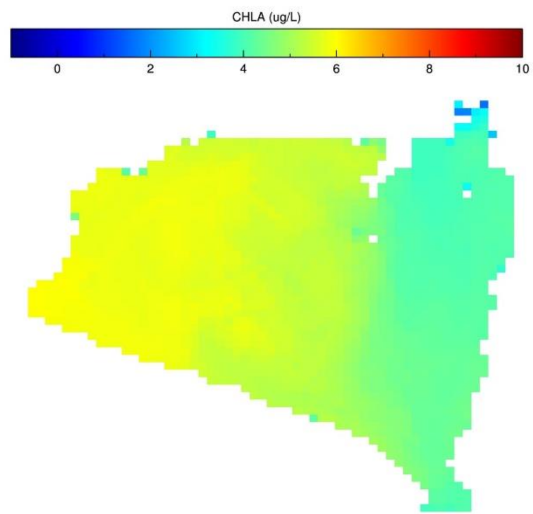
# 3-D simulation results –chl a Lake Onoke



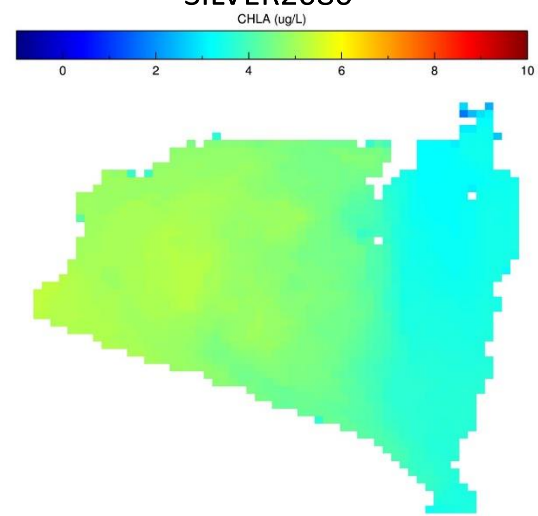
Baseline



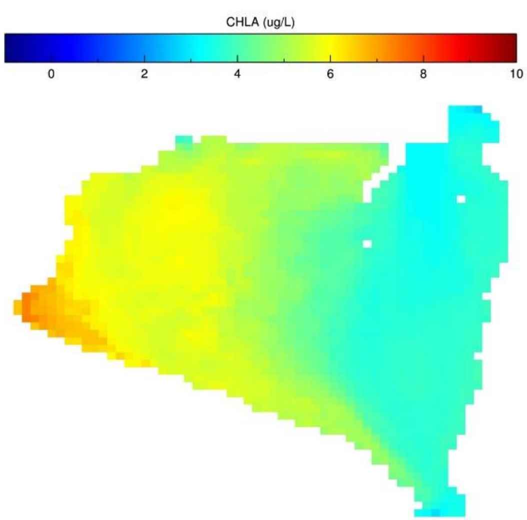

BAU2080



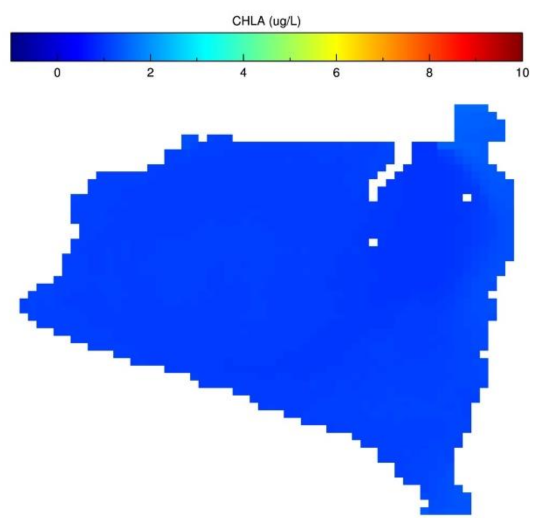

SILVER2080



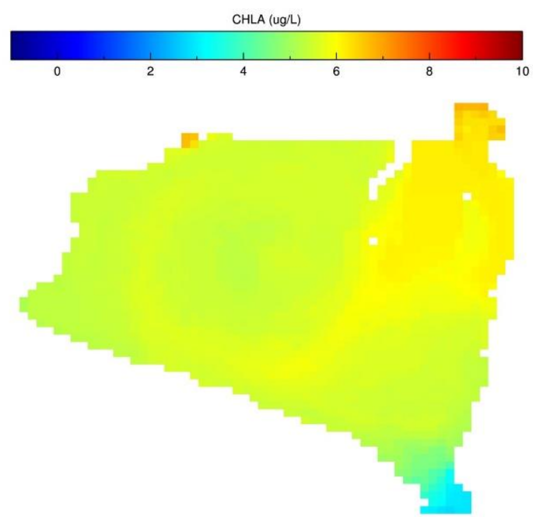

SILVER2080 1m increase




SILVER2080 outlet closed




SILVER2080 outlet closed Rua. diversion



# 3-D outputs – Middle site

| Attribute | Modelling data | | BAU | | Silver | | Gold | | Silver + 1m additional depth | | Silver + Onoke outlet closed | | Silver + Onoke outlet closed + all flows of Ruamāhanga into | | Silver + all flows of Ruamāhanga into Lake Wairarapa | | Silver + non-flood flows of Ruamāhanga into Lake Wairarapa | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No NOF band | NOF band | | | | | | | | | | | | | | | | |
| **Lake Wairarapa Middle** | | | | | | | | | | | | | | | | | | |
| Phytoplankton | | C | – | C | – | C | – | C | ↓ | D | | | | | ↓ | D | – | C |
| Total nitrogen | | B | – | B | – | B | – | B | – | B | | | | | – | B | – | B |
| Total phosphorus | | D | – | D | – | D | – | D | ↑ | C | | | | | – | D | ↑ | C |
| Trophic Level Index -TLI | 5.49 | | – | 5.49 | – | 5.31 | – | 5.32 | – | 5.17 | | | | | – | 5.56 | – | 5.24 |
| Total suspended sediment | 71 | | 1418 | 70 | 1417 | 70 | 1429 | 71 | 344 | 21 | | | | | 1357 | 68 | 1481 | 73 |
| Ammonia toxicity | | A | – | A | – | A | – | A | – | A | | | | | – | A | – | A |
| **Lake Onoke Middle** | | | | | | | | | | | | | | | | | | |
| Phytoplankton | | B | ↓ | C | – | B | – | B | ↓ | C | ↑ | A | ↓ | C | | | | |
| Total nitrogen | | C | ↑ | B | ↑ | B | ↑ | B | ↑ | B | ↑ | B | – | C | | | | |
| Total phosphorus | | B | – | B | – | B | – | B | – | B | ↑ | A | – | B | | | | |
| TLI | 4.64 | | – | 4.63 | – | 4.45 | – | 4.45 | – | 4.51 | ↑ | 3.98 | – | 5.00 | | | | |
| Total suspended sediment | 59 | | -30 | 41 | -36 | 37 | -36 | 38 | -65 | 21 | -9 | 53 | 56 | 92 | | | | |
| Ammonia toxicity | | A | – | A | – | A | – | A | – | A | – | A | – | A | | | | |

# Summary



- SILVER2080 and GOLD2080 catchment scenarios were not significantly different
- High internal loading of phosphorous from sediments in Lake Wairarapa results in reduction of effectiveness of mitigations compared to Lake Onoke
- Diversion scenarios can potentially increase chl *a* concentrations
- Below median Ruamāhanga diversion scenarios only estimated a small increase in chl *a* - this may not be significant
- Below median Ruamāhanga divisions reduce trophic state more than SILVER2080 alone in Lake Wairarapa

- Reducing external load + water levels increased = macrophyte re-establishment presents the best opportunity for water quality improvement in Lake Wairarapa

- Lake Onoke outlet closed reduced chl *a* (under non-division) concentrations, but this is due to higher TSS concentrations and higher light limitation

- Longer simulation periods needed for 3-D models to enable NOF estimation

# *Acknowledgements*

- Greater Wellington Regional Council staff
- Ruamāhanga Whaitua Committee
- Chris McBride (UOW)

USGS
science for a changing world

GLEON
global lake ecological observatory network

NASA

Ministry of Business,
Innovation & Employment