Human and Ecosystem health are 2 important values of water in Southland I will be discussing,
Human Health indicators I will discuss are a) the risk of illness from pathogens as a result of interacting with a water body and b) toxicity of nitrogen in drinking water supplies
Aspects of Ecosystem Health I will cover include risks for a) Toxicity - the degree to which a substance can damage another organism) to aquatic fauna b) trophic responses – nutrient enrichment driving plant and algae growth which can lead to

- decreased asthetic/recreational values, changes in in stream habitat
- changes to aquatic fauna community composition and productivity
- Potential toxicity, oxygen depleation

National Policy Statement for Fresh Water Management provides a number of national bottom lines for pathogens and toxicity and trophic responses including an A,B,C,D framework with C-D representing the national bottom line

Regional Water Plan includes some regional standards for water

MOH and MFE guidelines for drinking water to protect human health

And ANZECC 2000 Guidelines for the protection of aquatic ecosystem health provide guidelines which can illustrate levels of nutrients above which the risk of adverse effects occurring in the environment increases and could indicate the need to manage those nutrients in order to ensure the protection of ecosystem health

Maps are used to illustrate spatial variability

Human health summary

- Elevated microbial contamination in rivers
  - 6 of 55 don't meet secondary contact
  - No swimming sites meet primary contact
- Potentially toxic benthic algae in rivers
  - blooms observed in all main rivers
- Elevated contaminants in groundwater
  - 58 of 334 bores nitrate above drinking standard
  - 80 of 300 of bores with E.coli above drinking standard

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Ecosystem health summary

Lakes

- Glacial lakes in excellent condition
- Shallow coastal lakes degraded – nutrients; algae

Estuaries

- New River in decline -nutrient and sediment stress
- Jacobs River in decline -nutrient and sediment stress
- Fortrose – moderate health – nutrient stress
- Waikawa – good health – vulnerable to nutrient and sediment

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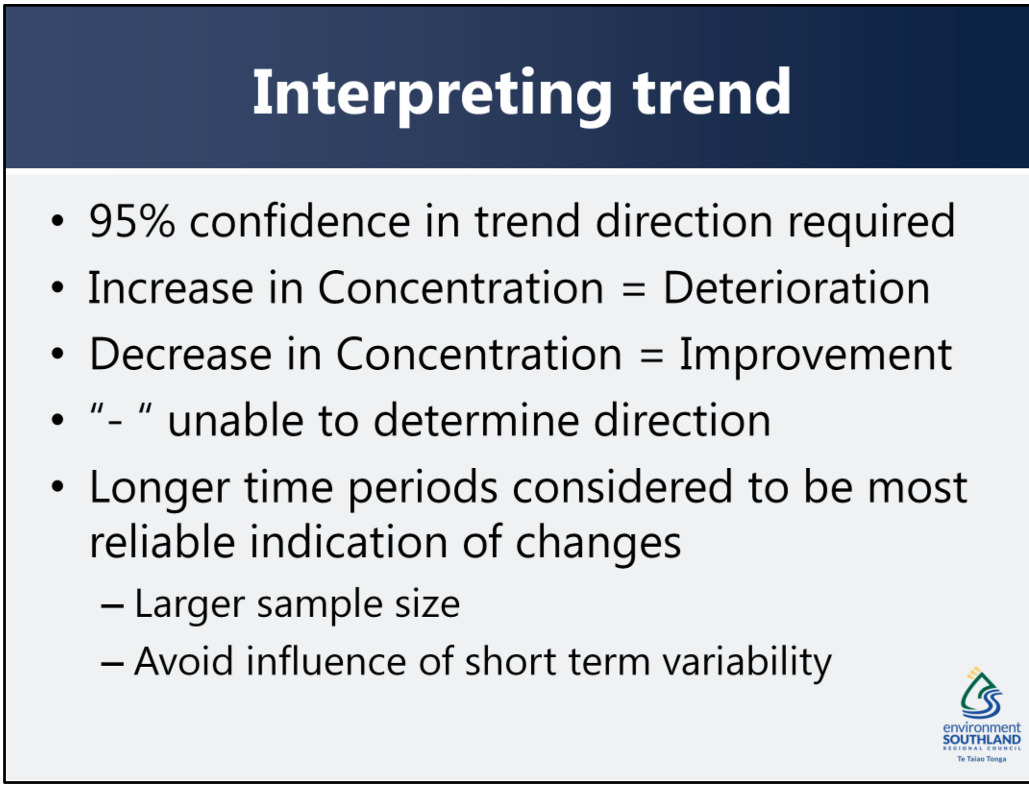
Ecosystem health summary

Groundwater

- Elevated nitrogen in managed aquifers pose potential risk to ecosystem health in connected surface waterbodies

Rivers

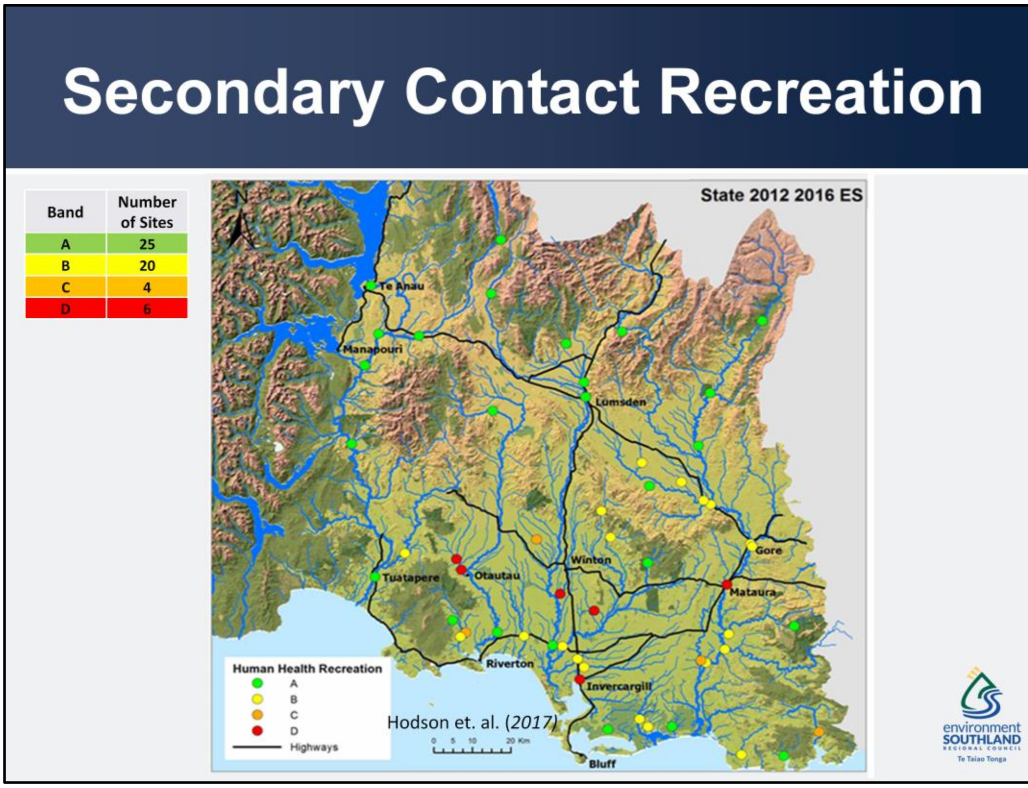
- No sites breach toxicity standards
- Guidelines for protection of ecosystem health are not met in many water bodies
- Nuisance growths of slime algae occur
- Macroinvertebrate community impacted & deteriorating



Trends are discussed, there are 4 outcomes, we require high level of confidence (95%) to identify 1) Improvement, 2) deterioration, 3) "-" unable to confidently determine direction/uncertain 4) not assessed – data available didn't meet minimum requirements for inclusion in analysis

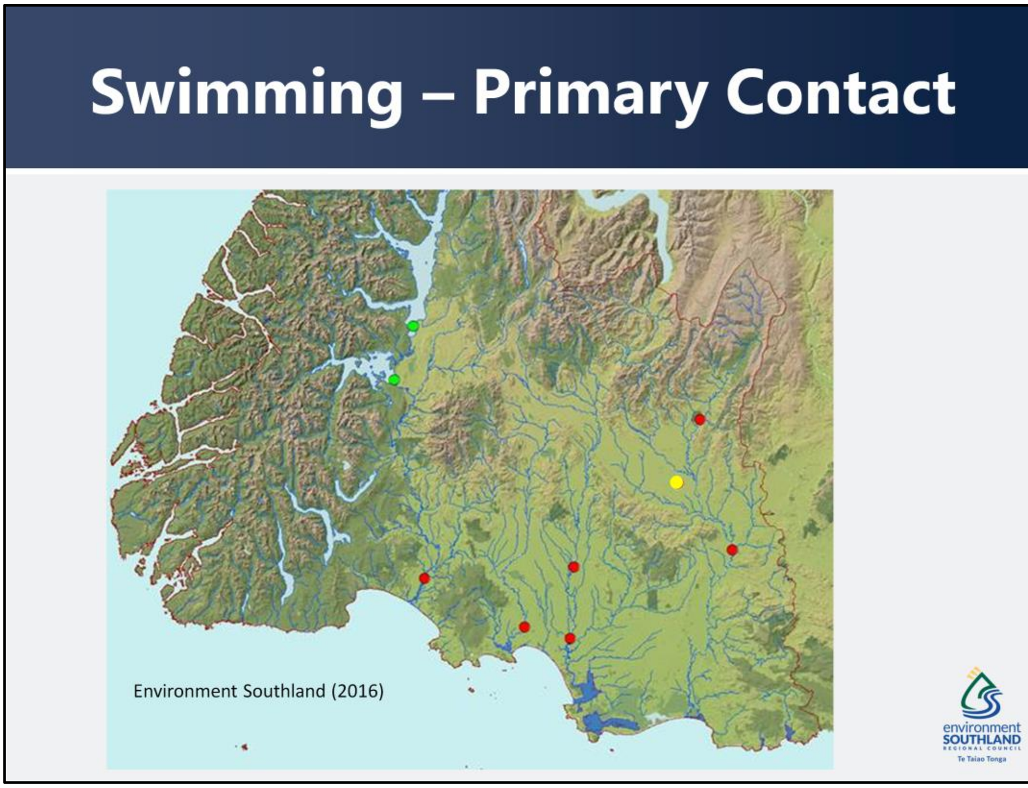
Trend summary

- Nitrate - groundwater
  - 2000 – 2016 deterioration at 15 of 23 ES operated sites, improvement at 3 of 23
  - 2012 – 2016 deterioration at 5 of 25, improvement at 6 of 25.
- Nitrate - surface water
  - 2000 – 2016 deterioration in 15 of 34 ES sites, 5 of 6 NIWA, improvement at 2 of 34 and 1 of 6
  - 2012-2016 improvements at 9 of 55 and deterioration at 2 of 55
- Macroinvertebrate Community
  - Deterioration in MCI at 19 of 72 (26%) sites



Hodson et al 2017 - Figure 9 on Page 21 of http://www.es.govt.nz/Document%20Library/Consultations/2016/Proposed%20Southland%20Water%20and%20Land%20Plan/Supporting%20Documents/7%20-%20Water%20Quality%20in%20Southland%20-%20Current%20State%20and%20Trends%20-%20April%202017.pdf

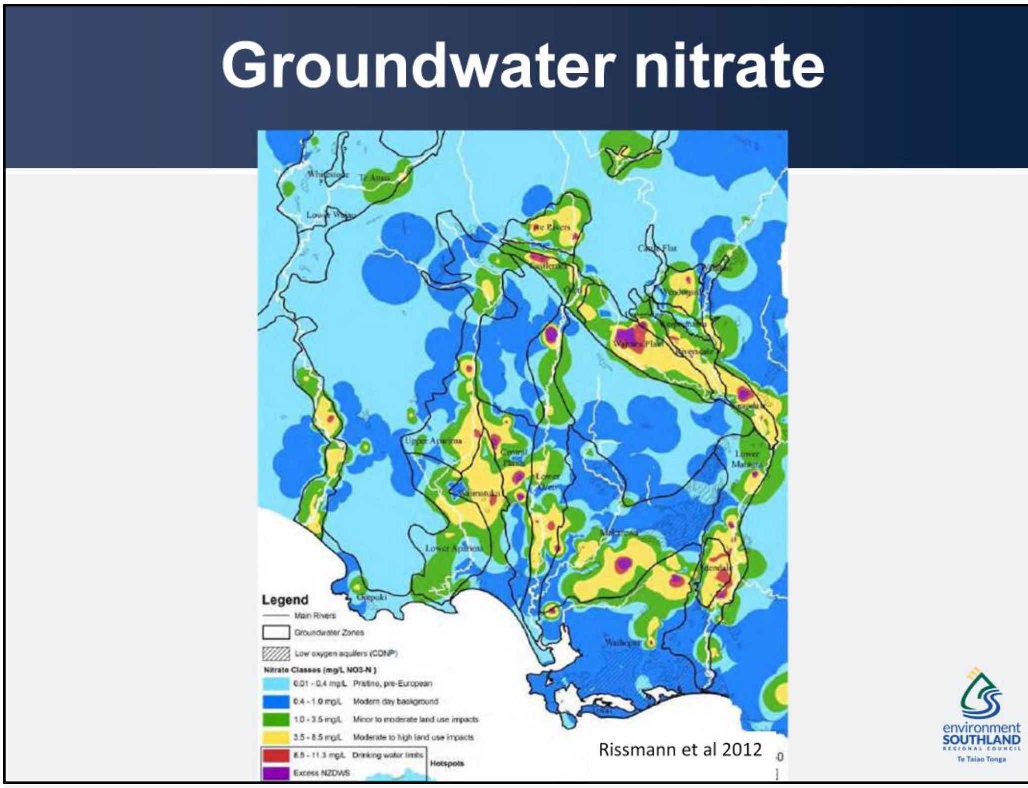
6 of 55 river sites do not meet NOF secondary contact recreation standard



http://www.es.govt.nz/document-library/agendas-and-minutes/Agendas%20and%20Minutes%20Library/TAG%20-%2011%20August%202016.pdf

6 sites in appendix k of RWP – red and fail primary contacts
7 sites in appendix G of pSWLP – Mataura at Riversdale added (yellow above) – ES has historical data to assess this
2 additional locations where ES collects bathing qualtiy weekly in Glacial lakes – not in RWP or pSWLP ES has historical data to assess this

Further 2 additional locaitons considered indicitative – Mavora Lake and Piano flat – not monitored weekly or illustrated



Page 656 of Hearing report

Rissmann et al 2012 : Rissmann, C., 2012. The Extent of Nitrate in Southland Groundwaters Regional 5 Year Median
(2007-2012 (June)) Environment Southland Technical Report 2012-09.

Extent of nitrate concentration – purple indicates where nitrate is greater than drinking water standard

In yellow ~20% of managed aquifers with nitrate greater than 3.5 pose a potential risk to ecosystem health in hydrologically connected surface water bodies

Ecosystem health overview

- Glacial lakes in good – very good condition
- Lowland lakes elevated nutrient; algae
- Degraded (gross eutrophic) areas of the Fortrose, Jacobs River and New River estuaries are increasing in size.
- No river sites breach toxicity standards
- A number of surface water bodies have N & P concentrations greater than ANZECC guidelines for ecosystem health protection
- Nuisance growths of slime algae (Periphyton) - Mataura, Aparima, and lowland tributaries of the Oreti
- Macroinvertebrate community health standards are not met at ~20% of sites

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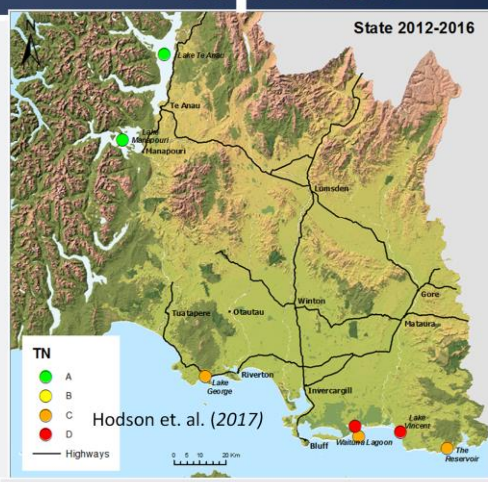
Lakes – Total N, trophic response

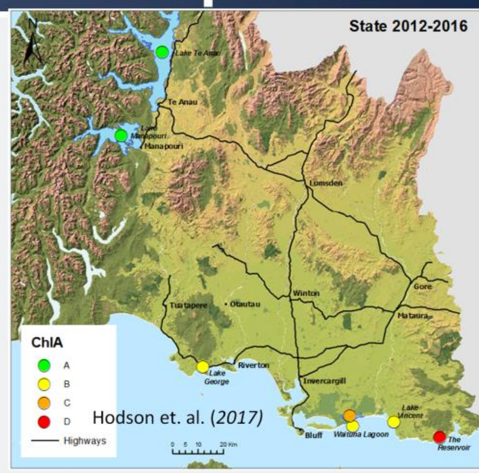


Band	Number of Sites	Sites
A	5	Lake Manapouri (3 sites) and Lake Te Anau (2 sites)
B	2	Waituna Lagoon (2 sites when open)
C	8	Lake George (2 sites) , The Reservoir (2 sites) , Waituna Lagoon (2 sites closed, 2 sites open)
D	4	Lake Vincent (2 sites), Waituna Lagoon (2 sites closed)

Figure 19 on Page 31 of Hodson et. al. 2017
http://www.es.govt.nz/Document%20Library/Consultations/2016/Proposed%20Southland%20Water%20and%20Land%20Plan/Supporting%20Documents/7%20-%20Water%20Quality%20in%20Southland%20-%20Current%20State%20and%20Trends%20-%20April%202017.pdf

Glacial lakes in “A” bands – good – very good condition
Lowland lakes
Total Nitrogen in Vincent and Waituna (closed) > NOF

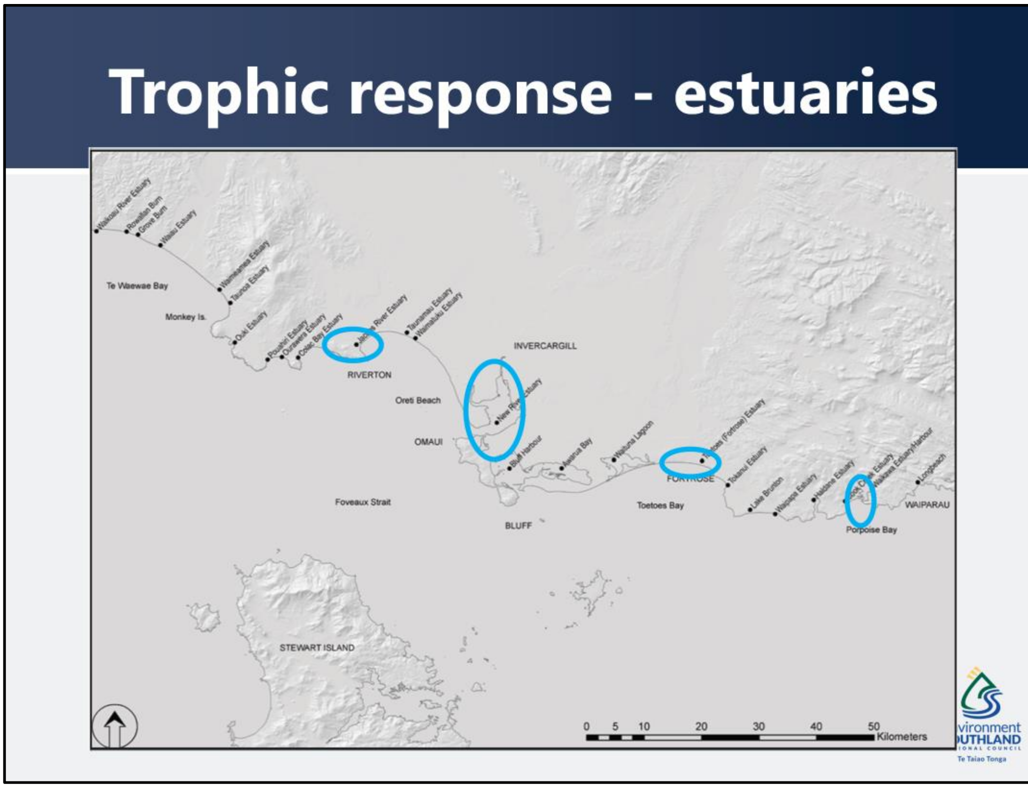
Lakes – phytoplankton, trophic response



Band	Number of Sites	Sites
A	7	Lake Manapouri , Lake Te Anau, Waituna Lagoon (2 sites when open)
B	6	Lake George, Lake Vincent, Waituna Lagoon (2 sites when open)
C	5	The Reservoir (1 site), Waituna Lagoon (4 sites when closed)
D	1	The Reservoir (1 site)

Figure 21 on Page 35 of http://www.es.govt.nz/Document%20Library/Consultations/2016/Proposed%20Southland%20Water%20and%20Land%20Plan/Supporting%20Documents/7%20-%20Water%20Quality%20in%20Southland%20-%20Current%20State%20and%20Trends%20-%20April%202017.pdf

Phytoplankton in the Reservior > NOF



Townsend and Lohrer 2015

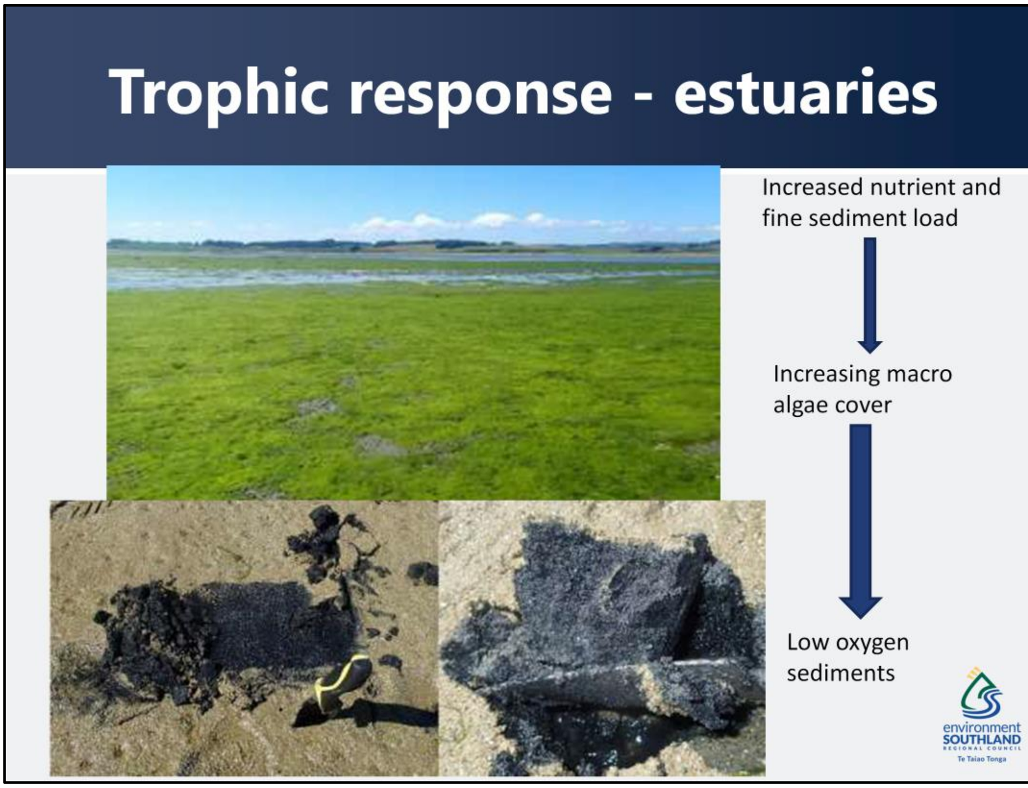
Increases in aerial coverage of degradation have resulted from the cumulative stress of elevated nutrient and sediment loading from upstream catchments

“the weight of evidence from multiple measured parameters indicates that the individual and combined effects of nutrients and sediments are negatively impacting the four estuaries to varying degrees”

Degraded (gross eutrophic) areas of the Fortrose, Jacobs River and New River estuaries are increasing in size.

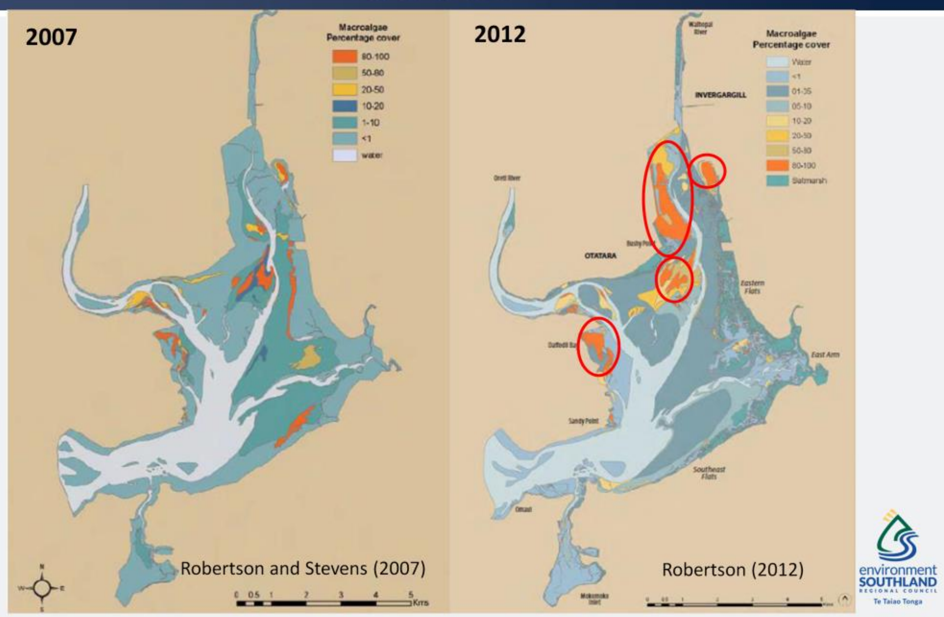
Waikawa Estuary is located south of Niagara on the Catlins Coast and appears to be in good health overall. However, the upper estuary is considered only moderately healthy. Management of nutrient input is necessary to prevent a threshold change, particularly in the sandflats area. See Appendix B8 for more information.

Fortrose (Toetoes) Estuary is situated at the mouth of the Mataura River and appears to be in a moderate state of ecological health. The main stress appears to be nutrient enrichment from the estuary catchment.



Figures from P 663 of the hearing report

New River Estuary macroalgae cover

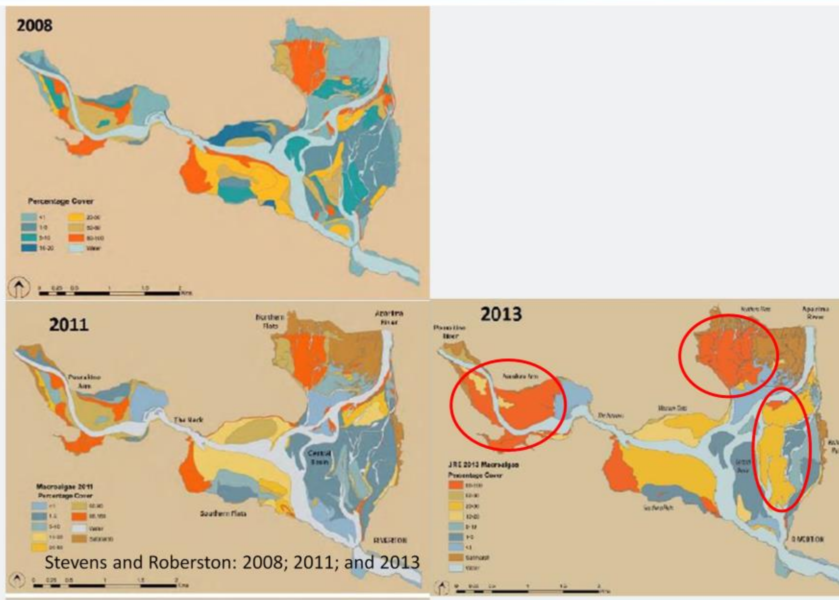


Figures from pages 658 and 659 of hearing report

Robertson and Stevens (2007) and Robertson (2012)

New River Estuary is located just south of Invercargill City and is the largest estuary in Southland. There are sections in the central and outer portions of the estuary that appear to be moderately healthy. However, there are also sections that are severely degraded. In general, the ecosystem health of the estuary is in decline, with impacts of nutrient enrichment being the main driver of degradation. See Appendix B5 for more information.

Jacobs River Estuary macroalgae cover



Figures from pages 661 and 662 of hearing report

Stevens and Roberston: 2008; 2011; and 2013

Jacobs River Estuary is located in Riverton and is also in ecological decline due to the impacts of nutrient enrichment and sedimentation. The ecological health of the estuary is severely compromised in certain parts, with no indications of improvement, and some evidence of further deterioration.

Ecosystem health- Rivers

- No sites breach toxicity standards
- N & P concentrations do not meet guidelines for ecosystem health protection in many waterbodies
- Nuisance growths of slime algae (Periphyton) occur – main stem Mataura, Aparima, and lowland tributaries of the Mataura, Aparima and Oreti
- Macroinvertebrate community health standards are not met at 20% of sites
- Macroinvertebrate community health deteriorating at 26% of sites

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NO3 – 38 of 55 > ANZECC 2000
DRP - 27 of 55 > ANZECC 2000
8 periphyton sites predicted to fail NOF
19 MCI sites don’t meet RWP or pLAWP MCI standards

Ecosystem health rivers – NOF

Environment Southland Sites (55)

Band	Nitrate	Ammoniacal nitrogen	Predicted Periphyton
	Fish toxicity	*Fish toxicity*	*Ecosystem Health*
A	29	31	8
B	17	20	8
C	9	4	9
D	0	0	8

NIWA Sites (6)

Band	Nitrate	Ammoniacal nitrogen
	Fish toxicity	Fish toxicity
A	4	6
B	2	0
C	0	0
D	0	0

No surface water sites breach NOF Toxicity criteria
9 sites in C band Nitrate
4 sites in C bad Ammonia
~20% of managed aquifers may pose a risk to ecosystem health in hydraulically connected surface water bodies.
C band nitrate ~ up to 20% of species effected
C band Ammonia ~ up to 20% of species effected

A = high conservation value, efects unlikely
B = growth effects on 5% species
C = growth effects on up to 20% species
D = impacts observed on multiple species

Nitrate toxicity

Band	Number of Sites
A	29
B	17
C	9
D	0

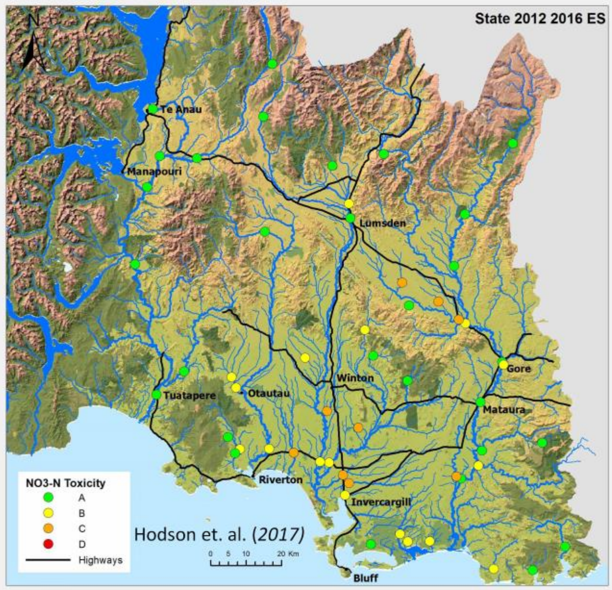

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Figure 2 on Page 14 of Hodson Et al 2017 http://www.es.govt.nz/Document%20Library/Consultations/2016/Proposed%20Southland%20Water%20and%20Land%20Plan/Supporting%20Documents/7%20-%20Water%20Quality%20in%20Southland%20-%20Current%20State%20and%20Trends%20-%20April%202017.pdf

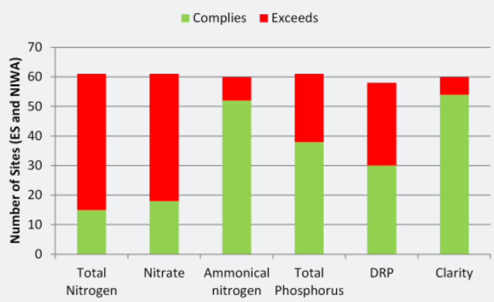
State of rivers – ANZECC guidelines

Environment Southland Sites

Band	Total Nitrogen	Nitrate	Ammoniacal nitrogen	Total Phosphorus	DRP	Clarity
Complies	14	17	47	33	25	48
Exceeds	41	38	7	22	27	6

NIWA Sites

Band	Total Nitrogen	Nitrate	Ammoniacal nitrogen	Total Phosphorus	DRP	Clarity
Complies	1	1	5	5	5	6
Exceeds	5	5	1	1	1	0



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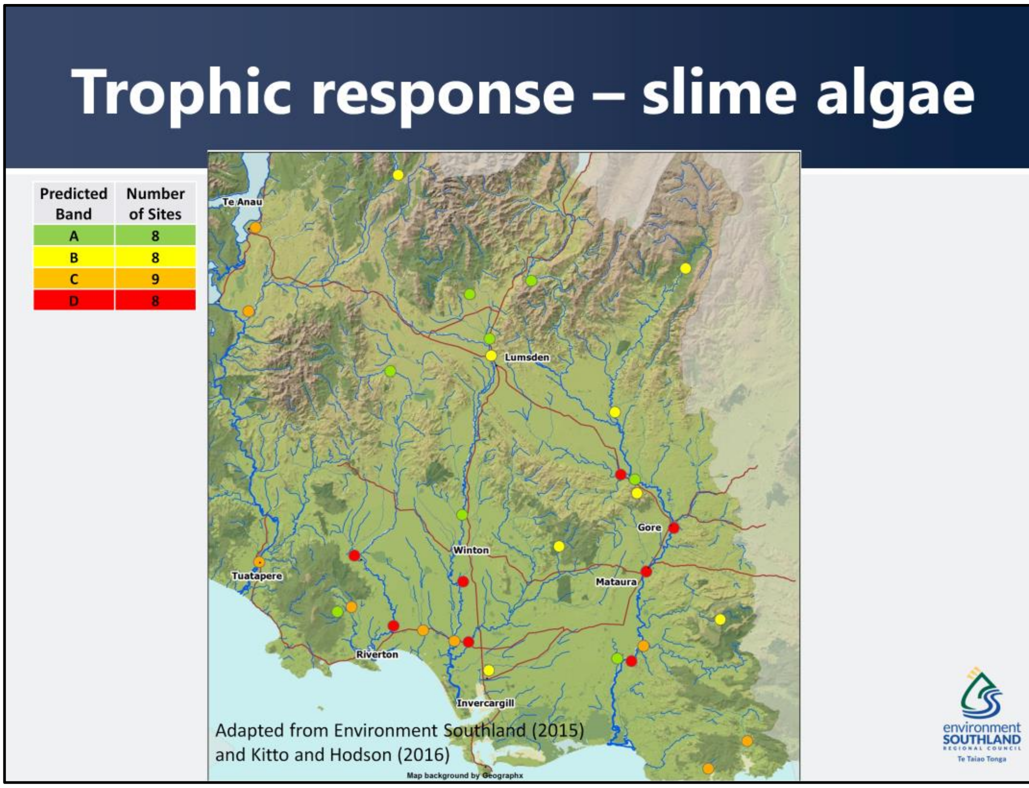
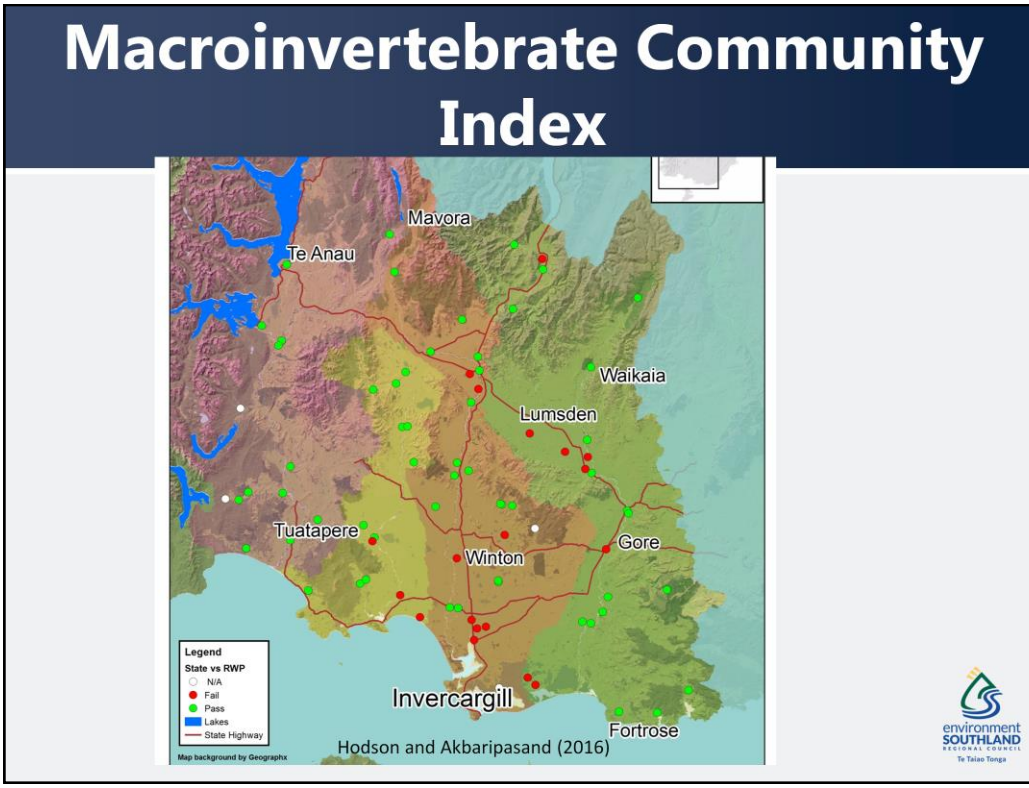


Adapted from Environment Southland 2015 and Kitto and Hodson 2016 – to illustrate periphyton only i.e. symbols are not usign four quadrants

Kitto, J. and Hodson, R.J.W., 2016. *Water quality state and trends for southland.* Dairy New Zealand
Poster. 2016 New Zealand Fresh Water Conference Proceedings, Invercargill. Page 683
http://www.es.govt.nz/Document%20Library/Presentations/Science%20Conference%2
0Posters%202016/Water%20quality%20state%20and%20trends%20for%20Southland.pdf

Environment Southland, 2016(b), *Water Quality in Southland,*
http://www.es.govt.nz/Document%20Library/Factsheets/Other%20factsheets/Water%20Quality%20
in%20Southland%20web.pdf



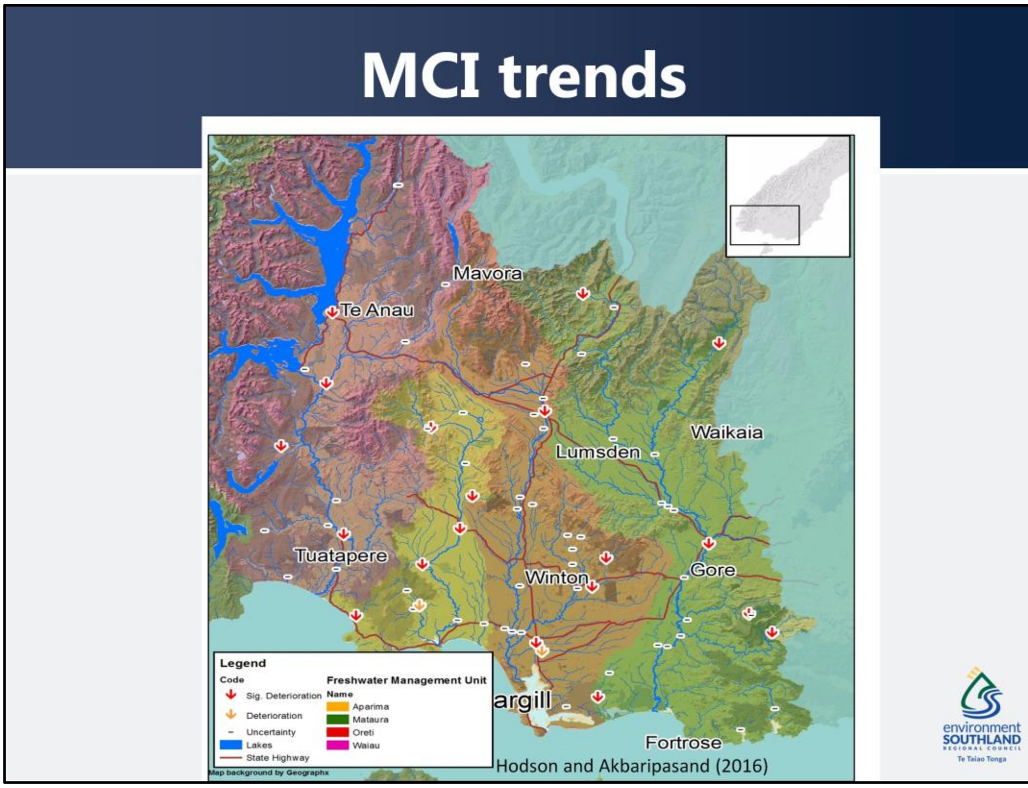
Hodson, R. and Akbaripasand, A., 2016. *State and Trends in Freshwater Macroinvertebrate Community Health in Southland.* New Zealand Fresh Water Conference Proceedings, Invercargill. http://www.es.govt.nz/Document%20Library/Presentations/Science%20Conference%20Posters%202016/State%20and%20Trends%20in%20Freshwater%20Macroinvertebrate%20Community%20Health%20in%20Southland.pdf

Figure available on page 670 of hearing report

19/81=23% -

Note for the mataura catchment where the regional water plan does not provide MCI standards, we applied the equivalent standard to hill, lowland hard bed, lowland soft bed to be able to make regional comparison.

Excluding the mataura 11 of 56 or 20 % don’t meet standatds



Hodson, R. and Akbaripasand, A., 2016. *State and Trends in Freshwater Macroinvertebrate Community Health in Southland.* New Zealand Fresh Water Conference Proceedings, Invercargill. http://www.es.govt.nz/Document%20Library/Presentations/Science%20Conference%20Posters%202016/State%20and%20Trends%20in%20Freshwater%20Macroinvertebrate%20Community%20Health%20in%20Southland.pdf

Figure available on page 671 of hearing report

19/72=26% -

Summary

- Elevated microbial contamination in Rivers
- Potentially toxic algae in rivers
- Elevated contaminants in Ground Water
- Estuaries - declines in health in response to catchment nutrient and sediment loads
- Nuisance slime algae growth in rivers
- Macroinvertebrate community impacted and deteriorating

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Water Quantity -
Groundwater and Surface Water

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Overview

- Changes to water quantity provisions largely represent 'tweaks' to the existing Regional Freshwater Plan (RFP) management framework
- Change from 'staged management' approach in RFP to fixed primary allocation volumes in pSWLP (consistent with NPSFM)

Groundwater

- Change to permitted activity threshold and recognition of non-consumptive takes
- Changes to groundwater management zone boundaries to reflect improved knowledge of regional hydrogeology
- Changes to primary allocation volumes to incorporate changes in spatial extent and improved recharge estimates

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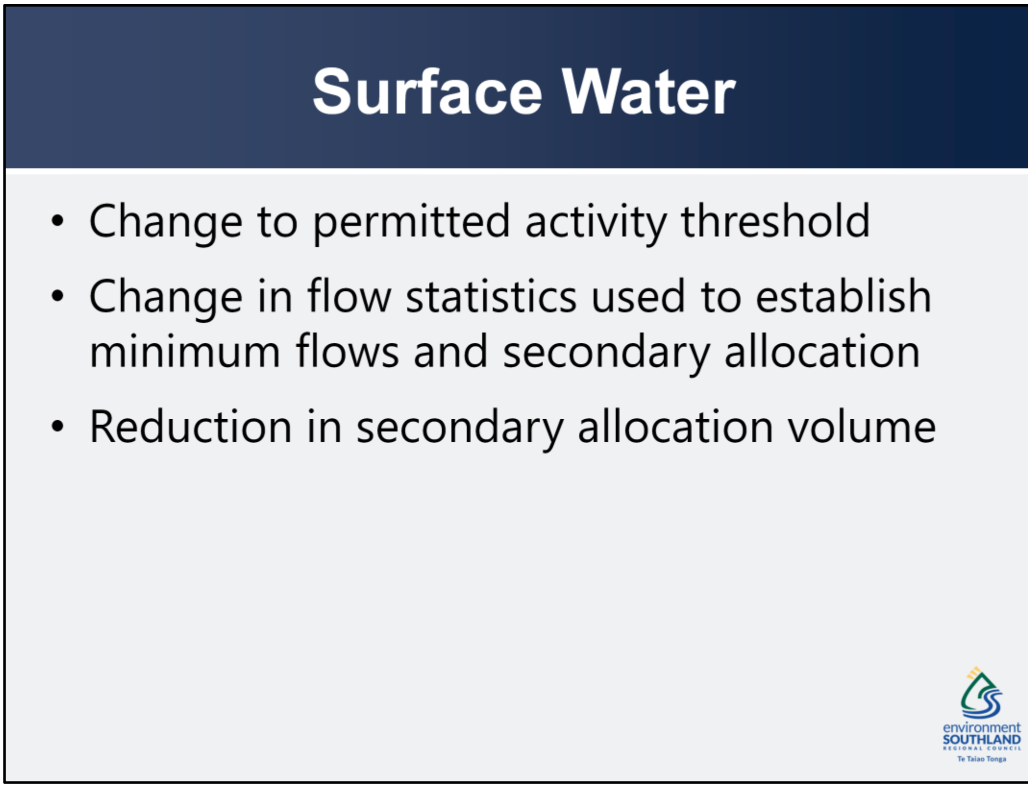
Groundwater

- Amendments to stream depletion and well interference methodologies
- Policies to improve both technical and allocative efficiency


Surface Water
• Change to permitted activity threshold
• Change in flow statistics used to establish minimum flows and secondary allocation
• Reduction in secondary allocation volume
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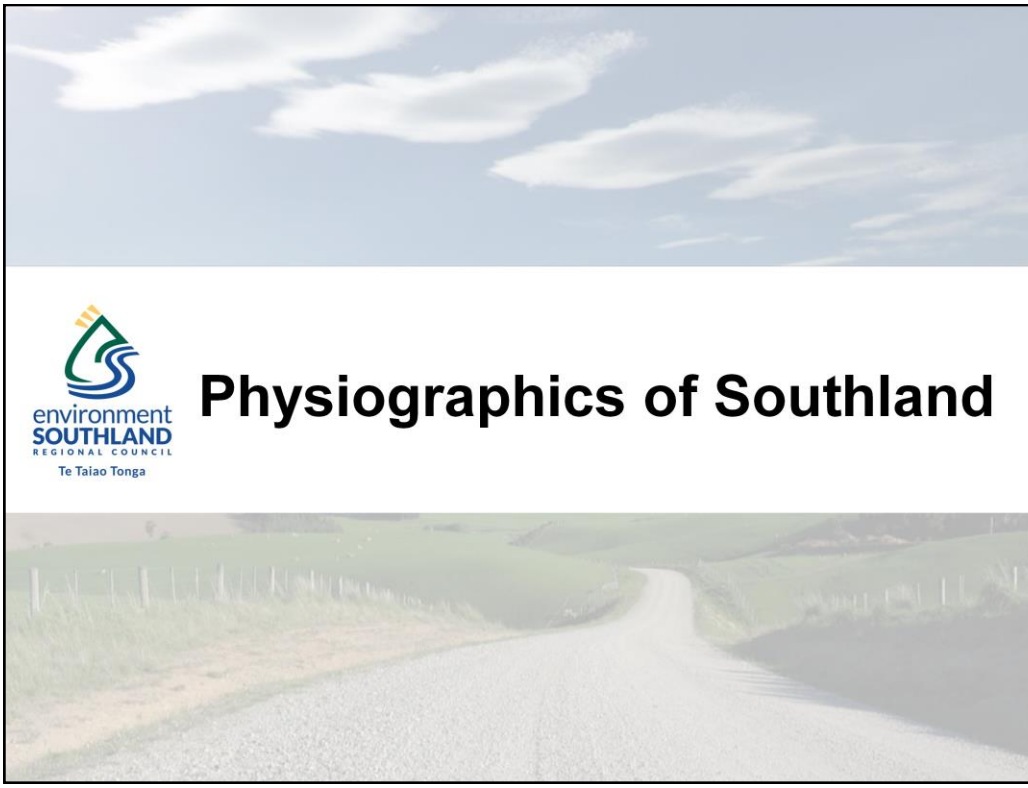
environment
SOUTHLAND
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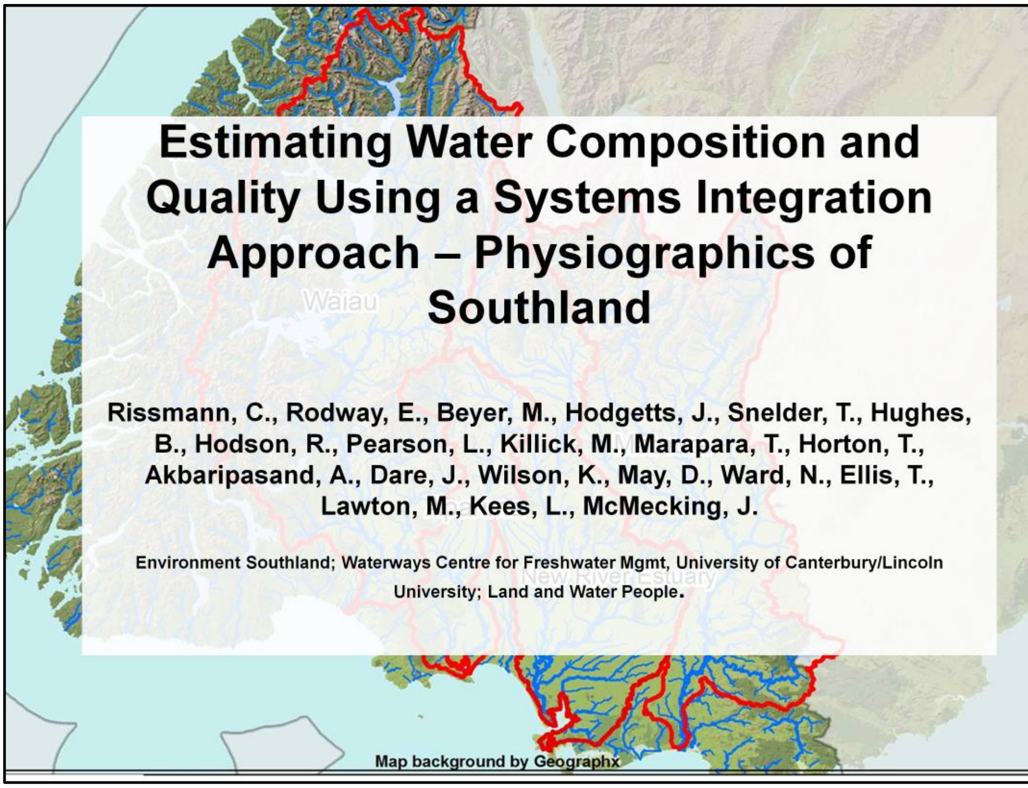
Physiographics of Southland


Estimating Water Composition and Quality Using a Systems Integration Approach – Physiographics of Southland
Waiau
Rissmann, C., Rodway, E., Beyer, M., Hodgetts, J., Snelder, T., Hughes, B., Hodson, R., Pearson, L., Killick, M., Marapara, T., Horton, T., Akbaripasand, A., Dare, J., Wilson, K., May, D., Ward, N., Ellis, T., Lawton, M., Kees, L., McMecking, J.
Environment Southland; Waterways Centre for Freshwater Mgmt, University of Canterbury/Lincoln University; Land and Water People.
New River Estuary
Map background by Geographx

Why?

“Why, given similar land use pressures, does water quality vary significantly in space (stream, aquifer, catchment, region)?”

*State and Trend

Many years of exhaustively looking at the data
Frustration with state and trend – does not say ‘how’ or ‘why’
Depends on who runs it!!!!

Slide 1 - why
Para 3.84 in S42a report

National and international research

Poor water quality outcomes are cause by anthropogenic land use

However:

Large proportion of variation in water quality outcomes within space (catchment or region) is mainly dictated by landscape features (attributes):

- Outcome type
- Magnitude of outcome

Slide 2 - national and international research
Para 3.86 of s42A

Water contains lots of info (signals)

Lots of information in water regarding processes

- Redox
- Major ion facies
- Isotopic
- Saturation indices
- Physical and biological signals
  - Water Composition
    - Not just N,P, Sed, M

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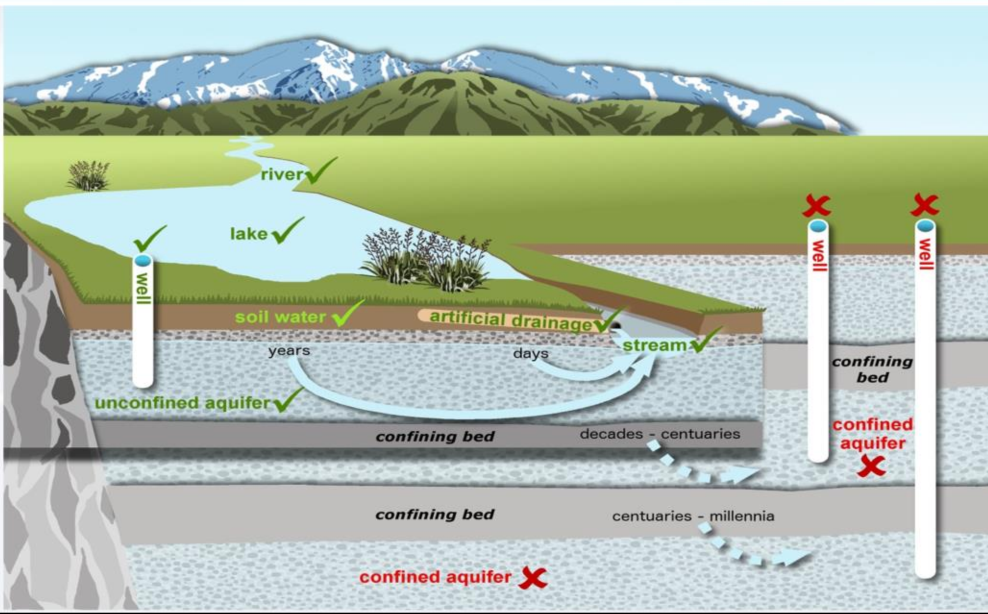
Slide 3 - water contains....
Para 3.98 of s42A

Overview of physiographic science



Slide 4 - overview....
Figure 2-4 pg 35 in Part 1 report

1. Landscape Attributes 2. Processes 3. Water Quality

Landscape attributes control the variation in processes that determine water composition

- Key processes are:
  - Atmospheric
  - Hydrological
  - Redox (stagnation)
  - Weathering

These processes occur in both natural state and areas of intensive land use

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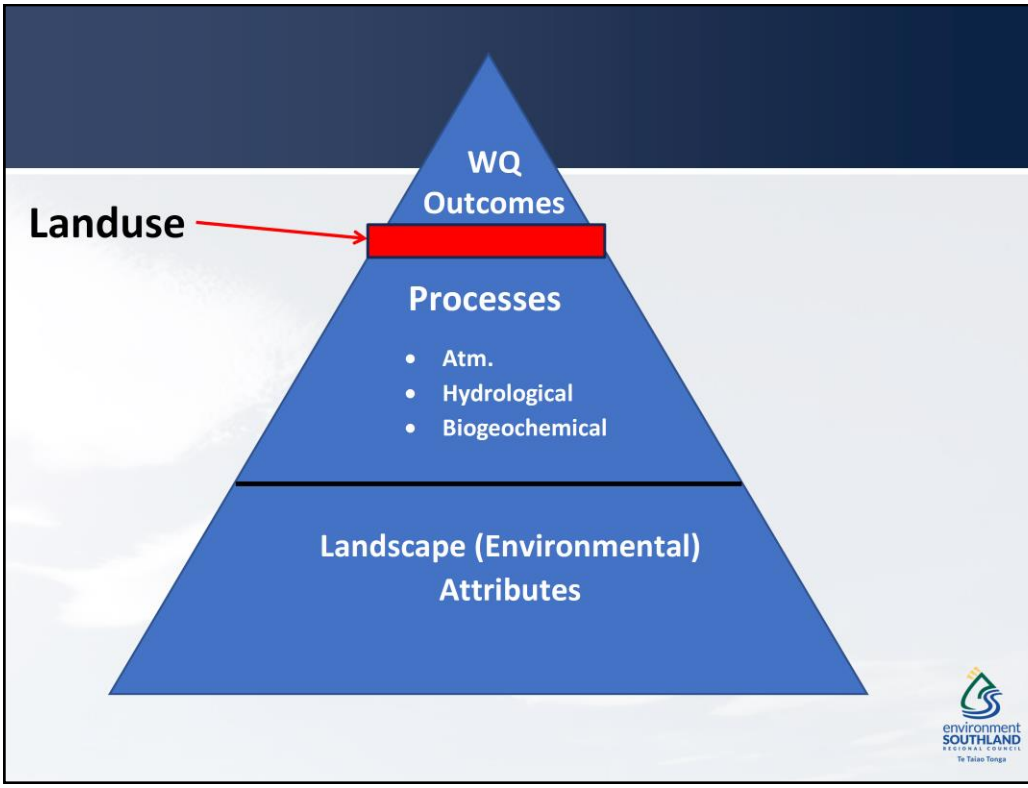
Slide 5 - landscape attributes.....
Para 3.97 of s42A


WQ
Outcomes
Landuse
Processes
Atm.
Hydrological
Biogeochemical
Landscape (Environmental)
Attributes
environment
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Assessing the relationship between water and the landscape

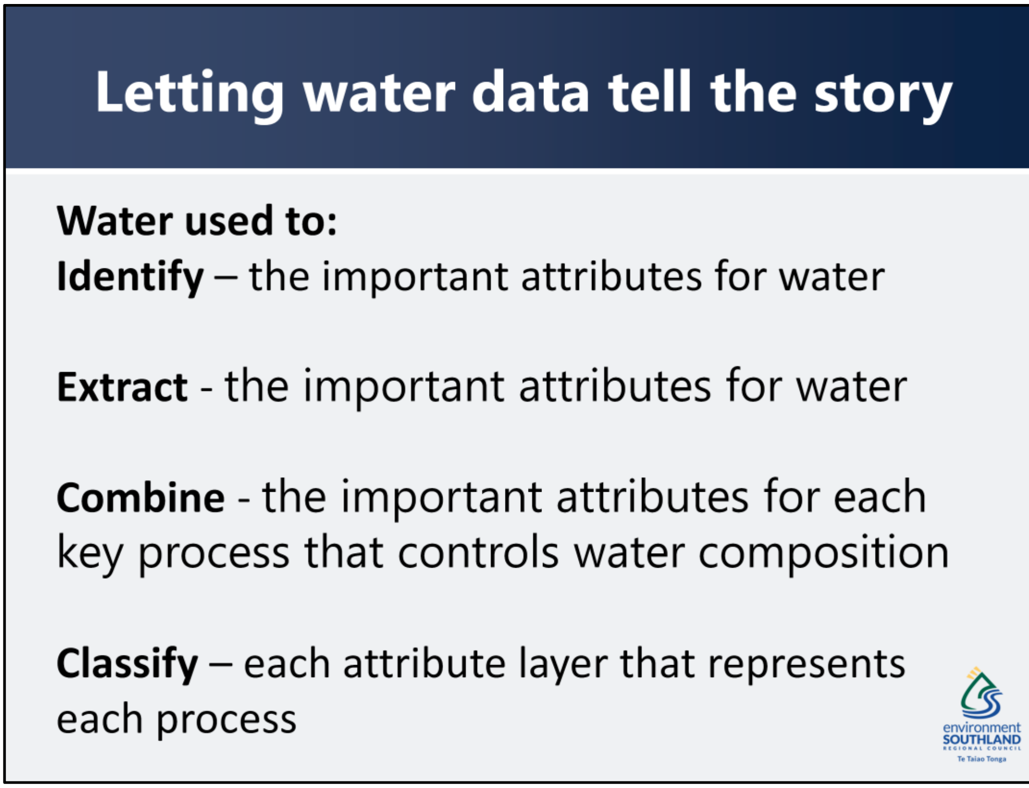
Exploring the relationship between water and landscape attributes, using:

Pre-existing spatial layers contain the key attributes
- Climate, Topography, Geology, Soil, Ecology, Hydrology, Hydrogeology...
  - e.g., c. 50 soil attributes but not all are important

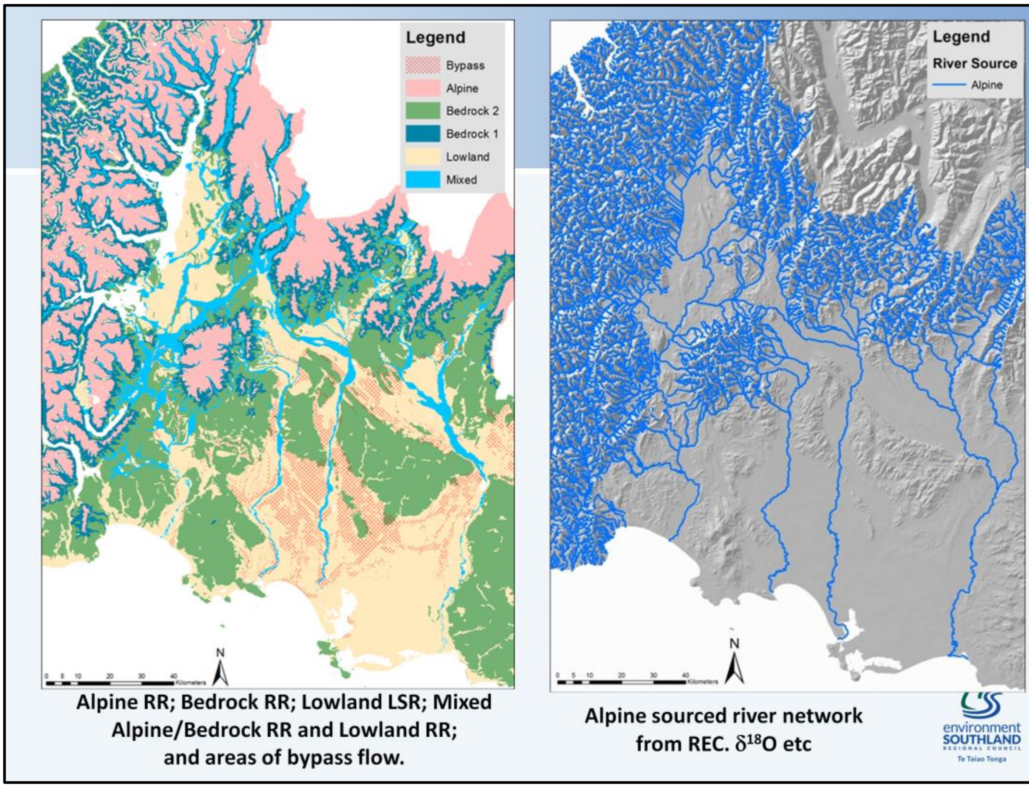
- Map units (polygons) or continuous (DEM)

Assessing water composition in space helps identify those important attributes that control water composition

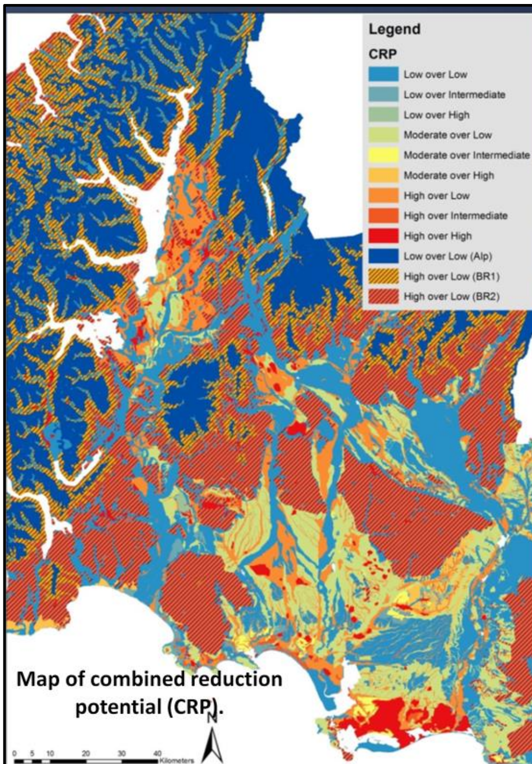
Slide 7 - assessing the relationship....
Para 3.97-3.98



Slide 8 - letting the data.....
Para 3.90-3.97



Slide 9 - redox
Figure a - figure 3-4
Figure b- figure 3-5
Figure c - figure 3-8
All Part 1 report



Map of combined reduction potential (CRP).

Redox

- Combined Reduction Potential

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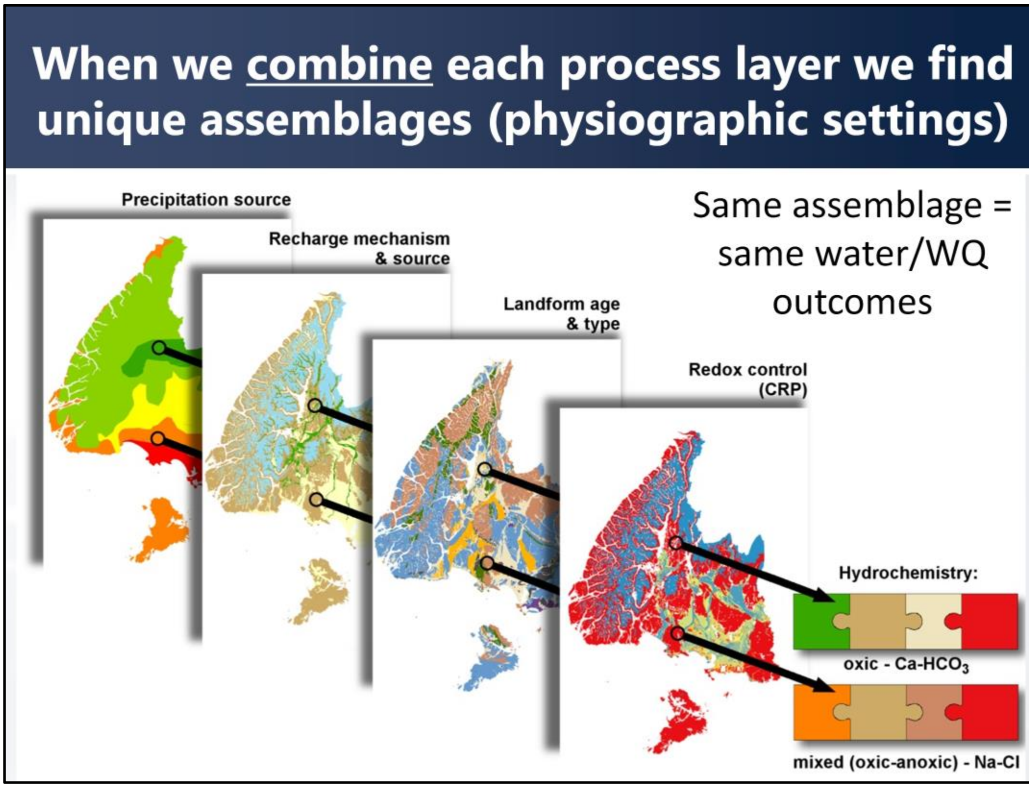
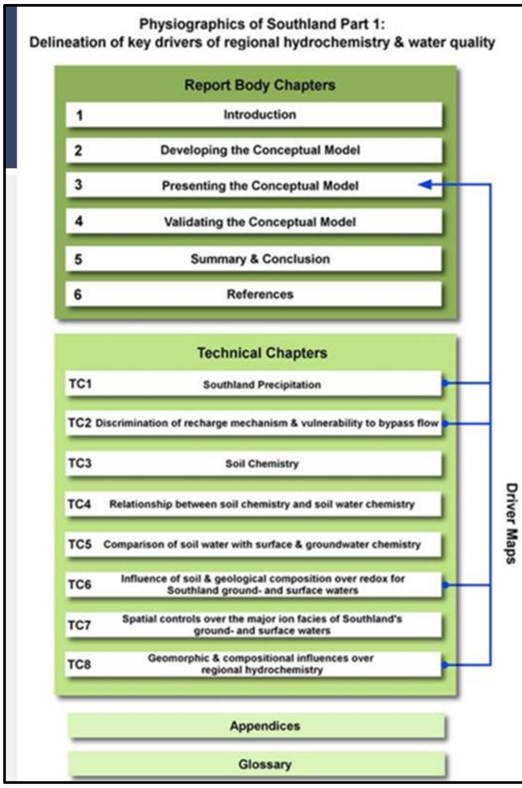


Slide 10 - when we combine...
Para 3.99
Figure 3-2 in part 1



Peer Reviewers

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Prof. Hans Schreier (UBC)
Dr Matthew Leybourne (UL)
Dr Clive Howard-Williams
Dr Scott Larned
Dr Travis Horton
Mr Trevor Webb
Dr Allan Hewitt
Dr Peter Almond
Dr Mike Scarsbrook
Dr Ranvir Singh
Dr Troy Baisden
Dr Maggie Lawton
Mr Vince Bidwell
Dr Ton Snelder
etc...

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Slide 11 - peer review...
Para 3.111-3.114
Figure 1-3 pg 18 part 1

Testing the Physiographic Science (Part 1)

Hierarchal Stratification – ES team

Empirical validation by Dr Ton Snelder

- Best performance to date
  - Shallow, ecologically important groundwater monitoring data is poorly represented by regional monitoring

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Slide 12 - testing
Para 3.107 - 3.110

Summary

- Water composition and quality outcomes (risk and state) vary in space even for equivalent land use pressures
- Variation in water quality outcomes is controlled by the natural variability of the landscape or its "physiographic setting"
  - Physical, Chemical and Biological attributes of the environment
    - Atmospheric, hydrological and biogeochemical processes

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Points of Difference

- Based on data
  - C. 28,000 samples of regional:
    - Precipitation
    - Soil water
    - Sources (animal and municipal effluents; fertilisers, pristine)
    - Ground and surface water
- Letting water tell the story
  - Used water finger prints to:
    - Identify
    - Extract
    - Combine
    - Classify
- Enables a high resolution understanding of the controls over water compositional and quality outcomes
  - "How and Why" water quality varies in space

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Application of Physiographics

- **Purpose** – a qualitative water quality risk assessment that provides a framework to apply mitigations to reduce effects of land use on water quality

- Water quality refers to nitrogen, phosphorus, sediment, microbes

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Realisation of water quality risk is dependant on land use

Classification system

- **Physiographic zones (9)**

Land areas with similar combinations of biogeochemical and hydrological controls that result in distinct water quality risks

- **Variants (8)**

Areas within each zone where there is increased water quality risk when soils are wet

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The classification system that we applied the water quality risk assessment to comprises …..

Water quality risk

- **How do contaminants move through the landscape?**
  - Overland flow
  - Artificial drainage
  - Lateral flow
  - Deep drainage (including natural bypass flow)

- **What natural processes influence contaminant concentrations and loads moving through the landscape?**
  - Dilution potential (water flux and mixing)
  - Reduction potential (soils and aquifers)
  - Filtration and sorption

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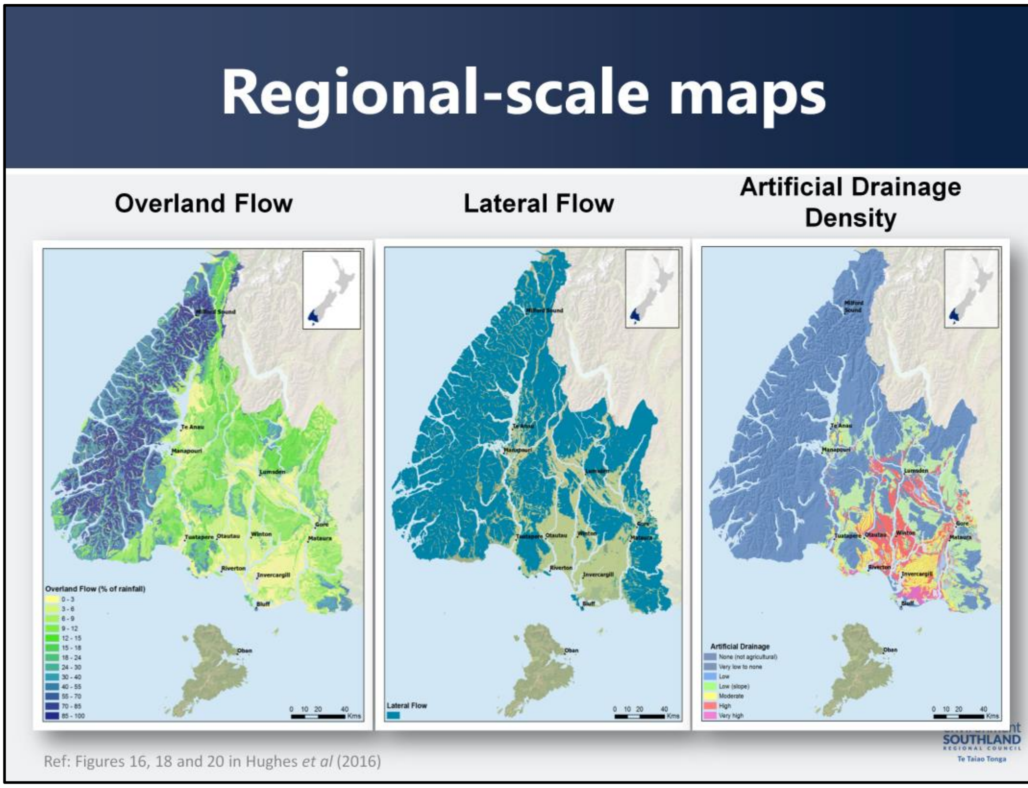
Drainage pathways
Identified 4 key pathways with deep drainage occurring in two forms: water moving through macropores such as cracks = natural bypass flow; and water moving through the soil and unsaturated geological matrix (or vadose zone).

Attenuation and dilution processes:

Dilution - Dilution reduces contaminant concentrations but does not influence loads. Considered water flux (i.e. volume of water) and mixing (i.e. ratios of water derived from local vs distal sources)
*Reduction Potential (or redox) – a*s Dr Rissmann mentioned, this can reduce nitrate concentrations through denitrification but can increase dissolved phosphorus concentrations under certain conditions.
Filtration and sorption – reduces microbes, sediment and phosphorus but because nitrate is so soluble, it has little effect on nitrogen.

We did not consider attenuation/dilution processes within surface water receiving environments because this is a water quality risk assessment.

Regional-scale maps developed for each of these attributes.



For each drainage pathway, attenuation and dilution process; a regional-scale map was produced

Water quality risk assessment

Physiographic Zone	Variant	Key contaminant pathways and contaminants				Water Quality Risk			
		Overland flow	Artificial drainage	Lateral drainage	Deep drainage	Nitrogen	Phosphorus	Sediment	Microbes
Alpine		N,P,S,M				High	High	High	High
Bedrock/Hill Country					N	Low*	Low	Low	Low
	Overland Flow	N,P,S,M				High	High	High	High
	Artificial Drainage		N,P,S,M			High	High	High	High
Central Plains			N,P,S,M		N	High	High	High	High
Gleyed			N,P,S,M			High	High	High	High
	Overland Flow	N,P,S,M				High	High	High	High
Lignite-Marine Terraces					N	Low*	Low	Low	Low
	Overland Flow	N,P,S,M				High	High	High	High
	Artificial Drainage		N,P,S,M			High	High	High	High
Old Mataura					N	High	Low	Low	Low
Oxidising					N	High	Low	Low	Low
	Overland Flow	N,P,S,M			N	High	High	High	High
	Artificial Drainage		N,P,S,M		N	High	High	High	High
Peat Wetlands			N,P,S,M	P, M	P	High	High	High	High
Riverine					N	High	Low	Low	Low
	Overland Flow	N,P,S,M			N	High	High	High	High

*Low risk due to high reduction potential (i.e. denitrification likely to occur)

Ref: Table 14 in Hughes *et al* (2016)

Using the regional scale maps, and by understanding the characteristics and processes occurring within each physiographic zone, we were able to develop a water quality risk table.

Risk assessment is binary (i.e. high or low)

Validation

- Variability within and between physiographic zones was well discriminated
- Validation results were stronger for surface water data than groundwater data
- Hypothesis testing results were largely consistent with expectations

Ref: Snelder *et al* (2016)

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The question we asked ourselves was: **are there differences between the physiographic zones and have they been characterised correctly?**

Statistical testing was undertaken on the landscape attributes identified as important controls over water quality outcomes (e.g. elevation, slope, soil drainage, redox) and we also tested water quality data.

Because the physiographic zones represent an integration of …., we tested for combinations of variables as well as testing individual water quality parameters (e.g. nitrate).

The results showed that for both the landscape attributes and river water quality data, the physiographic zones strongly discriminated the data. Variation in groundwater quality data was less well explained by the physiographic zones however there are several possible reasons for this which Dr Rissmann may which to expand on.

We also tested hypothesis developed from the underlying conceptual models for individual physiographic zones and testing showed the results were largely consistent with expectations. [We attempted to test variability in temporal data but the results were often inconclusive due to a lack of data].

Land Sustainability

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What the Land Sustainability team does –
FAFP
Community Groups
Individual, one on one farmers
Shelter/riparian planting
Soil health assessment
Forestry

Riparian management

Example - Extensive farming in hill country

Riparian fencing

Example – Intensive farming on lowland plains

In-line sediment traps

Critical Source Areas

Cultivation

Winter grazing

Soil management

Dairy NZ effluent resources booklet, includes

- Designing or upgrading effluent systems
- Compliance with rules
- Effluent storage (IPENZ PN 21 Farm Dairy Effluent Pond Design and Construction)
- Effluent containment infrastructure (IPENZ PN 27 Dairy Farm Infrastructure)
- Managing/operating effluent systems
- Finding the right professional (Accredited Effluent System Design Companies and Certified Warrant of Fitness Assessors)

Drainage

Drain through the property, old oxbows that have been straightened decades ago used to assist with filtering water, trapping sediment and enhancing biodiversity.

Opportunities for famers to utilise highly modified and artificially dug waterways for mitigation – duck ponds, sediment traps, nitrate catchers (Bog Burn) etc.

Sub surface drainage

Stop your farm going down the drain – factsheet for farmers with project information, costs, nutrient losses.