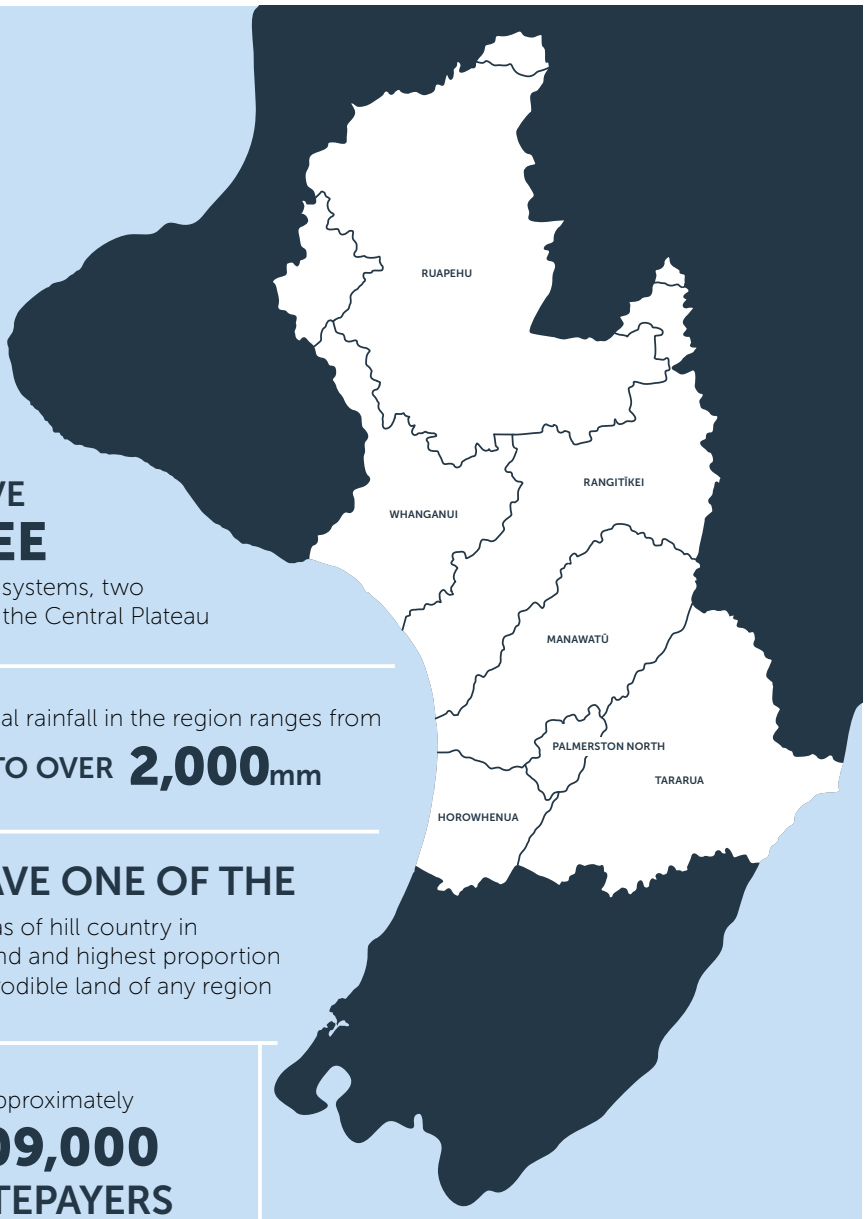
2019 STATE OF ENVIRONMENT

horizons
REGIONAL COUNCIL

Making the

HORIZONS REGION

a great place to live, work and play



Around
240,000
PEOPLE
call it home

WE HAVE
THREE
major river systems, two coasts and the Central Plateau

WE HAVE
SEVEN
DISTRICTS
and approximately
89%
of our ratepayers live in urban centres

Mean annual rainfall in the region ranges from
900 TO OVER **2,000mm**

WE HAVE ONE OF THE
largest areas of hill country in New Zealand and highest proportion of highly erodible land of any region

LAND USE IS:

45%	Sheep and beef
33%	Native cover
8%	Dairy
5%	Forestry
9%	Other

Approximately
109,000
RATEPAYERS
contribute to our work programmes

The Horizons Region is made up of
2.2 MILLION HECTARES
of land (8% of New Zealand's total land area), plus 31,000 hectares of marine area

WE HAVE OVER
226
LAKES
including Lake Horowhenua, New Zealand's largest dune lake

THERE ARE
40 ESTUARIES
in our region, including Manawatū Estuary, the internationally recognised RAMSAR site

We also have two coasts with jurisdiction extending
12
NAUTICAL MILES
out to sea

206,000
HECTARES
or 18% of the nation's versatile soils are in the region

THERE ARE OVER
35,000kms
of waterways in the Horizons Region

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TE ROHE

OUR REGION

INTRODUCTION

The Horizons Region extends over 2.2 million hectares, from Ruapehu in the north and Horowhenua in the south, to Whanganui in the west and Tararua in the east, and covers around eight per cent of New Zealand's total land area.

Natural resource management is a core function of Horizons as set out in legislation, our strategic direction, policies and community outcomes. One of these requirements is to monitor and report on the state of our environment. The purpose of this document is to provide information to our community on the current state and trends of our natural resources. Also included are some case studies that highlight some of the work being undertaken to address key issues.

So, before we dive into the report, let's set the scene for the Horizons Region. Formally known as the Manawatū-Whanganui Region, our patch of New Zealand is shaped by three major river systems: the Whanganui, the Rangitīkei and the Manawatū. Each of these catchments are unique, and have different pressures depending on the local geology, soils, climate and land use.

The region has approximately 35,000 km of stream length, 226 lakes and 40 estuaries. The Horizons Region

COME ACROSS A TERM YOU DON'T KNOW?

Check out the Glossary at the back of this report to learn more.

area also includes 3,100 km^2 or 310,000 hectares of marine environment spread across both the east and west coasts.

Sheep and beef farming is the predominant land use, covering around 45 per cent of the region. Over 60 per cent of the region is classified as hill country, and we have the largest proportion of highly erodible land of any region in New Zealand.

Maintaining and enhancing our natural environment also extends to biodiversity and recreation. Totara Reserve Regional Park is a great example of the indigenous forest that once covered much of our region, and many freshwater and coastal spots in our region are popular with swimmers over the summer months. Our environment is dynamic and challenges, such as the impacts of climate change, are becoming part of conversations with our communities.

Our communities are made up of the approximately 240,000 people that call the Horizons Region home, and around 109,000 ratepayers that contribute to our work programmes. Our region covers Ruapehu, Whanganui, Rangitīkei, Manawatū, Tararua, Palmerston North and Horowhenua, and parts of Taupō, Stratford and Waitomo districts — and around 89 per cent of our ratepayers live in urban centres.

We hope you find this report useful for providing an overview of the current state of our environment and some snapshots of how we are working in conjunction with our partners and community to make this region a great place to live, work and play.

COMMUNITY OUTCOMES

In consultation with our community, we have introduced six outcomes through Horizons' 2018-28 Long-term Plan. Our science and research work supports all of these outcomes, either directly (through monitoring and reporting) or indirectly (through data and information provision and technical support).

HE MANAWAROA I TE MŌREAREA

NATURAL HAZARD RESILIENCE

A community that is aware of hazards and is prepared and empowered to respond to, and recover from, a natural hazard or emergency.

How our science supports these outcomes:

- Monitoring of rivers and rainfall
- Flood modelling
- Climate change research
- Targeting erosion control works

HE OHANGA PAKARI

A ROBUST ECONOMY

and a regional economy that is diversified to take advantage of a range of opportunities, and resilient to changes in the national and global economy or other influences such as climate change.

How our science supports these outcomes:

- Characterising natural resource availability and informing policy development
- Informing regional growth initiatives
- Provision of technical information to policy makers

HE MĀIA I NGĀ WHAKATAUNGA

CONFIDENCE IN DECISION-MAKING

A community that has confidence in regional decision-making.

How our science supports these outcomes:

- Completing state of environment monitoring and reporting
- Provision of information to the community through guidance material, and the Horizons and Land, Air, Water Aotearoa websites
- Informing policy and non-regulatory programme development and evaluation

HE TAIAO MATOMATO

HEALTHY ECOSYSTEMS

Healthy and diverse ecosystems that provide for community needs now and in the future.

How our science supports these outcomes:

- Monitoring of ecosystems on land and in our waterways
- Targeting work programmes to address current issues and emerging pressures
- Research into drivers of ecosystem health, biodiversity and biosecurity

HE ORANGA TANGATA

HUMAN WELLBEING

Natural and built environments that support healthy people and communities.

How our science supports these outcomes:

- Monitoring and reporting of air quality
- Research into drinking water security, swimmability and contaminated land

HE HAPORI I TŪHONOA

CONNECTED COMMUNITIES

Connected communities supported by safe, reliable, efficient transport systems.

How our science supports these outcomes:

- Technical advice and support for resource consent decision making for roads and other infrastructure

HORIZONS' 2019 STATE OF ENVIRONMENT REPORT

Monitoring of and reporting on the state of the environment is a key function of regional councils. Under Section 35 of the Resource Management Act 1991, local authorities are required to compile and make available to the public a review of the state of environment monitoring results.

This report presents a range of indicators including pressures on the environment and state, as well as trends in both of these. The report also presents some information on our response to identified issues. While this information is not intended to provide a complete summary of work, it does provide a range of case studies, information on rates of progress, and projected outcomes for the region.

The 'Our Region' chapter of this report sets the scene, capturing some of the region's main features, and identifying our community outcomes. The background to state of environment reporting is provided, along with an overview of data and information that has helped shape this report. A summary of the findings for the Horizons Region is also provided.

The rest of the report is laid out in chapters for Climate, Air, Land and Water. Finally, the report wraps up with a section to guide readers who are seeking more information and a glossary for some of the technical terms.

DATA AND INFORMATION

This report draws information from a range of sources, including information from external agencies such as Statistics New Zealand and national databases. Much of the information is drawn from Horizons' monitoring programmes and the science completed by Horizons – often in partnerships with others.

Horizons has a range of monitoring programmes to report on the state of the environment. These programmes have evolved over time and the monitoring of some environmental indicators is more comprehensive than others. For example, Horizons has one of the most comprehensive river water quality monitoring networks in New Zealand with over 174 sites. In contrast, Horizons only monitors air quality in two places in the region. The report also uses monitoring from implementation programmes to update on the state of the environment. For example, monitoring of possum populations via Horizons' possum control operations provides an indicator of population density in the approximately 1.3 million hectares of area being managed.

Horizons' monitoring and science also continues to evolve in response to emerging issues and an increasing demand for scientific information. Over the period since the 2013 State of Environment report, the following has been achieved:

- Groundwater monitoring has increased from 21 sites measured every seven months for 24 parameters, to 31 sites measured every three months for 34 parameters;
- A lake monitoring programme has been initiated measuring water quality at 15 of the 226 lakes region-wide, while 31 lakes has been surveyed using LakeSPI (a measure of ecological health);
- An estuary monitoring programme has been initiated, and currently includes seven of the region's 40 estuaries;
- Summer swim spot monitoring increased from 17 to over 80 popular swim spots across the region in 2016;
- A regional soil health programme has been initiated and to date has measured 55 (of the target 100) sites;
- Horizons has undertaken investigations of sediment and nutrient transport, and contaminated land; and
- We have also initiated re-surveying of actively managed biodiversity sites to determine if the One Plan's anticipated environmental outcomes are being met.

A gap in the information sources is the input of Mātauranga Māori, which offers an opportunity to deepen and enhance our understanding and connection to the world around us. While we have a big journey ahead of us to truly embrace the value of Mātauranga, opportunities to incorporate cultural monitoring, and integrate Te Ao Māori with western science, are beginning to emerge through our freshwater and science programmes. For example, recent Te Mana o te Wai fund projects that Horizons has supported have included funding for capacity building and training to improve the linkage between western science and Mātauranga Māori. Freshwater Improvement Fund projects in the Manawatū and Horowhenua catchments are also working toward the incorporation of cultural monitoring, providing opportunities for shared knowledge and understanding.


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KEY FINDINGS FOR THE HORIZONS REGION

This section summarises some of the key findings for the 2019 State of Environment report. For further context and detail beyond the summarised text and infographics, please see the relevant chapters. Each chapter is set up by the following:

- Where we've come from;
- Where we are now – current state;
- What we're doing (case studies); and
- Where we're going and what you can do.

CLIMATE

The Climate chapter overviews the issue of climate change. It presents indicators that are projections for the region's climate into the future, based on modelling completed for Horizons by NIWA.

Key findings include that from the year 1909 annual average temperatures in New Zealand have warmed by 0.09 $\pm$ 0.3°C per decade and average annual temperatures are likely to increase by between 0.7 and 1.1°C by 2040 and up to 3.1°C by 2090. Annual average rainfall is predicted to be 15 to 20 per cent more in the northern part of the region (eg. Taumarunui) and potentially 20 per cent less in the south eastern part of the region (eg. Akitio) by 2090.

A case study of the impacts of climate change on sedimentation of rivers shows the current projected 27 per cent improvement in sediment loads in the region's rivers by 2043 due to hill country erosion control, are projected to reduce to 19, 12 or 5 per cent improvement under minor, moderate or major climate change scenarios, respectively. Further modelling suggests a greater pace of works will be required to offset the impact of climate change on sedimentation of rivers in the long term. A further case study predicts summer river flows in the Manawatū are projected to decrease by 14 per cent by 2090 and there is likely to be an increase in the number of high flow events per year.

AIR

The Air chapter reports that particulate matter (PM_{10}) monitoring of 12 towns in the winter of 2001 to 2003 identified Taumarunui and Taihape as having the worst air quality in the region. These are now monitored as the only designated airsheds in the region. Other towns identified with potential air quality issues were Ohakune, Feilding, Dannevirke and Pahiatua.

Monitoring in the Taumarunui and Taihape airsheds shows these sites meet the National Environmental Standard (NES) for air quality. Modelling also shows domestic heating contributes over 80 per cent of the PM_{10} in these areas and predicts that air quality will improve over time as more homes upgrade their heating sources.

LAND

The Land chapter reports on productive land, fluvial research and gravel use, as well as biodiversity and biosecurity.

PRODUCTIVE LAND

The Productive Land section includes information on land use, stocking intensity, versatile soils, and hill country erosion. Land use in the region is estimated to be 45 per cent sheep and beef, 33 per cent native cover, 8 per cent dairy, 5 per cent forestry, 1 per cent horticulture and 8 per cent other land uses.

Stocking rate is an indicator of the intensity of land use. Statistics New Zealand information shows that during the period from 1994 to 2017 the number of dairy cows has grown 69 per cent nationally compared to 50 per cent (155,000 cattle) in the Horizons Region. During this same period regional beef cattle numbers dropped by 239,000 and sheep numbers dropped by 2.4 million.

The Horizons Region has the most highly erodible land in pasture of any region in the country with approximately 260,000 hectares or 22 per cent of New Zealand's total area. Over the last 11 years, 22,000 hectares of erosion control works have been completed on highly erodible land in pasture, increasing the amount of land protected.

The region, which covers approximately 8 per cent of New Zealand, has 18 per cent of the nation's Class 1 land (34,000 hectares) and 14 per cent of Class 2 land (172,000 hectares). This State of Environment report has not assessed changes in land use on these lands due to the difficulty in obtaining data to do so. The 2013 State of Environment report identified 60 per cent of the elite and versatile soils were utilised for sheep and beef farming and 30 per cent for dairy farming.

Horizons established a soil health monitoring programme in 2015. At this early stage in the programme it is difficult to make summary statements; however, the results show 30 of 55 sites sampled so far fail to meet optimal range for at least one indicator.

FLUVIAL RESEARCH AND GRAVEL USE

Many of our region's rivers have stony, gravel beds, which provide a useful and convenient source of gravel for roading and construction. Gravel use in the region has remained relatively stable during the past five years, with around 340,000 cubic metres of gravel extracted annually for commercial use in our region. More than 30 of the region's rivers are surveyed at a frequency of between 5 and 10 years to track changes in our river channels over time. A targeted study to identify and track sediment movement in the Oroua River has identified that around a quarter of the total sediment contribution comes from natural processes, while hill country erosion

accounts for around 40 per cent and erosion of the river channel around 20 per cent. The study also identified key areas of erosion and deposition within the river channel that occurred during the last decade, providing useful information for erosion control and flood management.

BIODIVERSITY

The Biodiversity section reports 33 per cent of the region is in native cover (this includes native forest and bush remnants within private land) and that wetland extent has reduced from approximately 22,000 hectares historically to less than 700 hectares presently (3 per cent of the former extent). Over a thousand (1,109) biodiversity remnants covering 52,660 hectares have been identified in the region. Of these, we have visited and evaluated 500 remnants covering 20,865 hectares.

BIOSECURITY

The Biosecurity section reports that possum populations, in the approximately 1.3 million hectares that Horizons undertakes control in, are around 4 per cent residual trap catch – well below the 10 per cent target in the 2017-27 Regional Pest Management Plan. Rooks are a species of pest identified in the Plan, with a goal of halting breeding in the region. The rook control programme reports a reduction in active breeding nests (where eggs or chicks have been found) of 95 per cent, reducing from 2,942 nests in 2005-06 to 135 nests in 2017-18.

Overall the Regional Pest Management Plan provides for the management of 66 species of pest plants, with Horizons having active programmes for 29 species that are either controlled region-wide or in target areas. In 2017-18, 66 per cent of 5,179 managed sites report pest plants at zero levels, compared to 40 per cent of 1,600 sites in 2010.

WATER

The Water chapter overviews the state and trends of water allocation for surface and groundwater as well as information on the quality of groundwater, rivers, lakes, estuaries and coasts. Also included is a section on the swimmability of the region's rivers, lakes and coast.

WATER QUANTITY

Hydroelectricity is the largest user of water in the region using approximately 55 m^3/s or around 77 per cent of the water allocated in the region. Consented allocation for uses other than hydroelectricity has increased by over 161 per cent since 1997, from approximately 6.46 m^3/s to 16.9 m^3/s. The increase in allocation annually from 2013 to 2018 is approximately half that of the period from 1997 to 2018.

Consented allocation of groundwater and surface water (excluding hydroelectricity) is approximately evenly split, with the proportion of groundwater allocation increasing. Of the 124 surface water management zones in the region 15 zones (12 per cent) were over allocated in 2014. This has reduced to nine zones (7 per cent) in 2018. Overall the region's surface water is 61 per cent allocated. There are approximately 8,700 bores in the region with an average of approximately 50 new bores drilled per year over the last decade.

Consented groundwater allocation volumes in all groundwater management zones are within One Plan allocation limits. Groundwater levels are monitored at 145 bores in the region. Results show approximately 30 per cent of sites have increasing water levels and 14 per cent are declining, with the declines primarily in the Manawatū and Rangitīkei catchments where allocation levels have increased.

GROUNDWATER QUALITY

The groundwater quality monitoring network was upgraded following the last State of Environment report. Data from 2012 to 2017 shows nitrate concentrations are generally below the drinking water standard, with some elevated levels in Horowhenua and Tararua. Trends for nitrate concentration are generally indeterminate or improving, with one bore north east of Levin showing a declining trend.

Pesticide monitoring in 2014 returned no positive detections, including at locations with previous detections. Analysis of average surface water ages during low flows show results ranging from less than 12 months through to 17 years, providing an indication of average travel times between land and surface water.

RIVER WATER QUALITY

Upgrades to the water quality monitoring programme now provide further information on state and trends in the region. Comparison of the state of water quality compared to One Plan targets (Figure 1) shows nearly all sites meet ammoniacal nitrogen criteria. However, nearly all sites fail the criteria for dissolved reactive phosphorus, bacteria and water clarity. Grades varied for measures of soluble inorganic nitrogen, periphyton (chlorophyll *a*) and macroinvertebrate community index.

Comparison with the National Objective Framework of the 2017 National Policy Statement for Freshwater Management (Figure 2) showed most sites were in the A band for nitrate toxicity and ammonia toxicity. Of the 55 sites analysed for periphyton, many sites were in the A band; however, five sites were below the national bottom line.

Ten-year trends (Figure 3) show predominately degrading trends for periphyton (chlorophyll *a*), macroinvertebrate community index, dissolved reactive phosphorus, clarity, and spot measurements of dissolved oxygen. Predominantly improving trends were detected for soluble inorganic nitrogen, ammoniacal nitrogen, and the number of exceedances of the *E. coli* criteria for swimmability (540 MPN/100ml). Twenty-year trends for almost all parameters included both degrading and improving trends with a range of declining trends in the northern part of the region and a range of improving trends in the southern region.

RIVER WATER QUALITY RESULTS

The number at the top of each bar indicates the total number of State of Environment sites in the analysis. DRP = dissolved reactive phosphorus, SIN = soluble inorganic nitrogen, chl *a* = chlorophyll *a* (periphyton) and MCI = macroinvertebrate community index. The full suite of results, along with results for Impact and Discharge sites, can be found in the River Water Quality section of this report.

FIGURE 1: STATE COMPARED TO ONE PLAN TARGETS

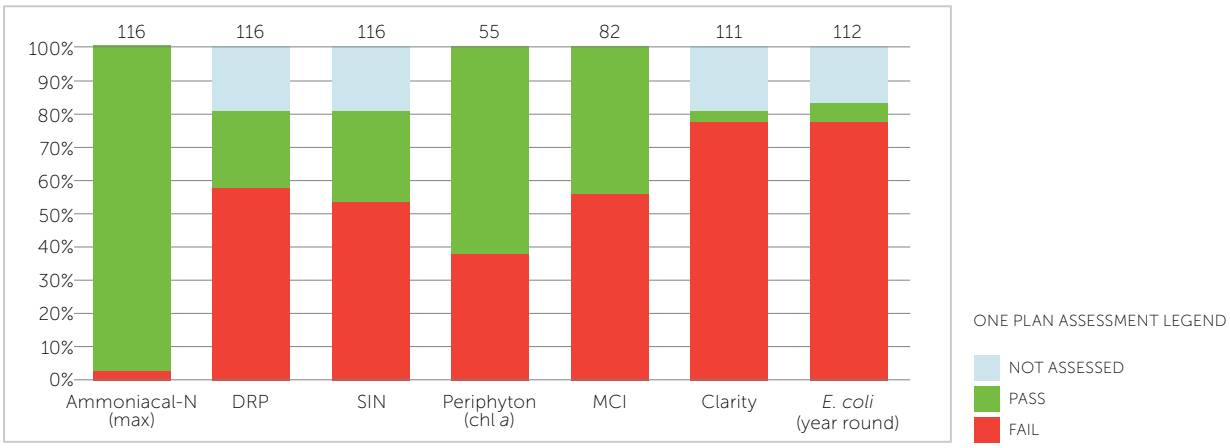


FIGURE 2: STATE COMPARED TO NATIONAL OBJECTIVES FRAMEWORK ATTRIBUTE BANDS

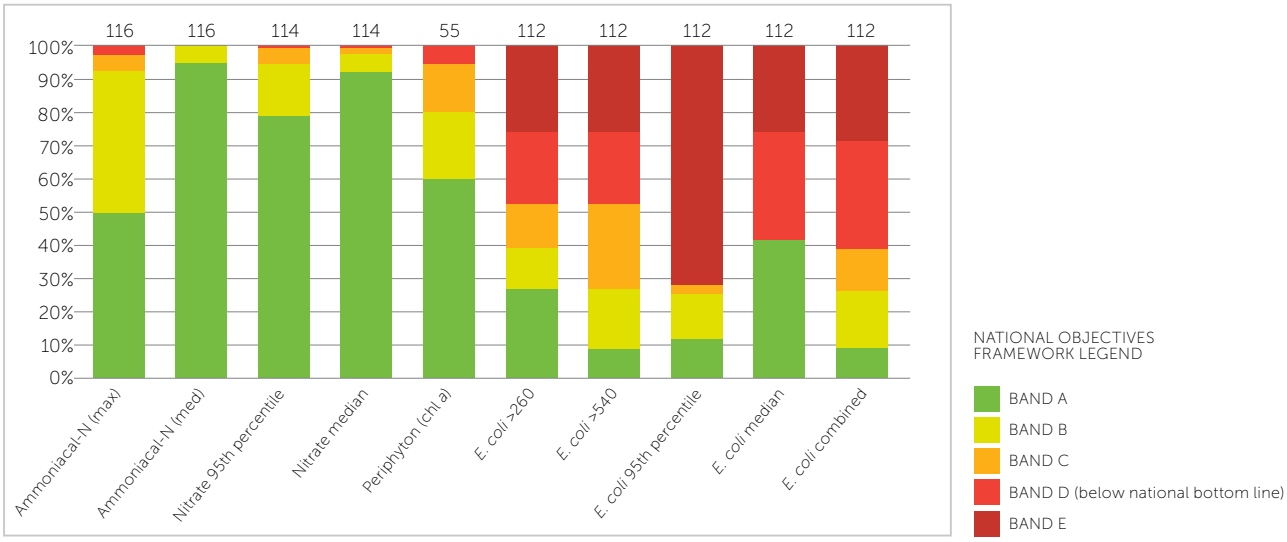
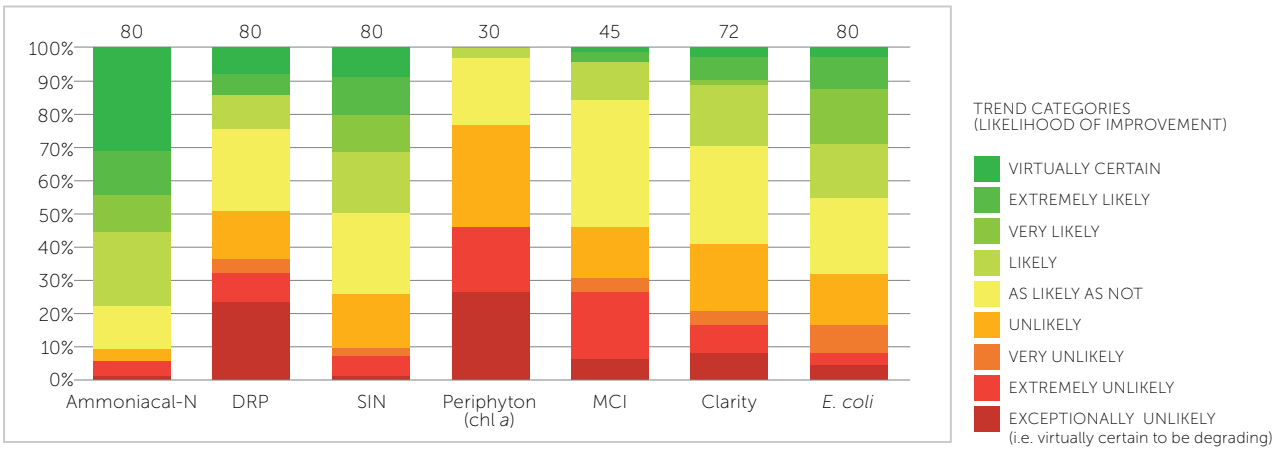


FIGURE 3: PROPORTION OF SITES SHOWING IMPROVEMENT OVER 10 YEARS



LAKES

A lakes monitoring programme has been initiated since the last State of Environment report including both water quality monitoring and monitoring of ecological condition using the LakeSPI method. Water quality monitoring of 15 of the 226 lakes in the region shows that nearly all monitored lakes fail the targets for chlorophyll a (algae), total nitrogen and total phosphorus; however, pass the ammoniacal nitrogen and bacteria targets (which apply to the bathing season and year round).

Trends were not able to be calculated due to the length of record and frequency of sampling. Comparison with the National Objectives Framework showed nearly all lakes were below the national bottom line for nitrogen and phosphorus, compared to approximately half the monitored lakes being below the national bottom line for a phytoplankton (chlorophyll *a*) measure. The ecological condition of 31 lakes, as assessed using the LakeSPI method, ranges from high or excellent (6 lakes, 19 per cent), moderate (14 lakes, 45 per cent), poor (7 lakes, 23 per cent), to non-vegetated (4 lakes, 13 per cent).

ESTUARIES AND COAST

The regional boundary includes 3,100km^2 or 310,000 hectares of coastal area, which equates to approximately 14 per cent of the regional area. There are 40 estuaries in the region – 25 on the west coast and 15 on the east coast. Of these, five estuaries (12.5 per cent) have been identified as moderate to high vulnerability to eutrophication (nutrient and sediment). These are the east coast estuaries Wainui and Tuatane and the west coast estuaries Kai Iwi, Hōkio and Waikawa. Two estuaries were identified as moderate vulnerability and the remainder as low to moderate (27 estuaries) or low (six estuaries). The Manawatū Estuary, which is internationally recognised as a RAMSAR site, has been assessed as low vulnerability to sediment and nutrient and is presented as a case study in the report.

Since the last State of Environment report, a stocktake of the region's estuaries and coast has been undertaken and monitoring programmes established that in time will provide further information on the state and trends of estuaries. The results from these programmes indicate three out of the six estuary sites meet the targets for chlorophyll *a* (algae) and three fail. Three out of the four beach sampling sites fail average chlorophyll *a*, nitrogen and phosphorus targets. A different combination of three out of the four coastal sites fail the targets for bacteria in during the bathing season.

SWIM SPOT MONITORING

Since the last State of Environment report, Horizons has upgraded its swim spot monitoring programme from 17 sites to over 80 popular sites across the region, with the results made available to our community on the Horizons and LAWA websites. During this time, central government has also introduced new requirements around swimmability through amendments to the National Policy Statement for Freshwater Management in 2017.

A regional assessment for Horizons completed by Land Water People (LWP Ltd) shows that One Plan targets are generally not achieved. Between 2006 and 2016, the length of all of the region's rivers in the swimmable category (with grades of 'fair' to 'excellent') increased from 35 per cent to 40 per cent, while large rivers (order 4 and above) increased from 34 per cent to 42 per cent. This broadly aligns with regional and national modelling that suggests the length of the region's large rivers are presently around 38-45 per cent swimmable.

As required by the National Policy Statement for Freshwater Management, Horizons has set a target of 70 per cent of the length of rivers being suitable for swimming by 2030 and 80 per cent by 2040 year round. There is also the additional goal of 90 per cent of these being suitable for swimming during the swimming season by 2040.

WHERE TO FIND FURTHER INFORMATION

LAND, AIR, WATER AOTEAROA

Land, Air, Water Aotearoa (LAWA) aims to connect New Zealanders with their environment through sharing scientific data online. This data is supplied by regional councils and made available to the public at **www.lawa.org.nz**.

HORIZONS' WEBSITE

Horizons provides access to a wide range of environmental data and information, including real time monitoring of rivers and rainfall, and water use data via our WaterMatters webpage. Our science is regularly reported to Horizons' Environment Committee, with the reports available on our website **www.horizons.govt.nz**.

MANAWATŪ RIVER LEADERS' ACCORD (MRLA) WEBSITE

The MRLA website provides the latest information about MRLA progress and community initiatives. You can check out the latest news, and find out what's happening in your area at **www.manawaturiver.co.nz**.

CLIMATE

New Zealand has warmed by approximately

0.09°C

PER DECADE SINCE 1909

Predicted regional improvement in

RIVER SEDIMENT LOAD OF

27%

BY 2043 COULD REDUCE TO

5-19%

due to climate change

Our region's temperatures are

LIKELY TO INCREASE

0.7-1.1°C

BY 2040 AND UP TO

3.1°C

BY 2090

Summer flows in the Manawatū River

ARE PROJECTED TO DECREASE

14%

BY 2090

and the number of high flow events are likely to increase

Annual average precipitation is predicted

TO INCREASE

15-20%

in the north of the region

AND DECREASE

20%

in the south east by 2090

AIR

2 AIRSHEDS IN THE REGION

Taihape and Taumarunui currently meet the national standard for air quality and are expected to improve as more homes switch to more efficient heating sources

OUR ISSUES ARE RELATIVELY MINOR

compared to other air quality sites in New Zealand

OVER **80%**

AIR QUALITY ISSUES

at our two designated airsheds relate to domestic heating

LAND

FROM 1994 TO 2017

the number of dairy cows has increased by

155,000

Beef numbers have dropped by

239,000

and sheep numbers by **2.4** MILLION

Despite occupying just 8% of New Zealand's total land area

THE REGION HAS

22% of the nation's most highly erodible land

18% OR

206,000 ha

of New Zealand's versatile soils are in our region

Early results for Horizons' soil health monitoring programme show

30 OF 55

SITES

fail to meet optimal range for at least one indicator

33% of the region is in native cover,

3% of original wetlands remain

1,109 biodiversity remnants have been identified in the region, covering

52,660 ha

Of these, we have visited and evaluated 500 remnants covering

20,865 ha

POSSUM POPULATIONS

are meeting target levels within the 1.3 million ha managed

Active rook breeding nests have reduced by

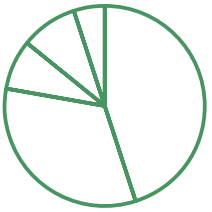
95% FROM 2,942 TO 135 NESTS since 2006

66%

OF 5,179

managed sites report pest plants at zero levels, compared to 40% of 1,600 sites in 2010

Land use in the region



45% Sheep and beef
33% Native cover
8% Dairy
5% Forestry
9% Other

WATER

77%

OF CONSENTED WATER USE
in the region is for hydroelectricity

Consented allocation for other uses has
INCREASED BY
161%
SINCE 1997
(excludes hydroelectricity)

The split of
GROUNDWATER AND SURFACE WATER
allocation (excluding hydroelectricity) is approximately even

Over-allocated surface water management zones have
REDUCED FROM
15 TO 9
since 2014

Of 145 monitored bores
30%
HAVE INCREASING
groundwater levels and
14%
ARE DECLINING

ALLOCATION IN ALL
groundwater management zones are within One Plan limits

3 OF 31
state of environment bores exceed the drinking water standard for nitrate

Most of the 64 sites monitored for periphyton are
WITHIN THE A BAND
5 sites (8%) are
WITHIN THE D BAND

10 YEAR TRENDS
IN RIVER QUALITY
are predominately DEGRADING for:
Periphyton (chlorophyll *a*) | Macroinvertebrate community index | Dissolved reactive phosphorus
Clarity | Spot measurements of dissolved oxygen

10 YEAR TRENDS
IN RIVER QUALITY
are predominantly IMPROVING for:
Soluble inorganic nitrogen | Ammoniacal nitrogen
The number of exceedances of the *E. coli* criteria for swimmability

ALL 15 MONITORED
LAKES PASS
the ammoniacal nitrogen and bacteria targets

ECOLOGICAL CONDITION
of 31 lakes assessed using the LakeSPI method show 19% at high or excellent, 45% moderate, 23% poor and 13% non-vegetated

7 of 40
ESTUARIES
have been identified as
VULNERABLE TO NUTRIENT AND SEDIMENT,
33 have low to moderate vulnerability

NEARLY ALL RIVER WATER QUALITY SITES MEET
One Plan ammoniacal nitrogen criteria

NEARLY ALL RIVER SITES FAIL
criteria for dissolved reactive phosphorus, bacteria and water clarity

The length of rivers considered suitable for swimming has
INCREASED FROM 35% IN 2006 TO 40% IN 2016

NEARLY ALL 15 MONITORED
LAKES FAIL
the targets for chlorophyll *a* (algae), total nitrogen and total phosphorus

3 OF 4 BEACH SITES
fail average chlorophyll *a*, nitrogen and phosphorus targets and another
3 OF 4 BEACH SITES
fail bacteria targets for bacteria during summer

National modelling shows 45% of the region's large river lengths and 55% of the region's lakes are considered
SUITABLE FOR SWIMMING
year round

TE ĀHUARANGI

CLIMATE

INTRODUCTION

Climate change is one of, if not the biggest, environmental challenges we face. Observed increases in temperature since the mid-20th century are now having measurable effects in many parts of the world including New Zealand. While we are uncertain about the pace and scale of change, we do know that a changing climate is likely to affect our economy, environment and way of life, and that this must be addressed with urgency.

In the Horizons Region, a changing climate is likely to lead to changes in land-use suitability and impacts on primary production. Changing weather patterns, such as a warmer climate, may provide new opportunities for horticulture or cropping in some areas of the region; other impacts may be more problematic, such as an increase in the frequency and magnitude of rainfall and flooding events.

Horizons recently engaged NIWA to downscale global and national climate models to investigate climate change scenarios for the region. This found that climate change could result in both positive and negative effects for the Horizons Region.

The region is likely to experience warmer winters with fewer frosts, but hotter summers will bring increased risks of heat stress and drought.

The introduction of new pests – or more favourable conditions for pests we already have – is likely to be an ongoing challenge, along with the possible introduction of subtropical diseases. Species that are already under threat or are at the limit of their climatic range may struggle to survive.

COME ACROSS A TERM YOU DON'T KNOW?

Check out the Glossary at the back of this report to learn more.

The effects of rising sea levels are the focus of much of the national adaptation conversation. Locally, the effects of sea-level rise on flood protection in Whanganui (Anzac Parade) have been explored and climate research is a strong focus for local iwi. Climate change has been identified as a significant issue in Horizons' 30-Year Infrastructure Strategy, and in 2018, we introduced a dedicated research programme to investigate the impacts of climate change in our region.

New Zealand has warmed by approximately

0.09°C

PER DECADE SINCE 1909

Predicted regional improvement in

RIVER SEDIMENT LOAD OF

27%

BY 2043 COULD REDUCE TO

5-19%

due to climate change

Our region's temperatures are

LIKELY TO INCREASE

0.7-1.1°C

BY 2040 AND UP TO

3.1°C

BY 2090

Summer flows in the Manawatū River

ARE PROJECTED TO DECREASE

14%

BY 2090

and the number of high flow events are likely to increase

Annual average precipitation is predicted

TO INCREASE

15-20%

in the north of the region

AND DECREASE

20%

in the south east by 2090

CLIMATE

WHERE WE'VE COME FROM

Since 1909, New Zealand has warmed by 0.09 ± 0.03 degrees Celsius (°C) per decade.

This has resulted in more extreme fluctuations in rainfall and temperature and an average rise in sea level of 1.7 ± 0.1 millimetres per year since 1900. Locally, an upward trend in mean temperature is apparent at the long-term climate monitoring site at Whanganui (Figure 1).

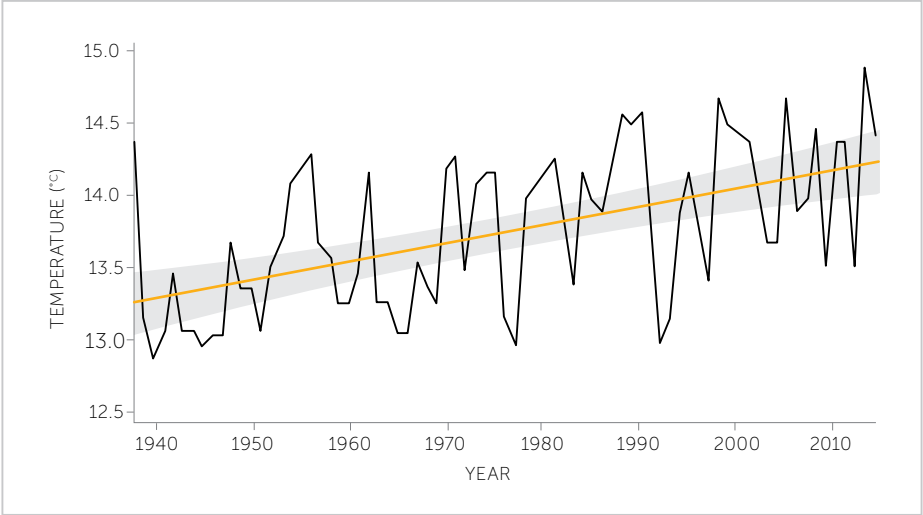


Figure 1: Annual temperature for Whanganui from 1938 to 2014. The orange line removes the year to year variability and shows an upward long-term trend; the grey shading shows the 95% confidence interval. Image courtesy of NIWA, 2016

To date, international efforts have focused on limiting global warming to no more than two degrees – mitigating climate change. The Paris Agreement, adopted in 2015 and signed by New Zealand and 195 other countries, provides for parties to set their own targets, known as Nationally Determined Contributions (NDCs), to reduce global greenhouse gas emissions.

NDC, which comes into effect from 2021, is a net reduction in emissions to 30 per cent below 2005 levels by 2030. This represents a reduction of approximately 16.6 million tonnes of carbon dioxide equivalent, to be achieved through a combination of reduction in emissions and offsets (eg. forestry). Achieving this target would mean a significant step-change in mitigation effort; New Zealand's net emissions increased by 55 per cent between 1990 and 2005 and have likely continued to drift upwards since.

CLIMATE

WHERE WE ARE NOW – CURRENT PROJECTIONS

CLIMATE CHANGE AND VARIABILITY IN THE HORIZONS REGION

It is almost certain that continued emissions of greenhouse gases will cause further warming and climatic change. Modelling enables us to explore the potential effects of these emissions on our region. Because there is much we do not yet know (for example, what mitigation measures might be put in place locally, nationally, or internationally, in the future), we need to consider a range of different possible scenarios.

Scenarios for New Zealand have been generated by NIWA scientists and are based on downscaling from 2013-14 global climate modelling by the Intergovernmental Panel on Climate Change (IPCC).

Horizons commissioned NIWA to make climate change projections for the Manawatū-Whanganui Region (2016) based on IPCC scenarios, to project regional changes in temperature, sea level, and precipitation for the coming century. Findings suggest annual average temperatures across our region are likely to increase by between 0.7°C and 1.1°C by 2040, and by up to 3.1°C by 2090. It is expected that this will result in an increase in hot days and decrease in cold nights by 2040, when compared to the period 1986 to 2005.

Seasonal precipitation is also expected to change by the end of this century. Even under the low emissions scenario, we can expect more snow and rainfall in

winter in western parts of the region, with Raetihi in the Ruapehu District potentially receiving up to 15 per cent more precipitation during winter by 2090. Assuming the worst case scenario, the northern part of our region could experience up to 20 per cent more snow and rainfall during winter, compared to 20 per cent less precipitation in the south eastern area (Figure 2).

The frequency of drought in the region is estimated to increase by around five per cent by 2030-2050 and up to ten per cent by 2070-2090, compared to 1980-1999. The frequency of extreme winds is also expected to increase in the lower North Island over the 21st century.

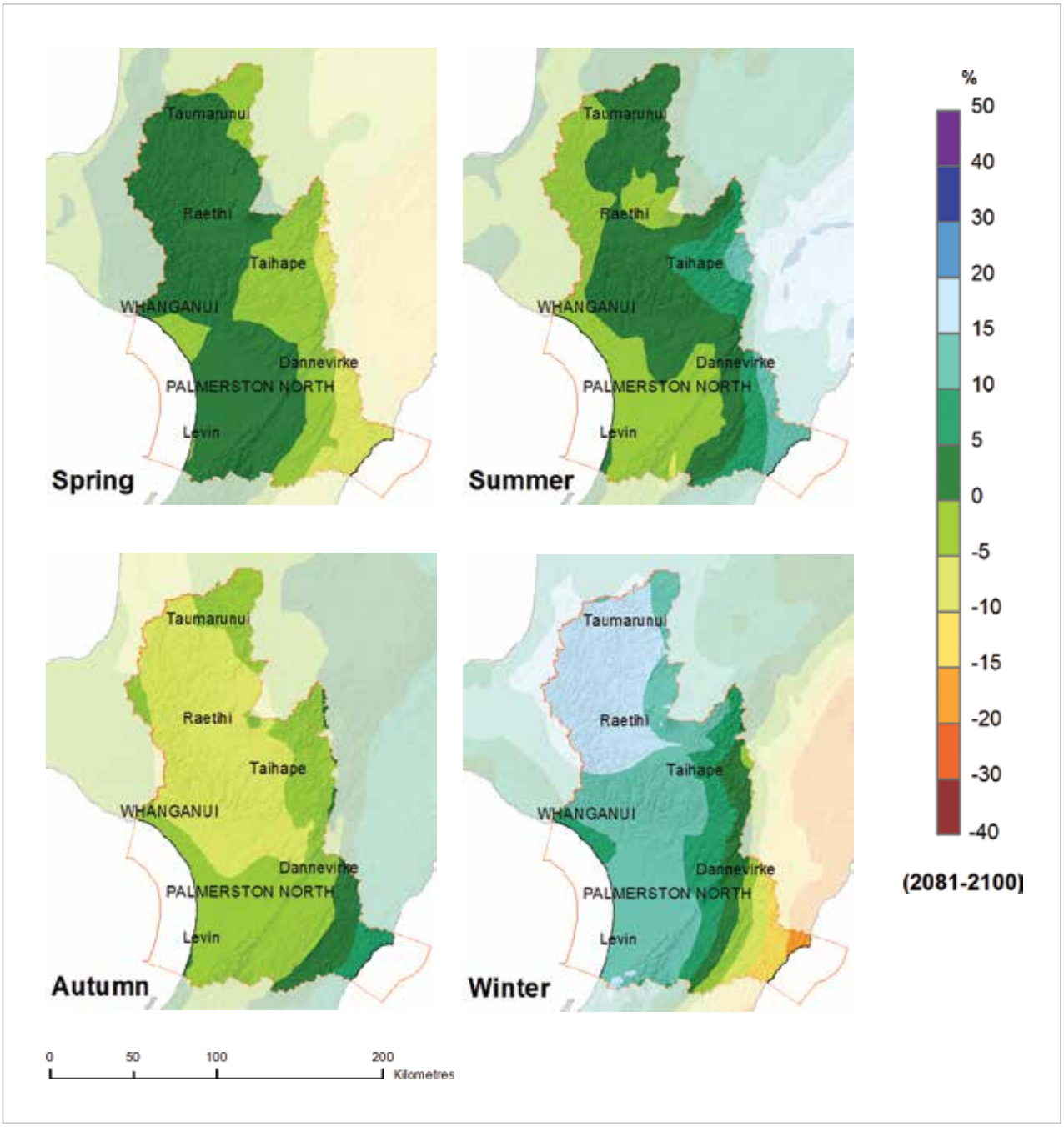


Figure 2: Projected seasonal precipitation to 2090 for the Horizons Region, assuming a high emissions scenario. Image courtesy of NIWA

WHAT WE'RE DOING

Four key impacts of climate change are identified for our region: sea-level rise, rising temperatures, changes in rainfall patterns, and an increase in the size and frequency of storms.

There is a need to grow and develop our awareness of climate change impacts, including understanding and managing our environment for future weather conditions. To date, research commissioned by Horizons has included the following two case studies that look at forecasting the long-term climate change impacts on the effectiveness of our Sustainable Land Use Initiative (SLUI), and investigating potential future changes for the Manawatū River flows.

HORIZONS IS WORKING TO

help our communities adapt to the effects of climate change. This includes:

PROMOTING RESILIENT LAND-MANAGEMENT PRACTICES

under Horizons' Sustainable Land Use Initiative (SLUI), which will reduce the impacts on freshwater ecosystems and flood schemes, and remove carbon from the atmosphere at the same time.

PLANNING FOR CHANGES

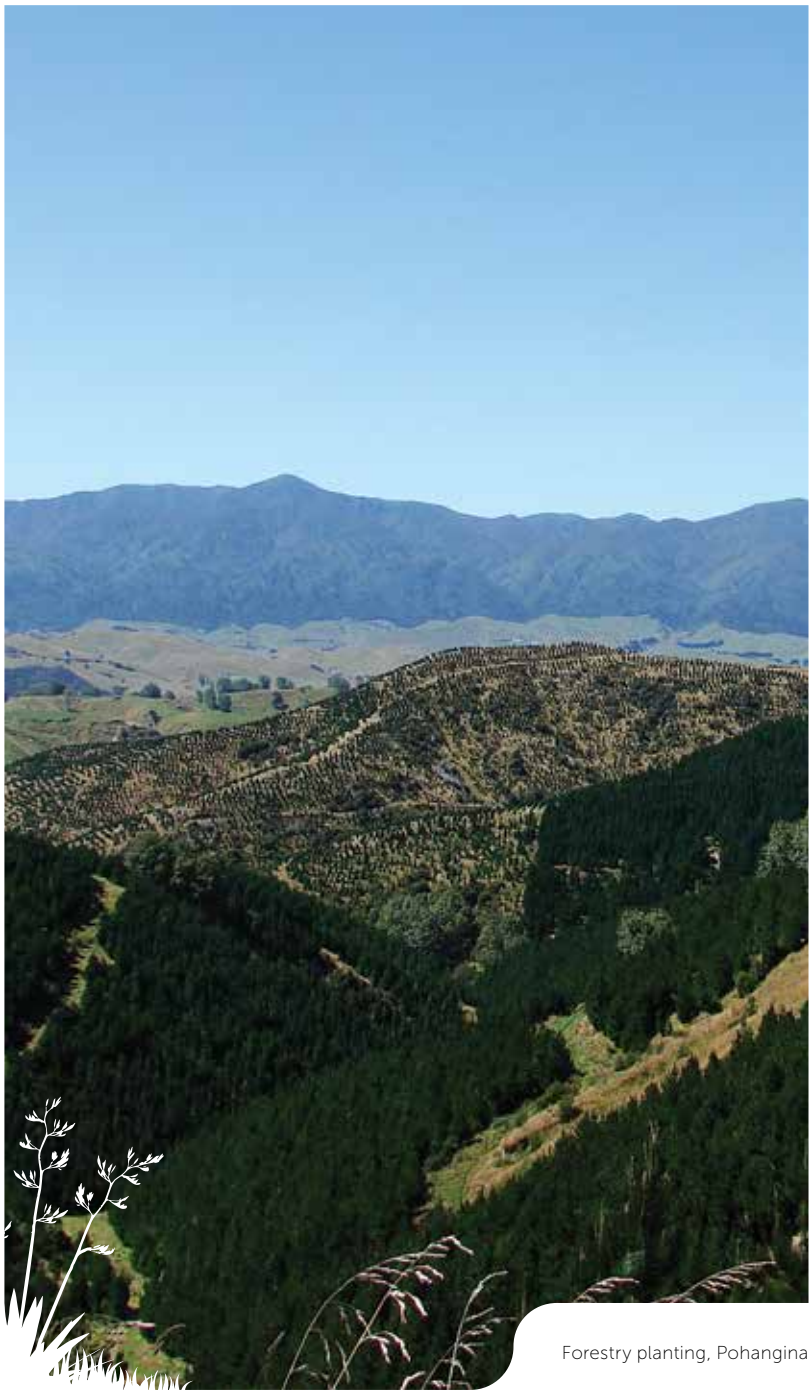
to the scale and frequency of natural hazards, for example through providing for climate change in our river management activities.

DEVELOPING A STRATEGY

to support a consistent and effective response and prioritise key actions across the Council.

RESEARCHING IMPACTS

of climate change on our communities and environment.



Forestry planting, Pohangina

RIVER SEDIMENTATION CASE STUDY

Climate change experts predict larger and more frequent storm events in our region during this century. The challenges ahead of us are significant, not only in terms of managing hill country erosion and increased sedimentation, but also responding to sea level rise and coastal erosion.

To explore possible effects of erosion on the region, global climate change projections have been used by Horizons and Manaaki Whenua – Landcare Research to model future sediment inputs using a national sediment model SedNetNZ.

SLUI works to date are estimated to have reduced sediment load in rivers by 835,000 tonnes (6 per cent), with the greatest reductions (up to 19 per cent) in Kai Iwi, East Coast and Lower Rangitīkei. With ongoing implementation of SLUI works similar to our current pace, the annual average sediment load could be decreased by 27 per cent and visual clarity improved by 29 per cent by 2043.

Climate change, however, is likely to alter annual rainfall patterns and impact rates of hillslope erosion and river sedimentation, particularly in the northern and western areas of the region. Modelling suggests that this could result in a potential change to the predicted reduction in sediment load from 27 per cent by 2043 to just 19, 12 or 5 per cent under minor, moderate and major climate change scenarios with the amounts varying across the region (Figure 3).

Modelling also shows that New Zealand's largest hill country erosion programme, SLUI, may not offset the increases in sediment load from climate change in the longer term, as sediment loads in the river could increase by between 40 and 180 per cent by 2090. This suggests the long-term effectiveness of work already undertaken through SLUI is expected to reduce under climate change, as heavier rainfall events increase sediment loading in the region's rivers. It also means that continued investment in SLUI, or other programmes for erosion mitigation, will be required to offset the potentially severe effects of climate change.

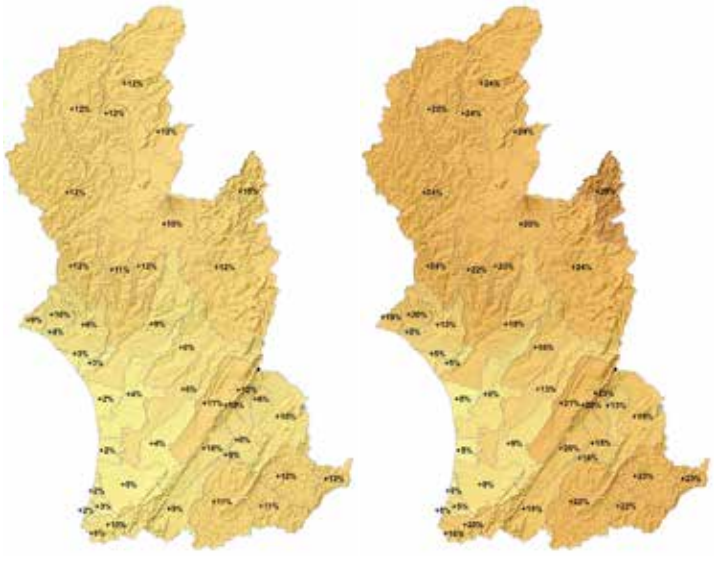


Figure 3: Projected sediment yield under minor, moderate and major climate impact scenarios. Image courtesy of Manaaki Whenua - Landcare Research

Feilding flood response

MANAWATŪ RIVER FLOW CASE STUDY

Climate change is a consideration in determining appropriate levels of flood control. Changing rainfall patterns are likely to be accompanied by changes in river flows throughout the region. This may require us to adapt how we manage the use of water, or design our infrastructure. To explore these potential effects, Horizons commissioned NIWA to model future flows for the Manawatū River in 2040 and 2090, under a range of climate change scenarios and compared them to climate data for the period 1986-2005.

Modelling suggests little change from the current average (mean) annual flow over the next 70 years, which means that, on average, the same amount of water will flow down the river every year. There are, however, likely to be changes in how and when flows occur. For example, summer flows are projected to decrease by 14 per cent by 2090, but we are likely to experience an increase in the average number of high flow (flood) events per year.

These projected outcomes present challenges, but there are also opportunities to adapt to change if we are adequately prepared. Further work is required to understand these changes and potential impacts, which is why Horizons recently introduced dedicated funding for climate change research through our 2018-28 Long-term Plan and identified climate change as one of the four key issues in its 30-Year Infrastructure Strategy.

Motoua Flood Gates, Manawatū River

WHERE WE'RE GOING AND WHAT YOU CAN DO

A changing climate is a part of our operating environment; both land and river management already factor adaptation into erosion and flood control planning. There is a need to develop further knowledge about other activities such as biodiversity, biosecurity, water availability, and healthy waterways and ecosystems.

Future work includes establishing a regional climate change strategy, region-specific modelling of sea-level rise and investigating coastal hazard drivers such as storm surge and waves, and flow projections for rivers across the region.

Responding to the future impacts of climate change requires long-term vision, a willingness to identify and embrace opportunities, and a commitment to act, despite uncertainty. While there are significant challenges ahead, there are also opportunities for our region. For example, trees planted to offset emissions can also stabilise vulnerable soils, reducing erosion and sedimentation of waterways and benefiting both flood control and freshwater aquatic systems.

During the next ten years, Horizons has committed to developing a climate change strategy and undertaking research around the potential impacts (and opportunities) climate change may bring.

WHAT YOU CAN DO...

- 'Investing in tomorrow' produced by the Ministry for Primary Industries highlights the wide range of national resources for sustainable land management and climate change completed between 2007 and 2018. Visit **www.mpi.govt.nz**;
- The Dairy Action for Climate Change, led by DairyNZ, supports farmers and industry to address on-farm methane and nitrous emissions. Find out more at **www.dairynz.co.nz**;
- According to the Ministry for the Environment, the transport sector contributes 19 per cent of New Zealand's total greenhouse gas emissions. Walking, cycling, catching a ride to work with a friend or co-worker, or taking public transport are ways to reduce our vehicle use;
- If you fly, look at setting up your next out of town meeting as a video conference rather than hopping on a plane;
- Reduce electricity usage by switching off lights and electronics when not in use; and
- Check out your own emission contribution using handy calculators at Enviro-mark Solutions **www.enviro-mark.com/calculators**.

TE HAU TAKIWĀ
AIR

INTRODUCTION

The quality of the air we breathe can have a huge impact on our health. While our region does not have a significant air quality problem when compared to other regions in New Zealand, in some areas local topography, winter weather and smoke from wood-burners for home heating and other sources combine to cause odour, smoke and hazes.

Horizons' focus for air quality is two fold: protecting air quality where it is already good, and improving air quality in areas where it is not so good. Areas in our region, such as Taihape and Taumarunui, have issues with air quality during the winter months because of a combination of topography, altitude and the use of home fires. Other areas, particularly urban, can have localised issues with burning rubbish and garden waste in the backyard, causing smoke and odours for neighbouring properties. To ensure our community stays healthy and can breathe easy, we monitor air quality, report any breaches, and work with our communities to reduce problems.

Many of our communities benefit from reducing air emissions, even outside of designated airsheds. Hence our efforts across the region are also focussed on educating communities via radio, local newspapers, our website and social media about the health risks posed by human activities and ways to minimise particulate emissions (PM_{10}) into the air. This chapter reports on PM_{10} monitoring in the region and indicates what contributes to degraded air quality.

COME ACROSS A TERM YOU DON'T KNOW?

Check out the Glossary at the back of this report to learn more.

2 AIRSHEDS IN THE REGION

Taihape and Taumarunui currently meet the national standard for air quality and are expected to improve as more homes switch to more efficient heating sources

OUR ISSUES ARE RELATIVELY MINOR

compared to other air quality sites in New Zealand.

OVER **80%** AIR QUALITY ISSUES

at our two designated airsheds relate to domestic heating

AIR

WHERE WE'VE COME FROM

The National Environmental Standards for Air Quality (NESAQ) and National Ambient Air Quality Guidelines provide minimum requirements that outdoor air quality should meet to provide a guaranteed level of protection for human health and the environment.

Regional councils and unitary authorities in New Zealand are responsible for managing air quality in their regions. We are required to identify areas, referred to as airsheds, where these national standards and guidelines for air quality are not always met. Councils are then required to monitor and track levels of particulate matter against these guidelines and standards and address the identified issue. The particle measured to determine the quality of air is PM_{10}, a mixture of gases, liquids and particles that are smaller than 10 micrometres, or one-fifth of the diameter of a human hair.

A winter monitoring programme of PM_{10} was carried out in 12 towns around the region over a three-year period from 2001 to 2003. This identified the towns of Taihape and Taumarunui as having the worst air quality in the region and as potential areas where air quality could breach the national air quality standards during winter months. As such, they were both gazetted as 'airsheds' in 2005 and are now monitored on a continuous basis. They are the only designated airsheds in the region; however, other areas including Ohakune, Feilding, Dannevirke and Pahiatua were identified as having the potential to exceed the standard.

AIR

WHERE WE ARE NOW – CURRENT STATE

The degraded winter air quality in Taihape and Taumarunui is largely due to their location, as both towns are situated in hill country valleys, the ideal conditions for temperature inversion and poor air quality to occur.

Modelling of data collected in Taihape and Taumarunui (Emissions Inventory, 2010) shows that the winter air PM_{10} concentrations in these towns are largely the result of open fires and inefficient wood burners.

Domestic heating contributes 82 per cent and 84 per cent, respectively, of the measured PM_{10} emissions in these towns. Outdoor burning contributes 10 per cent and 14 per cent, while transport contributes 1–2 per cent. While there is no notable industrial source contribution in Taumarunui, Taihape receives 7 per cent of its PM_{10} from industrial sources.

Ruapehu District Council encourages the use of efficient home heating through provisions in their District Plan. Modelling for both airsheds suggests that air quality is likely to improve over time as more homes switch to more efficient home heating sources.

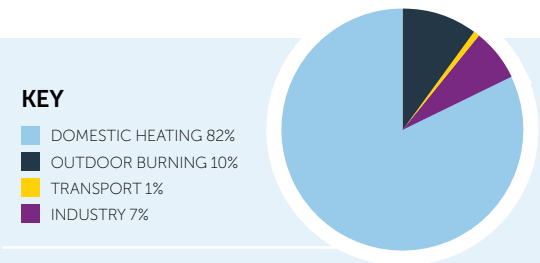


Figure 1: Relative contribution of coarse particles (PM_{10}) by source - Taihape

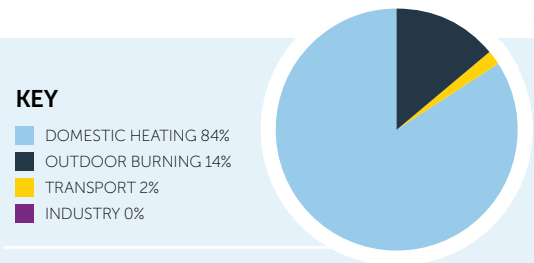


Figure 2: Relative contributions of coarse particles (PM_{10}) by source - Taumarunui

WHAT WE'RE DOING

Horizons' focus for air quality is two-fold: protecting air quality where it is already good, and improving air quality in areas where it is not so good.

Monitoring of Taihape and Taumarunui airsheds shows that we are achieving the National Environmental Standard for Air Quality (NESAQ) and regional standards for ambient air quality as set out in Horizons' One Plan.

The NESAQ sets a compliance standard of no more than one exceedance of the 50µg/m^3 PM_{10} concentration (averaged over a 24-hour period) during a 12-month period. The National Ambient Air Quality PM_{10} guideline value is set at 20µg/m^3 as an annual average. These are the thresholds that we measure for and aim to meet. We realise this is pretty technical so for more information on the NESAQ see the Ministry for the Environment website **www.mfe.govt.nz**.

The Ministry for the Environment *Our Air 2018* report notes that nationally, 30 of 51 airsheds exceeded the NESAQ for the 24-hour average over the period 2014-16, with some airsheds recording close to 50 exceedances in 2014.

On-going monitoring in Taihape and Taumarunui shows that these towns are largely complying with national standards and guidelines, although the occasional exceedance of the 50µg/m^3 PM_{10} standard, or recording above the alert level, are experienced for short periods. To date there have been up to 20 days per year in Taihape and Taumarunui when concentrations have triggered an 'alert' (where the concentration exceeds 33µg/m^3). However, monitoring results for both Taihape and Taumarunui sites show that PM_{10} ratings fall in the 'good' or 'acceptable' categories most of the time.

POLLUTION HOTLINE

Our Pollution Hotline service responds to complaints from the public around air quality and other environment related issues 24 hours a day. In excess of half the calls received during the 2017-18 financial year related to issues in regard to discharges to air, for example from odour, smoke or spray drift. The proportion of calls to our hotline relating to discharges to air, land and water are shown below.

Number of calls to Horizons' Pollution Hotline in the 2017-18 financial year

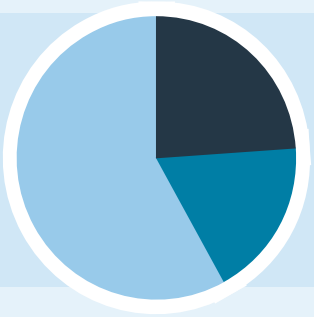


Figure 3: Proportion of calls to the Pollution Hotline during the 2017-18 financial year by receiving environment

When it comes to smokey backyard fires, the actions of a single person can have an impact on local air quality and upset a lot of people.
For more information about what you can do if you experience this:

- Horizons' One Plan sets out our regional rules to combat issues of backyard burning, rubbish fires, and spray drift and odour in rural areas. Check out **www.horizons.govt.nz** for more detail;
- Outdoor burning in urban areas is generally subject to local bylaws – contact your district or city council for advice; and
- For fire permits, or to check the urban or rural fire season status, go to **www.checkitsalright.nz**.

WHERE WE'RE GOING AND WHAT YOU CAN DO

Staff from the Ministry for the Environment, on behalf of the government have signalled a desire to make changes to the current air quality national standards as part of an integrated package that aims to provide incremental improvements for a healthier ambient environment.

Any changes will be informed by the latest information around the health impacts of particulate pollution. As such, a new standard may result, which means that Horizons will need to modify existing monitoring equipment to enable us to track fine particulate matter. Indications are that any changes are unlikely to be finalised until late 2020.

In the meantime, there are some simple things that communities can do to create healthy homes and help decrease the impact of their fires on their local air quality. You can:

- Make sure your home is well insulated to help keep the heat in by using drapes over windows and stopping draughts. A warm, dry home (especially in winter) is a healthy home. Practical tips for improving your energy efficiency can be found at **www.energywise.govt.nz**;
- The new EECA 'Warmer Kiwi Homes' is a 4-year government programme offering grants covering 67 per cent of the costs of ceiling and underfloor insulation and ground vapour barriers for eligible homeowners. The programme started 1 July 2018 and targets specific low income households only;
- Burn dry firewood – not only does dry firewood burn more cleanly, smoking less and therefore emitting fewer fine particles into the air than green or 'wet' wood, it also burns more efficiently, providing more heat to better warm your home; and
- Look at switching to a more efficient heating source. Options such as a modern wood burner or energy-efficient heat pump may also prove more cost-effective to operate in the long run.

Mt Ruapehu

TE WHENUA
LAND

INTRODUCTION

The wild beauty of New Zealand's landscape and our unique wildlife attracts 3.77 million visitors from all around the world every year. For Kiwis it is our playground, our place of work, our home. Our whenua – our land – is our pride, our mana.

Our diverse landscape provides for a wealth of ecosystems such as forests, lakes, wetlands and oceans, as well as an estimated 80,000 native animals, plants and fungi. In our region around 33 per cent of land area is covered in remnants of indigenous vegetation, and many people live in close proximity to the mountains or coast. A stroll, a tramp or a bike ride, to hunting or fishing – there is ample opportunity to enjoy all the special places our region has to offer.

Our land is one of our most valuable assets. In the Horizons Region farming and forestry provide dairy products, meat, wool, vegetables and timber to domestic markets and around the world, driving our economy and supporting local communities.

This chapter of the report covers productive land, fluvial research and gravel use, biodiversity and biosecurity. Key indicators for productive land include stocking rate, versatile soils and hill country erosion. We have also included case studies exploring the effects of land use activities on water quality. The Fluvial Research and Gravel Use section provides a case study on sediment source and transport in the Oroua River. In the Biodiversity section key indicators include the extent of native bush remnants and wetlands remaining, while the case studies cover a range of biodiversity partnerships Horizons are involved in. For biosecurity, key indicators are animal and plant pest extent and management, and the case studies look at velvet leaf management and biocontrol.

COME ACROSS A TERM YOU DON'T KNOW?

Check out the Glossary at the back of this report to learn more.

FROM 1994 TO 2017
the number of dairy cows has increased by
155,000
Beef numbers have dropped by
239,000
and sheep numbers by **2.4 MILLION**

Early results for Horizons' soil health monitoring programme show
30 OF 55 SITES
fail to meet optimal range for at least one indicator

33% of the region is in native cover,
3% of original wetlands remain

Active rook breeding nests have reduced by
95% FROM 2,942 TO 135 NESTS since 2006

66%
OF 5,179
managed sites report pest plants at zero levels, compared to 40% of 1,600 sites in 2010

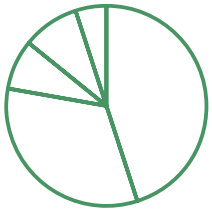
Despite occupying just 8% of New Zealand's total land area
THE REGION HAS
22% of the nation's most highly erodible land

18% OR
206,000 ha
of New Zealand's versatile soils are in our region

1,109 biodiversity remnants have been identified in the region, covering
52,660 ha
Of these, we have visited and evaluated 500 remnants covering
20,865 ha

POSSUM POPULATIONS
are meeting target levels within the 1.3 million ha managed

Land use in the region



45% Sheep and beef
33% Native cover
8% Dairy
5% Forestry
9% Other

NGĀ WHENUA WHAI HUA

PRODUCTIVE LAND

INTRODUCTION

Horizons is a pastoral region with extensive sheep and beef farming occupying nearly half the region. Other land use includes dairy, horticulture, arable farming and alternative productive uses such as mānuka honey.

The region has around 130,000 hectares of planted production forest. These forests are on average 18 years old and have an estimated standing volume of 24 million tonnes.

As the regional council, our role in land management is largely helping farmers get the best out of their productive land, while minimising the effects of land use activities on the environment and identified community values. This is a strong focus for our research programmes.

Our science and research informs land management initiatives and decision making so that we can provide for development in a sustainable way. A strong focus of our research programme is exploring ways to reduce the effects of land use activities on our region's waterways and ecosystems. We also provide technical advice around nutrient management, domestic wastewater system installation and maintenance, and support research around wastewater treatment, horticulture and arable farming.

PRODUCTIVE LAND

WHERE WE'VE COME FROM

Statistics New Zealand reports that during the past two decades, the total number of dairy cattle in New Zealand increased 69 per cent, from 3.84 million in 1994 to 6.47 million in 2017. Growth has been most notable in southern regions with estimated growth exceeding 400 per cent in Southland, Canterbury, and Otago. In the Horizons Region, the number of dairy cattle increased by 50 per cent from 308,000 in 1994 to 463,000 in 2017.

Regionally, this increase in dairy cattle (155,000 cattle) has been accompanied by a significant decrease in beef cattle, sheep and deer (Figure 1). Nearly 2.4 million fewer sheep and 239,000 fewer beef cattle were farmed in the region over the 1994 to 2017 period, while deer numbers have more than halved. Despite this decline, Horizons still has the most sheep of any region in Aotearoa and 40 per cent of the nation's lamb production comes from our region.

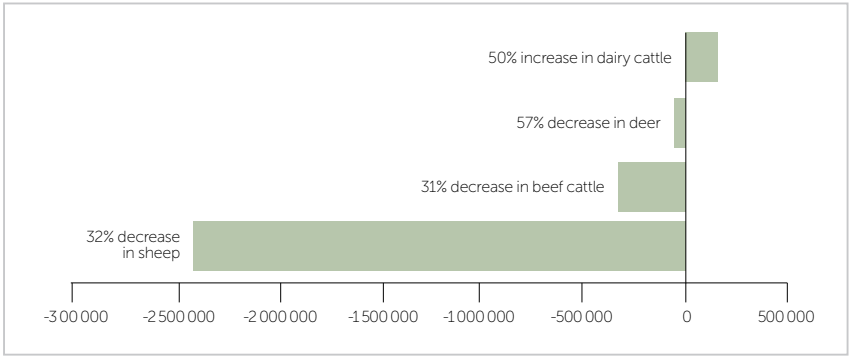


Figure 1: Change in stock numbers between 1994 and 2017. Source: Statistics NZ

PRODUCTIVE LAND

WHERE WE ARE NOW – CURRENT STATE

LAND USE

Land use within the region is approximately 45 per cent sheep and beef, 33 per cent native cover, 8 per cent dairy, 5 per cent forestry, and 9 per cent for other land uses (including 1 per cent for horticulture). Land use, and how it has changed with time, is difficult to calculate accurately with data currently available. The following map shows the approximate division of land use across the region, based on a combination of data sourced from the New Zealand Land Cover Database (2012) and Agribase (2018). Land use numbers reported have been calculated differently to those included in the 2013 State of Environment report. For example, areas of the region under native cover but located within farmland have been included as 'native cover' in this report, whereas in 2013 they may have been included in 'sheep and/or beef'.

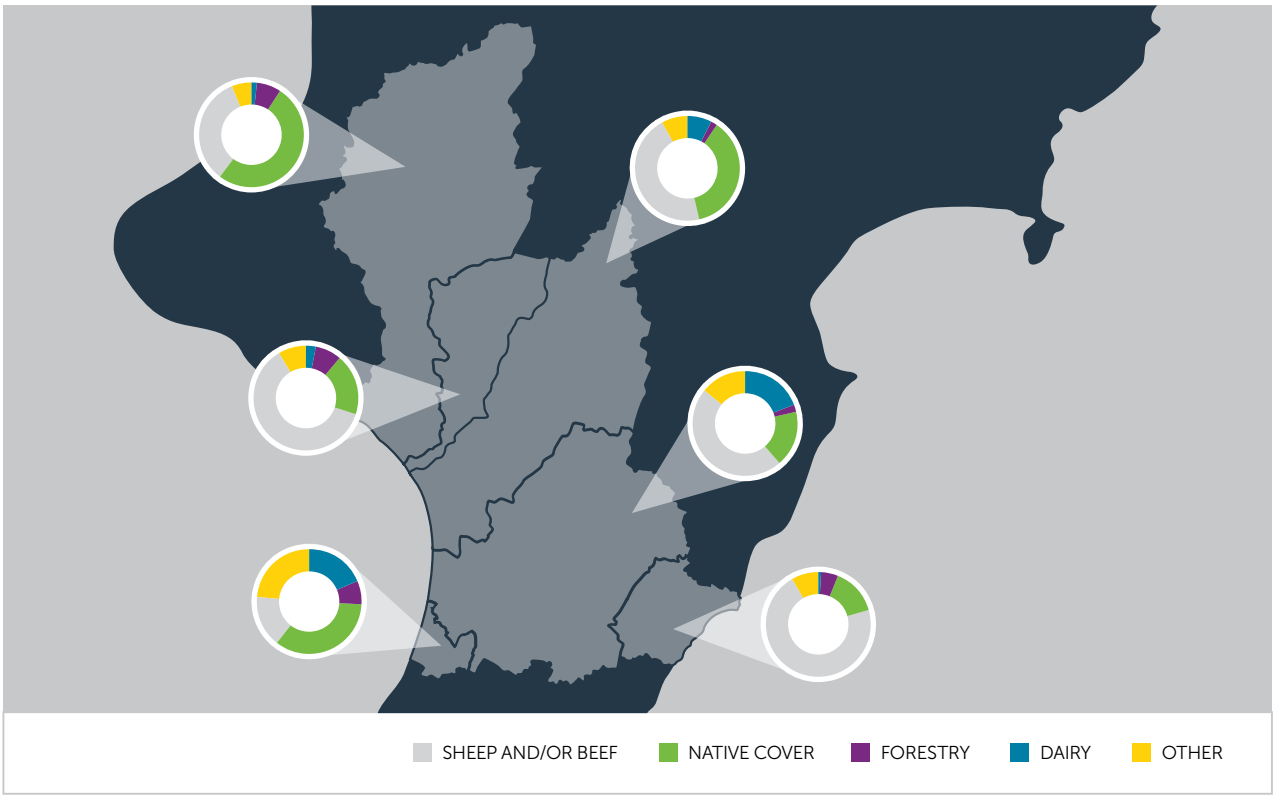


Figure 2: Proportion of land use within each Freshwater Management Unit (FMU), based on data sourced from the New Zealand Land Cover Database and Agribase

VERSATILE SOILS AND SOIL HEALTH

In New Zealand, highly versatile soils are known as Land Use Capability (LUC) Class 1 and 2 soils. These are the best quality soils, considered to be prime land for horticulture and agriculture. Horizons is one of four regions, including Canterbury, Taranaki and Waikato, where LUC Class 1 and 2 soils predominantly occur.

This State of Environment report has not updated this indicator due to the difficulties in obtaining data to access land use changes. However, the 2013 State of Environment report identified 60 per cent of the elite and versatile soils being utilised for sheep and beef farming, and 30 per cent for dairy farming.

Horizons introduced a state of environment soil health monitoring programme in 2015. Across the region, 55 sites have now been sampled with the goal to expand to 100 representative sites sampled every five years. Monitored sites cover a range of soil types and land use classes ranging from native bush to sheep and beef, dairy and horticulture.

Samples are assessed for physical condition, chemical fertility, trace elements and organic matter indicators, which are measured against optimal ranges. While the existing dataset is not yet suitable for drawing statistically valid conclusions, results to date show that 30 of the 55 sites sampled fail to meet the optimal range for at least one indicator of soil health. Identified issues include low macroporosity due to soil compaction, particularly under dairy farms; high phosphate (measured as Olsen P), which was generally associated with market garden farms; and low organic carbon.

HILL COUNTRY EROSION

Hill country erosion is a significant issue for our region, which has one of the largest areas of hill country farming and highest proportion of highly erodible land under private ownership in New Zealand.

Over 60 per cent of the region's total 2.2 million hectares is hill country, much of which is underlain by erosion-prone mud, slit or sandstone. In fact, the region has around 22 per cent of New Zealand's highly erodible land, despite covering only 8 per cent of New Zealand.

Over 260,000 hectares is identified as highly erodible land in pasture. This is high priority for erosion control through Horizons Sustainable Land Use Initiative (SLUI), with a further 200,000 hectares identified as highly erodible but protected from erosion by vegetated cover.

The SLUI is our main mechanism for tackling accelerated erosion in our region's hill country and represents a $79 million investment in the region by central government, Horizons' (regional ratepayers) and landowners. Over the past 10 years, 16 million trees have been planted under SLUI creating around 13,700 hectares of new forestry in the region. Through SLUI we have established relationships with more than 700 landowners to develop Whole Farm Plans on over 530,000 hectares, representing over half the highly erodible land in the region. We also provide advice on erosion and sediment control outside of SLUI areas, raise awareness around sustainable land management, and secure funding and grants to support stock exclusion and planting on farm.

The types of works undertaken include forestry, poplar pole planting, stream fencing, sediment traps, reversion of land in pasture to native cover, and fencing of existing bush remnants.

SLUI is the largest hill country erosion control programme in New Zealand and has completed over 35,000 hectares of works, with approximately 22,000 of these being on highly erodible land in pasture.

Horizons staff member removes a protective sleeve from a poplar pole

TRACKING NUTRIENTS FROM LAND TO WATER – CASE STUDY

Horizons maintains an active research programme to quantify the amount of nutrient in our rivers from different sources, and improve our understanding of the processes that nutrients, such as phosphorus and nitrogen, undergo as they move through land and water. This science is referred to as freshwater accounting and was initially completed in the region to model the likely outcome of the proposed nutrient management policies of the One Plan. Freshwater accounting is now required via the National Policy Statement for Freshwater Management.

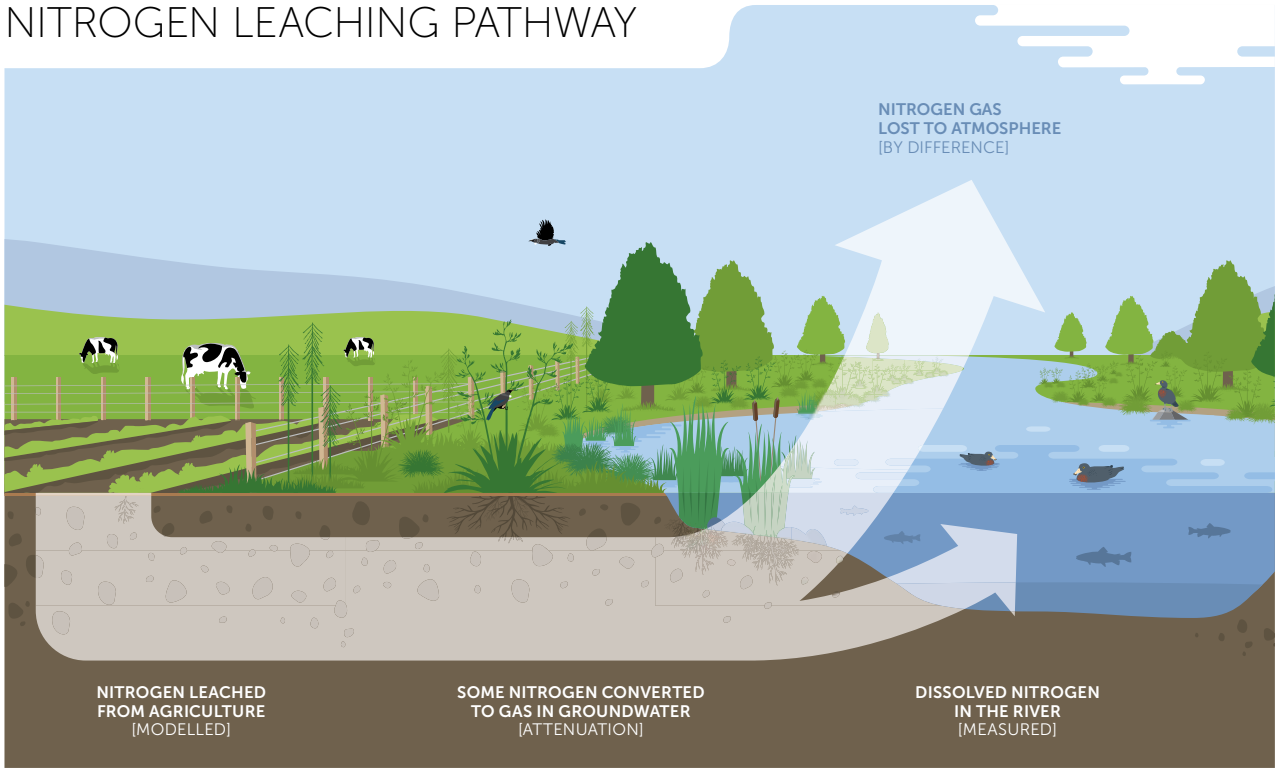
To calculate the amount of nutrient (known as a nutrient load), contributions from urban and industry wastewater are derived from state of environment and discharge monitoring data collected upstream and downstream of 26 effluent (point source) discharges throughout the region. Contributions from the landscape (diffuse sources), including different types of farming, forestry, urban areas and native bush, are modelled or estimated using the latest science, where possible.

We know that some nitrogen lost under agricultural land is dissolved in groundwater and reaches waterways, but some is converted to gas (attenuated) through processes such as denitrification before it gets there. At the time the One Plan was developed we used estimates of attenuation, and have sought to improve these. Through an on-going research collaboration, Horizons and Massey University have supported two PhD students and several post-graduate studies to measure the changes in nutrient loss from land to water. Researchers found that nitrogen attenuation can vary from 30 to 75 per cent within some catchments, depending on the predominant soil types, geology and groundwater chemistry, which can vary widely across catchments.

Research also shows that at some sites in the region, more than half of the nitrogen load transported in river over time occurs during flood flows, and that the relative contributions of some point source discharges can provide a more significant contribution when river flows are low. For example, downstream of Palmerston North at the Manawatū at Opiki monitoring site, 80 per cent of the nutrient load is estimated to come from diffuse sources such as agriculture and other land uses. When the lowest flows at this site occur (only ten per cent of the time), point source discharges are estimated to contribute over 60 per cent of the in-river soluble inorganic nitrogen load. This information helps inform decision-making about nutrient management in rivers.

Read more about nutrients and their impact on our region's rivers in the Water Quality section of this report.

NITROGEN LEACHING PATHWAY



MANAGING SEDIMENT IN THE ARAWHATA CASE STUDY

The Arawhata Catchment that feeds Lake Horowhenua is one of the region's main vegetable producing areas. The catchment has some of the highest nitrate concentrations of all monitored sites in the region, with land use and poor drainage contributing nutrients and sediment to local waterways. However, a growing range of on-farm mitigation techniques and tools are helping to reduce these contaminants to improve water quality.

Work to date has included surveying the drainage scheme, developing drainage and erosion management plans for local growers, monitoring water quality and flow, and carrying out an audit of compliance with cultivation rules in Horizons' One Plan. The approach has included working with local landowners to identify and remedy drainage issues and sediment loss, with the construction of a large-scale sediment trap to capture further sediment before it enters Lake Horowhenua.

To address nutrient contributions in the catchment, LandWISE is leading a three-year project, working alongside growers in the catchment to develop a catchment approach to maximise nutrient use efficiency and reduce nutrient loss to waterways. Supported by Horizons and the Ministry for Primary Industries Sustainable Farming Fund (SFF) and other partners, the project builds on previous work to reduce sediment loss from vegetable farms, as well as work undertaken by Horizons and other partners to reduce inputs from dairy farms in the catchment.

The SFF project is focussed on improving understanding of how much fertiliser is required and when it should be applied, to reduce the potential for nitrate to leach through the soil profile and into shallow groundwater. The project is also exploring ways of intercepting nitrogen before it enters waterways, including constructed wetlands and woodchip bioreactors, both of which convert nitrate and release less harmful nitrogen gas to the atmosphere.

This work links with other efforts to improve water quality as part of the Lake Horowhenua Accord. The next step for the Arawhata Catchment is the development of an integrated catchment drainage and sediment management plan to further optimise the drainage network, and provide landowners with options for on-farm works and mitigations.

PRODUCTIVE LAND

WHERE WE'RE GOING AND WHAT YOU CAN DO

Erosion control results in soil staying on farms, rather than in waterways. This improves habitat for aquatic life as sediment covers rocks and cobbles in river and stream beds resulting in a loss of places for ecosystems to thrive. With less sediment build up on banks, berms and river beds, rivers have more capacity during a flood and flood protection schemes will be more effective for longer. To reduce erosion and soil loss you can:

- Keep bare ground to a minimum – even pasture helps to retain soils and reduce surface runoff;
- Seek advice around alternative uses for erosion-prone land. Full retirement, conversion to forestry, or use of poplar trees might be options to consider for land that is highly erodible;
- Avoid cultivating steep slopes, and divert runoff away from waterways and unstable land; and
- Riparian planting helps reduce runoff and soil loss to waterways. Fence off any new plantings to prevent stock damage, and ensure your maintenance plan includes pest plant and animal control measures.

Minimising nutrient loss from farming and domestic wastewater systems is also important for reducing levels of nitrogen and phosphorus in our waterways. This can be achieved by maximising uptake of nutrients by pasture and crops, or through engineered management techniques.

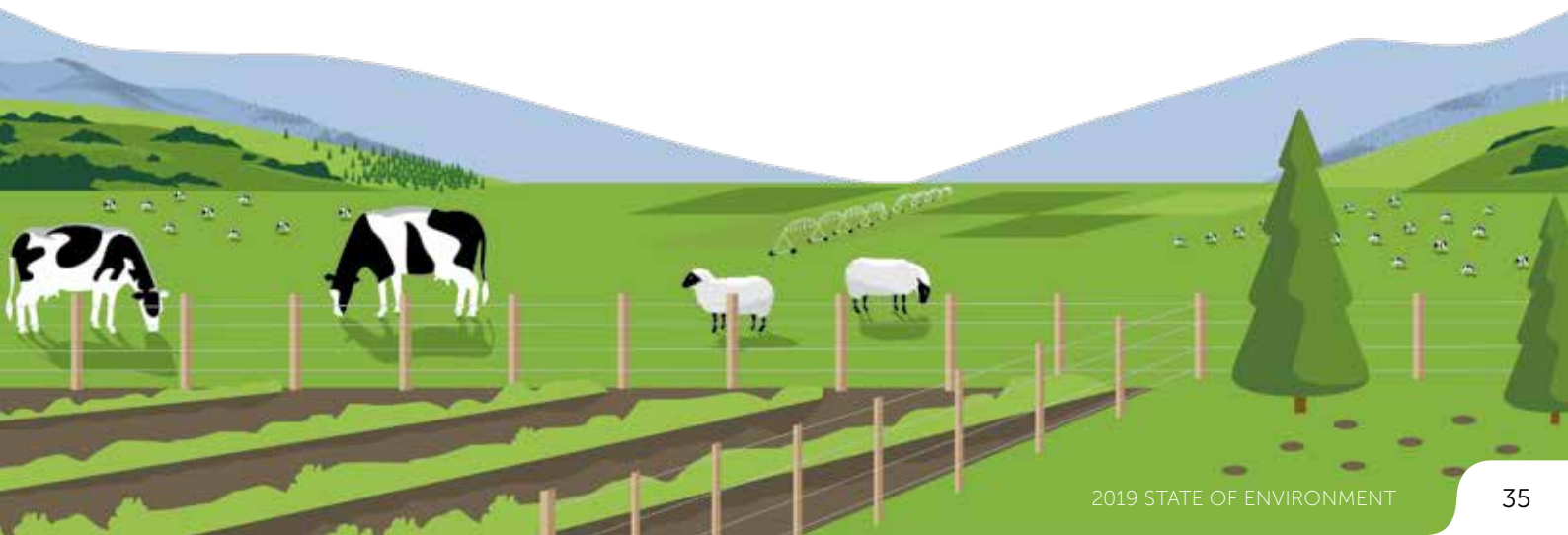
Actions vary but can include:

- Fencing natural seepage areas (including wetlands), to keep stock out and reduce nitrogen and sediment loss from runoff;
- If suitably located, constructed wetlands can remove, absorb and store nutrient loads in the receiving waters. They can also help retain phosphorus and sediment and reduce runoff;
- Planting native species and trees between agricultural land and waterways provides an attenuation zone for nutrients and sediment from surface and sub-surface runoff;

Horizons staff work with landowners to minimise the impacts of farming on soils and water

- Lining effluent storage ponds and deferring irrigation of animal effluent until conditions are suitable can reduce uncontrolled loss of nutrients from the root zone; and
- Joining a DairyNZ discussion group, or attending a Water Quality Update workshop in your local area.
  Check out **dairynz.co.nz\events** for further information.

Horizons has a range of programmes to support riparian fencing and planting, and hill country erosion control. For further information please contact us on freephone **0508 800 800**.



NGĀ RANGAHAU AWA ME NGĀ WHAKAMAHINGA KIRIKIRI

FLUVIAL RESEARCH AND GRAVEL USE

INTRODUCTION

With many urban communities located on flood plains, it is important to have robust measures in place to provide for the safety of the community and the protection of productive land.

Fluvial processes determine how rivers and streams function and in turn, how they shape the region. Traditionally, our fluvial programme has focused on managing gravel use. Recently, the programme has expanded to provide a broader view of our catchments. This will help us prepare for the impacts of climate change, such as increasing sediment loads in our rivers and the impact that this will have on our flood control schemes.

We also manage rivers through engineering works, allowing us to help limit the effects of floods, and provide adequate drainage to enable the productive capacity of land to be realised. However, it is important to note that we are in the business of river management – not river control. Our river systems are a force of nature and, as a result, managing them can be challenging at times.

Our 33 river and drainage schemes play a key role in making our region productive and prosperous and our science and research supports scheme management by providing important information about how our rivers function.

FLUVIAL RESEARCH AND GRAVEL USE

WHERE WE'VE COME FROM

Many of our region's rivers have stoney, gravel beds, which provide a useful and convenient source of aggregate for roading and construction. Horizons manages and monitors the extraction of gravel by selective removal and redistribution throughout the catchment. This is important for two reasons:

- The over-extraction of gravel can cause river channel degradation or scouring of the channel, changing the form of the river and making management more difficult; and
- Gravel build up (aggradation) can adversely affect infrastructure and flood protection works and decrease the river's ability to contain flood waters.

Gravel extraction for aggregate production is relatively stable in our region. During the past five years, around 340,000 cubic metres of gravel has been extracted annually for commercial use in our region (Figure 3).

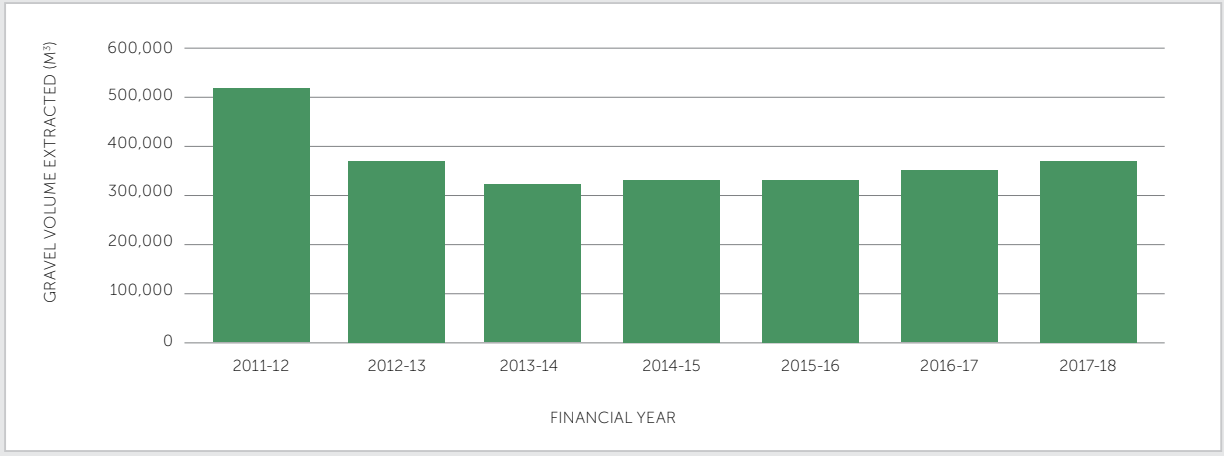


Figure 3: Volume of gravel extracted in the Horizons Region during the past seven years

FLUVIAL RESEARCH AND GRAVEL USE

WHERE WE ARE NOW – CURRENT STATE

In recent years, there's been a move towards taking gravel from river banks and flood plains rather than the wetted area of the river to reduce the effects of taking gravel on the bugs, insects and fish that call our rivers home. However, there is still a need to take gravel from stream and river beds at times when gravel build-up is affecting a river's flood carrying capacity.

This is the case in many of our larger rivers where gravel build-up occurs on the inside of bends, where there is insufficient energy to move the gravel through. Large floods can transport huge amounts of gravel through a river system, sometimes removing or depositing gravel and sediment where it can adversely affect bridges and other infrastructure.

Managed gravel extraction removes and redistributes gravel from locations where river channels have aggraded. This can help to return channels to a more stable state, protecting flood schemes and infrastructure. In general, areas of extraction tend to be in the lower reaches of our large rivers such as the Whanganui, Rangitīkei, Oroua, Pohangina, Manawatū and Ohau.

FLUVIAL RESEARCH AND GRAVEL USE

WHAT WE'RE DOING

Fluvial surveys provide information on the changes in the morphology (size and shape) of the region's rivers and streams so that we can make better decisions about how our rivers are managed.

River cross-sections, which essentially map the channel from one bank to the other, have been undertaken for several decades in all our major rivers including the Manawatū, Rangitīkei and Whanganui. There are currently more than 30 rivers included in our survey programme and each river is surveyed at a frequency of between 5 and 10 years. The timing and frequency of surveying is based on several factors including:

- Rate of gravel transport in the river – this may increase following a large flood and is generally greater in steeper rivers;
- Gravel extraction pressures upon a river or particular reach of that river; and
- Whether a river is experiencing obvious channel degradation (loss of gravel and sediment) or aggradation (build-up of gravel and sediment).

These surveys allow us to compare river beds and determine if the channel carrying capacity has changed. This helps us provide the right advice to consent applicants on where (and how much) gravel can be extracted. It also supports river management actions such as river alignment or the design of erosion control works. River cross-section surveys also form the basis of our flood models, ensuring consistent flood protection standards.

A new technique for establishing changes in channel erosion and sediment deposition over time is being developed through the use of aerial LiDAR surveying. LiDAR (Light Detection and Ranging) is a remote sensing technique that uses light in the form of a pulsed laser to measure distance. Data collected can then be used to generate precise, three-dimensional images of the earth's surface and generate more accurate digital elevation models. Water-penetrating green light can also measure river bed elevations and although it is not yet available in New Zealand, provides an exciting opportunity for catchment mapping.

TRACKING SEDIMENT CASE STUDY

River sediment can come from a range of sources, including hillslopes, floodplains or river terraces, and can occur via a range of processes. This can present challenges when it comes to making decisions around erosion control or flood protection, or linking land and river management interventions with water quality improvement.

To better understand this linkage Horizons commissioned Manaaki Whenua – Landcare Research and Massey University to employ a range of new techniques to track sediment movement through the Oroua River, a tributary of the Manawatū Catchment that stretches from the Ruahine Range, through Feilding and out to Opiki where it meets the Manawatū River.

Samples collected from different areas of the Oroua River help to identify different sources of sediment. Employing a range of techniques we are able to generate a 'sediment fingerprint' that can be traced as the sediment moves down the catchment.

Results show that while natural sources account for around 18 to 25 per cent of the total contribution, hill country erosion accounts for around 38 to 45 per cent. This confirms that significant gains can be made in the Oroua River by targeting land management interventions to erosion-prone hill country. Unconsolidated sediment, typically associated with gully erosion accounts for 26 to 29 per cent. Sediment from the erosion of channel banks is difficult to differentiate from other major sources, but could account for up to 18 per cent.

To complement the identification of sediment sources, high-resolution elevation data was used to establish changes in sediment volume in the Oroua catchment. LiDAR was flown across the Oroua River in 2006 and again in 2016, providing an opportunity to more accurately estimate the amount of sediment accumulation over a ten-year period. The analysis, completed by Massey University, suggests an overall net increase of sediment deposited in the catchment since 2006, and broadly identified areas of the Oroua River where erosion and sediment deposition occurred.

While further work is required to understand the impact of individual storm events, we now have a better understanding of both the sources and transport of sediment in the Oroua to support our catchment planning process, as well as support land and river management decision-making.

Gravel beach surrounds the Manawatū River opposite Anzac Cliffs

FLUVIAL RESEARCH AND GRAVEL USE

WHERE WE'RE GOING AND WHAT YOU CAN DO

The role fluvial research and gravel management plays in river management is paramount to our role of keeping communities safe in our region. With gravel extraction demand relatively stable from year to year, the current monitoring programme is well-placed to provide the data and information we need to manage this resource sustainably.

A key challenge for the region is sediment build-up in rivers and streams, reducing flood carrying capacity. This is identified as a significant issue in Horizons' 30-Year Infrastructure Strategy. Research is increasingly focussing on the broader question of sediment transport, and particularly the link between sediment transport and flood protection. Linkages with water quality outcomes, particularly the health of aquatic ecosystems that can be impacted by changes in channel morphology and sediment deposition is also another focus.

Horizons has, through our 2018-28 Long-term Plan, committed an additional $50,000 to fluvial research. This investment will be directed toward advancing our knowledge and understanding of erosion and sediment transport processes so that we can put the necessary actions in place to minimise the impact of these processes on the environment and infrastructure.

If you have any questions about gravel use in your area, please get in touch with our consents team on freephone **0508 800 800**.

NGĀ KANORAU KOIORA

BIODIVERSITY

INTRODUCTION

Aotearoa is special because many of our indigenous species are endemic – meaning they are found nowhere else in the world. Since the arrival of humans around one thousand years ago, loss of habitat has had a large impact on our indigenous birds, insects and mammals. This is largely due to changes in land use, and the introduction of pest plants and animals.

As the regional council, our focus is primarily on maintaining and enhancing indigenous habitats on private land. To achieve this we prioritise remaining forest and wetland habitat for management, which generally involves fencing, and pest plant and animal control. We also provide advice and support to landowners to help protect and enhance indigenous habitat, and manage our only regional park, Tōtara Reserve.

With much of our most threatened habitat located on private land, halting the decline of indigenous biodiversity requires the involvement and commitment of landowners, individuals and communities. At Horizons, we work in partnership with a range of organisations, iwi and our community to protect and enhance our patch of Aotearoa.

BIODIVERSITY

WHERE WE'VE COME FROM

Prior to human occupation the Horizons Region was covered almost entirely in podocarp-broadleaf-beech forest, with tussock land throughout the Central Volcanic Plateau. Huia, kererū, tūī and pōpokatea (whitehead) frequented the forests of the Ruahine and Tararua Ranges. Wetlands covered around ten per cent of the region, and near the coast, swamps, lakes and streams provided harakeke (flax), tuna (eel) and ngohi (fish).

Areas within the region characterised by cool climates, high rainfall and steep terrain have seen less habitat loss as a direct result of our actions. However, nationally around 57 per cent of threatened species are found in lowland forests and wetlands. Early clearance of indigenous vegetation and drainage of these lowland areas for agriculture or development, has reduced these once-dominant habitats to less than 20 per cent of their former extent.

Over the past 175 years, much of our indigenous vegetation has fallen below self-sustaining thresholds and, without management, the original ecosystem will collapse and disappear. If we are to succeed in protecting what remains, effort is required from many.

BIODIVERSITY

WHERE WE ARE NOW – CURRENT STATE

Much of our indigenous vegetation is located in the mountain ranges, central plateau and upland areas of the region, and is generally dominated by beech species, tussock lands, sub-montane shrubland, and podocarp/broadleaf forest.

Native bush would have once covered 86 per cent of the region, or around 1,912,000 hectares. Now less than 32 per cent of original bush cover remains, taking current extent to approximately 611,000 hectares. Around 80 per cent of this is estimated to be secondary cover, and much of the remaining 20 per cent is likely to have been modified by selective logging and is at risk from pest plants and animals.

Below 460 metres above sea level, lowland habitats have suffered the highest level of loss, with only 326,886 hectares or 22 per cent of the original extent remaining. For wetlands, less than 3 per cent (700 hectares) of the region's original 22,000 hectares of wetland habitat remain. Available information does not enable a comparison with wetland and bush extents reported in 2013.

In total, around 34 per cent of the region (757,000 hectares) remains under native cover. Horizons' One Plan recognises the importance of biodiversity and maintaining rare and threatened habitats, and restricts activities that are able to be carried out in such habitats.

Bush remnant, Horowhenua District

WHAT WE'RE DOING

Our approach includes a mixture of regulatory (rules) and non-regulatory methods such as the management of priority sites, collaborative programmes, and community biodiversity projects. This includes rules, set out in Horizons' One Plan, around clearing trees where there is risk of erosion. It also includes regulation of activities within or adjacent to rare, threatened, or at-risk habitats and sites of significance – land containing indigenous plant species, coastal dunes, wetlands, tussock or a waterway. These rules help ensure our indigenous species and habitats are looked after and maintained for everyone to enjoy.

Working alongside these rules are the non-regulatory methods in the One Plan. This includes all the biodiversity methods by which Horizons assists landowners in the protection of indigenous biodiversity, such as enhancement through fencing and pest control.

Horizons monitors biodiversity sites under protection and management to track changes in their ecological health. This provides an indication of which measures, such as plant or animal pest control, and/or habitat restoration, achieve the greatest outcomes so that this knowledge can be transferred to other sites.

Sites managed under our priority sites programme are usually privately owned; however, the list of sites does include some Department of Conservation (DOC) and Territorial Local Authority (TLA) reserves.

It also includes 'private' reserves such as Pryce's Rahui Reserve in Rangitīkei and McPherson's Bush in Whanganui, both of which are overseen by Forest and Bird.

Horizons has identified 1,109 biodiversity remnants in the region covering 52,660 hectares (Table 1). Of these, Horizons has assessed 500 sites (20,865 hectares), made a one-off contribution (such as fencing or pest control) to the management of 149 sites (10,830 hectares), and regularly contributed to a further 62 sites (2,957 hectares).

This programme of works continues, but the way in which we describe our onsite biodiversity works has recently been reviewed. Sites are now categorised from Level 1 through to Level 6 based on the level of management they have received, with higher levels reflecting more comprehensive management, often in conjunction with a more collaborative approach.

The new Level 1 sites have been visited by Horizons biodiversity staff, while Level 2 sites have received a one off contribution, often toward fencing; and Level 3 sites receive continuing surveillance and works, often plant pest control, when required. Level 4-6 sites reflect a variety of collaborative partnerships between landowners, Horizons, community groups and other agencies working together to ensure the site is maintained into the future.

Biodiversity Sites	Number of known sites	Number of sites assessed	Percentage of sites assessed (%)	Number of sites with Horizons' contribution	Percentage of sites with Horizons' contribution (%)
Terrestrial	801	376	47	145	18
Wetland	309	124	40	66	21
Total	**1,109**	**500**	**45**	**211**	**19**
	Total hectares of known sites	**Total hectares of sites assessed**	**Percentage of hectares assessed (%)**	**Number of hectares with Horizons' contribution**	**Percentage of hectares with Horizons' contribution (%)**
Terrestrial	45,754	17,480	38	11,631	25
Wetland	6,906	3,277	47	2,157	31
Total	**52,660**	**20,757**	**39**	**13,787**	**26**

Table 1: Summary of the terrestrial and wetland sites inventory. This includes the number and proportion of sites that have received a contribution toward their management from Horizons since the inception of the bush remnant and wetland programme

WORKING AS ONE

Protecting and enhancing our environment is very much a team effort. Horizons provides support for community groups to undertake biodiversity enhancement works to support 34 different projects across the region. These range from small community projects such as Puddleducks Montessori wetland restoration and Kimbolton School pest control monitoring, through to multi-agency partnerships such as Te Potae o Awarua, Cape Turnagain, Kia Wharite and Te Apiti – Manawatū Gorge.

Some of our most successful projects also provide additional benefits to the region, such as opportunities for economic growth through tourism and accommodation ventures.

TE POTAE O AWARUA – WHIO PROTECTION CASE STUDY

Te Potae o Awarua roughly translates to 'the protection of the Awarua lands', a 20,000 hectare area of high biodiversity value located in the north western part of the Ruahine Range. The project, operated jointly by the Aorangi-Awarua Trust and Department of Conservation has developed into a predator control programme to protect whio (blue duck) and kiwi. The project has gained widespread community support in recent years, particularly from trampers and deerstalkers.

Horizons' funding support helps the Trust with the costs of servicing the stoat lines on their land and also helps with the cost of transporting volunteers to service the lines on public land.

Whio or blue duck (pictured) and North Island brown kiwi benefit from improvements to biodiversity as a result of Kia Wharite, a partnership between Horizons, DOC and local iwi working to improve the health of more than 180,000 hectares of private and conservation land in the Whanganui Catchment

TE APITI – MANAWATŪ GORGE CASE STUDY

Te Apiti – Manawatū Gorge divides two mountain ranges (Tararua and Ruahine). Forming over thousands of years as the Manawatū River carved its way through the growing greywacke ranges, it is the only place in New Zealand where a river begins its journey on the opposite side of the main divide to where it joins the sea.

With its native bush and abundance of birds and insects, the Gorge provides a range of opportunities to explore the tawa and podocarp forest that once covered much of the region. With a range of walking tracks and Te Ara o Mahurangi mountain bike trail, Te Apiti really is an outdoor playground, offering biodiversity, recreational, cultural and educational experiences.

Extending your stay is possible too with nearby freedom camping and swimming at Ferry Reserve.

Management of the Gorge is led by Te Apiti – Manawatū Gorge Governance Group: a collaboration between Horizons, DOC, Rangitāne o Manawatū, Rangitāne o Tamaki nui a Rua, Kahungunu ki Tamaki nui a Rua, Palmerston North City Council, Tararua District Council, Manawatū District Council and a landowner representative.

The overarching project is focussed on four key pillars: biodiversity, recreation, education and culture. The Governance Group supports and funds a range of initiatives such as pest control and oversees the Biodiversity Management Plan for the area. Control of the pest plant Old Man's Beard is proving to be very successful and the group is now investigating the potential for species re-introduction into the area.

Whatonga, Te Apiti – Manawatū Gorge

TE POROPORO – CAPE TURNAGAIN CASE STUDY

Te Poroporo or Cape Turnagain, with its distinctive geology and unique ecosystems, is one of our region's most special and unique places. Towering mudstone cliffs rise steeply from the Pacific Ocean to the east, with an active wind-blown dune system to the west. The unique geology, crashing surf and open ocean create a spectacular coastal environment.

The Cape is a haven for wildlife. Fur seals haul out on the shore at the eastern end of the site. Shore birds can be seen feeding, roosting and breeding; notable among them are the little blue penguins that nest in the flax.

The area is also home to the small, but distinctive, bright orange and black *Notereas perornata* 'Cape Turnagain' moth, found nowhere else in New Zealand. They can be spotted in flight, or sunning themselves on bare ground or vegetation, with their bright wings folded out. *N. perornata* are easily disturbed by movement or shadows, and use their light-grey underwing to camouflage themselves.

With the help of the QEII National Trust, Horizons and Hawke's Bay Regional Council, local landowners have invested in the protection of covenanted areas by fencing off 9.3 kilometres of coastline and 400 metres of river, with a total of 13.5 kilometres of fencing. A recent grant from the Lotteries Commission will help support further work to restore over 200 hectares of coastal treeland, flaxland, dunelands and cliffs. Work includes the control of pest plant species (marram and pampas), propagation of *Pimelea prostrata* for revegetation projects at nearby coastal sites, and control of goats and other animal pests. This project will also help to preserve and enhance the cultural and historical significance of this landscape, while educating the local and wider community.

Notereas perornata

Cape Turnagain, Tararua

WHERE WE'RE GOING AND WHAT YOU CAN DO

In our region, large scale reduction in the extent of indigenous habitats, including wetlands and forests has slowed. That said, we have a big job ahead of us if we want to improve, or even just maintain, our natural heritage.

PRIORITISING ECOSYSTEM MANAGEMENT CASE STUDY

Ecosystems are complex and varied, ranging from forests and wetlands to frost flats, dune systems and coastal rock cliffs such as those found at Cape Turnagain, as well as a range of others. To ensure that we support the management of the full range of ecosystems present in the Manawatū-Whanganui region, Horizons has been reviewing the way sites are prioritised for management under our non-regulatory biodiversity programme.

Modelling and mapping of the region was recently commissioned to identify the full complement of ecosystems prior to human-induced land use change (Figure 4). By comparing previous ecosystems with current indigenous land cover, we are now able to better estimate which ecosystems were always rare and which have suffered the greatest loss as a result of human induced land use change (Figure 5). This information then informs the prioritisation of sites for protection, enhancement, and management.

Warm climate forests such as the dune forests found in isolated patches around the Foxton area have suffered some of the greatest loss, with less than half of the original 10 per cent remaining. Mild climate forests (for example, Manawatū Gorge Scenic Reserve) have fared somewhat better with up to one third of the original 62 per cent still intact. Other non-forest ecosystem types such as gravel-fields, some wetlands, cliffs, coastal saltmarsh and tussock-covered dunes have always been rare. While some of these ecosystems remain relatively intact, their limited extent means that protecting these areas is crucial to ensuring their survival.

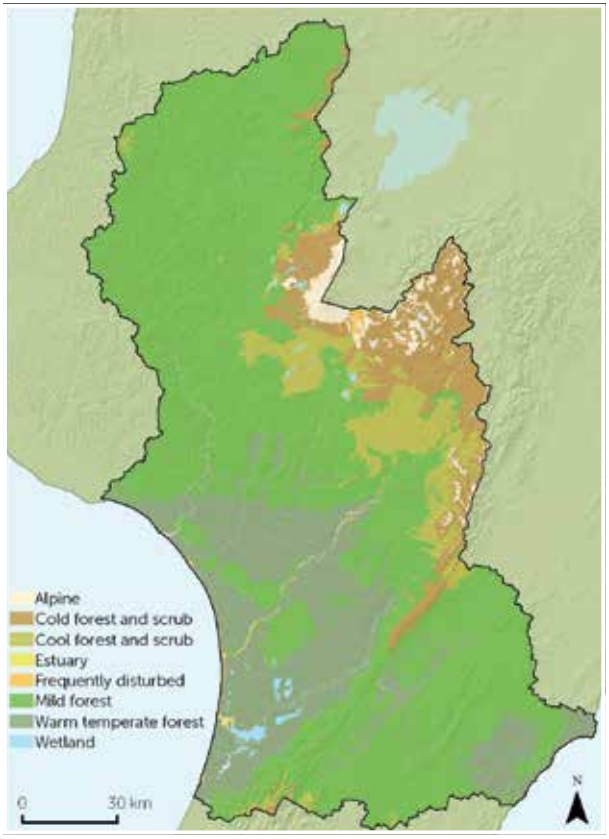


Figure 4: Predicted potential extent of native vegetation types in the Horizons Region prior to human settlement

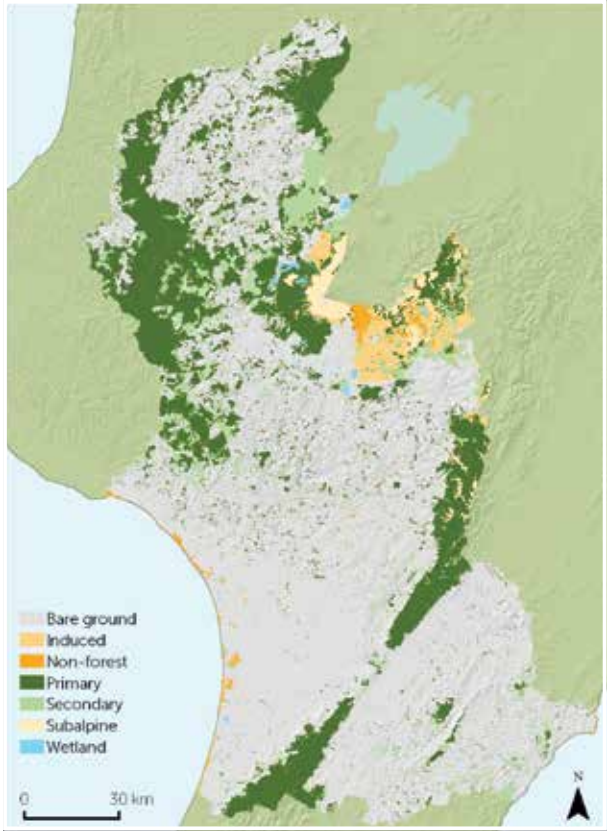


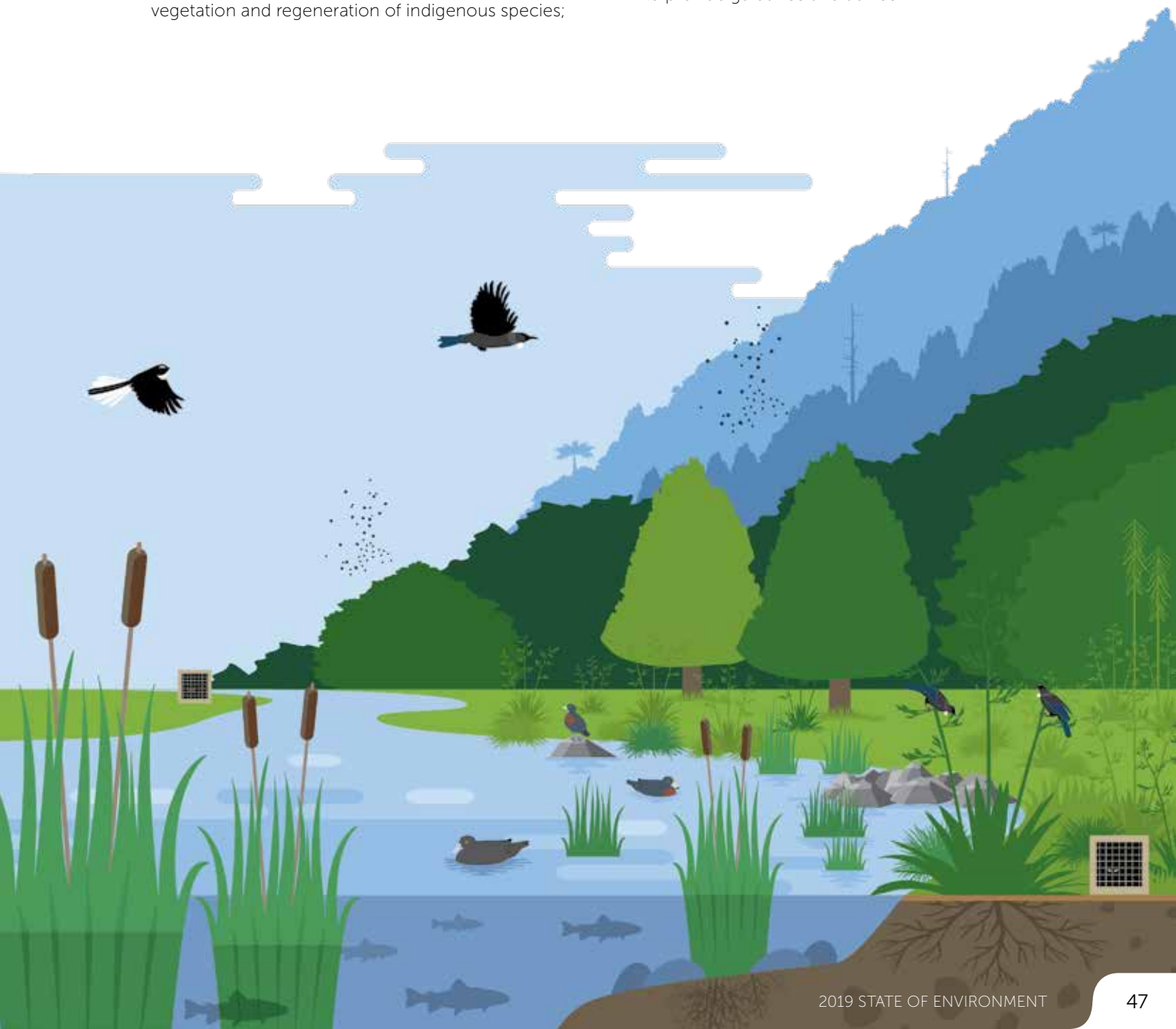
Figure 5: Extent of native vegetation now remaining in the region

GET INVOLVED

Protecting and enhancing our patch of native New Zealand requires a collective effort. Collaborating, combining resources and synchronising action, and raising the awareness of what we have and the value of it is an important part of this process. Horizons is committed to working in partnership with our communities to ensure the protection and enhancement of our indigenous species.

Here are some of the things you can do to help:

- Get involved! We have plenty of active community conservation groups and local habitat restoration initiatives underway in the region. Visit **Nature Space** or the **Department of Conservation** volunteer websites;
- Fencing a bush remnant from stock can make a significant difference to the protection of understory vegetation and regeneration of indigenous species;
- Planting native trees as shelterbelts and riparian margins provides habitat and food for birds and insects, shelter for stock, and can also reduce soil erosion and runoff. Attract birds, lizards and insects to your garden by planting trees and shrubs that produce foliage, flowers, nectar, berries or seeds;
- Where possible, select natives grown from locally sourced seed to preserve our unique local biodiversity and maximise the chances of your plants becoming established. Contact your local nursery or regional council for advice on the best plants for your area; and
- If you are looking at making changes that might affect native bush, wetlands or dunes, or interested in starting your own restoration project give us a call on **freephone 0508 800 800**. Horizons staff are happy to provide guidance and advice.



NGĀ HAUMARU KOIORA

BIOSECURITY

INTRODUCTION

Protecting our taonga, our economy and primary sector requires management of biosecurity. Horizons has a role in national biosecurity, which aims to stop pests and diseases before they arrive in Aotearoa and to control, manage, or eradicate them if they do arrive. Nationally this is managed by the Ministry for Primary Industries (MPI); however, regional councils, their communities and a host of other agencies also play a role in both preventing and responding to pest incursions.

While controlling and eradicating established plant and animal pests is important, it is also expensive. In New Zealand, the Department of Conservation (DOC) estimates around $70 million a year is spent on predator (rat, stoat, and possum) control alone. In our region, Horizons spends $4.2 million on animal pest control annually.

While animal pests receive plenty of publicity, one of the biggest threats to biodiversity and productive capacity in our region is the incursion of pest plants. Pest plants can cause the collapse of forest canopies, smother regeneration in natural areas, invade alpine tussock land, degrade wetlands, clog waterways, and reduce the productive potential of land, farms, livestock, fisheries, and forests. The region's economy is heavily reliant on our agricultural sector and therefore a regionally coordinated strategic and statutory framework for the management of production pest plants and animals is essential.

BIOSECURITY

WHERE WE'VE COME FROM

New Zealand's relative isolation from the rest of the world enabled our indigenous plants and animals to thrive in a stable environment. As people began to settle here, plants were introduced that out-competed our native species, and introduced animals preyed on our wildlife. Exotic species also brought with them new diseases, some of which thrived in our climate and spread throughout Aotearoa. These pests threaten our economy, environment, and our way of life.

Historically, biosecurity in New Zealand largely focussed on the protection of agricultural, horticultural and forestry industries from exotic pests and diseases. Over time the negative impacts of some introduced species on our environment and ecosystems became apparent and a broader and more systematic approach to protecting Aotearoa was developed.

Today, controls are much more stringent and new plants and animals cannot be brought into New Zealand without prior approval.

BIOSECURITY

WHERE WE ARE NOW – CURRENT STATE

New Zealand's natural assets drive a multi-billion dollar export economy and define our unique way of life. Both tourism and agriculture depend on a healthy natural environment and while many introduced organisms, such as fruit trees, pastoral grasses, cattle, and sheep form an important part of our economy, others have cost us significantly in terms of damage, control and lost revenue.

Pastoral weeds are conservatively estimated to cost the New Zealand economy $1.2 billion per annum and the direct economic cost of vertebrate pests to the primary sector are estimated at somewhere between $1 billion and $3.3 billion. These costs can increase with the arrival of new pests, such as myrtle rust and *Mycoplasma bovis*.

Eradication is possible in some situations. Early intervention, before pests have an opportunity to become established, generally gives us the best chance of success. Velvetleaf is an example of where rapid response to early reports of the incursion has limited the spread of this weed. Where pests are present in our region but limited in either number or extent of infestation, eradication may be a feasible and cost-effective solution.

However, despite best efforts pests and diseases still enter and establish throughout New Zealand. Unfortunately, sometimes the complete removal (eradication) of pest plants and animals is not feasible or cost-effective. Where this is the case, Horizons works to confine pests to contained areas and reduce the risk of spread to other areas. In the Horizons Region, one of our greatest biosecurity threats is from naturalised pest plants dispersing to the region or escaping from gardens.

WHAT WE'RE DOING

Under the Biosecurity Act 1993, Horizons produced and now implements the Regional Pest Management Plan 2017-2037 (Pest Plan). Our role under the Plan is to prevent the incursion of new animal and pest plants and sufficiently manage those already established.

The Pest Plan sets out strategies to maximise early detection of new pest species before they become widespread and outlines how each pest will be managed over a twenty-year period. Pest management is an individual's responsibility in the first instance. Certain pests have a good neighbour rule, which ensure that a person who is going to the trouble of managing these pests on the land they occupy is not incurring unreasonable ongoing costs resulting from a neighbour not doing the same.

Horizons' role is complementary to that of MPI and other agencies working to protect New Zealand from biological risk. Responsibility for control work lies with Horizons, the Crown, MPI, and landowners and occupiers. Horizons is responsible for ensuring those on private land are aware of their obligations for pest management on their properties. We also undertake direct pest control where there is clear justification and regional benefit.

Pest resources

PEST ANIMALS

The management of introduced predators like possums, cats and ferrets, and browsers like goats and deer, is required to safeguard the biological diversity of our region. These species are wide-spread and their management presents the challenge of doing too little in too many places. Horizons currently invests more than $4.2 million annually (2018-19) on animal pest control in the region, the majority of which is spent on possum control operations, as possums are incredibly destructive to our native environment and production. It's estimated that 14-15 possums can eat the same amount of grass as one sheep.

Initiated in 2006, Horizons' possum control programme aims to bring all rateable land under sustainable possum control over the next eight years. Initially, the programme covered around 70,000 hectares and has grown to just under 1.3 million hectares of which just over 917,000 hectares will receive control in 2018-19. Horizons' work complements possum control on Crown land carried out by DOC, and OSPRI work to control bovine tuberculosis, which is carried by possums, as well as a range of community initiatives.

Horizons biosecurity staff and contractors restock around 94,500 bait stations in control areas which are spread throughout areas of possum habitat. The goal of the control work is to keep the overall population numbers below ten per cent residual trap catch (RTC). RTC is a nationally recognised method of estimating possum abundance. Over recent years Horizons has used wax tags instead of leg hold traps to determine the RTC. Bite marks on the wax tags are analysed and bite mark index is converted to an estimated RTC. In 2018, average population densities were around 4 per cent RTC for new or existing Possum Control Operations (PCO) areas.

Rooks are also an area of focus for Horizons. A member of the crow family, rooks can cause significant damage to newly sown crops, vegetables and fruit. Our goal is to completely eradicate breeding rooks in our region. Action includes aerial nest baiting followed by ground control work throughout late spring, targeting birds that are feeding on crops and young grass paddocks.

Rooks were once widespread throughout the eastern area of the region. After 12 years of managing rook nests, the number of active breeding nests where eggs or chicks are found has reduced by 95 per cent, from 2,942 nests in 2005-06 to just 135 nests in 2017-18.

Applying lure to attract possums to a bait station

Lindavia intermedia (lake snow) monitoring at Lake Otamangakau

PEST PLANTS

The Regional Pest Management Plan includes 66 species of pest plants. Horizons funds and coordinates pest plant control for 18 plant species region-wide and a further 11 species inside individually managed zones for regional benefit. In addition to treatment and control, since 2010 we have also recorded spatial information, plant population measures and plant maturity to assess the risk of spread and abundance of these 29 species. Around $1.7 million is spent managing pest plants across the region every year.

The data shows that the inclusion of new species, along with continued progress on other species, has increased the number of sites where our biosecurity team is attempting eradication. Between 2010 and 2018 the number of managed sites has increased from around 1,600 to over 5,000. The proportion of sites where pest plants have been reduced to zero-level has increased from less than 40 per cent to 66 per cent. This shows that while the number of known sites is increasing, so too is the proportion of these sites at target levels.

The new Pest Plan has increased the number of species we are attempting to eradicate to 18 plant species, including Chilean rhubarb, Chinese pennisetum and woolly nightshade. These species are our highest priority as our goal is to reduce all populations to zero-levels as soon as we can. We currently know of and manage eradication species at 1,431 sites, an increase of 125 from last year. Of these sites, 963 (67 per cent) are at our target state of zero-levels due to staff and landowner intervention and ongoing survey and control.

Many of our pest plants are ornamental plants that are garden escapees, such as banana passionfruit, Old Man's Beard, and climbing asparagus. Chilean rhubarb remains one of the most contentious of the pest plants we control. Favoured for its place around ponds and in wetter gardens, it is held dear by many. Because of the many hectares of seeps, wet areas, bush tracts and kilometres of streams and rivers that Chilean rhubarb is transforming, Horizons remains committed to eradicating this pest plant in our region.

Aquatic pest plants are also something to be aware of for our region. Examples such as eelgrass, hornwort and oxygen weed are easily spread between lakes and waterways by boats, trailers and fishing gear. Once established, they quickly out-compete native aquatic plants.

In order to limit the spread of aquatic pests it is important to check, clean and thoroughly dry equipment in the sun. Many of these pests are aquarium species that have established in the wild. In 2018, lake snow or *Lindavia intermedia*, was discovered in the region for the first time in our northern lakes. In conjunction with Waikato Regional Council and MPI, we ran a public awareness campaign encouraging the public to report any sightings and to check, clean, dry to contain its possible spread.

VELVETLEAF CASE STUDY

Award-winning biosecurity team Rusty the Border Collie and his handler John Taylor have been helping fight the spread of velvetleaf in the Horizons Region. A vigorous plant, velvetleaf can out-compete arable crops for nutrients, space, and water so the aim is to locate, contain and safely remove any plants found. Individual plants can produce tens of thousands of durable seeds that are easily spread so early detection is vital.

Velvetleaf was first identified in our region in early 2016. In 2018, farmer and staff surveillance identified four paddocks with around 45 plants, along with a number of late season seedlings. This compares well to 2017 when six paddocks and 162 plants were found.

A regular visitor to our region, Rusty is one of only a few dogs trained to detect pest plants and can sniff out even the smallest velvetleaf plants amongst crops.

John Taylor and Rusty the velvetleaf dog

BIOSECURITY

WHERE WE'RE GOING AND WHAT YOU CAN DO

Horizons' biosecurity team are available to provide advice and information. We receive a large number of enquiries from landowners across the region relating to pest plant and animal issues each year.

In recent years, the number of enquiries has steadily risen to between 700 and 800 per year. Most enquiries received relate to backyard 'nuisance' animals such as possums, mustelids and rabbits.

In these situations, Horizons' animal pest management staff provide advice on control techniques and supply loan traps to landowners.

BIOCONTROL CASE STUDY

Horizons works alongside other local and central government agencies, as part of the National Biocontrol Collective, to achieve a coordinated and cohesive approach to biocontrol issues of national importance. Horizons is active in assisting with the development of agents, as well as their controlled release and monitoring.

Biological control (or biocontrol) uses one living organism, such as insects or fungi, to control another. The natural enemies of pests are studied carefully, and tested to ensure they will not damage desirable plants or cause unexpected problems if introduced to New Zealand. Biocontrol measures offer the prospect of suppression without the ongoing costs of physical or chemical intervention.

Presently, biocontrol in the region ranges from the green thistle beetle (*Cassida rubiginosa*), to the tutsan seed-eating moth (*Lathronympha strigana*), and broom gall mite (*Aceria genistae*). Horizons is also currently championing the rigorous testing and introduction of the leaf and bud galling mite (*Aceria vitalbae*) to assist with the control of Old Man's Beard.

Old Man's Beard (*Clemitis vitalba*) is an introduced vine that smothers and kills all plants to the highest canopy and prevents the establishment of native plant seedlings. It is of major concern in our native forests. Control is difficult and expensive. Horizons currently spends more than $500,000 a year trying to control this pest plant. For areas of the region with steep terrain, treatment such as aerial spraying can also pose a risk to native vegetation.

In this case, the mite attacks Old Man's Beard causing the formation of galls (large growths on the stem). The plant sends its energy to the gall, suppressing the growth of the plant which results in less vigorous growth and less seeding, providing native plants a chance to regenerate.

HOW TO TELL OLD MAN'S BEARD FROM OUR NATIVE CLEMATIS

Old Man's Beard has a purplish ribbed stem, five leaflets (whereas our natives have three), and the seed heads when present look like a fluffy old man's beard.

Native clematis

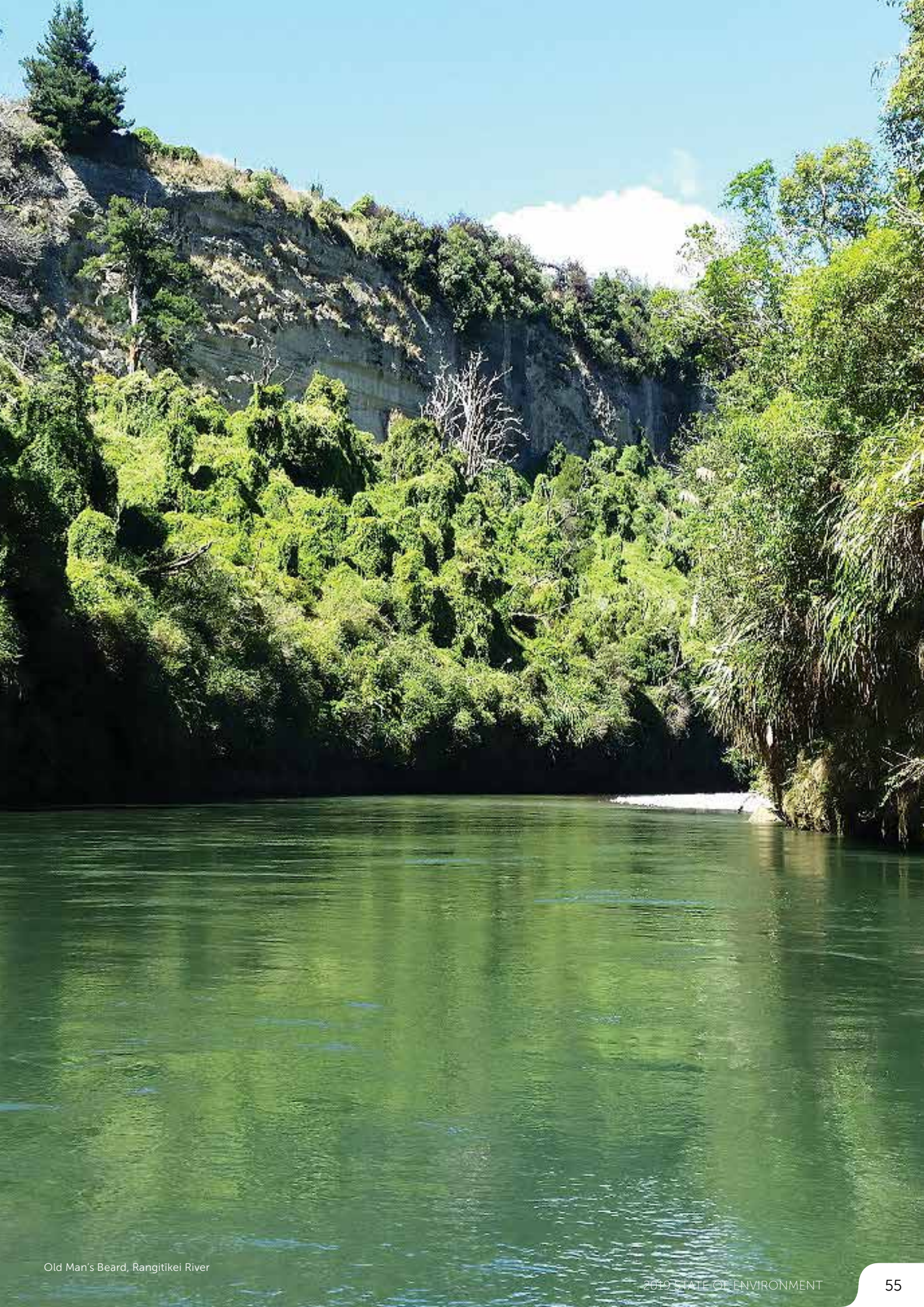
Old Man's Beard

GET INVOLVED

Biosecurity really is a collective task, requiring the efforts of everyone. There are a range of simple actions that we can all take:

- Unpack online purchases carefully in case any hitchhiker pests are inside;
- Make sure you (and your family and friends) are aware of our biosecurity rules if travelling to or from New Zealand;
- Learn to recognise pest plants and avoid growing them in your garden. Check out **www.weedbusters.org.nz** for information on common weeds and how to control them;
- Keep watch for anything that is potentially unwanted or a disease and report sightings to the MPI free **24 hour emergency hotline 0800 80 99 66**;
- Thoroughly check, clean and dry your boat and other water sports equipment between waterways to prevent the spread of invasive weeds;

- Don't release your goldfish (or other fish) into lakes or streams as they compete with native fish and alter the ecosystem; and
- Team up with others in your neighbourhood to control pests such as stoats, rats and mice. A collective approach is more likely to be effective and you'll get to know your neighbours better too.



Old Man's Beard, Rangitīkei River

TE WAI

WATER

INTRODUCTION

We know water matters to people. It is essential to all life and our sense of wellbeing - socially, culturally, spiritually and economically.

Water provides for our day to day needs, underpins our economy, is an important part of our culture and provides for a range of recreational activities. It is also essential for sustaining the region's ecosystems.

The Horizons Region has over 35,000 km of streams, 226 lakes more than a hectare in size, 40 estuaries and 3,100 km^2 of ocean. This chapter reports on water quantity, groundwater quality, river quality, lakes, estuaries and coast, and swim spot monitoring.

For water quantity, key indicators include changes in allocated use over time and groundwater levels. Groundwater quality indicators relate to nutrients, metals, bacteria, pesticides and herbicides, and emerging contaminants.

This section also looks at the time groundwater takes to flow to surface water. The River Water Quality section looks at indicators of state compared to One Plan targets and the National Policy Statement for Freshwater Management (amended 2017), and trends in the data that indicate change over time.

For the lakes within our monitoring programme, key indicators include water quality state and ecological health. For the region's estuaries and coast, the state of water quality and vulnerability of estuaries to sediment and nutrients are key indicators. Finally, the Swim Spot Monitoring section reports on Horizons' summer swim spot monitoring programme and the length of the region's rivers that are suitable for swimming, as well as changes over the last ten years.

77%

OF CONSENTED WATER USE

in the region is for hydroelectricity

Consented allocation has

INCREASED BY

161% SINCE 1997

(excludes hydroelectricity)

NEARLY ALL RIVER WATER QUALITY SITES MEET

One Plan ammoniacal nitrogen criteria

3 OF 31

state of environment bores exceed the drinking water standard for nitrate

NEARLY ALL RIVER SITES FAIL

criteria for dissolved reactive phosphorus, bacteria and water clarity

The split of

GROUNDWATER AND SURFACE WATER

allocation (excluding hydroelectricity) is approximately even

COME ACROSS A TERM YOU DON'T KNOW?

Check out the Glossary at the back of this report to learn more.

Over-allocated surface water management zones have

REDUCED FROM

15 TO 9

since 2014

10 YEAR TRENDS IN RIVER QUALITY

are predominately **DEGRADING** for: Periphyton (chlorophyll *a*) | Macroinvertebrate community index | Dissolved reactive phosphorus | Clarity Spot measurements of dissolved oxygen

10 YEAR TRENDS IN RIVER QUALITY

are predominantly **IMPROVING** for: Soluble inorganic nitrogen | Ammoniacal nitrogen | The number of exceedances of the *E. coli* criteria for swimmability

Of 145 monitored bores

30% HAVE INCREASING groundwater levels and

14% ARE DECLINING

ALL 15 MONITORED

LAKES PASS

the ammoniacal nitrogen and bacteria targets

NEARLY ALL 15 MONITORED

LAKES FAIL

the targets for chlorophyll *a* (algae), total nitrogen and total phosphorus

ALLOCATION IN ALL

groundwater management zones are within One Plan limits

ECOLOGICAL CONDITION

of 31 lakes assessed using the LakeSPI method show 19% at high or excellent, 45% moderate, 23% poor and 13% non-vegetated

3 OF 4 BEACH SITES

fail average chlorophyll *a*, nitrogen and phosphorus targets and another

3 OF 4 BEACH SITES

fail bacteria targets for bacteria during summer

Most of the 64 sites monitored for periphyton are

WITHIN THE A BAND

5 sites (8%) are

WITHIN THE D BAND

7 of 40 **ESTUARIES** have been identified as

VULNERABLE TO NUTRIENT AND SEDIMENT,

33 have low to moderate vulnerability

The length of rivers considered suitable for swimming has

INCREASED FROM 35% IN 2006 TO 40% IN 2016

National modelling shows 45% of the region's large river lengths and 55% of the region's lakes are considered

SUITABLE FOR SWIMMING YEAR ROUND

TE RAHI O TE WAI

WATER QUANTITY

INTRODUCTION

Measurement of rainfall and the quantity of water in the region's water bodies over time plays a key role in helping us prepare and respond to droughts and floods. It also helps us manage water use in the summer months when demand is high.

Horizons has responsibility for setting limits for water abstraction from all sources, and managing the allocation of that water across a range of users and competing values. To inform this Horizons tracks groundwater and surface water availability and its use throughout the region. This section of the report provides an overview of the region's rainfall and river flows, changes in consented water use, and trends in groundwater levels.

WATER QUANTITY

WHERE WE'VE COME FROM

RAINFALL

Rainfall measurements inform flood modelling, flood response, and the design of infrastructure, including stormwater networks and irrigation.

Horizons' rainfall monitoring network has 71 sites, most of which automatically communicate data to Horizons. Rainfall data informs near real-time modelling of river flows to predict the likely timing of flood peaks during rainfall events, as well as the timing of restrictions on water abstraction during low flows. Most sites collect data every six minutes, and have a backup recorder as well as a standard collection system to verify the data.

A regional map of annual rainfall, previously compiled for Horizons by NIWA, shows that mean annual rainfall in the region ranges from 900 mm at the coast, to over 2,000 mm in the ranges that run through the middle of the region (Figure 1).

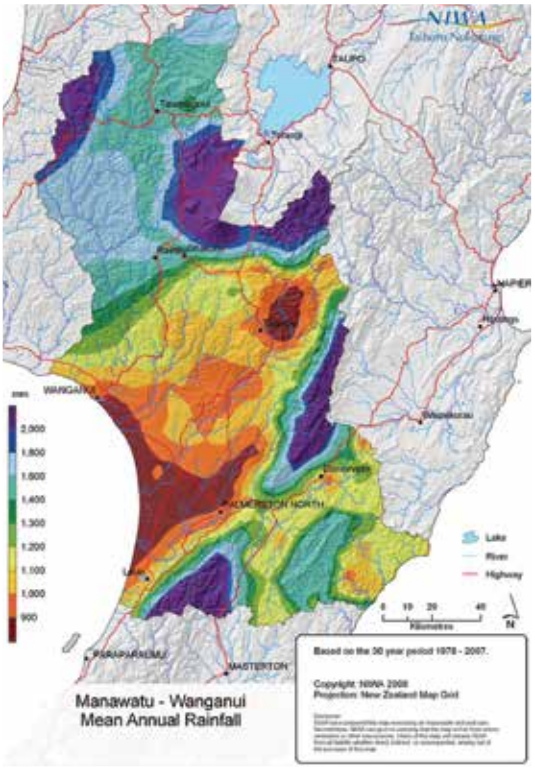


Figure 1: Regional map of mean annual rainfall produced for Horizons by NIWA (Tait and Sturman, 2008)

RIVER FLOWS

River flow information is used for a range of purposes including flood management, predicting suitability for swimming at some swim spots, and informing water abstractors when there are restrictions on the amount of water that can be used. River flow data also informs the analysis of water quality state and trend, and the calculation of nutrient loads in rivers.

Horizons' network includes the site with the longest continuous record of river flow in New Zealand. This site, Manawatū at Teachers' College, is located near the Fitzherbert Bridge in Palmerston North, where flows on this stretch of river have been recorded since 1923. Sites with long-term records such as this are valuable for helping us to understand longer-term changes in river flows, and calculate statistics such as 1 in 100-year flood levels.

Over time, the river flow monitoring network in the region has grown from a few sites in the 1940s, through to the network of 73 sites that exists today.

This network currently records approximately 30 million data inputs per year. Horizons' network is supplemented by flow recording sites from hydroelectricity generators and NIWA. Since the last State of Environment report, NIWA has exited some flow monitoring in the region and Horizons has taken over monitoring five of these sites.

The following table presents flow statistics for a range of key sites to provide an indication of the relative size of some of the rivers in the region during a range of flows. The summary includes the lowest flow recorded, mean annual low flow, median flow and highest flow recorded, and calculated across a common 20-year period from 1995 to 2015.

The data shows the Whanganui River is the largest in the region in terms of flow, followed by the Manawatū and Rangitīkei.

Site	Catchment Area (km^2)	Lowest recorded flow (m^3/s)	Mean annual low flow (m^3/s)	Median flow (m^3/s)	Mean flow (m3/s)	Highest recorded flow (m^3/s)
Whangaehu at Kauangaroa	1,917	10.4	13.4	27.2	41.8	1,871
Whanganui at Te Rewa	6,643	23.3	38.7	125	219	4,965
Turakina at Otairi	507	0.13	0.34	2.12	6.42	884
Rangitīkei at Mangaweka	2,695	9.00	13.2	45.4	63.6	1,804
Manawatū at Weber Road	713	1.09	1.71	6.69	13.6	1,410
Manawatū at Upper Gorge	3,231	5.92	9.87	52.6	86.9	2,698
Manawatū at Teachers College	3,900	8.91	14.8	67.4	107	3,515
Ohau at Rongamatane	105	0.58	1.07	3.87	6.48	452

Table 1: Flow statistics for a range of key sites in the Horizons Region.

WHERE WE ARE NOW – CURRENT STATE

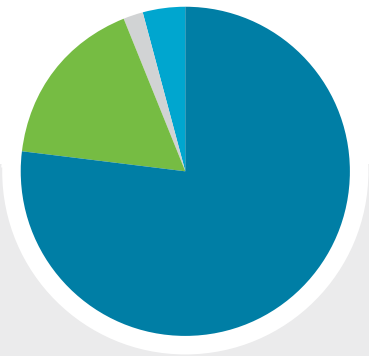
CHANGES IN CONSENTED WATER USE

Hydroelectricity is the largest user of water in the region, accounting for around 55 cubic metres per second (m^3/s), or 77 per cent of the total water allocated. In most cases, hydroelectricity use is non-consumptive, as water abstracted for power generation is eventually returned to the water body it was taken from. In the Horizons Region this isn't always the case – approximately 29 m^3/s is directed out of the region via the Tongariro Power Scheme. Another hydroelectricity take that diverts water between catchments within the region is the NZ Energy scheme, which takes water from the Whangaehu Catchment and discharges it to the Whanganui Catchment. The Mangahao Power Scheme near Shannon also diverts water from the upper reaches of the Mangahao River to the lower reaches of the Manawatū River via the Mangaore Stream.

As stated above and illustrated in Figure 2, hydroelectricity makes up approximately 77 per cent of the region's consented water use, while agriculture and horticulture account for around 17 per cent. Municipal supplies, which include some industrial and commercial use, use around 4 per cent. Industry and abstraction for a range of other purposes, such the irrigation of parks and sports fields, account for around 2 per cent. When hydroelectricity is excluded, agriculture and horticulture account for around 72 per cent of consented water use, public water supplies approximately 18 per cent, and industry and other uses account for the remaining 10 per cent (Figure 3).

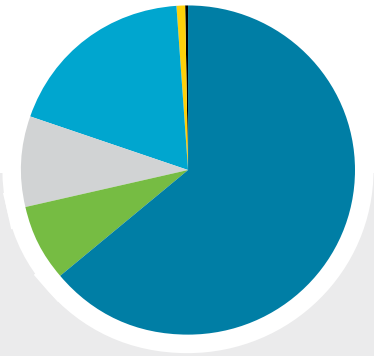
Allocation of water for uses other than hydroelectricity has increased by around 161 per cent since 1997, from approximately 6.5 cubic metres per second (m^3/s) to approximately 16.9 m^3/s (Figure 4). The average annual increase from 1997 to 2013 was 48,856 m^3/day, compared to 24,180 m^3/day per year for the period 2013 to 2018. Consented use is split almost evenly between surface water and groundwater, with groundwater accounting for around 56 per cent of this allocation, an increase from 53 per cent in 2013. Allocation of water since 2013 has mainly been for agricultural purposes, primarily irrigation and to a lesser extent stock water.

Figure 5 shows the division of use (excluding hydroelectricity) by Freshwater Management Unit (FMU). This highlights that most of the use for agricultural and industrial purposes occurs in the Manawatū and Rangitīkei, and municipal use is spread across the freshwater management units.



KEY	m^3/s	% SHARE
HYDROELECTRICITY:	55	77%
AGRICULTURE/HORTICULTURE:	12	17%
MUNICIPAL/DRINKING WATER:	3	4%
INDUSTRY AND OTHER:	1.7	2%

Figure 2: Proportion of water allocated for different uses in the region shown in m^3/s and percentage (%)



KEY	m^3/s	% SHARE
AGRICULTURE:	10.8	63.9%
HORTICULTURE:	1.3	7.7%
INDUSTRY:	1.5	8.8%
MUNICIPAL/DRINKING WATER:	3.1	18.5%
RECREATIONAL:	0.15	0.9%
LAND DISTURBANCE AND INFRASTRUCTURE:	0.01	0.1%
COMMERCIAL WATER BOTTLING:	0.02	0.1%

Figure 3: Proportion of water allocated for uses other than hydroelectricity in the region shown in m^3/s and percentage (%)

CHANGES IN WATER ALLOCATION 1997-2018

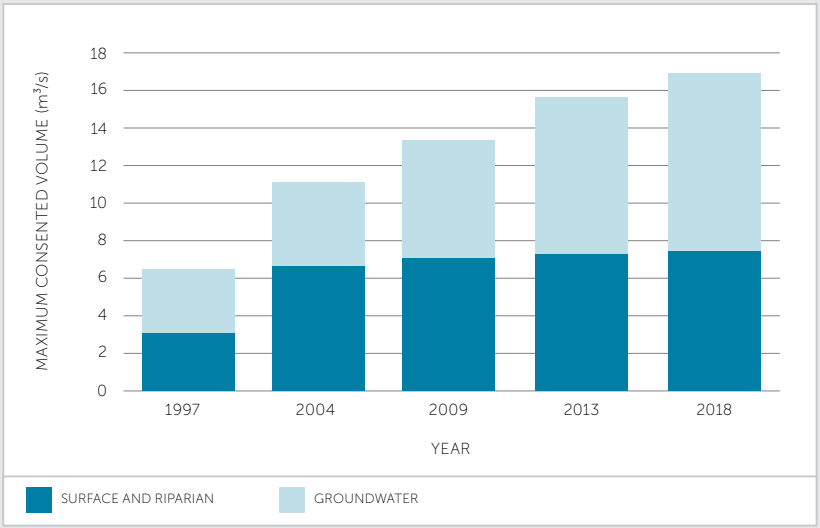


Figure 4: Changes in water allocation (excluding hydroelectricity) between 1997 and 2018

WATER ALLOCATION BY USE IN THE HORIZONS REGION

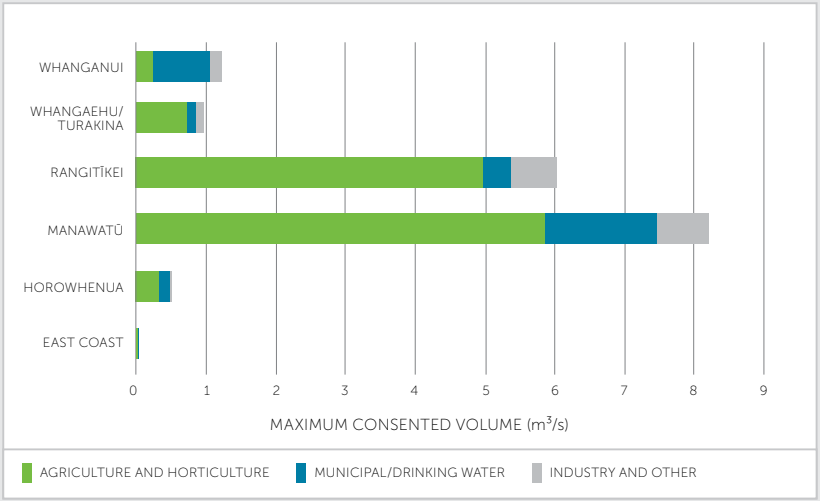


Figure 5: Current water allocation by use (excluding hydroelectricity) within major FMUs in the Horizons Region

Horizons gauges the flow of a stream

SURFACE WATER ALLOCATION

Surface water is all the water we can see, including: rivers, streams, lakes, drains, ponds, and wetlands. In some parts of the Horizons Region, the demand for surface water is greater than the amount available. During summer when river flows are at their lowest, taking too much water can affect the health of our freshwater ecosystems.

Dealing with the competing demands for water and balancing them with the needs of the environment is a high priority for Horizons. Horizons have put a detailed water allocation framework in place, setting out core allocation limits for surface and groundwater resources, and minimum flows for surface water takes. The framework is implemented through consenting processes.

During the development of the One Plan, a range of methods were used to set core allocation limits for all the surface water catchments, or water management zones. These limits are designed to protect and maintain instream habitat for aquatic life while allowing for reasonable out of stream water use. Minimum flows must also be maintained to support the fish and other life that lives in our rivers. This means that during low flows, surface water is unable to be taken unless it is for essential uses such as providing drinking water for animals and people.

Much of the water allocated in high demand areas was consented before the water allocation framework of the One Plan was in place resulting in some areas of the region becoming over-allocated when the framework was introduced. Horizons' aim is to bring all of the region's management zones back within their core allocation limits. We have made measurable gains in recent years. Since 2014 the number of sub-zones that are allocated beyond their respective core allocation limits has reduced from 15 out of 124 subzones (12 per cent), down to just to nine (7 per cent) (Figure 7). Of these over-allocated sub-zones, four are presently within ten per cent of the allocation limit. Overall, around 61 per cent of surface water is allocated for use.

We continue to work with consent holders to reduce the impact of water use in over-allocated catchments through consenting processes by promoting water use efficiency, and monitoring actual water use through a water metering programme.

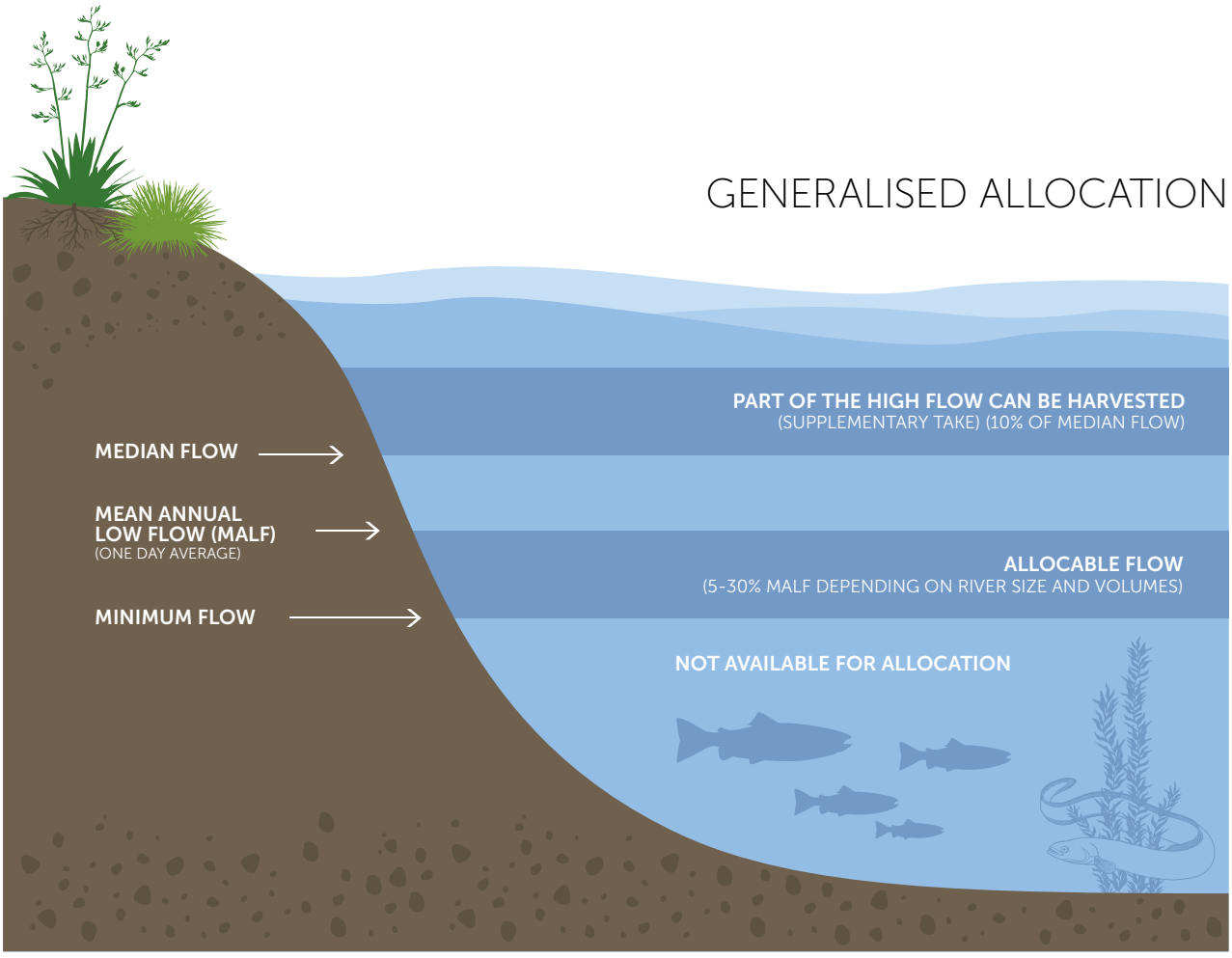


Figure 6: Horizons One Plan sets out a framework for allocation of surface water

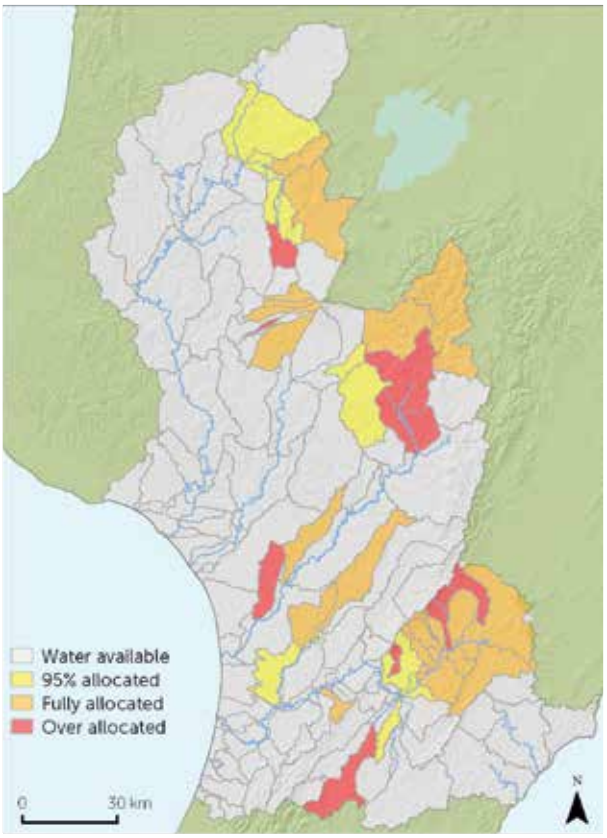


Figure 7: Surface Water allocation map for Horizons Region

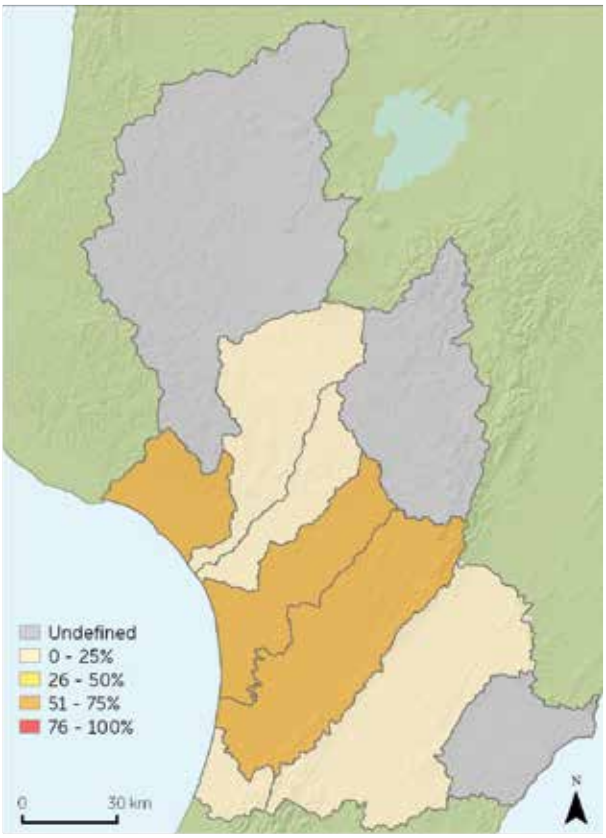


Figure 8: Groundwater allocation map for Horizons Region

GROUNDWATER ALLOCATION

Groundwater is all the water contained below the earth's surface. It comes from rainfall and river water that makes its way through the ground and accumulates in underground aquifers. An aquifer is somewhat like a sponge, where water moves slowly through layers of gravel, sand and hard rock. Generally there is more groundwater available than is currently being used in the region. However, abstracting too much groundwater can impact wetlands, rivers, and lakes. It can also affect the ability of other people to access groundwater, or in extreme cases, has potential to draw salt water from the sea into freshwater aquifers.

Groundwater is widely utilised, with around 8,700 bores located throughout the Whanganui, Rangitīkei, and Manawatū catchments. In our region, the groundwater resource is divided into ten management zones. Seven of these zones, where water is in demand, have annual allocation limits outlined in the One Plan. Remaining zones either have little groundwater available or have a high connection with surface water and are considered 'riparian' takes under the One Plan rules, which are essentially allocated as surface water.

Groundwater allocation limits were based on five per cent of the total annual rainfall over the management zones at the time the One Plan was developed. Presently, total allocation within all groundwater management zones remains within the limits set out in the One Plan, but these limits are currently being reviewed with new data and information.

CHANGES IN GROUNDWATER LEVELS

Below the earth's surface, groundwater is found in water-bearing rocks and sediment, known as aquifers. Monitoring of groundwater levels is important to check for changes over time, and to ensure this important resource is appropriately managed. The information we collect about our rivers, lakes and groundwater is also helping us to better understand the movement of water between surface water bodies and aquifers throughout the region.

Under natural conditions, the volume of water in an aquifer reflects an ever-changing balance between recharge and discharge. Aquifers are recharged directly from rainfall or from water loss from rivers and lakes. Groundwater moves through the sub-surface before it is eventually discharged to the ocean or to rivers, springs, streams, lakes and wetlands. This process can occur within days in shallow gravel aquifers, or take thousands of years in deep water-bearing strata. These natural mechanisms can be affected by groundwater use and artificial recharge from irrigation, which can affect the environment and other groundwater users.

Horizons also operates an extensive groundwater level monitoring network in the region that enables us to assess the current status of the resource, measure the effects of groundwater takes, and track changes over time. Monitoring began in the 1960s, and the network underwent a significant expansion in the early 1990s.

With the permission of bore owners, Horizons currently surveys around 130 bores every month and the data presented on both the Horizons and LAWA websites. At Whakarongo near Palmerston North, the Te Matai multi-level monitoring station measures groundwater levels at six different depths from 12 metres through to 87 metres to provide information on how groundwater responds to water use and climatic changes at different depths. We also maintain real-time monitoring of groundwater levels at a further 13 sites throughout the region.

A single groundwater level measurement reflects conditions at a given moment in time. As more measurements are collected, we can start to see trends emerge in the data we collect. Where climate and water use data is also available, we can begin to infer what might be causing a change in groundwater level. Such changes can be natural, or induced by activities such as abstraction and irrigation. Most often it is a combination of the two, which can make it difficult to determine the cause.

The monitoring network covers a range of depths from 2 metres to 630 metres, with an average depth of 77 metres. Over the past ten years, increasing water levels are evident in around 30 per cent of bores, while 14 per cent show declining trends (Figure 9). Bores with declining water levels are mainly located throughout the Manawatū and Rangitīkei catchments where demand for groundwater has increased in the past decade.

The results show an increase in the number of areas with declining groundwater trends. The last State of Environment report identified only one main area of decline, being at Santoft. The increase in number of declining trends has contributed to the decision to technically review groundwater allocation limits as outlined in the previous section.

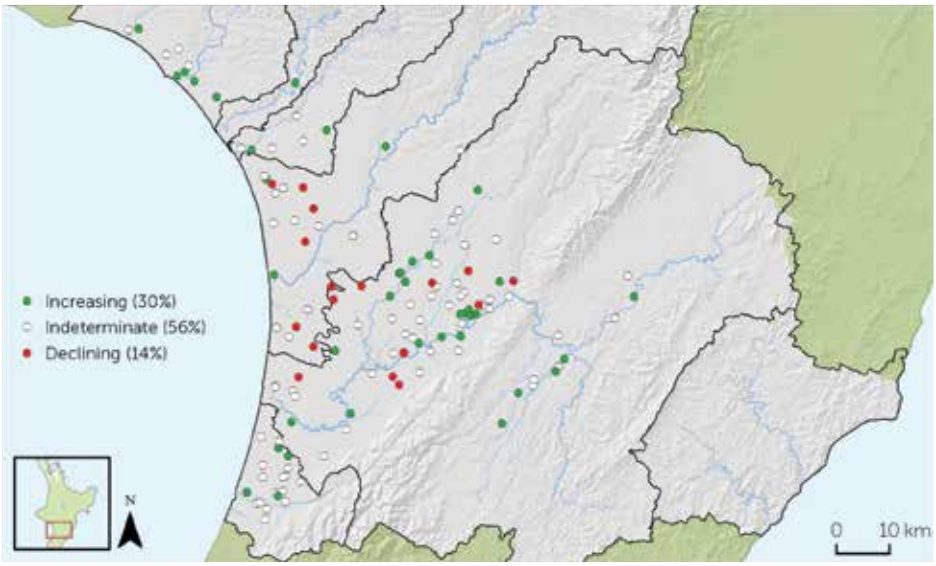


Figure 9: Groundwater levels are measured at 130 sites every month and every 15 minutes at 14 sites across the region

Horizons works with land owners to measure groundwater levels across the region

GROUNDWATER

WHAT WE'RE DOING

SANTOFT GROUNDWATER INVESTIGATION CASE STUDY

Increasing pressure on groundwater in the Santoft area near Bulls was recognised at the time of our last State of Environment report in 2013. At that time this was the only area where a significant pattern of declining water levels was noted. Horizons, with the support of the Santoft Water User Group, initiated an investigation into the groundwater resource to determine the cause and impact of this change on existing water users and the environment.

Monitoring and research initiated in 2014 confirmed that while climate was likely a factor, groundwater was also under pressure from increasing demand for water to irrigate pasture and crops. Modelling indicated that a continued decline in groundwater levels was possible, even if no further water permits were granted.

In response, Horizons developed new management methods for this area including establishing 'trigger levels'. Irrigation takes in the area are now required to reduce (or cease) abstraction once a certain threshold has been reached in a nearby monitoring bore.

Since this work was completed, groundwater levels in a number of bores have stabilised. This approach continues to provide a level of protection for existing water users and the water resource in this area.

MEASURING WATER USE CASE STUDY

Horizons has been undertaking automated reporting of water use since 2003. The programme has grown over time and in 2007 automated reporting via the WaterMatters webpage was introduced. National regulations requiring the measurement and reporting of water takes over 5 litres per second were phased in between 2010 and 2016. Presently, Horizons collects real-time water use data from over 350 sites, accounting for around 85 per cent of total water allocated (excluding hydroelectricity) across the region.

Water meter installation is a standard condition for nearly all surface and groundwater take consents granted in the Horizons Region, and in accordance with national regulations, the return of water use data is required for all consents that take at least five litres per second or more. The One Plan also has water metering policies including requiring measurement of use where the allocation in a water management zone is close to, or at, the limit of available allocation.

There is still work to do to fully implement the national water metering regulations in the region. Horizons is working with water users to ensure these requirements are fully implemented; however, a number of consented takes will remain unmetered until infrastructure to take water is in place.

Data collected by Horizons is useful for Horizons and landowners. Water use data helps us monitor overall compliance with consented limits and minimum flows, and informs water resource management decision-making. The telemetered data can also be fed into on-farm systems to plan and manage irrigation scheduling, alongside soil moisture information collected on site. Data collected via telemetry are available on Horizons' WaterMatters website for public viewing. Registered consent holders can view and download the data to assist in managing their abstractions and compliance with resource consent conditions. Telemetry installation also removes the need for daily water meter reading and manual return of the records to Horizons, increasing accuracy of data and decreasing effort for both the consent holder and monitoring staff.

Currently, telemetry equipment is provided, installed and maintained free of charge by Horizons who retains the ownership, with abstractors covering the cost of the water meter installation and ongoing meter maintenance and verification.

GROUNDWATER

WHERE WE'RE GOING AND WHAT YOU CAN DO

SEAWATER INTRUSION CASE STUDY

At the coast, freshwater mixes with seawater at what is known as the freshwater/seawater interface. When freshwater is pumped from the ground faster than the ground can replenish it, it can cause salt water to be drawn into the bore and surrounding aquifer. This is known as seawater intrusion and it can have a major impact on drinking water supplies and irrigated crops and pasture, which can in-turn reduce the availability of groundwater for use.

Horizons has undertaken studies into seawater intrusion and the risk is generally considered to be low for much of the region. To date, there have been no significant signs of seawater intrusion in monitored bores; however, once seawater intrusion occurs it is difficult to remediate. This is why we maintain a network of eight automatic seawater intrusion monitoring wells along the western coast. At these sites, groundwater pressure and conductivity measurements are collected at 15-minute intervals and sent back to Horizons via telemetry.

Where there is a risk of seawater intrusion, water users may need to carry out additional monitoring. In some cases they are required to cease or reduce their water take when certain water level or conductivity thresholds in the monitoring network are reached. This is similar to the approach applied with surface water, where consent holders may be required to restrict their water use during low river flows. This is a precautionary measure to ensure that action can be taken before freshwater aquifers become contaminated.

PREDICTIVE MODELLING CASE STUDY

Horizons, with support from Envirolink, recently commissioned groundwater scientists at Aqualinc to develop a simple tool to forecast groundwater levels over future months. By predicting likely future groundwater levels, water managers and water users are better placed to make decisions around water use over the forecast period.

Eigen models are a simple tool that have been used to better understand the relative impacts of climate and abstraction on groundwater levels. This new approach takes Eigen modelling one step further by utilising historic climate forecast information, along with Horizons' water use and monthly groundwater level monitoring data, to predict end of summer groundwater levels. Predictions were compared to groundwater level data to test the viability of the approach.

The initial results suggest that groundwater levels predicted by the model were reasonably similar to those measured in the groundwater bores. While further testing and development is required, initial indications show that the tool could provide useful information to help inform people's decisions around how they manage their water supply, particularly during dry periods.

WATER METER TIPS AND HINTS

Keeping track of your water use can be really simple. If you have a water metering system there are some simple things you can do to make sure you get the best out of your system:

- Read your resource consent to ensure you're familiar with your obligations and limits;
- Regularly inspect your pipe work for any obvious damage or leaks;
- Check your water meter is working and verified – get professional help from an IrrigationNZ 'Blue Tick' accredited installer if it needs attention;
- Get in touch with Horizons on **0508 800 800** if you need help with telemetry faults, or have any questions about your consent; and
- Register to access your data on the WaterMatters website (visit the My Meter page).

TE PAI O TE WAINUKU

GROUNDWATER QUALITY

INTRODUCTION

Although it is rarely seen, groundwater makes up the vast majority of freshwater on the planet. Held in the pore spaces between the rock, sand, silt and clay particles beneath the earth's surface in aquifers, the movement of water within an aquifer is described in a continuous cycle of recharge and discharge, part of a larger system known as the water cycle.

Rainfall on the land surface provides most groundwater recharge, with some seepage from rivers and lakes. Groundwater moves slowly through aquifers, eventually discharging out to sea along the coast or into lakes, estuaries, streams and rivers, which helps maintain their levels during summer time when there is less rainfall.

For the past 30 years, Horizons has monitored groundwater in the region to understand how the quality of the resource is changing over time. We also participate in national monitoring programmes and invest in research to understand how groundwater is being impacted by land-based activities such as farming and industry.

This section of the report provides an overview of groundwater processes and indicators of groundwater quality in the region, including:

- Where aquifers are confined and unconfined;
- Types of groundwater in the region (reduced or oxidised);
- Groundwater quality information for nitrogen, bacteria, iron, manganese and arsenic;
- Results from pesticide/herbicide and emerging contaminant monitoring; and
- Information on Horizons' groundwater science programmes, including studies of water age and drinking water supply security.

DYNAMIC AND COMPLEX: THE GLOBAL WATER CYCLE

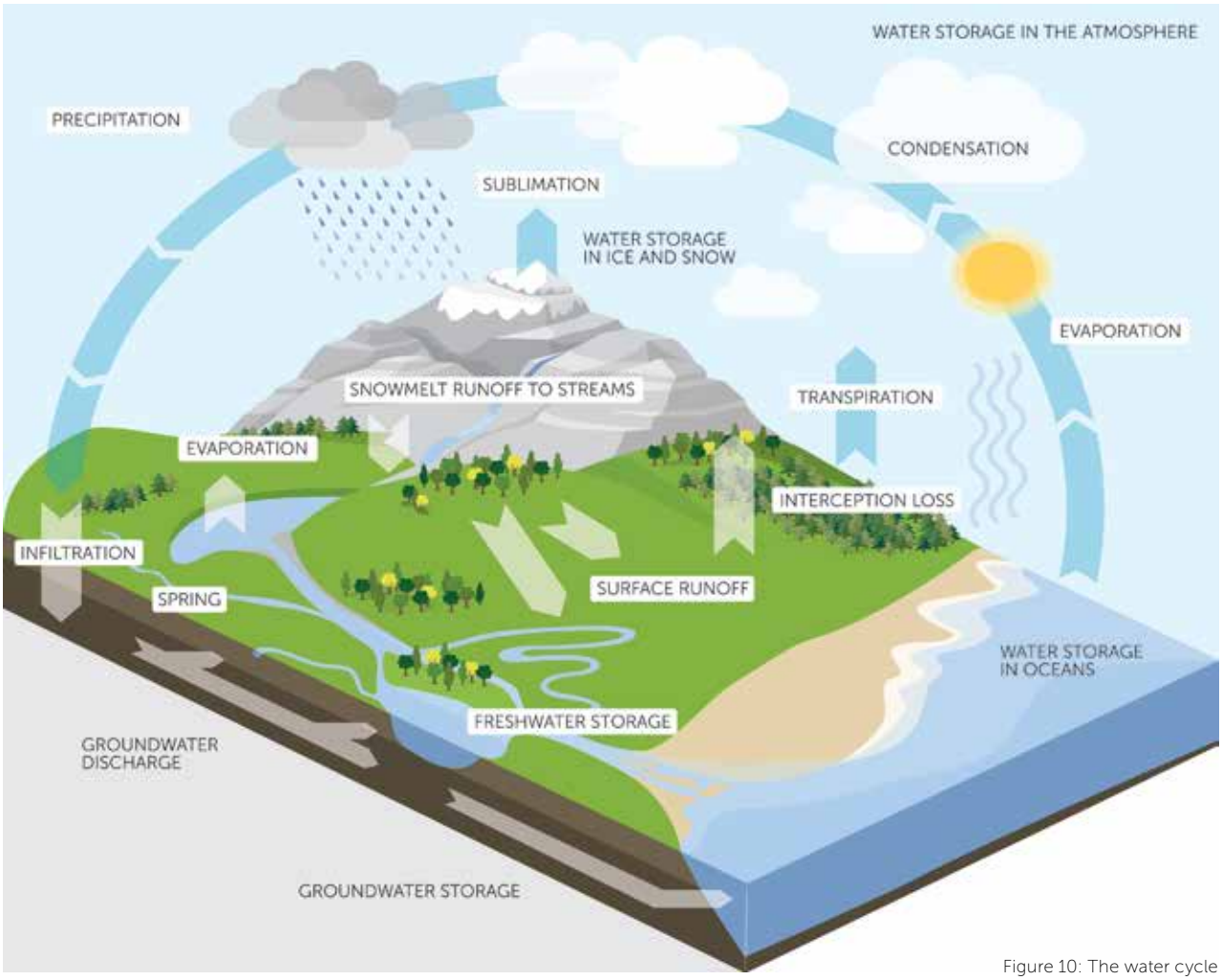


Figure 10: The water cycle

GROUNDWATER QUALITY

WHERE WE'VE COME FROM

There are over 8,700 bores registered with Horizons, with an average of 50 new bores drilled each year for the past decade. The One Plan introduced requirements for new bores to be permitted before they are drilled. This helps ensure that new bores are properly installed and that Horizons is aware of the location of existing bores so that the effects of new water takes on existing users can be adequately assessed. However, because many of these bores were installed prior to the One Plan, there is a legacy of bores where there is little information about their infrastructure and security.

Groundwater in the region has been monitored for a range of water quality indicators since the late 1980s. The monitoring network was expanded throughout the 1990s and is regularly reviewed, as bores naturally deteriorate over time. Regular monitoring includes physical, chemical and biological parameters and this was increased from seven-monthly to quarterly in 2014 to increase both the frequency and number of parameters we measure. Prior to 2014, 21 bores were monitored every seven months for 24 parameters. To keep better track of changes in our groundwater resource, Horizons now samples 31 bores for 34 parameters every three months. Each parameter measured helps us describe groundwater in terms of its water type, current state, suitability for a range of uses, and how it is changing with time.

The monitoring network is supplemented by additional sites that are sampled less frequently but provide further information for targeted investigations and national monitoring programmes. Additional measures such as water age, and presence of potential contaminants (such as pesticides, herbicides, and wastewater), are collected less frequently but help to complete the picture. Where appropriate, these data are used to inform the state and trends analysis summarised in this report.

Groundwater age testing of all monitored bores was completed in 2015. A range of pesticides and herbicides are also sampled every four years as part of a national survey. The most recent survey was completed in 2018 and included glyphosate (found in products such as *Round-up*) and a range of emerging contaminants.

Prior to the inception of the One Plan, few dedicated studies of groundwater quality are documented. Targeted investigations focussed on known or suspected contamination, such as elevated nitrogen in the Horowhenua Catchment, and detections of arsenic in groundwater supply bores in the lower Manawatū basin near Tangimoana. Other studies include monitoring of discharges from landfills and industrial discharges, and information collected for resource consent monitoring; however, much of this early data and information is limited and not easily accessible.

In the past five years, investigations and research have provided further information about the region's groundwater resource. Some of these findings are outlined in this section of the report.

GROUNDWATER QUALITY

WHERE WE ARE NOW – CURRENT STATE

CONFINED AND UNCONFINED AQUIFERS

The groundwater resource within the Horizons Region is found mainly in geologically young gravels and sands, deposited on land and in the ocean over millions of years. Water quality is determined by a wide range of factors, from natural processes to human (anthropogenic) activities.

Where stock water and domestic groundwater supplies in the Horizons Region are drawn from shallow sand and gravel aquifers, they have often formed in old river channels. This groundwater is described as 'unconfined', meaning that the aquifer has a direct path to the land surface.

Water in shallow, unconfined groundwater systems is often recharged directly from rainfall or from water lost from the base of streams and rivers. While this water is quickly replenished, it also results in an increased risk of contamination. Nutrients, bacteria and other contaminants can be transported by water moving through soils and waterways into the groundwater system.

This is apparent in areas such as Horowhenua and the Mangatainoka Catchment in the Manawatū where elevated levels of nitrogen can be found in shallow groundwater.

In deeper aquifers such as those found in Whanganui and other parts of the Manawatū, layers of sediment such as clay and mudstone create a barrier (known as a confining layer) that restricts the flow of groundwater between the aquifer and the surrounding rock.

Water in deep, confined aquifers can be hundreds or even thousands of years old. Because of the time it takes for water to reach these aquifers, there is generally a low risk of contamination from bacteria or nutrients. However, over time this water becomes more mineralised and can have elevated concentrations of heavy metals such as iron, manganese and arsenic.

Deeper aquifers can become contaminated if the wellhead is not properly secured, or where pumping draws in water from other (contaminated) groundwater. This is why it is important to manage the use of groundwater and why Horizons has rules around the installation and maintenance of groundwater bores.

CONFINED AND UNCONFINED AQUIFERS

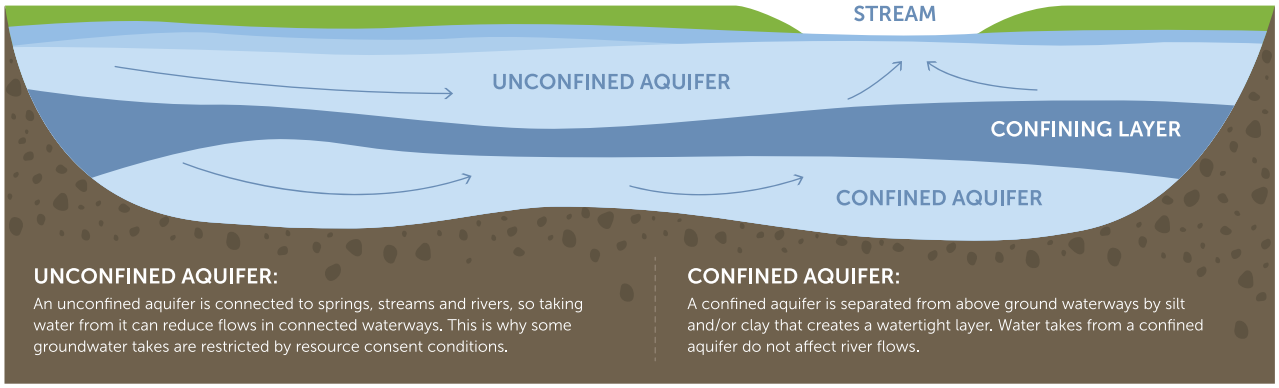


Figure 11: Groundwater can be unconfined, confined or semi-confined, depending on the surrounding rock types

WATER TYPE

Water type broadly fits into two overall categories: reduced or oxidised. The dominant water type is determined using a statistical technique analysing some of the parameters collected through our state of environment monitoring. This has important implications for water quality management as the water type broadly indicates the suitability of groundwater for different uses and identifies areas of risk for nutrient enrichment. Water type also appears to play a role in the type of ecosystems that are found in groundwater.

Reduced water is typically old, often decades or more, has less oxygen and generally lower nitrate concentrations but higher levels of minerals such as iron and manganese. This is because reduced water has generally travelled further and had more time to interact with soil and rock, changing the chemistry of the water over time. Elevated levels of naturally-occurring heavy metals such as arsenic can make groundwater unsuitable for drinking in some areas of the region.

Oxidised water is typically younger, generally days or months through to a few years. Groundwater in these gravel-rich aquifers tends to move more quickly and water is more oxygenated, with lower concentrations of dissolved metals. These zones are more susceptible to elevated levels of nitrate as they lack the conditions that encourage processes such as denitrification – where nitrate is converted to less harmful forms of nitrogen. Generally oxygen-rich water is found near the earth's surface in shallow aquifers (such as in the Tararua area of the Manawatū), but can also occur at depth in gravel and sand basins (such as those found in Horowhenua), as shown in (Figure 12).

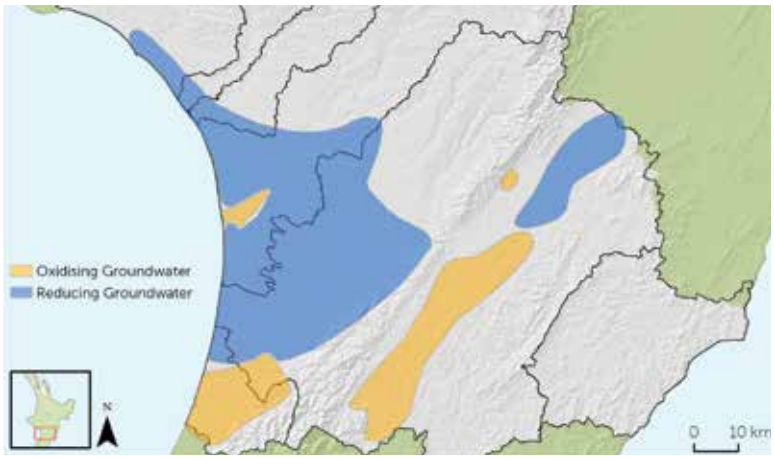


Figure 12: Redox zones across the Horizons region

GROUNDWATER ECOSYSTEMS

When we think of aquatic ecosystems, we tend to think of fish and bugs that live in rivers and lakes. Groundwater systems don't tend to come immediately to mind, but they are home to many types of bacteria, fungi and invertebrates, interacting with each other and their surrounding environment.

Some groundwater systems depend on oxygen, organic matter and nutrients that are carried into the aquifer by recharge water. These organisms appear to be significant not only in terms of their biodiversity values, but also the important services they provide, such as filtration and remediation, and denitrification (conversion of nitrate). Water type (oxidising or reducing) appears to play an important role in the type of organisms that are found.

On farm groundwater bore

GROUNDWATER QUALITY RESULTS

Water quality parameters are generally compared to guidelines or standards set for the protection of ecosystems or human health. For the purposes of this report, levels of key indicators are compared to the Ministry of Health Drinking Water Standards for New Zealand (revised 2008). However, in some cases, such as where groundwater and surface water are closely linked, it may be more appropriate to consider other criteria, such as ecosystem health guidelines for freshwater.

The current state is calculated from median values for samples collected from more than 80 bores between 2012 and 2017, while changes over time (temporal trends) present either the short term (five years, from 2012 to 2017) or long term (all data available) for 31 bores in the core State of Environment network.

Bacteria

In groundwater *Escherichia* coli (*E. coli*) are an indicator of faecal contamination, which poses a risk to human health and can make water unpalatable for stock. It is important to note that Horizons carries out environmental monitoring and this sampling methodology is not suitable for providing assurance around drinking water security. Conclusions should be drawn with caution; however, to provide some understanding around the levels of *E. coli* in groundwater, we have compared the results with the New Zealand Drinking Water Standards.

Of the 31 monitoring bores, 19 (58 per cent) recorded *E. coli* concentrations that exceeded the drinking water standard of 1 MPN/100 mL. There is no clear spatial pattern to the occurrence of *E. coli*; however, detections are generally more frequent in shallow groundwater that is more vulnerable to contamination. Detections in deeper bores (more than 50 metres deep) require further investigation. Private bore owners should be aware that a deep bore does not guarantee that a supply will be free of bacteria, and should ensure their water is tested and treated appropriately.

Nitrogen

Nitrogen is an essential plant nutrient that can be measured in different forms in the environment. In groundwater, we generally measure nitrogen as nitrate, nitrite and ammoniacal nitrogen (ammonia).

Elevated nitrate is often a result of agricultural land use or wastewater disposal. Soluble in water, nitrate is easily transported with groundwater to waterways where it contributes to the growth of nuisance algae. You can find out more about this in the Rivers and Lakes sections of this report. Nitrate can also cause health issues, particularly for babies as it can inhibit oxygen movement around the body. National drinking water standards specify a maximum nitrate-nitrogen limit of 11.3 mg/L to prevent effects on pregnant women or bottle-fed babies.

Nitrate concentrations are well below the drinking water standard across most of the region but are elevated in Horowhenua and Tararua (Figure 13). In the region, three of the State of Environment bores, and two additional bores show concentrations that are above the drinking water standard, including some deeper bores (>50m deep). Both short term (five year) and long-term (10-20 year) trends in nitrate concentrations are generally indeterminate or improving, with only one bore to the north-east of Levin showing a slight degrading trend over five years, and a bore near Whanganui showing a small magnitude degrading long-term trend.

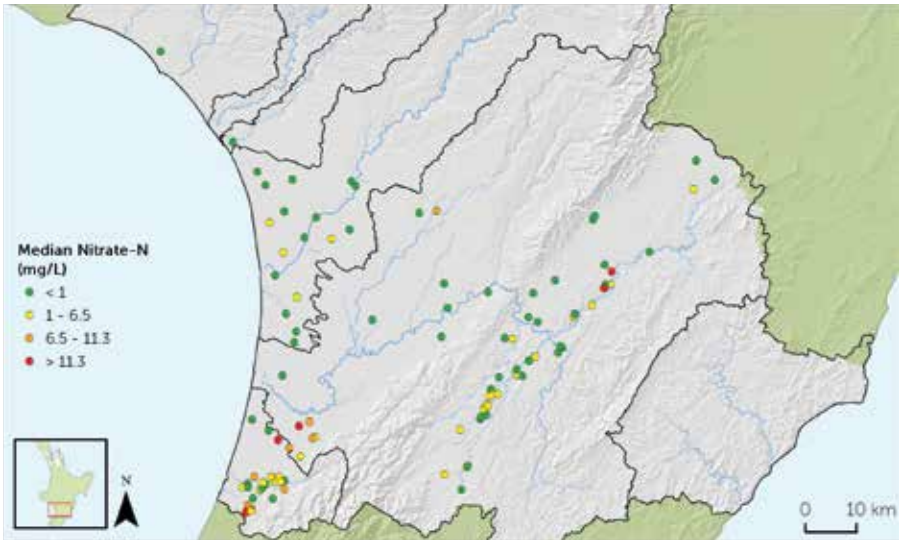


Figure 13: Median nitrate-nitrogen concentrations in bores across the region

Iron, manganese and arsenic

Naturally occurring minerals such as iron, manganese or arsenic can be dissolved in groundwater, affecting the way it looks, smells and tastes. This is often a natural feature of older, reduced groundwater which has had more time to mix with the rocks around it.

Both iron and manganese concentrations show similar spatial patterns to ammonia with generally lower concentrations throughout the Tararua and Horowhenua areas and higher concentrations observed throughout the rest of the region (Figure 14). Median concentrations of both iron and manganese exceed their respective drinking water criteria in a number of bores throughout the Manawatū and Rangitīkei catchments. In general these exceedances appear to be associated with areas of reducing groundwater and are likely to be a natural feature of the groundwater in those areas.

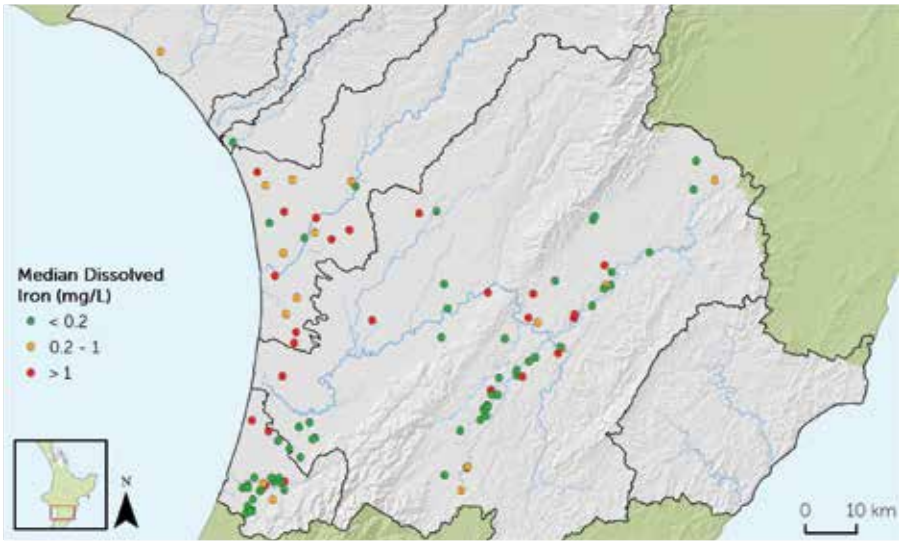


Figure 14: Median iron concentrations in bores across the region

Pesticides, herbicides and emerging contaminants

Groundwater has been sampled for a range of pesticides and herbicides throughout the region every four years since 1990, as part of a national pesticide survey.

Previous surveys have indicated low levels of pesticides, particularly in shallow bores that are more vulnerable to contamination. However, results from 2014 returned no positive detections, including at locations with previous detections in 2006 (four sites) and 2010 (seven sites). The most recent survey took place in late 2018 and also included a range of emerging contaminants such as glyphosate, hormones and antibiotics. The results will be available later in 2019.

Per- and polyfluoroalkyl substances (PFAS)

The emergence of other potential contaminants such as per- and polyfluoroalkyl substances (known as PFAS) has recently become a focus following the discovery of PFAS in soil and water on and around the New Zealand Defence Force Base Ohakea, near Bulls.

Widely used since the 1950s in commercial and industrial products such as non-stick cookware and food packaging, PFAS resist heat, stains, grease and water, making them very effective for smothering petroleum fires. However, because of these properties they are difficult to break down and have a tendency to accumulate in people, animals and in the environment. These foams have been widely used in specialised firefighting foams at airports and training bases throughout New Zealand.

The long-term effects of PFAS exposure are not well-known. Interim guideline limits established for New Zealand have been exceeded in areas such as Ohakea. Horizons has been working with the New Zealand Defence Force to understand the extent and likely impacts of PFAS at Ohakea. We have also undertaken sampling to better understand the extent of contamination near Bulls, and identify other possible sites in our region where PFAS might impact water quality. Information on PFAS can be found at **www.mfe.govt.nz**.

Measuring reference levels for groundwater height

WHAT WE'RE DOING

While there is still much to discover about our groundwater resource, through research and investigations we have greatly advanced our understanding. Since our last State of Environment report in 2013 we have:

- Upgraded our State of Environment groundwater monitoring programme, increasing the frequency of sampling from every seven months to every three months to identify seasonal trends over time, and expanded the range of parameters we analyse to better characterise the groundwater resource;
- Completed catchment characterisation studies in the Manawatū, Horowhenua and Rangitīkei catchments to better understand land use effects on water quality, and groundwater and surface water interaction;
- Established groundwater and surface water age and transport (lag) times across the region;
- Supported two Massey University PhD studies investigating the fate and transport of farm nutrients, and a number of MSc studies. A graduate of the programme is now one of our scientists;
- Completed hydrogeological studies throughout the region, including Whanganui, Turakina-Rangitīkei, Manawatū (Tararua and Whakarongo) and Horowhenua (Lake Horowhenua and Ōhau-Waikawa); and
- Initiated a regional drinking water programme to improve management of public water supplies and provide advice and guidance to the public around private supplies.

WATER AGE CASE STUDY

Water has a fingerprint or signature that can tell us how old the water is, where it has come from and how it has moved and changed along the way. In much of the region, groundwater is very old – hundreds or even thousands of years throughout much of the Manawatū-Whanganui area. However, until recently we knew little about how groundwater feeds our rivers.

During 2013 the region experienced widespread drought conditions, with some of the lowest river flows on record. This certainly created challenges for water users throughout the region, but it also provided a unique opportunity to establish the average age of groundwater entering our rivers and streams during low flows. This was the first time a region-wide study employing the age dating techniques used had been undertaken anywhere in the world, and we had to respond quickly before conditions changed.

Teams were mobilised to collect samples from 161 sites across the region. With the assistance of the expert team at GNS Science's age dating laboratory, many of these samples have since been analysed for the age tracer tritium (a form of hydrogen) and isotopes. This has helped us to establish how long water takes to travel from the first drop of rainfall, via land to our rivers, providing us with important information around how and when land use activities might impact our waterways.

Water age is described as a 'mean residence time' because it is the average age of many droplets of water that have travelled a range of distances, over different time periods. From our investigations, we know that the average age of surface water during low flows ranges from less than 12 months through to 17 years.

Whanganui River water is (on average) 6-7 years old during low flows while water in the Rangitīkei is just 3 years (Figure 15). The Manawatū River shows a range of average travel times, depending on the local geology. Water moving quickly through shallow gravel strata into the Mangatainoka River can be less than a year old, but more than 11 years old to the east, where mudstone and siltstone slow the passage of water.

This new knowledge has important implications for how we manage land and water, and provides information about how long it might take to see measureable changes in our waterways as a result of our actions on land.

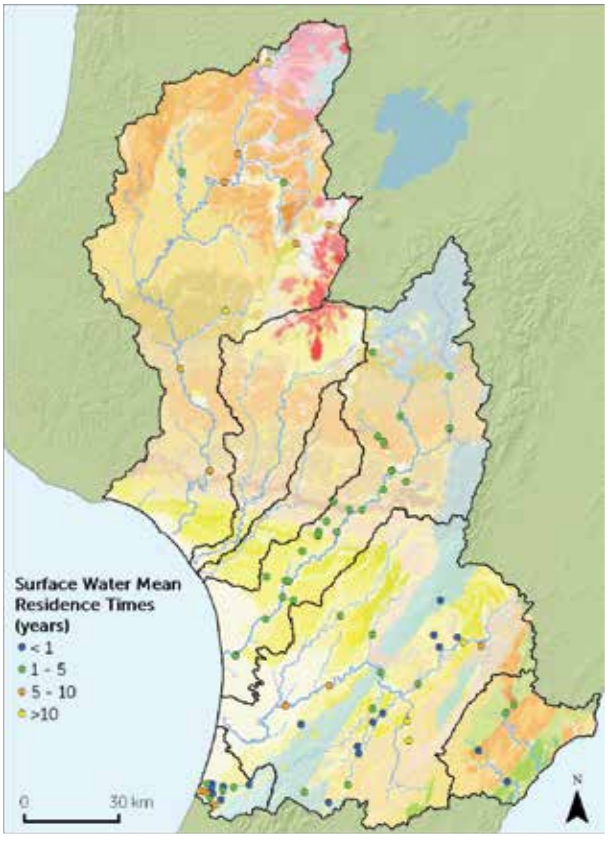


Figure 15: Mean residence time (MRT) for groundwater discharge in rivers and streams throughout the Horizons Region

WHERE WE'RE GOING AND WHAT YOU CAN DO

DECISION-MAKING AROUND DRINKING WATER

People often assume that if water comes out of the ground it is going to be safe to drink. Unfortunately, this isn't always the case.

In August 2016, around 5,500 people in the town of Havelock North became ill from Campylobacter in the local public water supply, resulting in a widespread outbreak of gastroenteritis in the community. Investigation into the source of the contamination identified that the shallow groundwater supply was contaminated by sheep faeces.

The subsequent enquiry into the contamination of the Havelock North public water supply has highlighted a number of areas for improvement in the management of public water supplies throughout New Zealand. This included improving knowledge and understanding of sources of contamination, ensuring good communication between different agencies, and reviewing treatment systems in light of identified risks.

A number of agencies, including regional councils, district healthboards and city/district councils are involved in the management of drinking water both regionally, and nationally. Horizons has recently initiated a collaborative approach with local public health officers and city/district councils to improve knowledge around our public water supplies and improve communication between agencies.

In the Horizons Region, an initial stocktake and risk assessment highlighted a number of areas for improvement in the management of both existing and future public water supplies, which are now being addressed. This programme is currently focussing on identifying potential sources of contamination that might impact water supplies, and developing 'source protection areas' for city and district water supplies. Through this collaborative project, we are also carrying out checks to ensure groundwater bore infrastructure is secure, and that any necessary steps are taken to address issues with water supply security.

Woodville drinking water processing plant

GUIDANCE FOR PRIVATE BORE OWNERS

In most cases groundwater is suitable for stock water and irrigation but, throughout much of the region, water drawn from a bore will require some form of treatment before human consumption. If you have a private groundwater well or bore, there are some important steps you can take to look after it and minimise the risk of you or your family getting sick:

1. Ensure your bore is located as far as practical from potential sources of contamination such as septic tanks, offal holes, and effluent disposal areas. If you are thinking of installing a bore, Horizons can provide advice on the appropriate set-back distances from potential sources of contamination;
2. To prevent stormwater and contaminants entering the water supply, the top of the bore should be securely sealed; the bore casing should extend above the ground and ideally be surrounded by a sloping concrete pad. Where necessary, fence the bore to prevent stock access;
3. Be sure to include a backflow prevention device to stop contaminated water flowing back into your water supply;
4. Water quality can be checked by collecting a sample and sending it to an independent and accredited laboratory for testing. Most labs can send out simple test kits and instructions; and
5. Unused or abandoned bores should be backfilled and securely sealed to prevent contaminants entering the aquifer.

Further information is available in our guidance information for bore owners on Horizons' website.

A secure groundwater supply requires a sealed wellhead, concrete pad and backflow prevention device, to reduce the risk of contaminants entering the bore

KOUNGA O NGĀ AWA

RIVER WATER QUALITY

INTRODUCTION

The nature of river systems is that at the top of a catchment, where there is little impact from people and animals, the quality of water is at its best. However, as water makes its way downstream, moving out of our native forests through urban and rural areas to the coast, its quality generally declines. This pattern applies to the rivers in our region.

In addition to the measurement of river flow, Horizons also collects information about the quality of water in the region, and the ecosystems our rivers support. We are fortunate to have one of the most extensive river monitoring networks in the country, which is largely representative of different land cover such as native forest or pasture, and land use including agriculture, production forestry and urban environments.

In recent years, the health of our rivers has become a key topic of interest for many people. Whether we live in town or in the country, our actions contribute to the health of our rivers and their suitability for recreation, drinking water, stock water and for a range of industrial uses. This means that we all have a part to play in improving water quality and ensuring our rivers can be enjoyed by generations to come.

When it comes to our rivers, our communities value he taiao matomato (healthy ecosystems) and he oranga tangata (human wellbeing). This section of the report outlines our progress toward these outcomes and water quality monitoring.

RIVER WATER QUALITY

WHERE WE'VE COME FROM

The challenges we face today are different from those of the past. Reports from the 1950's describe conditions in the Manawatū River that included untreated wastewater and freezing works discharges, along with visible sewage scum and animal fat. As awareness about the importance of water quality grew, action was taken to reduce the effects and limit further degradation. By 2012 all of the region's discharges of dairy farm effluent to water ceased, and secondary wastewater treatment processes and land discharge were introduced.

In our rivers, water quality monitoring has been carried out as part of Horizons' State of Environment programme since around 1978. Initial monitoring was largely exploratory, mainly for the purpose of resource assessment, and regular monitoring was not introduced until a decade later. By 1989, 12 sites were monitored across the region as part of regional and national monitoring programmes.

Further sites were added in 1994, following a review of the programme, and by 2006 there were 35 sites

monitored every month, with a further 46 sites included on a rotational roster (sampled monthly for a year, every three years). This water quality information was analysed and reported in the 2005 State of Environment report and to inform the One Plan policy development process.

Following a review of the programme by the science team in 2007-08, Council invested in an upgraded monitoring programme that doubled the size of the network and included sites upstream and downstream of the treated effluent discharged by major point sources. These changes sought to align monitoring with the new water management zone framework, and separate out the relative contributions to water quality outcomes of point source and diffuse discharges, and track changes in these over time. The information is used for policy formation and evaluation, as well as consenting and compliance processes.

To assess the health of our region's rivers, we monitor up to 16 different physical, chemical and biological parameters at 174 sites every month. A list of these parameters is provided in Appendix A of this report. The network includes 90 state of environment monitoring sites, as well as 26 sites upstream, 26 downstream and 32 effluent sites from discharges of treated urban or industrial wastewater across the region. In this report, these sites are reported as 'State of Environment' sites that include; the 26 sites upstream of discharges; 'Impact' sites, which are those located immediately downstream of discharges; and 'discharge' sites, which represent the effluent discharges themselves.

Monitoring of macroinvertebrates commenced in 1999 and in 2008 the programme was aligned with the river water quality and flow monitoring network to allow for the assessment of potential drivers of invertebrate community health. Additional macroinvertebrate sites upstream and downstream of specific point source discharges were added to the programme in 2012 to further understand the impact of these discharges on ecosystem health.

Historically, periphyton monitoring was carried out annually as part of macroinvertebrate monitoring. In 2007 Horizons reviewed the programme with assistance from Massey University and NIWA. An upgraded monitoring programme was introduced in 2009-10. The monthly periphyton monitoring programme now includes 67 sites across the region and is one of the most comprehensive of its type in New Zealand.

Water quality monitoring, Rangitīkei

WHERE WE ARE NOW – CURRENT STATE

The data and information we collect helps us to assess the effectiveness of both regional and national policy. It also helps us to track changes in water quality over time, and assess the effectiveness of initiatives such as the Manawatū River Leaders' Accord and Sustainable Land Use Initiative (SLUI) programme.

Horizons' One Plan is the regulatory document that sets the policy and rules for how the region's natural resources can be used. This includes a range of water quality targets that aim to provide for identified freshwater values. The National Policy Statement for Freshwater Management (NPS-FM), although broadly of similar intent, sets out some different criteria to the One Plan through the National Objectives Framework (NOF). This framework describes compulsory freshwater values for both ecosystem health and human health and now includes specific measures, known as attributes, which regional councils and unitary authorities must report their performance against.

Water quality state is a characteristic value derived from the measurement of a particular parameter (generally the median of monthly measurements over five years). For each of these parameters, a grading for each site has been determined by comparing this characteristic value with its respective One Plan target to provide an assessment of the current state of water quality in the region's rivers. Where applicable, sites have also been assigned to attribute bands set out in the National Objectives Framework (NOF) of the National Policy Statement for Freshwater Management (NPS-FM) to present a national perspective on water quality.

In this section we present the results of an independent analysis of water quality by LWP Ltd. for a range of indicators at 'State of Environment', 'Impact' and 'Discharge' sites, as outlined in the previous section. Impact site and discharge monitoring is directly targeted to areas with known water quality pressures whereas state of environment monitoring generally provides a dataset that is more representative across the region hence we have reported these results separately. It is important to note that this report does not provide an assessment of consent compliance for point source discharges; however, we have provided an indication of changes in river water quality over time, referred to as trends. These are presented as the proportion of sites that show improvement for a range of parameters, as outlined in Appendix A. This section also provides an overview of monitoring of dissolved oxygen and fish, both of which are important indicators of ecosystem health.

COMPARISON TO ONE PLAN TARGETS

Many parameters at state of environment (SoE) sites almost uniformly achieved or failed to achieve their respective One Plan targets (Figures 16 and 20). Site grades based on Horizons' One Plan criteria for SoE sites generally failed to achieve the targets for dissolved reactive phosphorus (DRP), *Escherichia coli* (*E. coli*) and clarity. Conversely, almost all sites achieved the One Plan targets for ammoniacal-nitrogen (NH_4-N), cyanobacteria, periphyton (mats) and volatile matter (POM). Grades varied across the region for spot measurements of dissolved oxygen saturation (DO), the periphyton biomass measure chlorophyll *a*, macroinvertebrate community index (MCI), periphyton (filaments) and soluble inorganic nitrogen (SIN).

Most Impact sites (sites immediately downstream of point source discharges) failed to achieve One Plan targets for phosphorus (as dissolved reactive phosphorus), periphyton (as chlorophyll *a* and filaments), macroinvertebrates (MCI) and nitrogen (as soluble inorganic nitrogen). Results are show in Figures 18 and 22.

Horizons' One Plan also sets targets for changes in water quality indicators that can occur as a result of point source discharges. This is determined by comparing the change in specified indicators between upstream and downstream monitoring sites. A comparison of pH, water temperature, clarity and macroinvertebrates (as indicated by the quantitative macroinvertebrate community index or QMCI) shows that the majority of sites are failing to achieve One Plan targets for changes in these measures. While the data is presented here, a copy of the technical report is available on our website.

COMPARISON TO NATIONAL CRITERIA

To determine performance against the National Objectives Framework, a grade from band 'A' (best) to 'D' or 'E' (worst) is assigned to each attribute. The lower boundary of band 'C' is defined as the national bottom line, and if values fall below this bottom line, steps must be taken to improve water quality. For sites above the national bottom line (A-C), water quality must be maintained; however, communities may also wish to work toward improvement.

The NOF criteria includes nitrate nitrogen (median and 95th percentile), ammoniacal nitrogen (maximum and median), periphyton (chlorophyll *a*), and bacteria (*E. coli*). Comparison of water quality state at SoE sites against the NOF criteria (Figures 17 and 21) shows most sites were in the A band for both nitrate toxicity (NO_3-N) and ammoniacal-N (median) criteria. Most sites were generally in the A band for the periphyton criteria; however, five sites were below the bottom line (D band) including two impact sites downstream of Palmerston North City and Raetihi treated wastewater discharges, and three SoE sites: Makuri River at Tuscan Hills, Tiraumea River upstream of the Manawatū confluence, and the Moawhango River at Waiouru.

The results of grading the impact sites according to the NOF criteria are shown in Figures 19 and 23. Most sites were in the A band for both nitrate nitrogen toxicity criteria. Similarly, most sites were in the A band for the ammoniacal nitrogen (median) criteria, however there were small number of sites that were below the bottom line (D band). Grades were much more variable across the region for the periphyton, ammoniacal nitrogen (maximum) and *E. coli* criteria.

WATER QUALITY TRENDS

Many of the major upgrades to the various aspects of water quality monitoring have reached a 10-year maturity and we can now undertake a 10-year trend analysis (2007-17) for more sites than we could previously. We can also determine 20-year trends (1997–2017) for some parameters at 18 sites in our region.

The trend analysis employed here is an updated approach that builds on the methodology of Larned et al. (2015) and has recently been utilised by the Ministry for the Environment (MfE) and Land, Air, Water Aotearoa (LAWA) for environmental reporting. Different confidence categories of trend ranging from 'virtually certain to be improving' through to 'extremely unlikely to be improving' are assigned to each site/parameter. For the state of the environment network (including sites upstream of major point sources), individual site trend assessments were aggregated to provide an overall picture of trends for the region for the 10-year (Figures 24 and 28) and 20-year (Figures 25 and 29) periods.

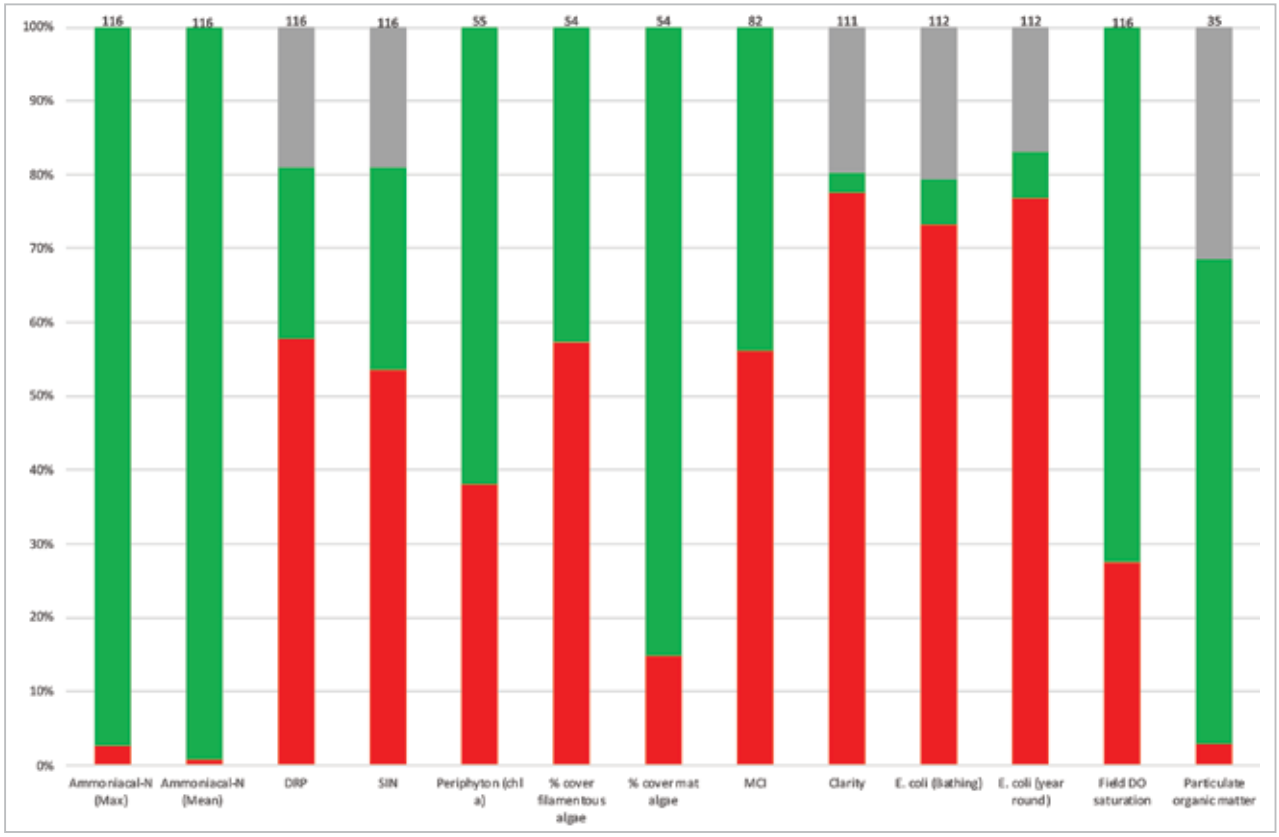
Over the 10-year period, parameters showing a higher proportion of degrading trends include periphyton (chlorophyll *a*), macroinvertebrate community index (MCI), dissolved reactive phosphorus (DRP), clarity, and spot measures of dissolved oxygen saturation (DO Sat). Parameters with a higher proportion of sites that showed improvement included: *E. coli* (as G540 which is the measure of exceedance of 540MPN/100ml); ammoniacal nitrogen (NH_4-N); soluble inorganic nitrogen (SIN); and particulate organic matter (POM). It is noted that the dissolved oxygen measure analysed in this report is based on monthly measurements of dissolved oxygen, and trends identified in this measure may be the result of changes in the time of day the parameter was measured.

Over the 20-year period, both dissolved reactive phosphorus and ammoniacal nitrogen showed improving trends at the majority of sites, whereas monthly measurements of dissolved oxygen showed mostly degrading trends.

While trend magnitude varied widely between sites, the largest degrading trends were generally associated with sites that have poorest water quality (in the worst state). It is these sites that are likely to warrant the greatest effort to reverse degrading water quality.

Contrary to the pattern for most parameters, the largest magnitudes of improvement in *E. coli* were at sites that were in the worst state (NOF E band). Over the 10-year period, significant relationships were evident between decreasing *E. coli* trends at discharge sites, and decreasing *E. coli* trends at associated downstream impact sites. There is strong evidence of regional improvement in *E. coli* associated with improvements to point source discharge quality over the past decade. However, the relationships between sites upstream and downstream of major discharges were much weaker (or non-existent) for other variables.

The next step, which is now underway, is to investigate the relationship of land use, point source discharges and management actions with water quality outcomes. These potential drivers of change are now being analysed to help us understand impacts at a more localised scale and prioritise actions to improve water quality.



ONE PLAN ASSESSMENT LEGEND

NOT ASSESSED

PASS FAIL

Figure 16: One Plan status for SoE sites. Red indicates sites not achieving the specified One Plan target, green indicates sites that have achieved the target, and grey indicates sites that were not analysed as there was no flow data available. The number at the top of each bar indicates the total number of sites in the analysis

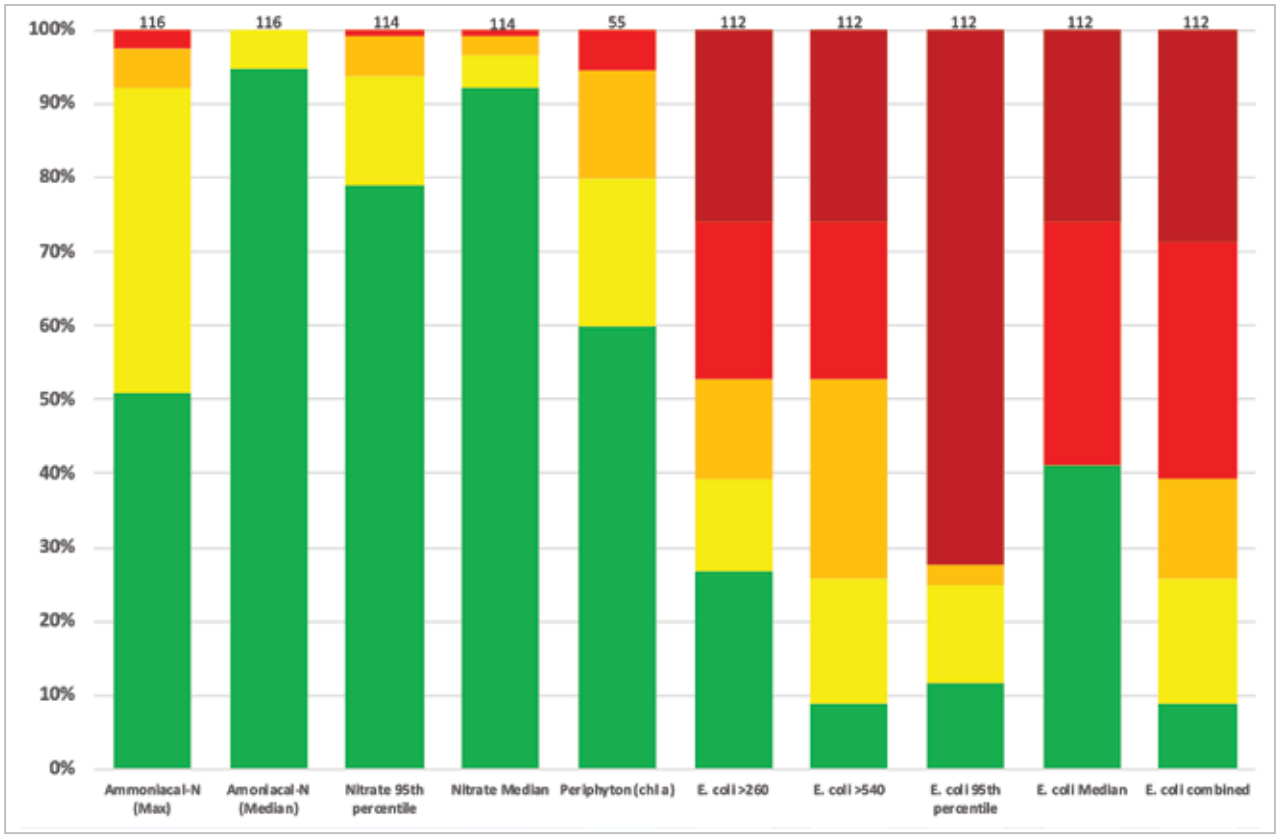
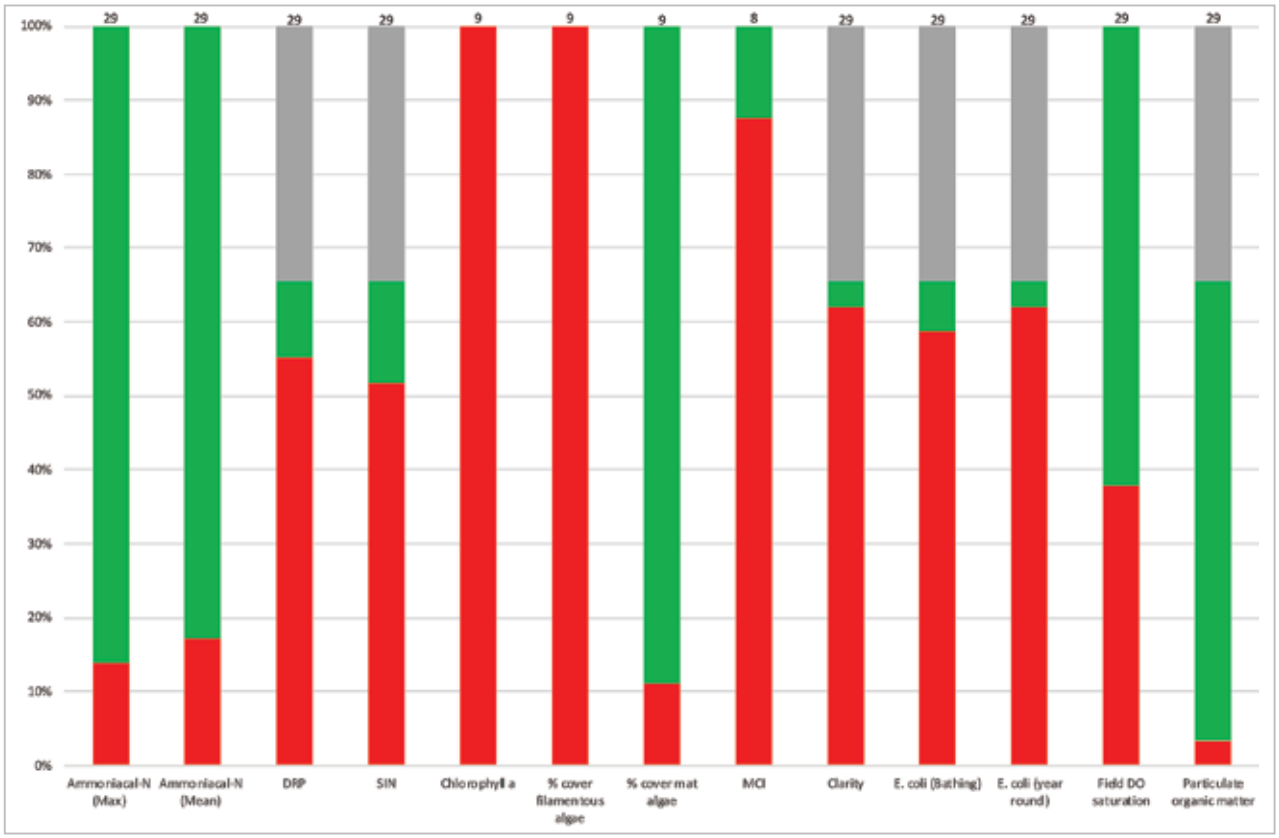


Figure 17: National Objectives Framework (NOF) status for SoE sites. Green indicates band A, yellow indicates band B, orange indicates band C, red indicates band D (below the bottom line) and dark red indicates band E (*E. coli* measures only). The number at the top of each bar indicates the total number of sites in the analysis

NATIONAL OBJECTIVES FRAMEWORK LEGEND BAND A BAND B BAND C BAND D (below national bottom line) BAND E



ONE PLAN ASSESSMENT LEGEND

NOT ASSESSED

PASS FAIL

Figure 18: One Plan status for Impact sites. Red indicates sites not achieving the specified One Plan target, green indicates sites that have achieved the target, and grey indicates sites that were not analysed as there was no flow data available. The number at the top of each bar indicates the total number of sites in the analysis

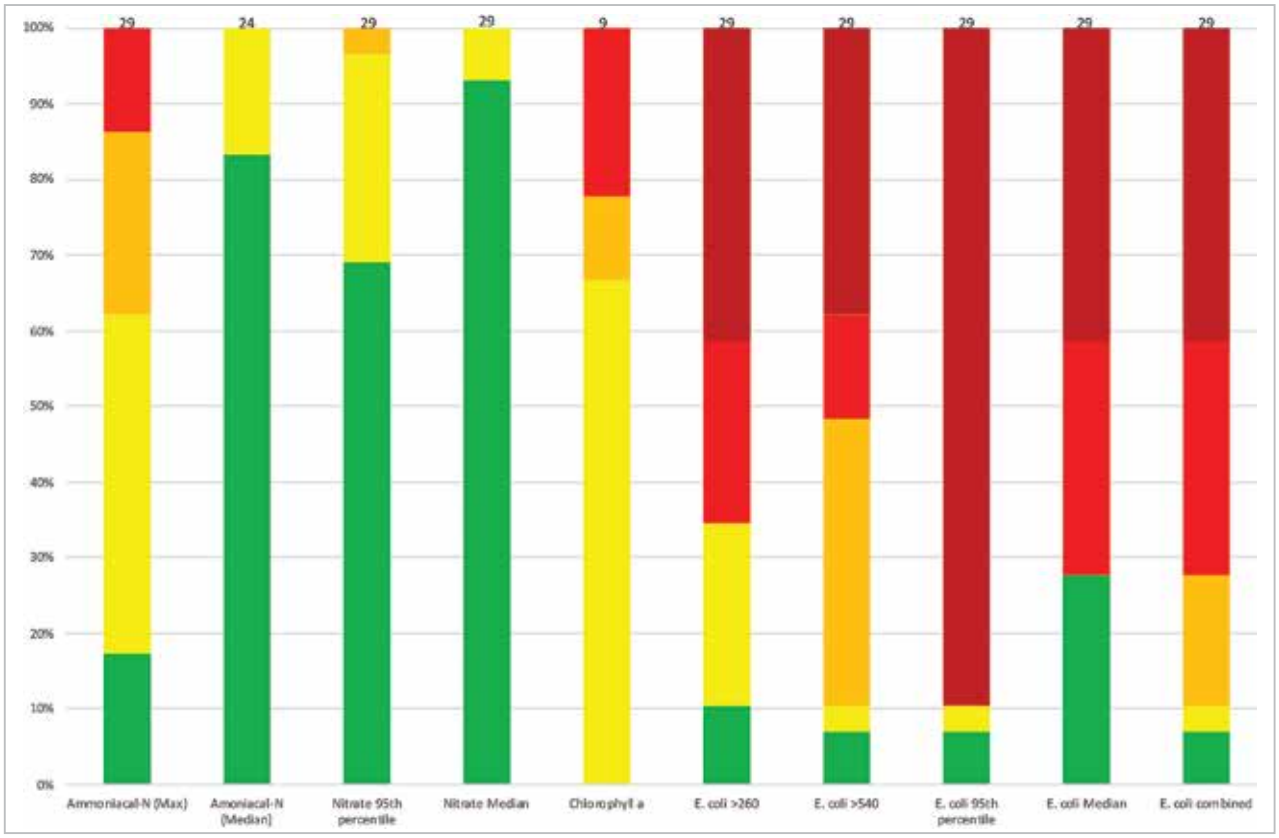


Figure 19: National Objectives Framework (NOF) status for Impact sites. Green indicates band A, yellow indicates band B, orange indicates band C, red indicates band D (below the bottom line), and dark red indicates band E (*E. coli* measures only). The number at the top of each bar indicates the total number of sites in the analysis

NATIONAL OBJECTIVES FRAMEWORK LEGEND BAND A BAND B BAND C BAND D (below national bottom line) BAND E

Figure 20: Maps showing SoE site state grades based on Horizons' One Plan criteria. Sites that required flow data for the state statistic but for which flow percentiles were estimated only from gaugings are shown as triangles. Grades for sites that did not meet the specified sample number requirements are shown with open shapes

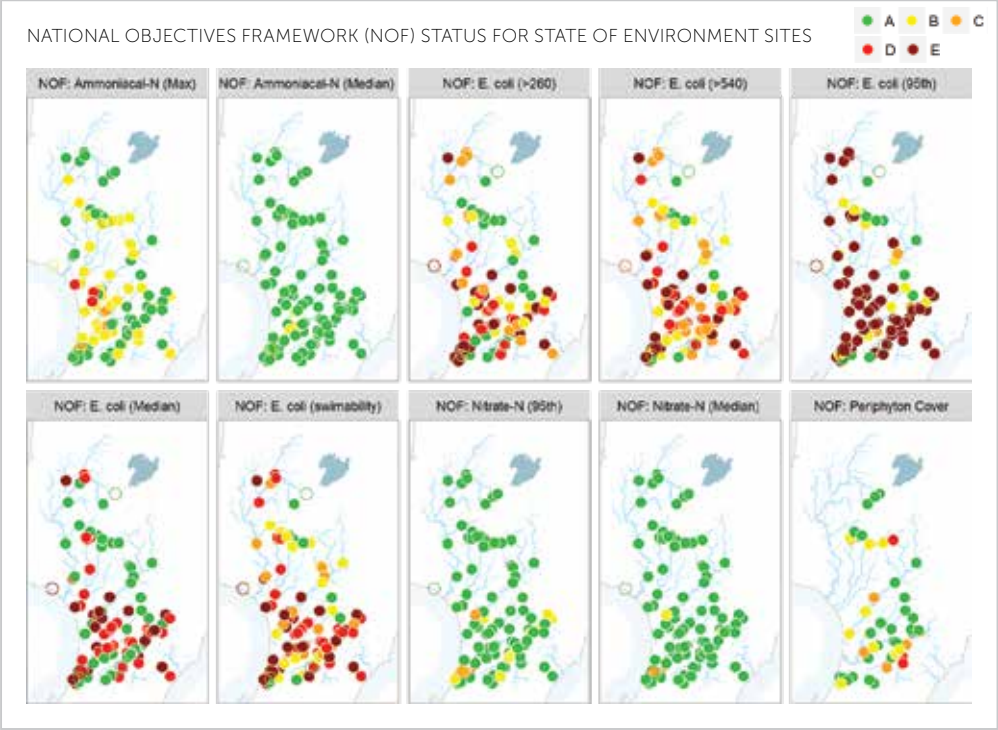


Figure 21: Maps showing SoE sites categorised by the NOF attribute bands. Bands for sites that did not meet the sample number requirements are shown with open circles. Note the measure referred to as NOF:Periphyton Cover is a comparison of the NOF attribute for periphyton that is a measure of Chlorophyll *a*

Figure 22: Maps showing impact site state grades based on Horizons' One Plan criteria. Sites that required flow data for the state statistic but for which flow percentiles were estimated only from gauging data are shown as triangles. Grades for sites that did not meet the specified sample number requirements are shown with open shapes

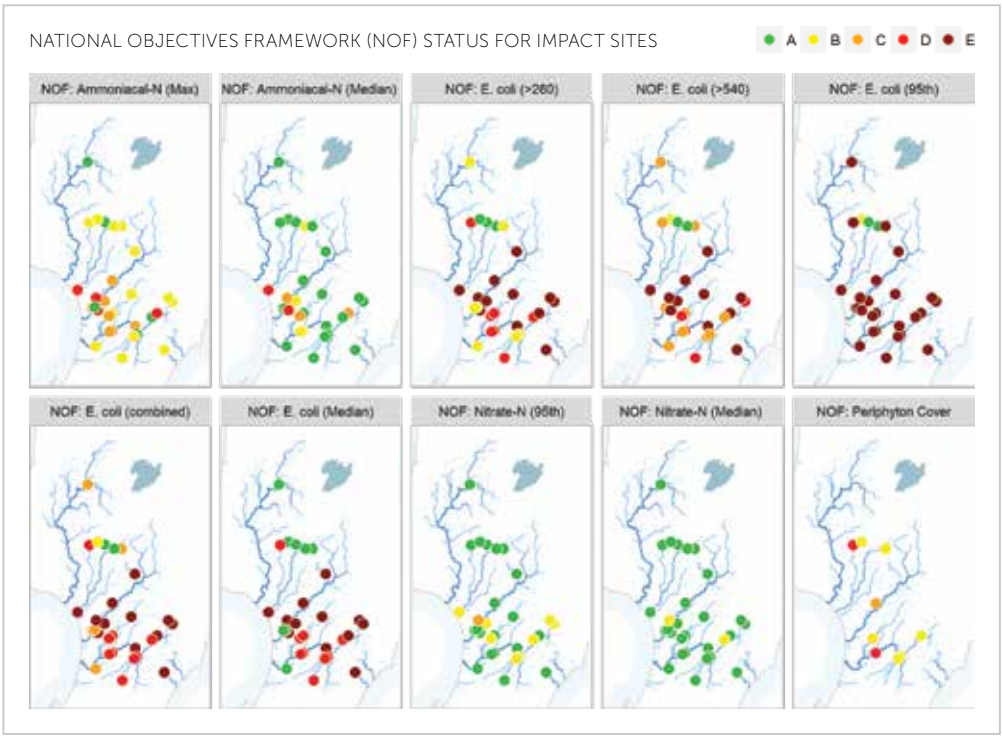


Figure 23: Maps showing impact sites categorised by the NOF attribute bands. Bands for sites that did not meet the sample number requirements are shown with open circles. Periphyton Cover in this context is assessed using chlorophyll a measurements

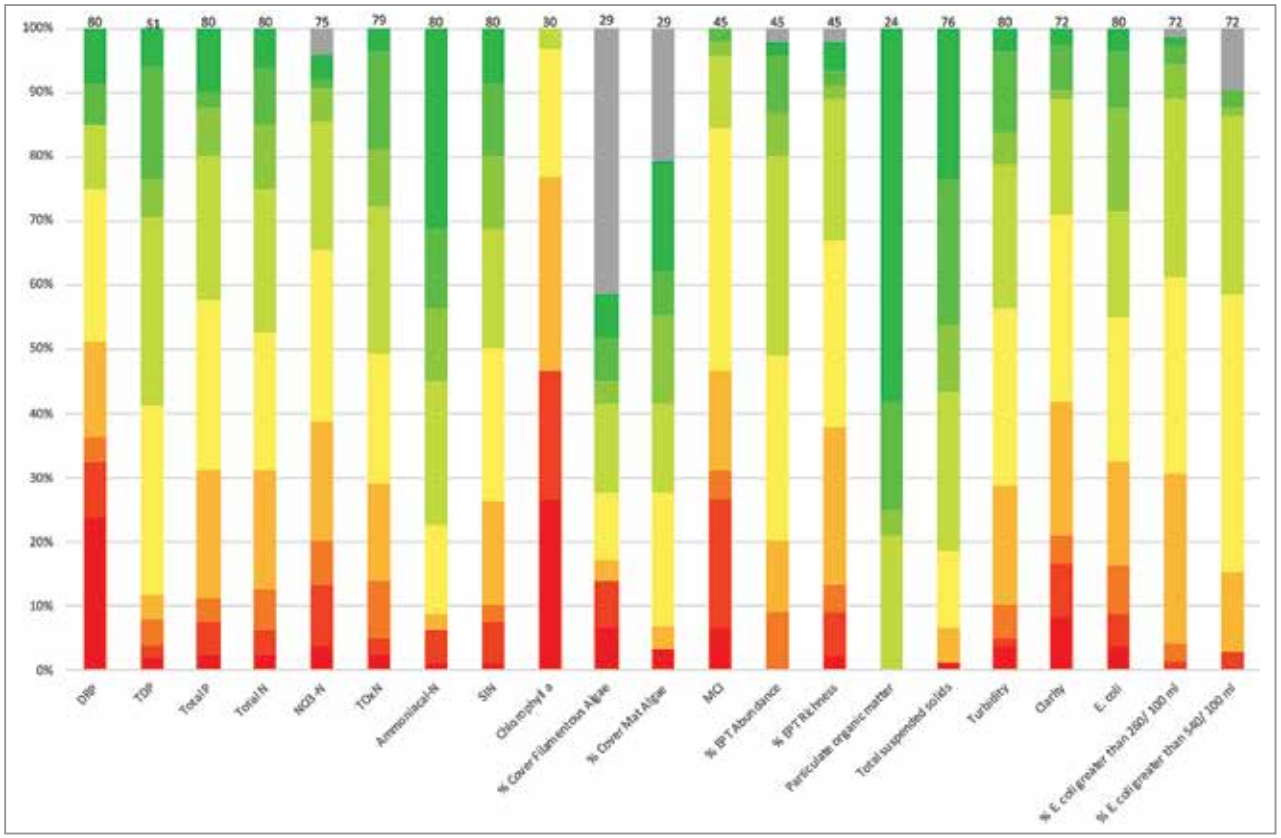


Figure 24: Proportion of SoE sites showing improving trends for the 10-year period ending July 2017. The number at the top of each bar indicates the total number of sites in the analysis

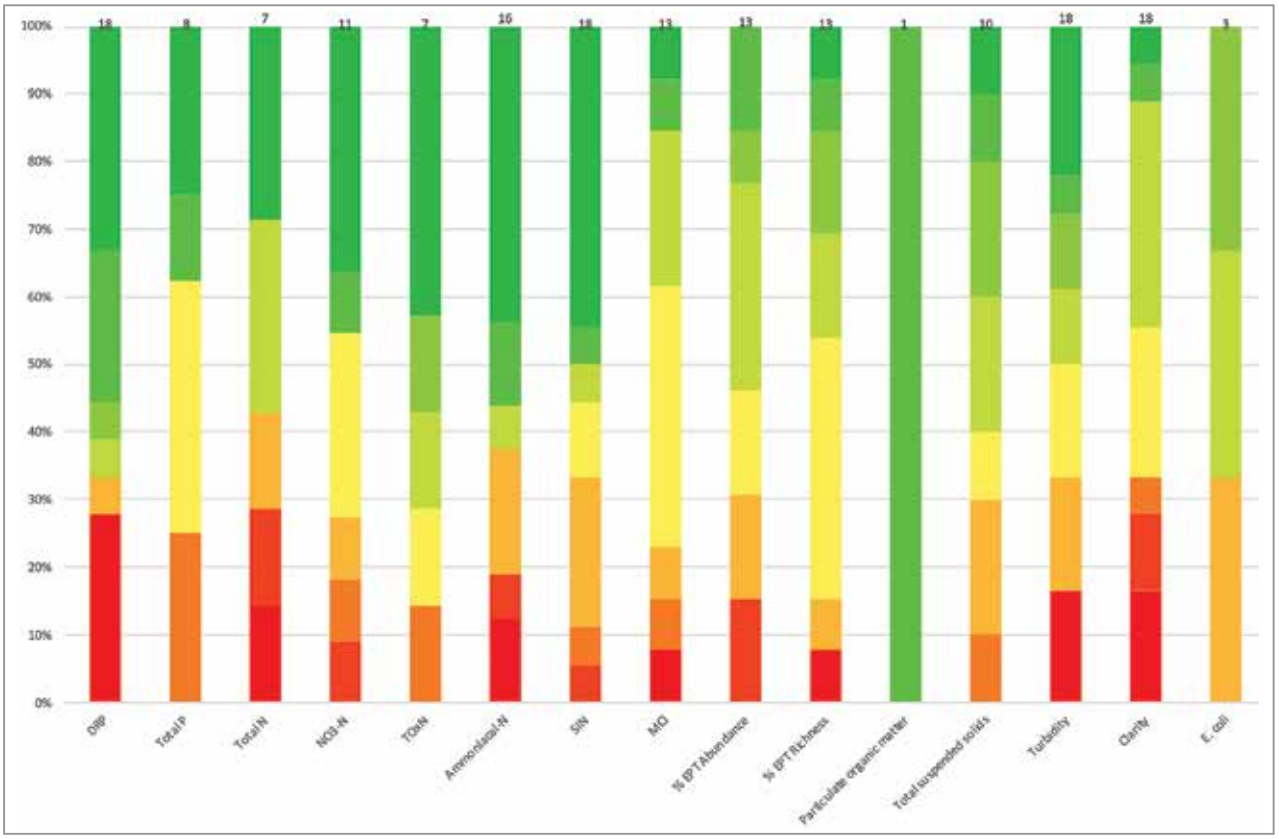


Figure 25: Proportion of SoE sites showing improving trends for the 20-year period ending July 2017. The number at the top of each bar indicates the total number of sites in the analysis

TREND CATEGORIES (LIKELIHOOD OF IMPROVEMENT)
VIRTUALLY CERTAIN
EXTREMELY LIKELY
VERY LIKELY
LIKELY
AS LIKELY AS NOT
UNLIKELY
VERY UNLIKELY
EXTREMELY UNLIKELY
EXCEPTIONALLY UNLIKELY (i.e. virtually certain to be degrading)

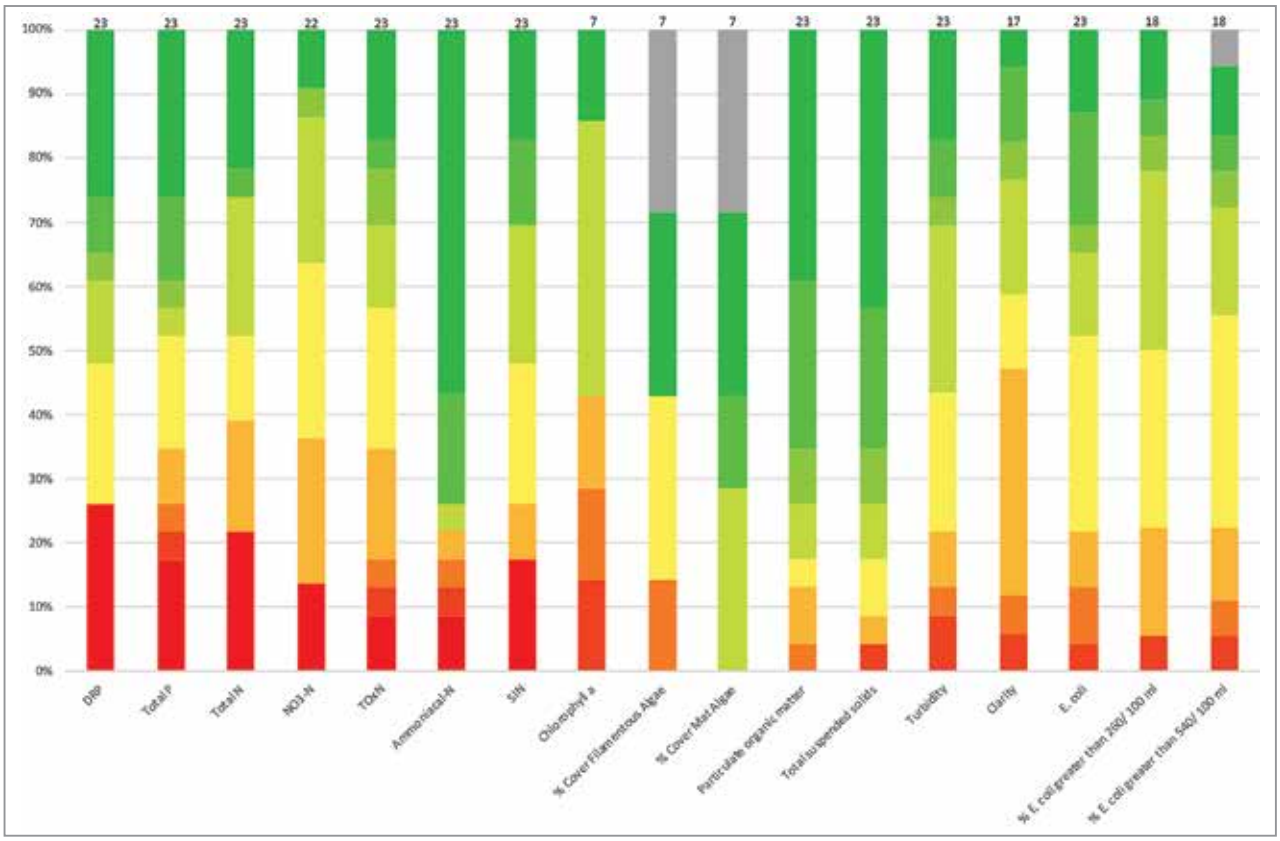


Figure 26: Proportion of Impact sites showing improving trends for the 10-year period ending July 2017. The number at the top of each bar indicates the total number of sites in the analysis

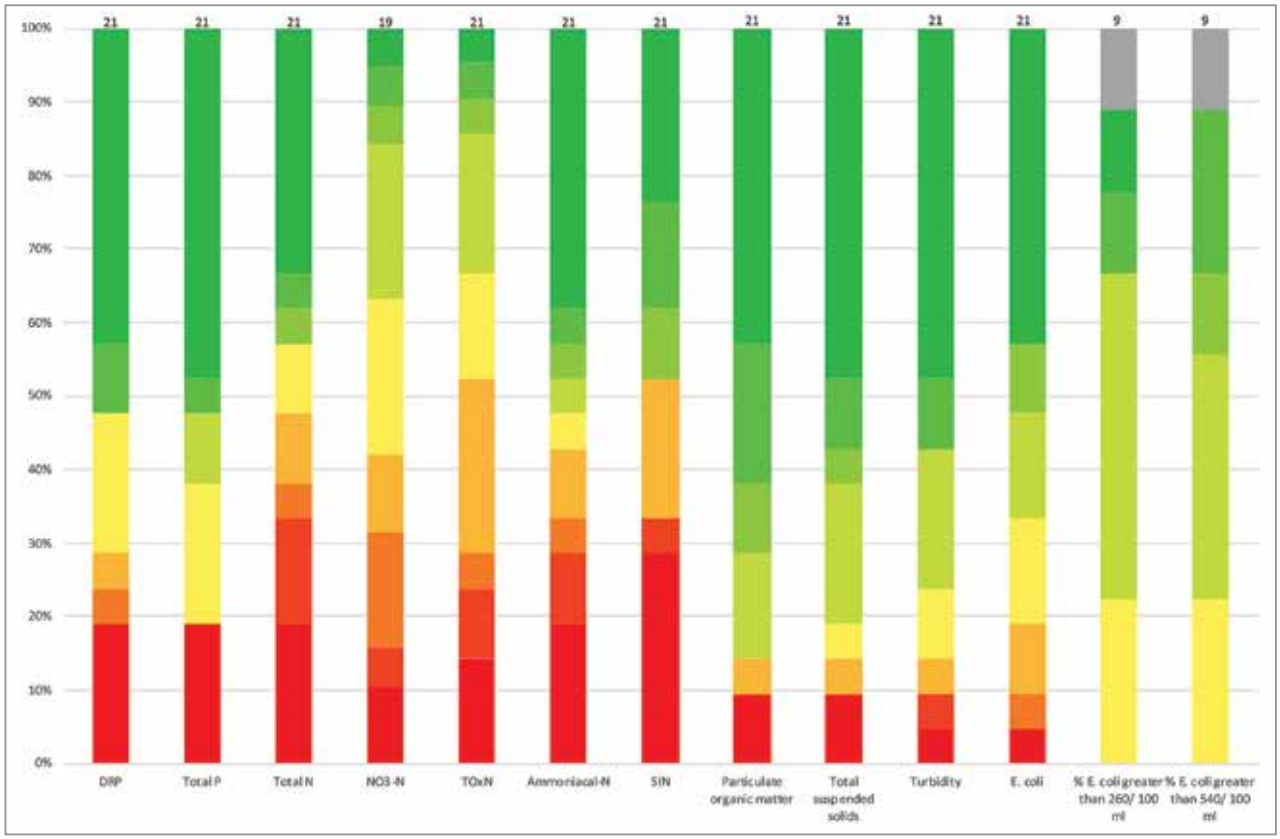


Figure 27: Proportion of State of Discharge sites showing improving trends for the 10-year period ending July 2017. The number at the top of each bar indicates the total number of sites in the analysis

TREND CATEGORIES (LIKELIHOOD OF IMPROVEMENT)
VIRTUALLY CERTAIN
EXTREMELY LIKELY
VERY LIKELY
LIKELY
AS LIKELY AS NOT
UNLIKELY
VERY UNLIKELY
EXTREMELY UNLIKELY
EXCEPTIONALLY UNLIKELY (i.e. virtually certain to be degrading)

PROBABILITY OF IMPROVEMENT - 10-YEAR TRENDS: REPSITE

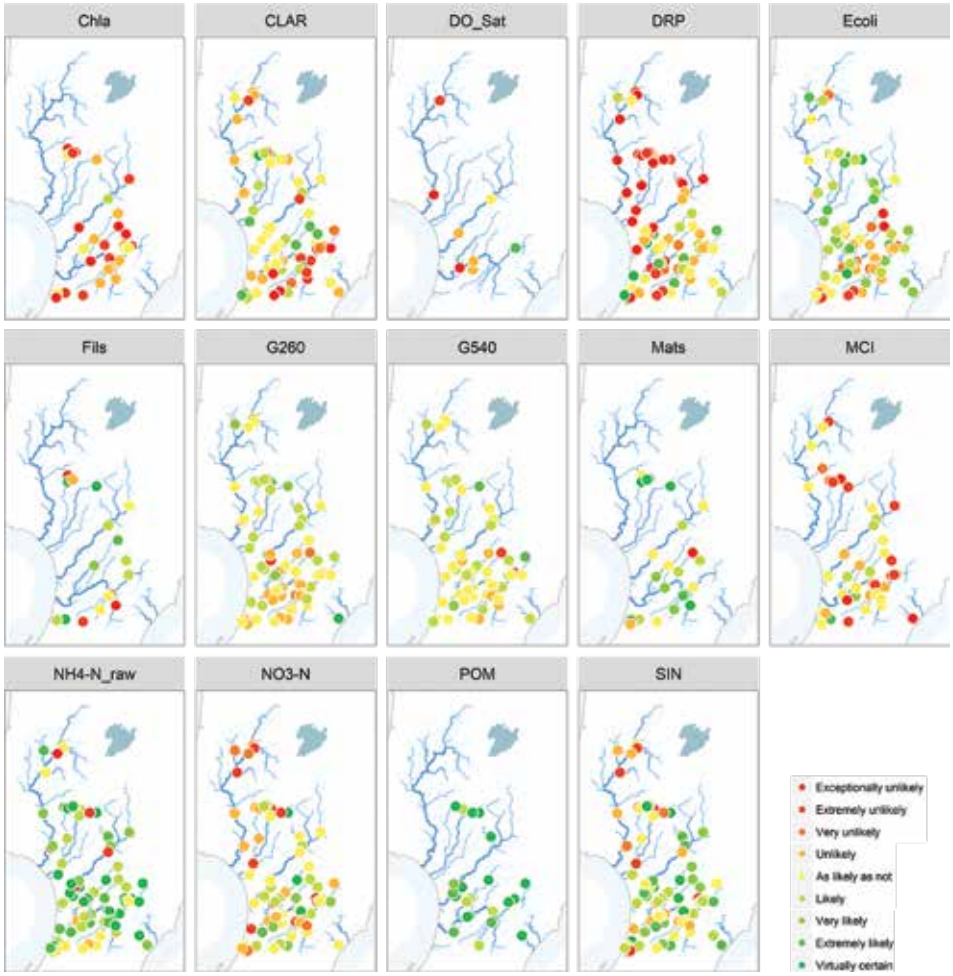


Figure 28: Map of SoE sites categorised by their 10-year raw water quality trend probability of improvement

PROBABILITY OF IMPROVEMENT - 20-YEAR TRENDS: REPSITE

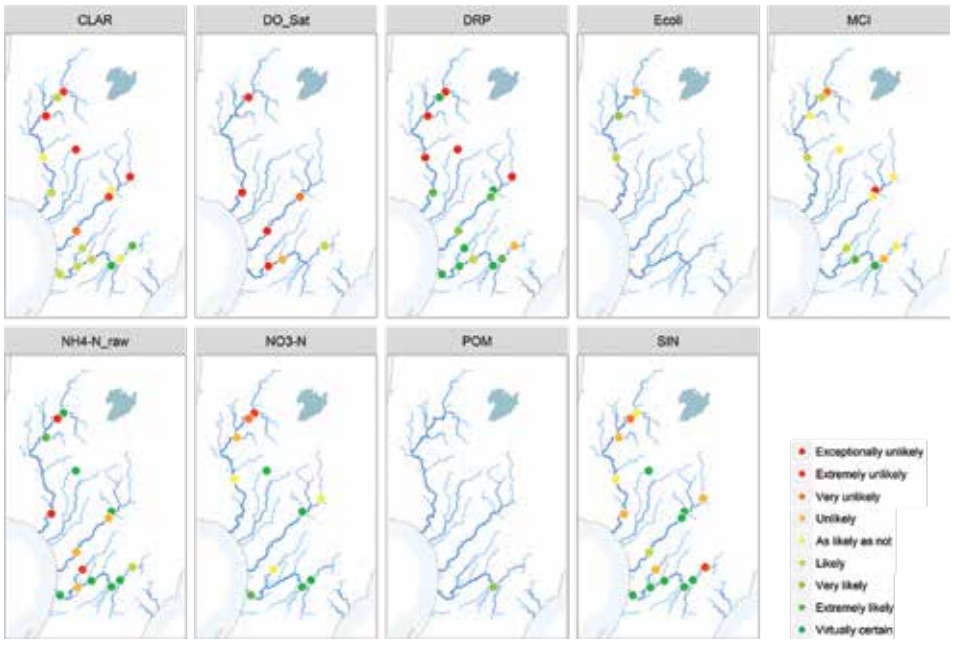


Figure 29: Map of SoE sites categorised by their 20-year raw water quality trend probability of improvement

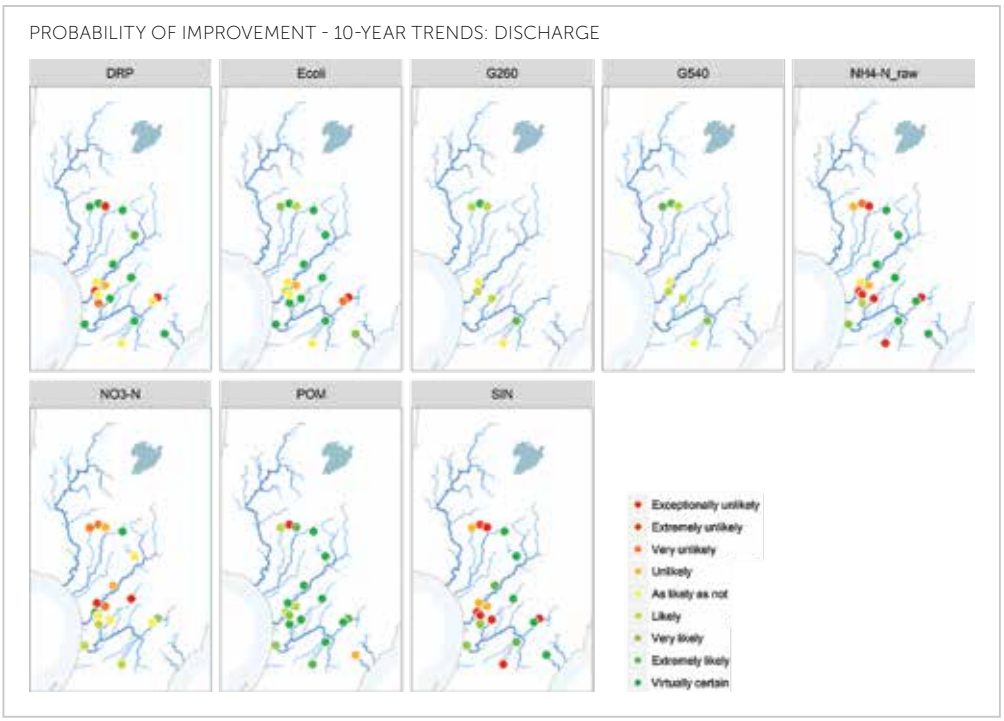


Figure 30: Map of discharge sites categorised by their 10-year raw water quality trend probability of improvement

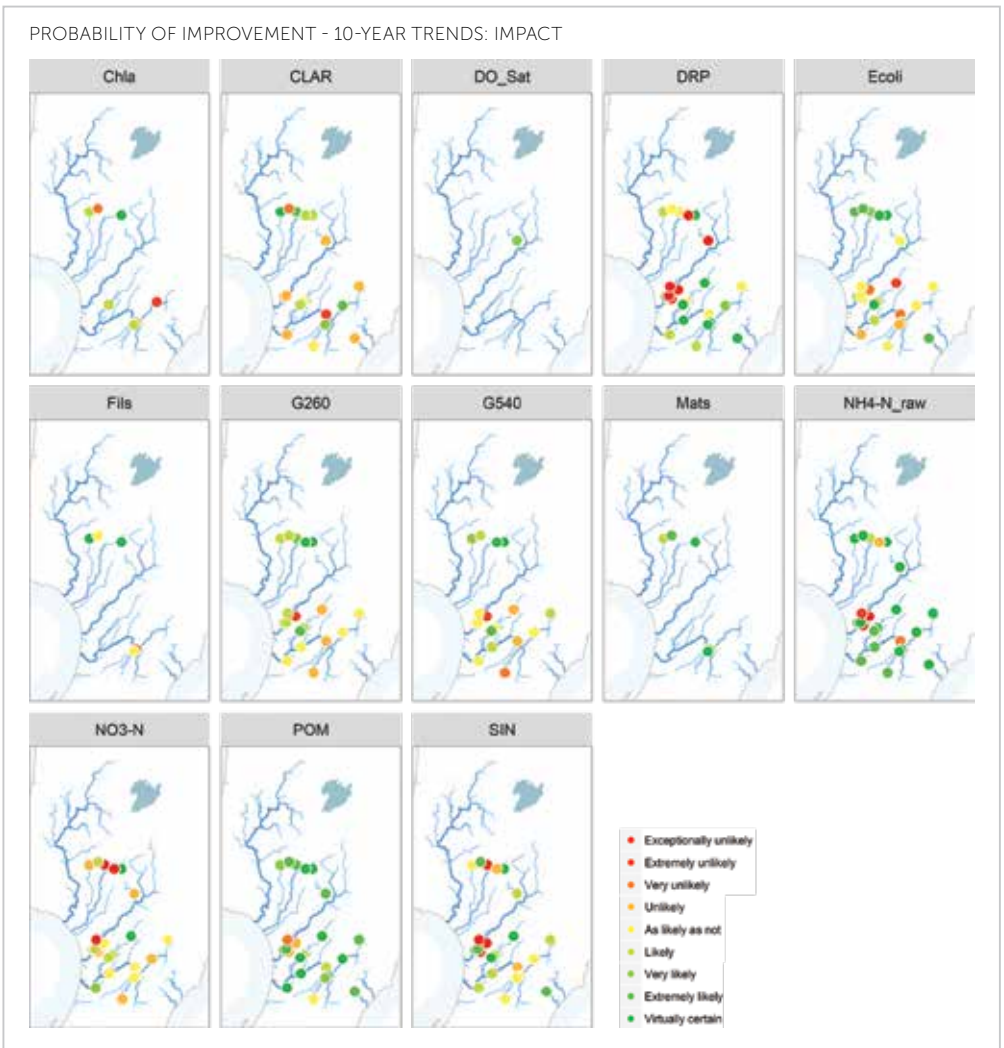


Figure 31: Map of impact sites categorised by their 10-year raw water quality trend probability of improvement

DISSOLVED OXYGEN

Like us, fish and macroinvertebrates need oxygen to survive. Decomposition of organic matter and excessive growth of algae (periphyton) or aquatic plants can cause significant fluctuations in dissolved oxygen (DO). Periphyton and aquatic plants impact on DO as photosynthesis occurs during the day, adding oxygen to the water; when respiration occurs at night, oxygen is removed from the water. High concentrations of decaying organic matter can also significantly deplete dissolved oxygen levels instream as bacteria use oxygen as they break this material down.

Horizons' One Plan requires DO to remain above specified target concentrations in sub-catchments at all times, while the National Policy Statement for Freshwater Management (NPS-FM) only applies to rivers below point source discharges and requires DO to be assessed in a different way.

We currently measure DO monthly at 142 sites as part of our water quality monitoring programme. Ten-year trend analysis of monthly DO measurements (as seen in Figure 32) shows predominately degrading trends for DO in the Whanganui River and lower reaches of the Manawatū River, but a likely improving trend in the Upper Manawatū Catchment.

To better understand the fluctuations in DO during the day and night, we have also maintained a network of six continuous dissolved oxygen sites in the Manawatū and Rangitīkei catchments since 2011. At these sites we measure dissolved oxygen and other key parameters (such as temperature) at 15-minute intervals. In 2017 we commissioned NIWA to analyse the six years of continuous data available and found that daily minimum dissolved oxygen saturation was above the One Plan target 90 per cent of the time at all six monitoring sites, but only above the national bottom line around 75 per cent of the time. Under the current National Objectives Framework set out in the NPS-FM, four sites were in the C band and two (Manawatū at Hopelands and Mangatainoka at Pahiatua Town Bridge) were below the national bottom line (D band).

Dissolved oxygen saturation failed to achieve both One Plan targets and the NOF bottom line most frequently in autumn and summer, when water temperatures are warmest and aquatic plant and periphyton growth is highest. Options for managing DO include reducing the amount of organic matter in the streams, lowering periphyton and aquatic plant growth, lowering stream temperature, and enabling further mixing of oxygen into the water.

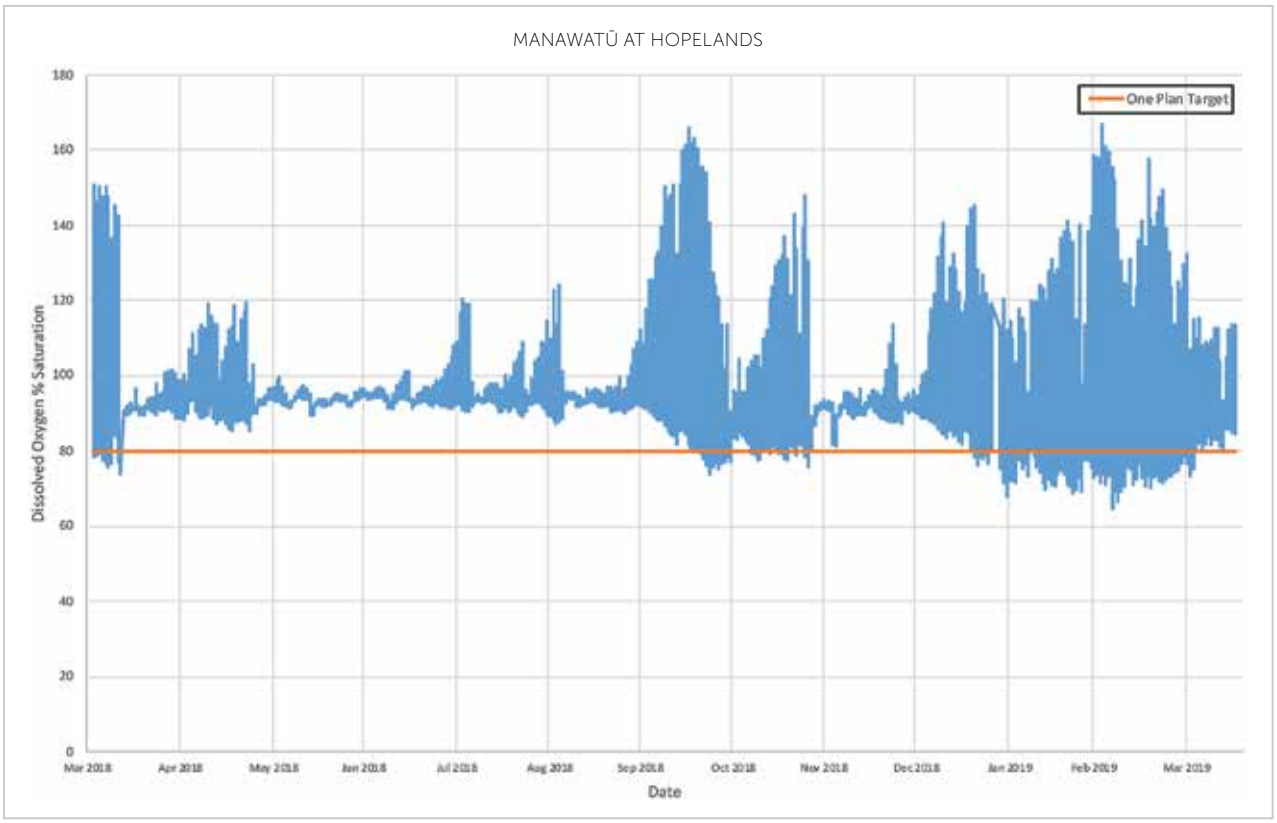


Figure 32: Dissolved oxygen is monitored on a continuous basis at six sites across the region, including the Manawatū River at Hopelands, north of Woodville. The largest fluctuations are evident in the warmer months when water temperatures and low flows support an increase in algal growth and decomposition of organic matter

FISH

Both native and non-native fish such as trout, are valued by people throughout our region. Historically, many of our native fish declined in numbers due to loss of wetland and forest habitat, which once provided food, shade and shelter from predators. Increased nutrient levels have, in some areas, led to more algae and less oxygen for fish. Recreational and commercial fishing has inevitably impacted native fish, along with predation from introduced species, including trout. Pest fish, such as catfish and koi carp have also invaded some waterways in the region, damaging ecosystems and competing with native species.

Many of our native fish species such as our longfin and shortfin eels, and the less commonly known Lamprey, are diadromous. This means they spend part of their life cycle in freshwater as well as in estuaries or at sea. In fact, whitebait are the juveniles of up to five native species including Inanga, Shortjaw Kokopu, Giant Kokopu, Banded Kokopu and Koaro. Because so many of our native fish are migratory, the presence of barriers to fish passage, such as dams, weirs, or overhanging culverts, can have a significant impact on fish communities. Modification of waterways and removal of instream woody debris, can also impact fish habitat.

Fish data for the Horizons Region is collected by different agencies such as Horizons, Fish and Game and the Department of Conservation. Some of this information is collated in a national database; however, much of our nation's data and information about fish – native and introduced – still resides within individual agencies and a greater effort is required to facilitate sharing of this information. Monitoring by Horizons includes annual fish surveys and we also carry out work to identify and remediate fish barriers. Following the completion of works, we also carry out monitoring to test the effectiveness of the fish passes we have installed.

Available data on native fish has been used to develop an index for biotic integrity (IBI). The IBI provides a comparison between native fish (and trout) species observed in our rivers and what we would expect to see based on key measures such as distance to the sea and elevation. Sites graded 'excellent' or 'good' indicate the presence of many of the native species of fish that are expected to be found. A site graded 'poor' or 'very poor' has very few (or none) of the expected native species. The index of biotic integrity for all sites that have fish data across the Horizons Region as at August 2017 is shown in (Figure 33).

The Horizons Region is home to many freshwater fish species. From the endemic longfin eel (*Anguilla dieffenbachia*) to the five species that make up the whitebait catch (*Galaxias sp.*), the cryptic brown mudfish (*Neochanna apoda*) and the multiple species of bully (*Gobiomorphus sp.*), there are at least 17 native freshwater fish species found within our region. Introduced sport species such as rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) are commonly found within our waterways, and brook char (*Salvelinus fontinalis*) in a few harder to find locations. Coarse fisheries species such as perch (*Perca fluviatilis*), and to a much lesser extent tench (*Tinca tinca*), can also be found. Finally there are several marine wanderer species such as grey mullet (*Mugil cephalus*) and black flounder (*Rhombosolea retiaria*) that travel upstream from the sea and are occasionally seen or caught in our estuaries, rivers and lakes.

Unfortunately, invasive pest species are increasingly common in our waterways. Goldfish (*Carassius auratus*), gambusia (*Gambusia affinis*), koi carp (*Cyprinus carpio*), rudd (*Scardinius erythrophthalmus*) and bullhead catfish (*Ameiurus nebulosus*) have all been recorded in our region to various degrees. These species are capable of causing damage to water quality, and native fish populations, and can alter the food webs within aquatic systems.

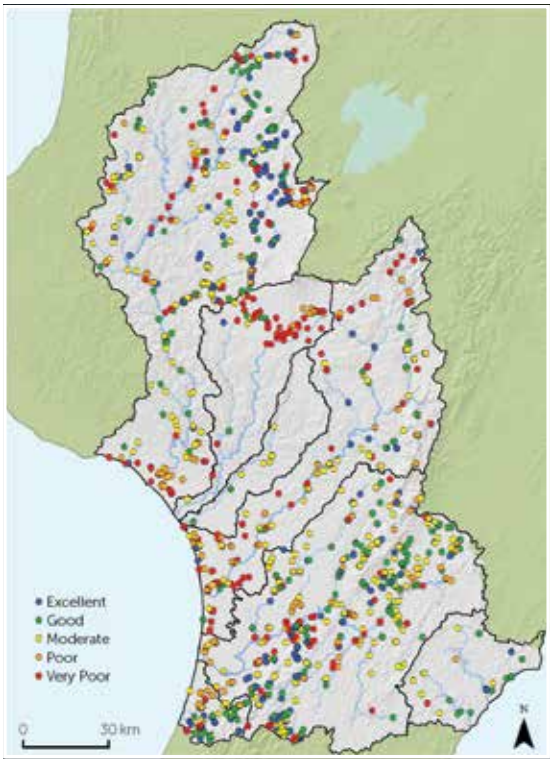


Figure 33: The map shows the index of biotic integrity for all sites within the Horizons Region that are recorded in the New Zealand Freshwater Fish Database (a database administered by NIWA and contributed to by regional councils, the Department of Conservation, universities and other researchers) as at August 2017. It doesn't include some fish species such as the brown mudfish that were not assessed during the original assessment

NATIVE FISH

There are approximately 17 species of native fish found in the region. This page provides some further information on one of the most common native species, inanga, and the rarely seen pirahau (lamprey).

Inanga

Inanga (*Galaxias maculatus*), the smallest of our whitebait species, are found throughout our region's streams, rivers and estuaries. More than 90 per cent of whitebait caught in our region are Inanga, and Horizons has an active programme dedicated to identifying the location and extent of their spawning habitat in the region. This is so that we can better manage consented activities in these areas and, where necessary, work with landowners to restore spawning habitat.

In autumn, Inanga migrate down to our estuaries, where they await the king tide. They gather and lay their eggs at the base of grasses near the water's edge, so that when the tide subsides the eggs remain clear of the water. Here they are kept damp by the thick mass of grass roots and stalks on which the eggs adhere. Around two weeks later, the next king high tide arrives, covering the eggs with water. The eggs hatch and the newly hatched fry are washed out to sea where they stay for around six months before returning for their freshwater run in early spring.

Piharau/Lamprey

Recently, while undertaking fish monitoring in the Kahuterawa Stream, staff identified a population of Piharau, otherwise known as Lamprey (*Geotria australis*). These rarely seen and unusual fish spend much of their juvenile life in freshwater environments buried into stream substrate, filter feeding from the flowing water above them. They have several life stages: first as a brown and blind ammocoete, before undergoing a metamorphosis into a strikingly blue and silver macropthalmia; then ultimately changing into an adult lamprey when they migrate to sea and attach themselves onto the sides of a fish. Here they rasp a hole through the skin and feed parasitically on the fish before returning to freshwater streams to breed. During the survey, both ammocoete and macropthalmia life stages were found. There are only two previous records of Lamprey in the Kahuterawa Stream in the national freshwater fish database, one of which was recorded in 1963.

In 2016, NIWA and Horizons carried out a semi-quantitative study of the distribution of Piharau in the Whanganui Catchment by measuring pheromones released by larval Piharau. Results showed that the Ohura River and Manganui o te Ao River catchments have a higher abundance of larval Piharau relative to other sites sampled, indicating that these could be important spawning and larval rearing habitats.

Inanga fish pass test

NON-NATIVE FISH

There are at least nine species of non-native fish found in the region. This page provides some further information on both trout, and pest fish.

Trout

Areas valued for recreational fishing are identified in Horizons' One Plan as trout fishing and trout spawning values. The responsibility for the collection of information on trout currently lies with the New Zealand Fish and Game Council.

Horizons recently worked with Fish and Game to assess trout information in the region. Cawthron Institute were commissioned to review data holdings for the region and concluded that although there was a range of data available, much of it was not electronic and unable to be used to report on regional trout populations.

In terms of information about trout, the most robust dataset currently available to Horizons is the National Angler Survey, administered every five years by NIWA on behalf of Fish and Game and the Department of Conservation. During the two decades of angler surveys, recreational fishing appears to have remained relatively constant, with angler days numbering around 35,000.

Popular rivers include the Whakapapa and the Manganui o te Ao rivers, the mainstem of the Whanganui River, the Mangawhero in the Whangaehu Catchment, the Kawhatau and Hautapu rivers and mainstem of the Rangitīkei. In the Manawatū Catchment, popular sites span the Manawatū mainstem, Oroua, Pohangina, Mangahao, Mangatainoka and Makuri rivers.

Other useful information held by New Zealand Fish and Game includes drift dive and spawning surveys, electric fishing and tagging surveys, and an otolith (fish ear bone) collection, which could be used to establish information about population structure and migration patterns.

Pest fish

Horizons has not included any pest fish into the Regional Pest Management Plan. However, the region does include many water bodies susceptible to the introduction of pest fish. We already have within the region; Koi carp (at least 12 sites), gambusia (at least 6 sites), brown bull headed catfish (suspected at 6 sites), and Rudd (known from at least 5 sites). Horizons relies on the Department of Conservation to take the lead on managing/controlling existing and new incursions of these pests under its mandate from the Conservation Act 1987 and the Freshwater Fish regulations 1983.

Pest fish surveys have been carried out in some areas of the region such as Lake Horowhenua and Lake Dudding as part of Horizons' lake restoration programmes. The pest fish survey in Lake Horowhenua in 2013 found perch, goldfish, koi carp and potential koi-goldfish hybrids.

RIVER WATER QUALITY

WHAT WE'RE DOING

Identifying drivers of ecosystem health has been a key focus for our research programme during the past two years. In partnership with NIWA and DairyNZ, we are currently delivering cutting-edge research into drivers of algal growth and macroinvertebrate communities.

Since our last State of Environment report, in addition to further refinement and improvement of our monitoring programme; we have:

- Completed a stocktake of available information around regional stormwater management;
- Undertaken testing and validation of new continuous nitrate sensor technology;
- Carried out research into native fish, development of an Index of Biotic Integrity for the region, lamprey and mudfish monitoring, and assessment of fish barriers;
- Analysed dissolved oxygen levels in the Manawatū and Rangitīkei rivers;
- Significantly advanced our understanding of state, trends and drivers of periphyton (algae) and drivers of potentially toxic algae (*Phormidium*) in our rivers; and
- Utilised DNA tracking to identify sources of faecal contamination at popular swimming spots.

IMPROVING HABITAT FOR FISH CASE STUDY

Improving freshwater habitat for fish is an important part of our business. Horizons staff work with landowners to fence and plant waterways, helping to improve water quality and to provide habitation and shading for aquatic life. We also work with territorial authorities, transport authorities and landowners to identify and fix barriers to fish passage.

Since our last State of Environment report, 380,408 new native plants have been planted across our region to provide shade, food and shelter for native fish. Fifty-one barriers to fish passage have been addressed through remediation works. Monitoring of fish passes that have been remediated to test their effectiveness is also an important part of the work Horizons' undertakes.

The identification and enhancement of fish spawning habitat has also been carried out in rivers such as the Manawatū and Whanganui, which are known to be significant areas for inanga spawning in the region.

Other activities include a wide range of works to support the Manawatū River Leaders' Accord, Lake Horowhenua Accord, and Te Mana o Te Wai projects, including sewage treatment plant upgrades, establishing sediment traps, and working toward establishing weed harvesting at Lake Horowhenua.

Kingston Road culvert with greater than 1 metre perch and undercut. Not fish passable

Kingston Road culvert following installation of rock ramp to enable fish passage

MANAWATŪ RIVER LEADERS' ACCORD CASE STUDY

The Manawatū River is a beacon for challenges facing freshwater quality in New Zealand. That is why, in August 2010, iwi/hapū, local government, farming, and industry leaders along with Massey University and environmental and recreational advocacy groups from around the Manawatū Catchment formed the Manawatū River Leaders' Forum.

Pledging to work together to improve the health of the Manawatū River and its catchment, Forum members signed the Manawatu River Leaders' Accord, setting out the focus, vision, and goals for the river. Accord members firmly believe that by working together we can achieve more than working alone, for the benefit of all. We are all kaitiaki (guardians) of the river, so if we step up and protect our taonga, its mauri (lifeforce) will return and thrive for future mātātahi (generations).

The main goal of the Accord is to improve the Manawatū River, such that it sustains fish species, and is suitable for contact recreation, in balance with the social, cultural and economic activities of the catchment community. Specific goals set out in the Accord are:

- The Manawatū River becomes a source of regional pride and mana;
- Waterways in the Manawatū Catchment are safe, accessible, swimmable, and provide good recreation and food resources;
- The Manawatū Catchment and waterways are returned to a healthy condition; and
- Sustainable use of the land and water resources of the Manawatū Catchment continues to underpin the economic prosperity of the region.

The Accord brought us together and set a vision and goals for improving the health of the awa. The next step was to identify priority areas and understand where the greatest impact could be made. The Action Plan (2011-2015) was developed, and Accord members committed to making change with six priorities and over 130 tasks identified in a huge collaborative effort. Alongside the Action Plan (2011-2015), the Accord Forum utilised opportunities as they arose, delivering on a $46 million work programme through the Manawatū Freshwater Clean-up fund project in partnership with Central Government.

A great deal has been accomplished but there is still plenty more work to be done. A second iteration of the Action Plan (2016-21) was launched in March 2016, with 34 diverse signatories agreeing to the delivery of over 100 tasks to improve the health of the Manawatū River. A further $534,000 of funding was secured through the Te Mana o te Wai fund, towards the $814,000 Tū Te Manawa project. This iwi-led project coordinated and supported efforts to share histories and stories of the awa with the community while enhancing and protecting sites of significance. In 2017 $2.9 million was secured from Central Government through the Freshwater Improvement Fund, supplementing $4.3 million contributed by councils and landowners to support a range of projects over five years. In November 2018 the most recent progress report was launched, as well as a new website **www.manawaturiver.co.nz** and the first Manawatū River festival.

RIVER WATER QUALITY

WHERE WE'RE GOING AND WHAT YOU CAN DO

Much work has been undertaken in the region to improve water quality over the past two decades. Our recent state and trend analysis provides us with sound information to inform decision-making around resource consenting, policy implementation, communication and the Our Freshwater Future policy process, and we are now building on this initial work with additional modelling to explore the linkages between natural resource use, water quality and management interventions. This information also informs non-regulatory work such as that undertaken under the Sustainable Land Use Initiative (SLUI), and the Freshwater and Partnerships programme.

There are so many practical ways that we can all do our part to improve water quality. Did you know...

- Horizons offers advice and grants for riparian planting projects, subject to conditions. We also provide advice around fencing, planting and weed management – contact us on freephone **0508 800 800**;
- Industry groups such as DairyNZ provide Regional Planting Guides and have developed, in partnership with Landcare Research, a web-based Riparian Planner Tool;
- Advice on weed management is available from Weedbusters: **www.weedbusters.org.nz**; and
- Your riparian planting could be tax deductible, check out: **www.ird.govt.nz/technical-tax/legislation/2013/2013-52/2013-52-riparian/leg-2013-52-riparian.html**

NGĀ ROTO

LAKES

INTRODUCTION

Lakes and their associated wetlands are some of our most treasured freshwater systems. They provide for a range of ecological, cultural and spiritual values and are often popular areas for water sports, fishing and hunting, and gathering of kai.

In the Horizons Region there are around 226 lakes greater than one hectare in size. These range from coastal dune lakes such as Lake Wiritoa and Lake Horowhenua, through to landslide lakes found throughout the hill country to the north of the region, and volcanic lakes such as the Crater Lake on Mt Ruapehu.

Lakes are unique and incredibly diverse, making them complex systems to understand. They are also vulnerable to the pressures of land use, water use, recreation and a changing climate. Over time these pressures have resulted in degraded water quality and the spread of invasive weeds in some of our lakes. This is particularly notable in our dune lakes, where around 68 per cent of the surrounding catchments have been converted to pastoral agriculture. In some cases, intervention is now necessary to remediate degraded lakes, and ensure those lakes in good health are managed and maintained.

Because every lake behaves in a slightly different way, no one solution will be suitable for every lake. Effective management requires sound understanding of ecological risks and cultural sensitivities, as well as logistical and financial challenges. Horizons is actively working with local iwi, landowners, territorial authorities and lake experts from around New Zealand to improve our understanding of our region's lakes, inform current management, and support future decision making.

LAKES

WHERE WE'VE COME FROM

Lakes are generally bodies of standing water greater than one hectare in size; however, smaller lakes are sometimes included on the basis of depth, permanence or the presence of typical lake processes such as stratification. Lakes may have associated wetlands with distinct ecosystems, and in some cases form an open water area of a much larger wetland system.

Most lakes in the region have been affected to some degree by changes in water quality and through the introduction of invasive aquatic plants and animals, or by the clearance of indigenous vegetation and draining of wetlands. Early monitoring of the region's lakes focussed on identifying the submerged plant species that were present. The aim was to prevent the spread of introduced aquatic plants between lakes, primarily through public education.

During the development of the One Plan, Horizons' focus shifted to further understanding the current state of health of the region's lakes. At that time, the health of some of the region's lakes, such as Lake Horowhenua, was known to be poor; however, water quality data was limited and very little was known about other lakes in the region.

Monitoring of the water quality of Lake Horowhenua was re-instated in 2013 with the installation of a permanent monitoring buoy. In 2014 Horizons commenced water quality monitoring at three of the region's deep coastal lakes on a quarterly basis and in 2015 another 11 lakes were added to the water quality programme on a quarterly basis. These coastal dune lakes were initially selected due to their identification as priority catchments for nutrient management, as set out in the One Plan.

The same year, a programme called LakeSPI commenced with the assistance of local iwi and lake experts from NIWA. LakeSPI stands for Lake Submerged Plant Indicators, a monitoring technique where divers look at the presence of both native and introduced submerged macrophytes as an indicator of ecological health. LakeSPI surveys are now undertaken every year at different lakes throughout the region.

WHERE WE ARE NOW – CURRENT STATE

Lakes are vulnerable to a wide range of threats from vegetation clearance and land use impacts, to the abstraction of surface and groundwater, and the introduction of pest fish and aquatic pest plants. Indicators of lake health include water quality indicators such as nutrients, bacteria and algae. These indicators are measured and reported against regional (One Plan) targets and national (NPS-FM) attributes.

To date, monitoring and research has largely focussed on the region's coastal dune lakes, of which there are 57. This focus was primarily driven by the need to understand the current state of the health of the lakes to inform implementation of the One Plan nutrient management rules for priority catchments. The limitations of such an approach are acknowledged and it is important to note that water quality and ecological status of the remaining 169 lakes within the region is presently poorly understood and in many cases, unknown.

Figure 34 shows the number of lakes currently monitored compared to the range of morphological lake types found in the region. This shows that there are over 100 lakes in the Landslide/Slump category; however, presently none of these lakes are included in the state of environment monitoring programme.

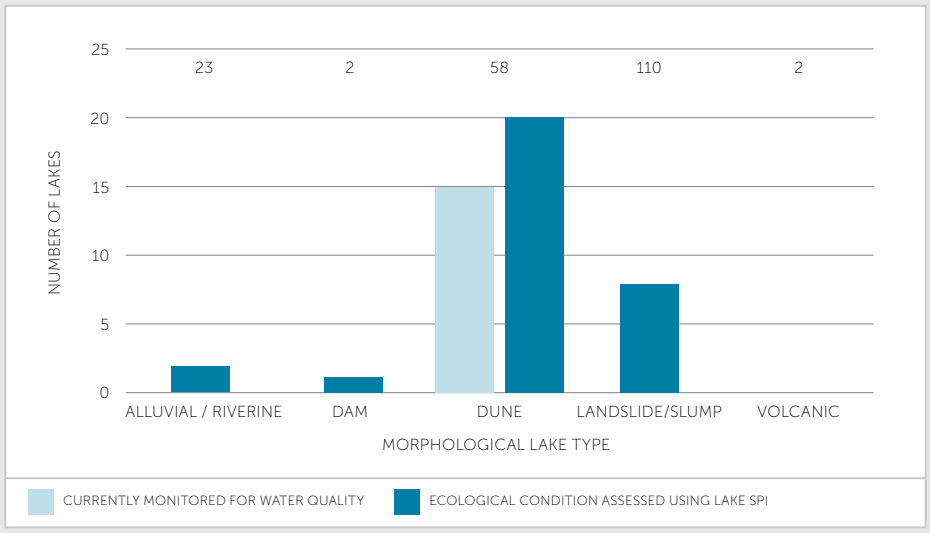


Figure 34: Many of the region's morphological lake types are not yet represented in Horizons' state of environment monitoring programme. Lake type (morphology) is recorded for 195 of the region's 226 lakes. This graph shows the number of lakes in each category, with the bars showing the number of lakes currently monitored for water quality, and those assessed for ecological condition

LAKE WATER QUALITY

State comparison to One Plan targets

The current state of 15 of the 226 lakes regionally has been determined for a range of water quality parameters. Results are compared to One Plan targets for algae, bacteria and nutrients, which either pass or fail.

Combined water samples from three different sites at each lake (composite samples), are collected from 14 lakes four times per year and monthly from Lake Horowhenua. Presently, only Lake Horowhenua has sufficient data to analyse state (with the exception of *E. coli* and ammoniacal nitrogen). For other lakes, the quarterly sampling and short length of record presently provide an insufficient number of samples to estimate the state of water quality in a statistically robust way. Monthly sampling of a wider range of lakes is recommended to increase the accuracy of the statistical analysis and provide a broader picture of lake health for the region.

One Plan targets for lake algae (measured as average and maximum chlorophyll *a*) are generally not met at monitored sites with Lake Koitiata being the only exception (Table 2). All sites perform poorly for nitrogen and phosphorus; only Lake Koitiata met the total phosphorus target. Most sites, where there is sufficient data for analysis, do meet the One Plan target for ammoniacal nitrogen. With the exception of Omanuka Lagoon and Lake Waipu, all lakes meet the bacteria (*E. coli*) targets during the bathing season. Lake Heaton and Lake Waipu are the only monitored lakes that fail to meet the winter *E. coli* target.

Site name	One Plan chlorophyll a (average)	One Plan chlorophyll a (maximum)	One Plan total nitrogen	One Plan total phosphorus	One Plan ammoniacal nitrogen	One Plan *E. coli* (bathing)	One Plan *E. coli* (winter)
Lake Alice	Fail	Fail	Fail	Fail	**Pass**	**Pass**	**Pass**
Lake Dudding	Fail	Fail	Fail	Fail	**Pass**	**Pass**	**Pass**
Lake Heaton	Fail	Fail	Fail	Fail	Fail	**Pass**	Fail
Lake Herbert	Fail	**Pass**	Fail	Fail	NA	**Pass**	**Pass**
Lake Horowhenua	Fail	Fail	Fail	Fail	**Pass**	**Pass**	**Pass**
Lake Kohata	Fail	Fail	Fail	Fail	**Pass**	**Pass**	**Pass**
Lake Koitiata	**Pass**	**Pass**	Fail	**Pass**	NA	**Pass**	**Pass**
Lake Koputara	Fail	Fail	Fail	Fail	**Pass**	**Pass**	**Pass**
Lake Pauri	Fail	Fail	Fail	Fail	**Pass**	**Pass**	**Pass**
Lake Waipu	Fail	Fail	Fail	Fail	NA	Fail	Fail
Lake Westmere	Fail	Fail	Fail	Fail	**Pass**	**Pass**	**Pass**
Lake William	Fail	Fail	Fail	Fail	NA	**Pass**	**Pass**
Lake Wiritoa	Fail	Fail	Fail	Fail	**Pass**	**Pass**	**Pass**
Omanuka Lagoon	Fail	Fail	Fail	Fail	NA	Fail	**Pass**
Pukepuke Lagoon	Fail	Fail	Fail	Fail	**Pass**	**Pass**	**Pass**

Table 2: Lake water quality compared to One Plan targets (composite samples). Results are indicative only and should be interpreted with caution

State comparison to national criteria

Nationally, lake water quality is compared to the National Objectives Framework (NOF) attributes set out in the National Policy Statement for Freshwater Management (NPS-FM).

Although current water quality monitoring data is sparse, it shows that for all monitored lakes, at least one parameter falls into band D and therefore fails the national bottom line criteria under the Freshwater National Policy Statement (Figure 3).

The majority of these lakes (13 out of 15) fail for both nutrient attributes, with the exception of Lakes Kohata and Koitiata both of which are graded a 'C' for phosphorus. Eight of the 15 sites fail at least one measure of algae. Lakes Heaton, Horowhenua and Wiritoa fail to meet the national bottom line on all counts. In a number of cases, nutrient levels fail to meet the national bottom line, but sites achieve a band 'B' or 'C' for algae (phytoplankton).

Site Name	NOF: Lake phytoplankton (median)	NOF: Lake phytoplankton (maximum)	NOF: Lake total nitrogen	One Plan total phosphorus
Lake Alice	B	D	D	D
Lake Dudding	C	C	D	D
Lake Heaton	D	D	D	D
Lake Herbert	C	C	D	D
Lake Horowhenua	D	D	D	D
Lake Kohata	C	D	D	C
Lake Koitiata	A	A	D	C
Lake Koputara	D	D	D	D
Lake Pauri	B	C	D	D
Lake Waipu	B	C	D	D
Lake Westmere	C	C	D	D
Lake William	C	D	D	D
Lake Wiritoa	D	D	D	D
Omanuka Lagoon	C	D	D	D
Pukepuke Lagoon	B	C	D	D

Table 3: Lake water quality compared to One Plan targets (composite samples). Results are indicative only and should be interpreted with caution

Lake monitoring

Lake Trophic Level Index (TLI)

The Trophic Level Index (TLI) for lakes is a common measure of ecological health in lakes. It consists of four components that each play an important role in the ecological functioning of a lake: chlorophyll a, the nutrients nitrogen and phosphorus, and water clarity where this information is available.

Based on the TLI, lakes can be classified in seven trophic categories ranging from <1 ultra-microtrophic (pristine) to >6 hypertrophic (highly degraded). As the TLI score increases, the ecological condition of the lake declines.

Of the 15 lakes we currently monitor, one falls within the eutrophic category, being Lake Koitiata. More than half of the monitored lakes are classed as supertrophic, meaning that they often have poor water quality and excess algal growth as a result of high nutrient levels. Eight of the lakes we monitor in our region fall into the worst category for ecological health (hypertrophic), as shown in Table 4.

Trophic state	Lake condition	TLI score	Number of monitored lakes	Percentage of monitored lakes (%)
Ultra-microtrophic	Clear, with extremely low levels of nutrients and algae.	< 1	0	0
Microtrophic	Clear with very low levels of nutrients and algae	1-2	0	0
Oligotrophic	Clear with low levels of nutrients and algae	2-3	0	0
Mesotrophic	Moderate levels of nutrients and algae	3-4	0	0
Eutrophic	Murky with higher amounts of nutrients and algae	4-5	1	7
Supertrophic	Fertile and saturated in phosphorus and nitrogen, often associated with poor water quality. Excessive algae growth can occur.	5-6	6	40
Hypertrophic	Highly fertile and super-saturated in phosphorus and nitrogen and with excessive algae growth. Poor water clarity and poor water quality.	>6	8	53

Table 4: Fifteen lakes are monitored for water quality in the Horizons region. TLI scores are based on the annual average of the four samples collected during 2017 (or 12 samples for Lake Horowhenua)

LAKE SUBMERGED PLANT INDICATORS (LAKESPI)

Increased sediment and nutrient loading from catchment activities, and displacement of native vegetation by invasive alien plant species are major influences on lake ecology and condition. Every year, Horizons engages a team of experts from NIWA who don scuba and snorkel gear, to assess aquatic plants along a series of transects in each lake. This method, known as LakeSPI (Submerged Plant Indicators), is a bioassessment method that uses the degree of development by native submerged plants, and level of impact by non-native, invasive weeds to indicate an ecological condition.

Since 2015, 31 lakes have been surveyed using the LakeSPI method. The majority of these lakes have been recorded as having at least one introduced macrophyte species present. Five lakes are in excellent condition, having a LakeSPI index that exceeds 75 per cent, and one lake is determined to be in high ecological condition meaning it has little or no impact from invasive weed species. Fourteen lakes (45 per cent) are classified as 'Moderate', reflecting some degree of impact from invasive weeds and/or restricted development of native plant communities. Seven lakes (23 per cent) are categorised in poor condition, with these lakes being heavily impacted by hornwort (*Ceratophyllum demersum*) or egeria (*Egeria densa*). Four lakes (13 per cent) were identified as non-vegetated.

Poor water quality and prevalence of algal blooms were noted for most lakes, with the prolonged effects of these impacts likely to lead to further deterioration of submerged vegetation.

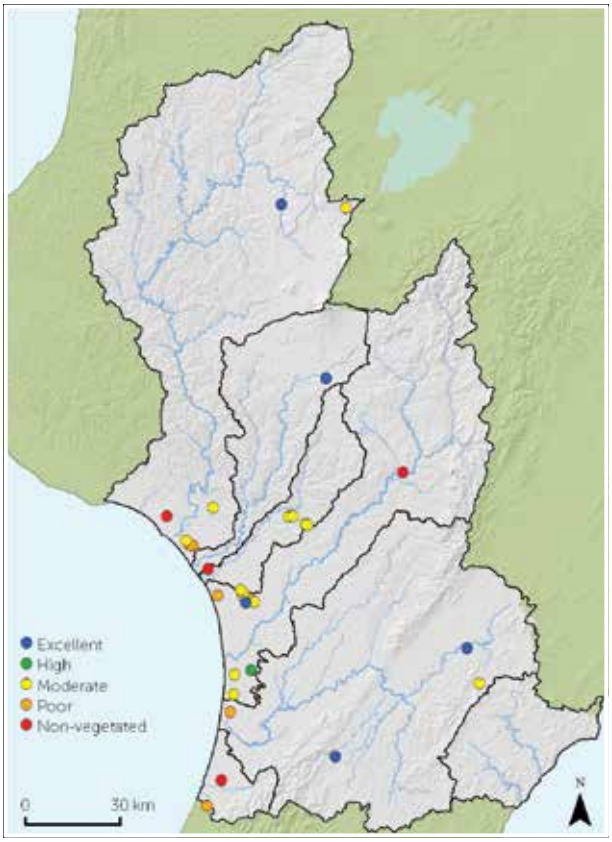


Figure 34: LakeSPI (Submerged Plant Indicators) is a bioassessment method that uses the degree of development by native submerged plants, and level of impact by non-native, invasive weeds to indicate an ecological condition. Indices, ranging from 0 per cent (heavily impacted lakes) to 100 per cent (pristine, unimpacted lakes), are shown for lakes surveyed in the Horizons region from 2015 to 2018

LAKES

WHAT WE'RE DOING

Our knowledge of the region's lakes has grown significantly since our last State of Environment report was released in 2013. Over the past five years we have:

- Installed a lake buoy for the continuous monitoring of Lake Horowhenua, to complement monthly monitoring of lake water quality and lake inflows and outflows;
- Initiated quarterly monitoring of 14 coastal lakes;
- Conducted bathymetric surveys including depth profiles, weed mapping and sediment composition for seven coastal lakes;
- Completed groundwater catchment mapping for 26 lakes, with more detailed water balance and hydrological studies completed for 3 lakes;
- Mapped 31 lakes using LakeSPI to determine submerged plant (macrophyte) cover;
- Supported the Lake Horowhenua Accord to restore Lake Horowhenua;
- Secured additonal funding through the Freshwater Improvement Fund for the removal of the Rātana wastewater treatment plant (WWTP) discharge to Lake Waipu and instead applying the discharge to land; and
- Through collaboration with iwi/ hapū and local stakeholders we have developed restoration plans for Lakes Horowhenua, Pauri, Wiritoa, and Oporoa. Two further reports completed in 2018 identify the information that is required to fully inform the development of restoration plans for a number of shallow and deep dune lakes.

LAKES

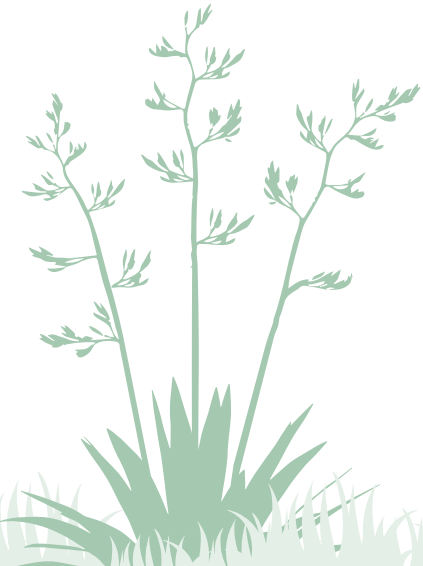
WHERE WE'RE GOING AND WHAT YOU CAN DO

RESTORING LAKE HOROWHENUA CASE STUDY

In pre-European times, Lake Horowhenua was a cleanwater supply and valued fishery for the Muaūpoko iwi who lived in the coastal forest that surrounded the lake. Clearance of coastal forest, draining of swamps, intensification of land use, urban expansion, and the disposal of treated effluent in the lake between 1962 and 1987 has lead to significant degradation of Lake Horowhenua. In 2010 Lake Horowhenua was ranked as the 7th worst out of 112 monitored lakes in New Zealand for the Trophic Lake Index measure.

In 2013, the Lake Horowhenua Trust, Lake Horowhenua Domain Board, Horowhenua District Council, Horizons Regional Council and the Department of Conservation agreed to work together to provide leadership, halt degradation and put in place remedial measures on Lake Horowhenua and Hokio Stream that will ensure these taonga (treasures) hold pride of place in the local community.

Lake Horowhenua is regularly closed for recreation in summer due to the presence of potentially toxic cyanobacteria. This is related to the large amounts of nutrients and sediment entering the lake combined with large amounts of sediment and nutrients already present in the lake. Monitoring data shows that Lake Horowhenua has very poor water quality and is classified as supertrophic on the trophic level index (TLI). The lake currently fails to meet the national bottom line under the National Policy Statement for Freshwater Management for all measures (Table 5).



Present band	TP	TN	TAN	Chl a	Cyanobacteria
	Annual median (mg/m^3)	Annual median (mg/m^3)	Annual maximum (mg/m^3)	Annual maximum (mg/m^3)	80th percentile (mm^3/L)
A	<10	<300	**<0.05**	< 10	**<0.5**
B	**>10 and <20**	>300 and <500	**>0.05 and <0.4**	**>10 and <25**	N/A
C	**>20 and <50**	500 and < 800	**0.4 and < 2.20**	**>25 and <60**	>0.5 and <10
D	**>50 (250)**	**>800**	**>2.20**	**>60**	**>10**

WHERE WE ARE NOW
WHAT WE COULD ACHIEVE

Table 5: Current and predicted water quality for Lake Horowhenua assessed against criteria set out in the National Policy Statement for Freshwater Management (amended 2017)

Likely improvements from key lake interventions, which include reducing sediment and nutrient inputs from local land use, and harvesting of lake weed to reduce the toxicity issues of cyanobacteria and ammonia in the lake, have been predicted by Dr. Max Gibbs of NIWA and are shown in (Table 5). The predictions indicate four of these five parameters will improve to above the national bottom line if the actions of installing a sediment trap on the Arawhata and lake weed harvesting are completed.

To date, the Lake Accord has enabled the reestablishment of monitoring at the lake, and development of the subsequent Action Plan. Lake restoration initiatives have been greatly enhanced with funding from central government through the Freshwater Clean-up Fund, Te Mana o Te Wai fund and Freshwater Improvement Fund, and in-kind support from all Lake Horowhenua Accord parties, the Tararua Growers Association and DairyNZ.

The fifth anniversary of the signing of the Lake Accord was celebrated on the 4th of August 2018. Through the Lake Accord, the parties have collaborated in the restoration of Lake Horowhenua. This includes the completion of environmental management plans for all ten dairy farms in the catchment, and sediment and erosion control plans for growers covering 80 per cent of the horticultural land in the Arawhata Sub-catchment. The formation of a sediment trap at the base of the Arawhata Stream seeks to reduce sediment and phosphorus entering the lake during high flows. Other actions have included establishing a fish pass on the lake outlet weir, community planting days and development of a plant nursery.

However, while efforts are being made to build momentum around further action and some interventions are underway, progress continues to be hindered by ongoing legal challenges and court processes. Lake Horowhenua has had a long complicated history of management and this presents challenges for the various agencies and organisations that have statutory functions to improve the health of the lake.

Despite these challenges further plans for Lake Horowhenua include actions to address the quality of stormwater entering the lake catchment, and an investigation of groundwater in the catchment through the Freshwater Improvement Fund project that is currently underway. Horizons is also continuing work to implement the lake weed harvesting activity.

Community planting day held at Lake Horowhenua

RESTORATION OF LAKE OPOROA, RANGITĪKEI CASE STUDY

Located near Utiku, Lake Oporoa is a small, shallow lake in the upper Rangitīkei Catchment. The lake is of significant cultural importance to Ngāti Hauiti, and in the past has provided for the traditional harvesting of tuna (eels). In recent years poor water quality and algal blooms have resulted in the lake being unsuitable for contact recreation and harvesting of tuna.

The lake was identified for action through the Ngā Pae o Rangitīkei project, known as Ngā Puna Rau. Lead by iwi, with additional funding and support from Te Mana o Te Wai fund, Horizons and landowners, an intensive monitoring programme was undertaken throughout summer-autumn 2017. This monitoring has since helped inform the development of a restoration plan for Lake Oporoa that seeks to align with Ngāti Hauiti values and aspirations.

Monitoring of the lake involved the deployment of a continuous buoy for five months, monthly water quality sampling over this period, analysis of sediment quality, and the completion of LakeSPI monitoring. Monitoring identified low dissolved oxygen near the bottom of the lake, rendering bottom waters uninhabitable for fish and leading to the release of dissolved phosphorus and ammonia from lake sediments into the water column. The release of phosphorus in turn drives the algal blooms observed by local iwi.

Key drivers of water quality in Lake Oporoa include the mudstone geology that erodes easily, providing nutrient-rich sediment to the lake, and the high organic content of lakebed sediments that have arisen from sources including seasonal inputs of leaf-litter from surrounding poplar trees. The surrounding forest also shelters the lake from wind, reducing wave-driven mixing of the lake resulting in temperature stratification.

The restoration plan, developed by staff at the Cawthron Institute, aims to reduce organic inputs through the removal of deciduous trees and replacement with low-growing, shrubby native vegetation. This is scheduled to occur in May 2019. The plan also identifies a range of potential interventions to break the current pattern of nutrient cycling and reduce algal blooms.

WHAT YOU CAN DO

Lakes are susceptible to the impacts of land use including earthworks and drainage, which can impact groundwater flow and lake water levels. Sediment runoff and nutrient leaching from farming, and bacteria from septic systems can also introduce contaminants that degrade the health of a lake and make it unsuitable for recreation. If you are planning on undertaking activities in a lake catchment, give Horizons' consents team a call on **0508 800 800.**

Lake Horowhenua

NGĀ WAHAPŪ ME TE TAKUTAI

ESTUARIES AND COAST

INTRODUCTION

Our coast and estuaries provide important habitat for a diverse range of life including plants, birds, fish and other biota. They are also great places for recreational activities such as swimming, kayaking, fishing, or bird watching.

The coastal marine area (CMA) of the Horizons Region includes parts of both the Tasman Sea and Pacific Ocean. The regional boundary extends 12 nautical miles out to sea on both the east and west coasts, encompassing approximately 3,100 km^2 of coastal waters, around 14 per cent of the total regional area. With its narrow sandy beaches and sea cliffs to the north and sandy beaches and dune systems to the south, the west coast spans around 120 kilometres, while the east coast, with its rocky platforms and cobbled or sandy beaches, extends 40 kilometres from Cape Turnagain to the Owahanga River mouth.

In our region estuaries, freshwater from streams and rivers mixes with seawater, influenced by tides as water flows upstream and downstream twice each day. There are 40 estuaries in the region, 25 on the west coast and 15 on the east coast. This represents almost ten per cent of the nation's estuaries. Estuaries receive and transport nutrient and sediment daily from land, and via streams, rivers and from the sea. They are highly productive, providing habitat for a range of birds, fish and other aquatic life.

This chapter presents information on:

- Estuary vulnerability to nutrient and sediment;
- Estuary and coastal water quality;
- A case study of the Manawatū Estuary; and
- An overview of some recent science around the region's estuaries and coast.

ESTUARIES AND COAST

WHERE WE'VE COME FROM

Estuaries have changed a great deal since people first arrived in New Zealand. Deforestation and the subsequent erosion of hill country has accelerated the amount of sediment build-up in estuarine environments and increased the volume of sediment discharging from rivers to the coast. Rural land use, as well as discharges from industry and urban wastewater, contribute nutrients, bacteria and other contaminants such as metals, which can accumulate and degrade these important habitats. Build-up of nutrients (eutrophication) can lead to increased algal growth and poor water quality. Excessive sediment build-up

in estuaries destroys habitat, reduces water clarity, and can create low oxygen zones where shellfish and other organisms cannot survive.

Estuary vulnerability is determined by a range of factors including size, depth, residence time, ecological diversity, and ability to flush sediment and nutrients. In the region's low-risk estuaries, nutrient and sediment loads can be quite large, but because these estuaries are generally small with low ecological diversity, and experience regular periods of high flushing, they are unlikely to be subjected to long periods of eutrophication and sedimentation. Estuaries in the region that are moderately or highly vulnerable are often closed at the estuary mouth and poorly-flushed, particularly during summer.

Horizons commissioned a region-wide study of estuary habitat and vulnerability to sediment and nutrient in 2016 to inform the development of an estuary monitoring programme. This was undertaken using a combination of existing monitoring information, field visits and broad-scale mapping of dominant habitat and substrate types, and catchment-derived sediment and nutrient loads to provide information for 40 estuaries across the region. Five of these estuaries have been identified as moderately to highly vulnerable to excess nutrient and sediment loads. These are the east coast estuaries Wainui and Tuatane, and the west coast estuaries Kai Iwi, Hōkio and Waikawa. Two estuaries have been assessed as being of moderate vulnerability, 27 estuaries are considered low to moderate vulnerability, and the remaining six have low vulnerability to nutrient and sediment.

ESTUARIES AND COAST

WHERE WE ARE NOW – CURRENT STATE

Like our lakes programme, estuary and coastal monitoring and research is relatively new when compared to rivers and groundwater. The coastal monitoring programme began in 2011 and estuary monitoring in 2015. Both programmes are currently developing in response to identified pressures such as the impacts of climate change. With assistance from NIWA's coastal scientists, we are currently redesigning our coastal and estuary monitoring programme and actively exploring opportunities to build upon our existing knowledge base.

Presently, Horizons monitors four beaches and seven estuaries around the region for a range of water quality indicators. A comparison of the current state of water quality is provided for both coastal and estuary monitoring data. An analysis of trends has not been completed due to the short length of monitoring record available.

COMPARISON OF COASTAL WATER QUALITY TO ONE PLAN TARGETS

While we currently have very little information about the condition of our coastal environments, a foreshore water quality programme was established in 2011 to provide an initial assessment of coastal water quality in our region.

When comparing the last five years of coastal water quality data with One Plan values, all beach sites meet the criteria for ammoniacal nitrogen, but fail to the meet the criteria for chlorophyll *a*, total nitrogen and total phosphorus, with the exception of total nitrogen at Akitio Beach (Table 6).

Akitio Beach, located on the East Coast of the region, meets all criteria except total phosphorus and bacteria (enterococci), supporting our broad understanding that sediment and run-off are key challenges for this catchment. On the west coast, algal growth (chlorophyll *a*) is an issue at all monitored sites, along with elevated nutrients (total nitrogen and total phosphorus) and bacteria (enterococci), particularly throughout the bathing season.

Kai Iwi Beach, Whanganui

	Chlorophyll *a* (average)	Ammoniacal Nitrogen (average)	Total Nitrogen (average)	Total Phosphorus (average)	Enterococci (bathing season)	Enterococci (non-bathing season)
Akitio Beach at Surf Club	**Pass**	**Pass**	**Pass**	Fail	Fail*	Fail*
Himatangi Beach at Surf Beach	Fail	**Pass**	Fail	Fail	Fail	**Pass**
Kai Iwi Beach at Kai Iwi Stream Bridge	Fail	**Pass**	Fail	Fail	Fail*	**Pass***
Waitarere Beach at Waitarere Surf Beach	Fail	**Pass**	Fail	Fail	**Pass**	Fail

Table 6: Beach water quality monitoring sites and their One Plan compliance. Insufficient data for statistically robust analysis marked by * and results should be interpreted as an indication only

COMPARISON OF ESTUARY WATER QUALITY TO ONE PLAN TARGETS

For our estuaries, a comparison of water quality to One Plan targets also highlights issues at some estuary sites (Table 7). As with our beaches, all sites meet the criteria for ammoniacal nitrogen and temperature, with the exception of the Rangitīkei Estuary where the average temperature was 1.3°C higher than the target value.

Manawatū Estuary at Foxton and Rangitikei Estuary both fail to meet one of the four reported targets (chlorophyll *a*, and temperature, respectively). The Ōhau and Waikawa Estuaries fail to meet One Plan targets for dissolved oxygen and chlorophyll *a*.

	Chlorophyll *a* (average)	Dissolved oxygen saturation	Ammoniacal Nitrogen (average)	Temperature
Akitio Estuary at Coast Rd Bridge	**Pass**	**Pass**	**Pass**	**Pass**
Manawatū at Foxton	Fail	**Pass**	**Pass**	**Pass**
Mowhanau	NA	Fail	**Pass**	**Pass**
Ohau at Estuary	Fail*	Fail*	**Pass***	**Pass***
Rangitīkei Estuary at River Mouth	**Pass**	**Pass**	**Pass**	Fail
Waikawa Estuary at Footbridge	Fail	Fail	**Pass**	**Pass**
Whanganui Estuary at Wharf St Boat Ramp	**Pass**	**Pass**	**Pass**	**Pass**

Table 7: Estuary water quality monitoring sites and their One Plan compliance. *Insufficient data for statistically robust analysis, results should be interpreted as indicative only. For our estuaries, flow data is required to assess One Plan compliance for a number of additional water quality parameters. As flow data are currently unavailable for these sites, we have not included those parameters in this assessment; however, data can be provided to interested parties on request

ESTUARIES AND COAST

WHAT WE'RE DOING

Our coastal and estuary programme is still in its infancy, with our effort directed to establishing monitoring programmes, undertaking research and compiling available information to guide the future direction of the programme.

Additional science around estuaries and coast has been enabled through Horizons applying to the Envirolink Fund. Envirolink is funded by the Ministry for Business, Innovation and Employment to provide for the transfer of science and technical advice from research providers to qualifying regional councils.

HABITAT MAPPING CASE STUDY

While water quality data is informative, the vulnerability of the region's estuaries to nutrient enrichment and sedimentation is assessed by habitat mapping and sediment monitoring. Horizons introduced a habitat monitoring programme in 2015 to complement the water quality monitoring programme. In future, this information will guide the development of appropriate policy and ensure actions are tailored to meet the needs of each estuary.

Horizons now carries out habitat characterisation at a number of different estuaries, following a ten-year work-rotating monitoring programme that includes a range of estuary types. This includes broad-scale mapping of three estuaries (Manawatū, Rangitīkei and Whanganui), fine-scale habitat mapping of two estuaries (Manawatū and Whanganui), and targeted synoptic surveying of four east coast and four west coast estuaries, including the five identified as most vulnerable to eutrophication. Annual monitoring of sedimentation carried out over a ten-year period is also underway in the Whangaehu Estuary, which was initially identified as being highly vulnerable to sediment build-up.

A scientist inspects herbfield and rushland in the middle reaches of the Ōhau Estuary, Horowhenua

MANAWATŪ ESTUARY CASE STUDY

The Manawatū Estuary is a regional treasure. Covering 533 hectares near the coastal settlement of Foxton Beach, it is the largest estuary and wader bird feeding ground in the lower North Island and has the most diverse range of birds to be seen in any one place in New Zealand.

Wader birds such as the kōtuku ngutupapa (Royal spoonbill) and matuku hūrepo (Australasian bittern) are regular visitors. Every year during March and October a welcome and farewell to the migrating birds is held by the Manawatū Estuary Trust to give the public a close-up view of species such as the kuaka (godwit) and hauhou (knot) that travel great distances from Alaska and Siberia.

Vegetation clearance and land disturbance has, over time, lead to extensive modification, degrading both saltmarsh and the riparian margin where whitebait release their eggs. The banks of the Manawatū River are one of the most extensive inanga spawning sites in the region and this has been enhanced and protected through the Manawatū River Leaders' Accord.

Water quality monitoring carried out by Horizons shows that sediment and nutrients are key issues in the Manawatū Catchment. While fine sediment and nutrients largely pass through the estuary to the open sea due to the flushing nature of the Manawatū River, estuary monitoring suggests that action is required to minimise ongoing fine sediment in order to prevent deterioration in the health of the estuary. While currently not a significant issue in the estuary itself, high nutrient concentrations flushing through the estuary may be contributing to impacts in coastal areas outside of the estuary.

Because of its rich and diverse plant and animal life, around 200 hectares of the Manawatū Estuary was designated a Wetland of International Importance in July 2005 under the RAMSAR Convention (a wetland conservation treaty signed by more than 150 countries). Horizons, along with the Manawatū Estuary Trust and Department of Conservation, played a significant role in gaining this recognition.

Habitat mapping courtesy of Wriggle Coastal Management

ESTUARIES AND COAST

WHERE WE'RE GOING AND WHAT YOU CAN DO

COASTAL INFORMATION INVENTORY CASE STUDY

While our existing estuary habitat mapping and coastal water quality monitoring provide useful information about our estuaries and foreshore, there is still much to learn about the open coastal waters, rocky reefs and sandy beaches of the region. Horizons, with support from Envirolink, recently commissioned coastal scientists at NIWA to compile an inventory of existing information about the state of open coastal environments in our region and identify any knowledge gaps that could be addressed.

The report highlights the wealth of physical oceanographic data and modelling already available for the western coastal marine area in the South Taranaki Bight (the large bay that extends from Taranaki through to Kapiti Coast), along with information on patterns of primary production in the eastern coastal marine area. Additional information on seafloor sediment, selected threatened or vulnerable seafloor species and marine mammals, seabirds and fish is also available for both coastal marine areas.

The report also presents a range of options for gathering new knowledge to inform management of the coastal environment, particularly relating to the sources, fate and impact of sediment, and the likely impacts of sea level rise.

ESTUARY TROPHIC INDEX CASE STUDY

To provide national consistency to the assessment and prediction of estuary eutrophication, regional councils recently championed the development of an Estuary Trophic Index (ETI) with support from the Ministry of Business, Innovation and Employment's Envirolink Fund.

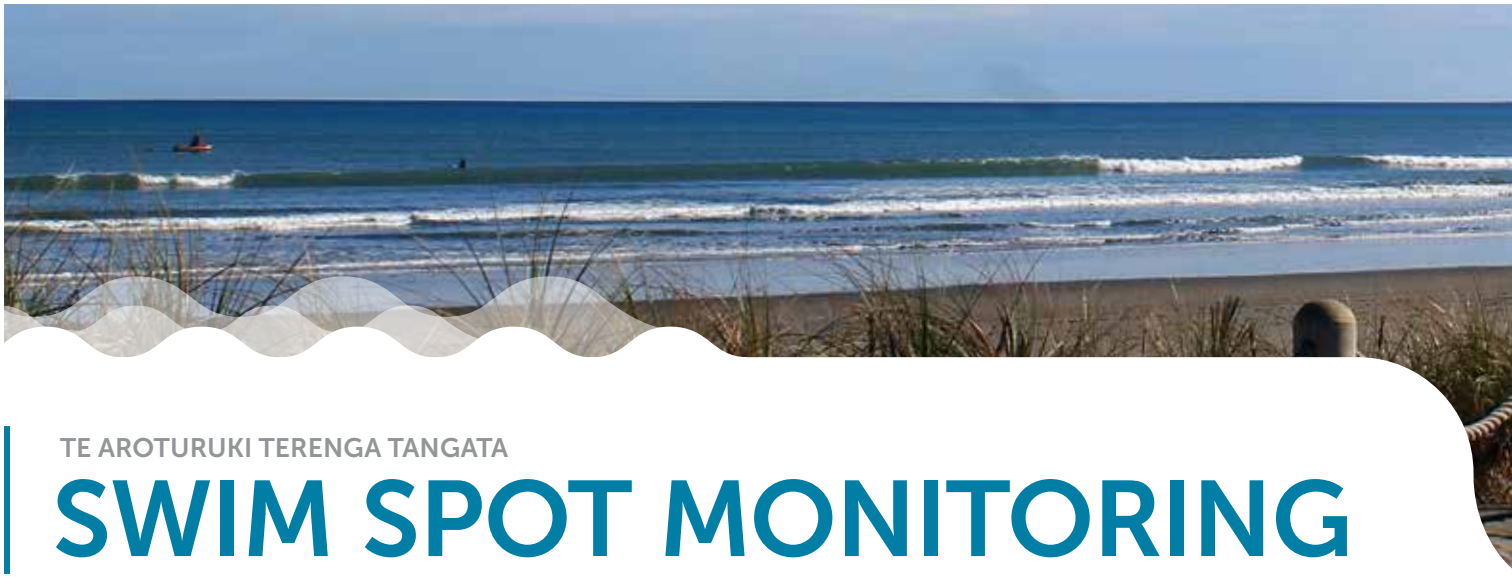
Developed by NIWA, Wriggle Coastal Management, regional council coastal scientists and Hume Consulting, the ETI tools enable users to determine the susceptibility of an estuary to eutrophication, assess the current trophic state, and assess how changes to upstream nutrient loads may alter the estuary ecosystem. ETI scores range from minimal to high eutrophication and are set out in much the same way as the National Policy Statement for Freshwater Management. Scores are available for over 400 estuaries across the nation.

In the Horizons Region, trophic scores have now been calculated for the Ōhau and Waikawa estuaries. Ōhau Estuary has a score of 0.68 and is classed as Band C (moderate), while Waikawa Estuary has a trophic score of 0.85, placing it in the Band D (high) category.

A consultant coastal ecologist measures the depth of sediment deposited in Manawatū Estuary since last visit

GET INVOLVED

- Citizen science projects such as Marine Meter Squared encourage community participation in long-term monitoring of the marine environment. Visit www.mm2.net.nz to sign up (it's easy and free!);
- Protect sensitive coastal environments by walking instead of driving. Driving on beaches, sand dunes and/or salt marsh can kill plants and animals living there and destroy the habitat so they cannot resettle;
- Seaweek – Kaupapa Moana is a national event held in March each year. Check out **www.seaweek.org.nz** to see what's happening in the region; and
- Marine pests can overrun natural ecosystems – keep your boat hull clean; pests are less likely to hitchhike on a clean boat.



TE AROTURUKI TERENGA TANGATA

SWIM SPOT MONITORING

INTRODUCTION

The region's rivers, lakes and beaches provide for a range of recreational uses. This chapter of the report presents indicators that relate to the suitability of freshwater and coastal areas for recreation, drawing on these indicators to provide a summary of the findings.

In this chapter you can find information on:

- The criteria used to assess and report on suitability for swimming;
- How bacteria, measured as *Escherichia coli (E. coli)* and enterococci, are tracking in relation to regional and national targets for water quality, and how they are changing over time;
- Suitability of the region's waterways for recreation, as set out in the National Policy Statement for Freshwater Management (amended 2017), which introduced new water quality attribute criteria and national bottom lines for swimming in rivers and lakes. The revised policy also introduced a new requirement for regional council's to set targets for the length of large rivers and lakes that will be swimmable by 2030 and 2040. This report presents data for all rivers in the region, in addition to the large rivers; and
- Horizons' swim spot monitoring programme, provides weekly information on the suitability of water quality for swimming at over 80 popular swim spots around the region. Sites include rivers, lakes and beaches where staff carry out weekly monitoring of bacteria and potentially toxic algae and data is made available via the Horizons and LAWA websites.

SWIM SPOT MONITORING

WHERE WE'VE COME FROM

CRITERIA FOR ASSESSING SUITABILITY FOR SWIMMING

We recognise the importance of our communities being well informed, and that is why every week during summer we monitor over 80 swim spots across the region.

Horizons has been monitoring popular swim spots in our region for over ten years. Sites were initially selected in consultation with local council and staff from MidCentral Public Health Services. Between 2006 and 2011 the programme largely focussed efforts where there was a greater risk to public health, or at popular coastal streams and beaches. By 2011 Horizons monitored 13 sites, with a further 10 sites determined through established bacteriological indicator relationships with river flow. In 2016 the programme was expanded to over 80 sites across the region.

New Zealand employs a risk-based approach to monitoring water quality for recreation. The guiding document for advice and monitoring is the 'Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas', published by the Ministry for the Environment and Ministry of Health. As recommended by this guidance document, Horizons measures *Escherichia coli* (*E. coli*) in freshwater rivers and lakes, and enterococci at our beaches on a weekly basis from 1 November through to the 31 March. We also monitor potentially toxic algae in rivers and lakes.

		Green	Amber	Red
	Advice	Safe to swim	Caution advised	Avoid swimming
Marine	Enterococci / 100 ml	Less than 140	Between 140 and 279	Two consecutive samples of 280 and more
Freshwater	*E. coli* / 100 ml	Less than 260	Between 260 and 539	540 and more

Table 8: Human health risk in relation to enterococci and *Escherichia coli (E. coli)* is categorised for marine and freshwater in line with the 'Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas'. Source: Ministry for the Environment

Potentially toxic algae, also known as cyanobacteria or blue-green algae, are generally harmless but can produce toxins, that may cause nausea and diarrhoea. In some cases exposure to cyanotoxins has led to liver damage or even death. Dogs are particularly susceptible.

In rivers, benthic cyanobacteria form glossy black, slimy mats on rocks that have a strong musty or earthy smell. In lakes, planktonic cyanobacteria form visible green scum at the water surface, often pooling around the water's edge. Cyanobacteria are often seen in summer when temperatures are warm and river or lake levels are low.

		Green	Amber	Red
	Advice	Safe to swim	Caution advised	Avoid swimming
Lakes	Cyanobacteria biovolume (mm^3/L)	Less than 0.5	Between 0.5 and 1.8 for potentially toxic species. Between 0.5 and 10 for all species	More than 1.8 for potentially toxic species. More than 10 for all species
	Other criteria	Less than 500 cyanobacteria cells/ml		Cyanobacterial scum consistently present. More than 12 µg/L of microcystein.
Rivers	Per cent coverage of potentially toxic cyanobacteria attached to the substrate	Less than 20 %	Between 20 % and 49 %	50% or more
	Other criteria			Up to 50% coverage of visibly detaching cyanobacteria from the substrate, accumulating as scum on the river's edge or becoming exposed at low river levels.

Table 9: Human health risk in relation to potentially toxic algae (*Phormidium*), also known as cyanobacteria, is categorised for lakes and rivers in line with the 'Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas'. Source: Ministry for the Environment

MONITORING FOR POTENTIALLY TOXIC ALGAE

While we do monitor potentially toxic algae in rivers and lakes across the region, conditions can change very quickly – sometimes between our weekly visits. The best way to keep your children, pets and yourself safe from toxic algae in lakes and rivers is to know what they look like and avoid them. Fortunately, this is easy!

Potentially toxic algae in rivers are of the genus *Phormidium*. These are cyanobacteria that produce toxic substances that can be harmful for our skin and especially if ingested. In a river, these 'algae' settle on bigger rocks rather than finer gravel and sand and tend to grow in shallow water where there is plenty of sunlight.

Phormidium form a slimy, green-brown cover on the rocks. The highest risk to people and animals occurs when rocks covered with *Phormidium* mats become exposed during low flows, or when mats detach and are washed up at the river's edge. This is when they are in easy reach of children and dogs.

Phormidium mat in a river

In lakes, potentially toxic algae can be seen as bright green 'blooms'. Surface scums in a range of green and blue can also occur, and are often seen at the lake edge. These blooms and scums are not always toxic. Occasionally small cells can be seen in the water, and Horizons confirms the presence of toxic species such as *Microcystis* and *Dolichospermum* by microscope examination.

It is recommended that people avoid contact with algal blooms and scums in lakes. People with sensitive skin or allergies may experience skin irritation even when non-toxic species are present.

Cyanobacteria scum at Lake William

WHERE WE ARE NOW – CURRENT STATE

STATE AND TRENDS OF BACTERIA IN RIVERS COMPARED TO ONE PLAN TARGETS

The river quality section of the water chapter presents *E. coli* data collected from across the state of environment monitoring network compared to One Plan targets for *E. coli* related to the bathing season (1 Nov to 30 April) and year round. Essentially, these targets require *E. coli* not exceed 260MPN/100ml during the bathing season or 550 MPN/100ml during the year, subject to specified river flows. Almost all state of environment reporting sites across the region and all impact sites (downstream of point source discharges) fail to achieve these criteria.

The river quality section of this chapter also presents data on trends of a range of *E. coli* statistics and trends over recent ten and twenty-year periods. The analysis of the trend information at the 80 state of environment sites shows that over the ten-year period nine per cent were degrading and 12 per cent were improving – the rest had insufficient data to be confident about trend direction.

Trends in *E. coli* have also been analysed to determine if there was a region-wide trend in the parameter; no overall regional trend was found. Analysis of the combination of state and trends showed that for *E. coli* the largest improving trends were generally related to the sites with the worst state. The analysis also investigated the relationships between improving trends in *E. coli* in the treated effluent that is discharged from point sources and the sites directly downstream of the discharge point. The analysis concluded that there is strong evidence of regional improvements in *E. coli* associated with improvements in point source discharge quality over the past decade.

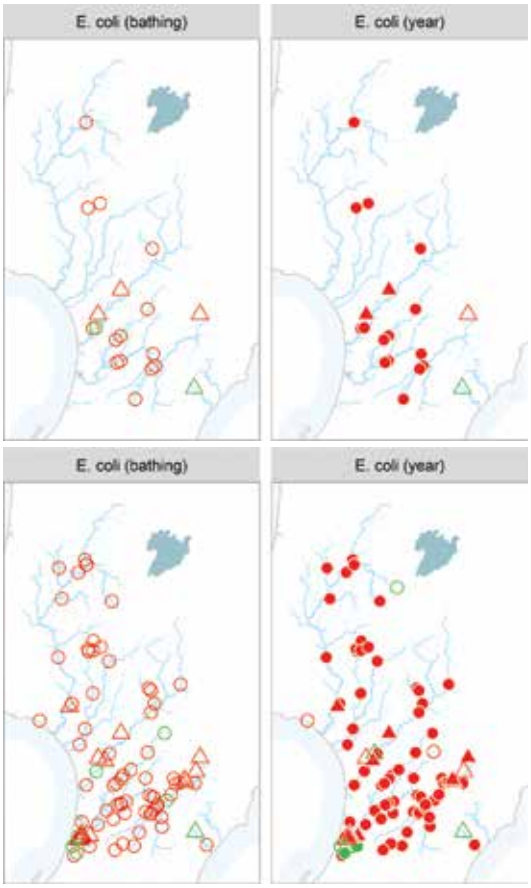


Figure 36: Maps showing current state of SoE sites (top) and Impact sites (bottom) compared to One Plan targets for *E. coli*. Results are presented for the bathing season (1 November–30 April) (left), and full year (right)

The trend analysis results showed some variability in the proportion of improving and degrading trends in *E. coli* across Freshwater Management Units (FMUs). The Manawatū Catchment has a higher proportion of degrading (67.5 per cent) than improving trends (32.5 per cent). The Rangitīkei, Whangaehu and Whanganui FMU's all showed a higher proportion of improving trends (Table 10).

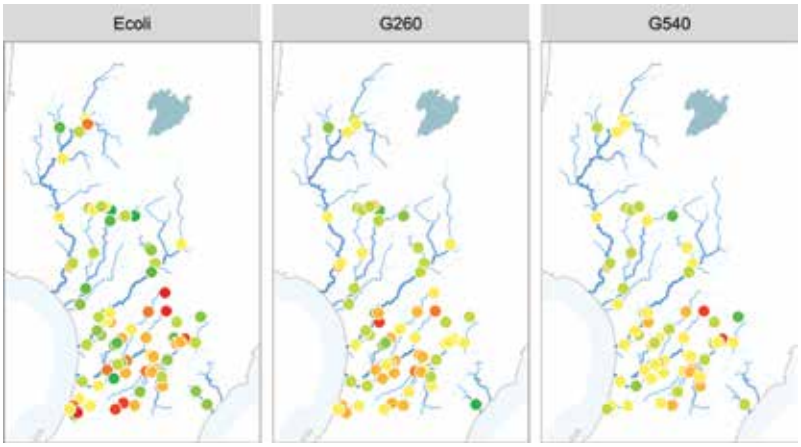


Figure 37: Probability of improvement in indicators of swimmability over ten years at SoE sites

Freshwater Management Unit	Number of sites	Proportion of degrading *E. coli* trends	Proportion of improving *E. coli* trends
Regional	80	47.5% (4%)	52.5% (4%)
East Coast	2	0% (18.9%)	100% (18.9%)
Horowhenua	6	67.7% (15.3%)	33.3% (15.3%)
Manawatū	40	67.5% (5.5%)	32.5% (5.5%)
Rangitīkei	13	23.1% (10.1%)	76.9% (10.1%)
Turakina/Whangaehu	11	18.2% (10.8%)	81.8% (10.8%)
Whanganui	8	25% (14.4%)	75% (14.4%)

Table 10: Proportion of improving and degrading trends in *E. coli* by FMU for the ten-year period from 1 July 2007 – 30 June 2017. The number in brackets is the standard error for the proportion (Fraser and Snelder, 2018)

NATIONAL TARGETS FOR SWIMMABILITY

The National Policy Statement for Freshwater Management (as amended in August 2017) directs all regional councils and unitary authorities to set regional targets to improve the quality of fresh water so they are suitable for swimming more often. Council recently resolved to set a target of 70 per cent for swimmable rivers and lakes in the Horizons Region, to be achieved by 2030.

A regional assessment for Horizons completed by LWP Ltd shows that swimmability in the region has improved in the past ten years. Between 2006 and 2016, the length of all of the region's rivers in the swimmable category (grades 'fair' to 'excellent') increased from 35 per cent to 40 per cent, while large rivers (order 4 and above) increased from 34 per cent to 42 per cent. This broadly aligns with regional and national modelling that suggests the length of the region's large rivers are presently around 38-45 per cent swimmable.

While modelling is associated with a degree of uncertainty, this regional assessment suggests that we will see further improvement in swimmability of up to 60 per cent (over the 12 years to 2030) as a result of work already underway. It is important to note that this modelling does not account for other factors that may influence swimmability, such as climate change, economic or social drivers, or future changes in policy.

While Horizons' existing rate of investment in better water quality is high, swimmability remains below the national average and further investment in water quality improvement will be necessary if we are to meet our year-round regional target of 70 per cent by 2030 and 80 per cent by 2040. An additional goal of 90 per cent of large rivers and lakes being suitable for swimming by 2040 has been set for the swimming season.

WHAT WE'RE DOING

In 2016-17, Horizons' Swim Spot programme increased from 17 to over 80 sites across the region and currently includes 66 river and estuary sites, 11 beaches and 5 lakes or lagoons.

REGIONAL SWIM SPOT MONITORING CASE STUDY

Summer swim spot monitoring shows that our beaches are generally lower risk than rivers for bacterial contamination during the bathing season. During 2017-18, ten out of 11 beaches were suitable for swimming at least 84 per cent of the time and four beaches were swimmable throughout the entire season. Water quality at beach sites along the western coast (from Manawatū to Horowhenua) were occasionally affected by high sediment and bacteria inputs from rivers during and after rain, which lead to some occasions when swimming was not advised at these sites.

During 2017-18 most sites were swimmable for the majority of the summer. For our rivers, 42 of 66 sites were swimmable more than 60 per cent of the time, 24 sites were swimmable more than 75 per cent of the time, and three sites were swimmable more than 90 per cent of the time. Hot, sunny weather throughout the summer of 2017-18 did lead to growth of potentially toxic algae (*Phormidium*). Many rivers with otherwise good water quality such as the Ohau and Pohangina, as well as the Mangatainoka and Mangahao, had extended periods when swimming was not advised due to the presence of *Phormidium*.

2019 #swiminourregion winner, Mangawhero River in Ohakune

WHERE WE'RE GOING AND WHAT YOU CAN DO

Horizons Regional Council has accelerated its programmes to complete physical works to improve swimmability of the region's rivers over recent years through a range of partnership projects. Many of these projects have applied for and secured government funding to be used alongside local funding, including ratepayer and landowner funding. The programmes include:

- Two Freshstart for Freshwater Clean-up projects (Manawatū Catchment and Lake Horowhenua Catchment);
- Four Te Mana o te Wai projects (Manawatū Catchment, Lake Horowhenua, Rangitīkei Catchment and Kai Iwi Catchment);
- The Sustainable Land Use Initiative (region-wide); and
- Four Freshwater Improvement Fund projects (Manawatū, Lake Horowhenua, Whangaehu, and Lake Waipu near Ratana).

In response to the additional funding from the Freshwater Improvement Fund for projects that started this year, Council increased staffing and provided additional ratepayer funding to enable stream fencing and planting grants to be provided in catchments where there is not a Freshwater Improvement Fund project. Council has also enabled the use of reserve funding to complete additional fencing and planting grants in recent years, including this year for both the Freshwater and SLUI programmes.

There are actions within the Freshwater and Partnerships programme beyond the fencing and planting that contribute to improved swimmability of the region's waterways including work to improve discharges of treated wastewater to water and funding to transition these to discharges to land.

The regulatory programmes of Horizons, combined with the efforts of local landowners and other agencies, also contribute to improvements in swimmability in the region.

The programmes to improve swimmability and applications for funding are underpinned by the data collected across the monitoring programmes. Faecal source tracking is used in catchments where *E. coli* is identified as an issue to determine the source of the bacteria and guide the interventions required.

Piripiri swim spot, Manawatū

APPENDIX A

Surface water quality parameters measured by Horizons. Those referred to in this report are highlighted in grey.

Variable type	Variable name	Description	Units
Physico- Chemical	CLAR	Black Disc Visibility	m
	Cond	Field Conductivity	µS cm^{-1}
	DO_Conc	Field Dissolved Oxygen Concentration	g m^{-3}
	DO_Sat	Field Dissolved Oxygen Saturation	%
	DRP	Dissolved Reactive Phosphorous	g m^{-3}
	NH_4-N	Ammoniacal Nitrogen	g m^{-3}
	NO_2-N	Nitrite	g m^{-3}
	NO_3-N	Nitrate	g m^{-3}
	pH	Field pH	pH
	POM	Volatile Matter	g m^{-3}
	SHMAK	SHMAK Tube	m
	SIN	Soluble Inorganic Nitrogen	g m^{-3}
	SSC	Suspended Sediment Concentration	g m^{-3}
	TDP	Total Dissolved Phosphorus	g m^{-3}
	Temp	Field Temperature	°C
	TN	Total Nitrogen	g m^{-3}
	TO_x-N	Total Oxidised Nitrogen	g m^{-3}
	TP	Total Phosphorous	g m^{-3}
	TSS	Total Suspended Solids	g m^{-3}
	TurbEPA	Turbidity EPA	NTU
	TurbISO	Turbidity ISO	NTU
	TurbISO-NTU	Turbidity ISO-NTU	NTU
Microbiological	Ecoli	*E. coli* by MPN	MPN 100mL^{-1}
	Entci[a]	Enterococci	MPN 100mL^{-1}
Biological	Chl_a[a]	Chlorophyll-*a*	mg Chl-a m^{-3}
	Chla	Chlorophyll-*a* (cover)	mg Chl-a m^{-2}
	Cyano	Cyanobacteria cover	%
	Fils	Filamentous Periphyton cover	%
	Mats	Mat Periphyton Cover	%
	MCI	Macroinvertebrate Community Index	MCI
	NoInd	Count: No of Individuals	no.
	NoTaxa	Count: No of Taxa	no.
	pEPT_A	Count: % EPT Abundance	no.
	pEPT_R	Count: % EPT Richness	no.
	QMCI	Quantitative Macroinvertebrate Community Index	QMCI

Notes: [a] these variables are not measured at river sites

GLOSSARY

Abstraction: the act of taking water from a water body such as an aquifer, river or stream.

Airshed: a geographical area where air quality could exceed national air quality standards. These areas are identified based on existing air quality data and factors that affect the spread of pollution such as local geography and weather.

Aquifer: an underground layer of water-bearing rock or sediment.

Awa: the Māori name for river

Biodiversity (short for biological diversity): The number and variety of living things found in a particular habitat or ecosystem.

Biosecurity: the management of pest plants and pest animals that affect economic, amenity or environmental values.

Bore: a hole that is dug or drilled into the ground for the purposes of extracting groundwater, monitoring groundwater levels, or monitoring groundwater quality.

Bush remnants: areas of native bush

Catchment: An area bounded by natural features such as hills or mountains from which surface and sub-surface water flows into streams, rivers, lakes and wetlands.

Chlorophyll *a*: a pigment present in most algae and plant species that is crucial for photosynthesis. Chlorophyll *a* provides a surrogate measure of biomass or rate of growth of species such as periphyton.

Climate: average weather conditions over a long period (generally 30 years or more).

Climate Change: the change in climate over long periods due to a combination of natural and human causes.

Core allocation limit: the total volume of water that may be abstracted from a water body at flows above the minimum flow.

Cropping: an area of land used to grow crops such as cereal, grains or peanuts. Horizons' One Plan specifies a minimum area of 20 hectares to define cropping and does not include crops grazed by or fed to animals.

Cyanobacteria: also known as blue-green bacteria, blue-green algae, and *Cyanophyta*, these are bacteria-like organisms that obtain their energy through photosynthesis.

Dairy farming: under Horizon's One Plan, this is defined as any area of land in excess of four hectares for the farming of dairy cattle for milk production.

Diatom: a microscopic single-celled marine or freshwater algae.

Drought: prolonged periods of below-average precipitation, resulting in water shortage, which can last for weeks, months or even years.

Ecology: the study of how organisms interact with one another and their physical environment.

Endemic: a species that is indigenous only to a certain area.

Erosion: process by which earth and soil is worn away by the action of water, wind, river flow or other elements.

Escherichia coli (E. coli): a type of faecal bacteria commonly found in the intestines of humans, other warm-blooded mammals and birds, and is normally excreted in their waste.

Fluvial: the physical interaction between flowing water and the natural deposits and landforms associated with rivers and streams.

Freshwater: naturally occurring water that includes ice, glaciers, lakes, rivers streams and groundwater, but excludes seawater or brackish water.

Freshwater Improvement Fund (FIF): the New Zealand Government has committed $100 million over 10 years to improve the management of New Zealand's freshwater. The Fund supports projects, with a total value of $400,000 or more, that help communities manage freshwater within environmental limits.

Geology: the study of earth, the rocks of which it is composed, and the processes by which it forms.

Greenhouse gases: gases such as water vapor, carbon dioxide, methane, nitrous oxide and ozone that can trap heat and contribute to climate change.

Groundwater Management Zone (GWMZ): an area defined in Horizons' One Plan (Schedule D) to which a specific allocation limit is either applied or unspecified.

Headwaters: the upper reaches of a river close to or forming part of its source.

Hill country: country side that predominantly consists of hills for grazing, rather than flat areas

Highly Erodible Land (HEL): land classified as having moderate to severe risk of erosion due to landslide, earthflow or gully erosion.

Hydrology: the study of earth's water and its movement, particularly in relation to land.

Indigenous (biodiversity, ecosystems): the living organisms, habitats, and ecosystems that are naturally found in the Region or in New Zealand.

Intensive sheep and beef farming: under Horizons' One Plan this refers to properties greater than four hectares engaged in the farming of sheep and cattle, where any of the land grazed is irrigated.

Introduced (species): living organisms that are not native to New Zealand but were transported here, deliberately or accidentally, by humans.

Intergovernmental Panel on Climate Change (IPCC): a United Nations body for assessing the science related to climate change.

International Accreditation New Zealand (IANZ): New Zealand's accreditation body that provides recognition of competence, integrity and reliability for organisations carrying out measuring and testing.

Land, Air, Water Aotearoa (LAWA): a website established by regional councils and unitary authorities for sharing environmental data and information.

Macroinvertebrate: aquatic animals such as insects, worms and snails.

Macroinvertebrate Community Index (MCI): an index that provides us with information on water quality based on the number and type of macroinvertebrates found at a site. It is calculated by assigning a score to aquatic species depending on their tolerance to organic enrichment.

Mana: legitimacy to act in an authoritative and responsible capacity; prestige.

Matauranga Maori: a way of being or engaging in the world that draws on a combination of kawa (cultural practices) and tikanga (cultural principles) to provide knowledge, comprehension or understanding.

Mauri: essential life force or principle; a metaphysical quality inherent in all things animate and inanimate.

Median: a statistic that is the middle number in a set of numbers ordered from highest to lowest.

Minimum flow: in relation to surface water allocation, this is the measured flow in the river at which non-essential abstractions must cease.

Model: a representation of a process or system used to describe complex data and relationships.

National bottom line: Under the National Policy Statement for Freshwater Management (amended 2017) this is defined as the minimum acceptable state for specified compulsory values.

National Environmental Monitoring Standards (NEMS): documents that prescribe technical standards, methods and other requirements to provide consistency in the way environmental monitoring data is collected and handled throughout New Zealand.

National Objectives Framework (NOF): a national framework which guides regional decision-making in the setting of freshwater objectives and limits.

National Policy Statement (NPS): policy documents that set out objectives and policies for matters of national significance, such as freshwater management, coastal policy, and indigenous biodiversity (the latter is in development).

Naturalised (species): an introduced species that has formed self-sustaining and persistent populations.

Natural resource: materials or substances occurring in nature, such as air, land and water, which can be used for economic gain.

Non-point source (diffuse): contaminants that cannot be easily defined as originating from a particular point or activity but are derived from the surrounding landscape. Diffuse contaminants can include run-off from agricultural and urban landscapes and leaching from activities such as agriculture, unlined waste stabilisation ponds and landfills.

Non-regulatory: non-legislated approaches to environmental management.

One Plan: Horizons Regional Council's combined resource management plan and policy statement for the next ten years. It sets out policies and rules around the way in which we interact with our natural environment in order to balance the need to use natural resources for economic and social wellbeing while keeping the environment in good health.

Over-allocation: a situation where the resource has been allocated to users beyond a specified limit. Under the National Policy Statement for Freshwater Management, this also refers to a situation where the resource is being used to a point where a freshwater objective is not being met.

Parameter: (or variable) refers to a physical, chemical or biological measure, such as temperature, dissolved oxygen or nitrogen.

Paris Agreement: a global agreement on climate change mitigation and adaptation, requiring countries to determine, plan, and regularly report on the contribution that it undertakes to mitigate global warming.

Particulate Matter (PM): gases, liquids and other particles found in the air.

Pest: means a pest as defined in the Biosecurity Act 1993.

PM_{10}: a measure of air quality, PM^{10} is particulate matter that is less than 10 microns in diameter.

Pathogen: a bacterium, virus, or other microorganism that can cause disease.

Periphyton: the collective of diatoms, fungi and algae found on the beds of rivers and streams.

Podocarp: southern hemisphere conifer species such as tōtara, matai, miro, kahikatea and rimu.

Point-source discharge: a discharge that can be attributed to a specific outlet such as a pipe or drain and can be sampled for physical, chemical and biological components.

Pole planting: an unrooted tree stem which will grow into a tree when planted.

Possum Control Operation (PCO): an overarching operational and management programme that seeks to control possum numbers within defined possum control areas.

Precipitation: a component of the water cycle that distributes fresh water on the plant. Types of precipitation include rainfall, snow, hail and sleet.

Rangi: Maori word for sky, air

Regulatory: comprising rules and requirements, such as standards and practices, associated with environmental management many of which are established through legislation.

Resource Management Act (RMA): New Zealand's main piece of legislation which sets out how we should manage our environment.

Riparian planting: trees and plants planted alongside waterways to act as a margin between land and water

River catchment: all the land from the mountains to the sea that is drained by a single river and its tributaries.

Seawater intrusion: the movement of saline water into coastal freshwater aquifers due to natural processes or human activities.

Sediment: soil or other fine-grained weathered rock

SedNetNZ: a model developed by Manaaki Whenua – Landcare Research that provides sediment budgets and predicts sediment supply from erosion.

Significant trend: a trend that is statistically significant (within a 5% margin of error) but with a rate of change less than 1% per year.

State: the average condition of an environmental variable for a given period of time. For water quality indicators this is often the average concentration over five, ten or twenty years.

Substrate: the surface or material on or from which an organism lives, grows, or obtains its nourishment. Including stones, rocks, gravel, logs and sediment on the river bed that provide a home for fish and insects.

Surface water: water that collects on and moves across land, for example streams, rivers, lakes and wetlands.

Sustainable Land Use Initiative (SLUI): a mountains to the sea approach to managing erosion on hill country farmland.

Target: Under Horizons One Plan a target is defined as an objective or result for water quality towards which efforts are directed. The National Policy Statement for Freshwater Management (amended 2017) defines a target as a limit which must be met at a defined time in the future, and only applies in the context of over-allocation.

Telemetry: an automated means of returning environmental monitoring or water use data to Horizons via the cell-phone network.

Te Mana o te Wai: recognises the connection between water and the broader environment.

Trend: a pattern determined by the statistical analysis of a data series, often representing change over time.

Tributary: a stream that flows into a larger stream or body of water.

Upgrade: bringing a programme, structure, system or facility up to date, or improving its functional characteristics.

Value: a mathematical variable or number

Water management zone (WMZ): for the purposes of managing water quality, water quantity and the activities in the beds of rivers and lakes, the river catchments in the region have been divided into 43 water management zones and 124 sub-zones (WMSZ). Groundwater has been divided into ten Groundwater Management Zones (GWMZ).

Water take: the abstraction of water from a waterbody for use.

Whakapapa: genealogy in a wider context, encompassing how one identifies with people and place.

Whenua: Maori word for land.

Whole Farm Plans (WFPs): a farm-scale plan that addresses farm design and management, combining strategies to maximise production within environmental constraints.

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AUTHORS (IN ALPHABETICAL ORDER):
Barnett H, Binsted S, Bocker E, Boyte S, Collins S, Daly E, Gemmell M, Hesselin C, Hurst I, Kamke J, Matthews A, Mercer R, Morrison C, Patterson M, Patterson M, Prouse E, Robb J, Roygard J, and Todd M.

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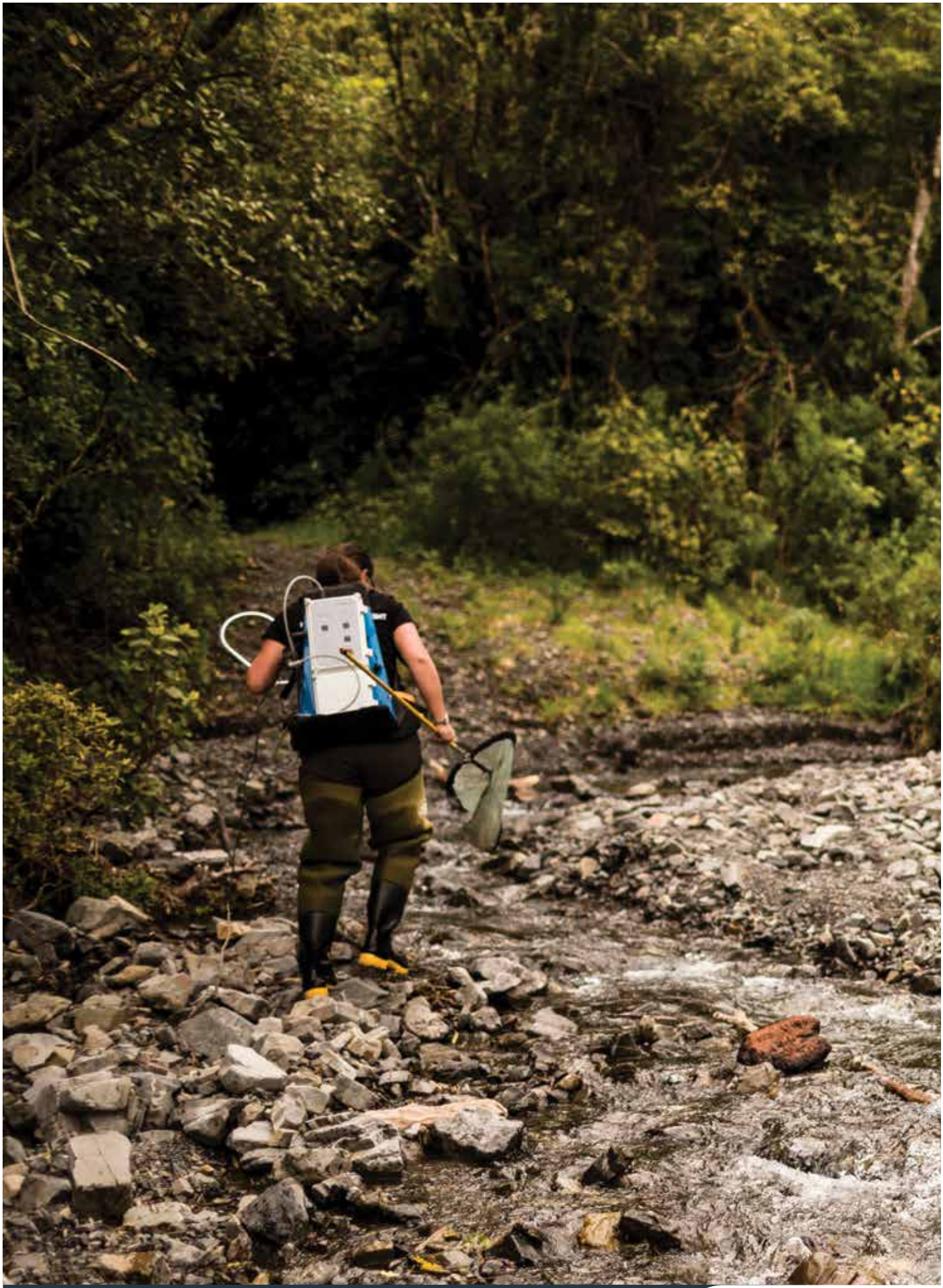

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