Hawke's Bay Trends

THE STATE OF OUR ENVIRONMENT

Summary Report
2009-2013

Front Cover: Southern North Island Forest Gecko *Mokopiririakau* - see page 114.

HBRC Plan No. 4734
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INTRODUCTION BY FENTON WILSON,

CHAIRMAN OF HAWKE'S BAY REGIONAL COUNCIL

There are many facets to the Hawke's Bay environment - the air we breathe, the weather influencing our business and leisure, the Pacific Ocean we swim and fish in, the land where we grow our food, and the wetlands, rivers and aquifers that supply us with water and special habitats for wildlife.

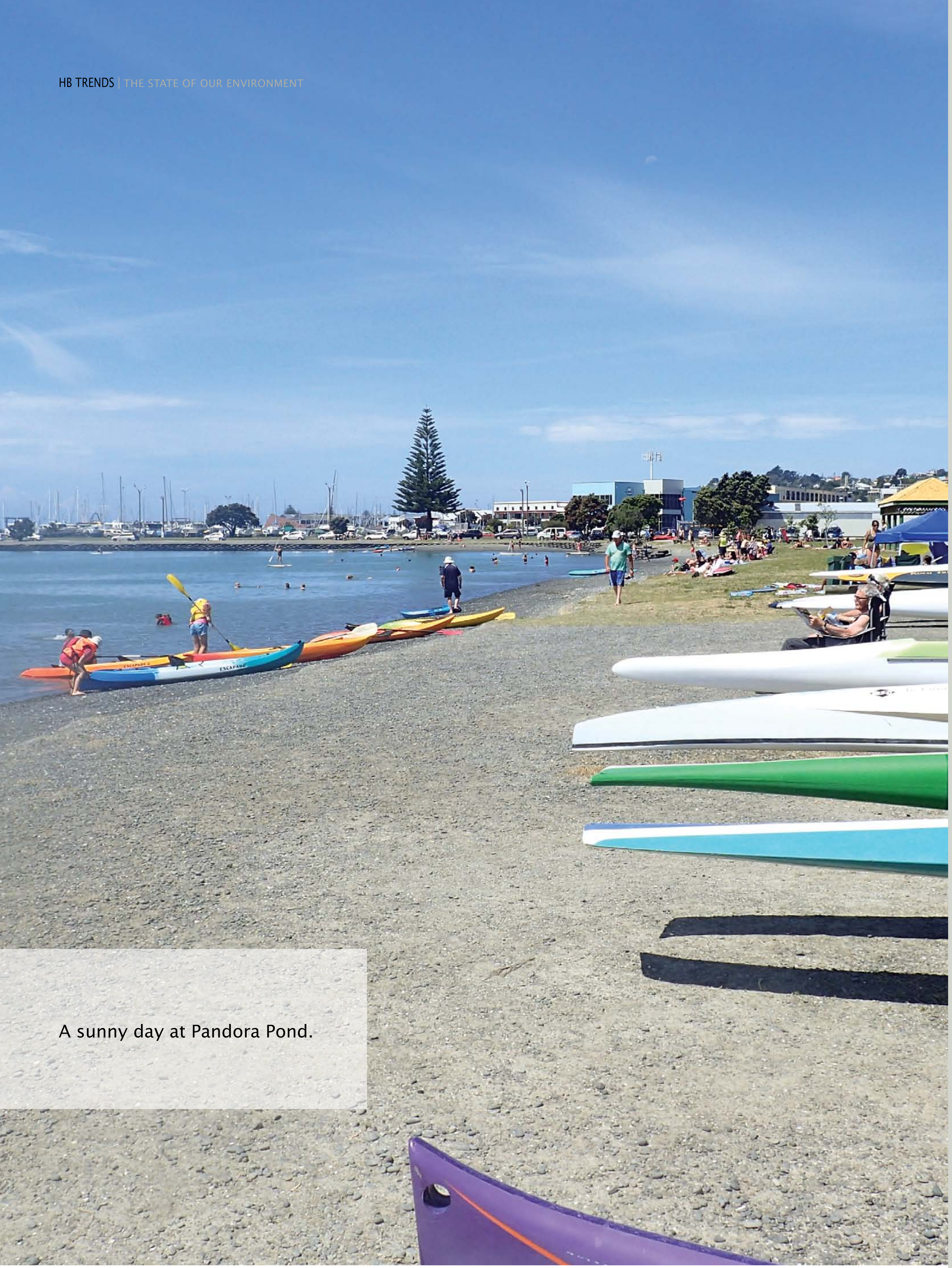
The stewardship of your regional council maintains and improves the Hawke's Bay environment so that it is healthy and supports people and the species we value.

The regional council monitors the state of our environment through a wide range of programmes. Some of our monitoring was established many decades ago. For example, rainfall monitoring sites were first established in the 1930s, while river monitoring started in the 1950s and groundwater monitoring in the 1960s. We also use data supplied by farmers and water users, research organisations and other agencies.

More recently, advances in instrument technology and communications have allowed us to monitor a wider range of environmental conditions, more frequently, more precisely, and at lower cost. For example, we now remotely monitor ocean water quality with HAWQi (see page 125), when just a decade ago this sort of equipment would have been too expensive for us to buy and operate in Hawke Bay.

Much of our environmental data is available from our website (www.hbrc.govt.nz). Here you can obtain, in near real time, much of the environmental data we collect from our extensive region wide network of monitoring sites. In addition we are moving more of our real-time environmental data to the Land Air Water Aotearoa (LAWA) website (www.lawa.org.nz). LAWA has information on water quality in our rivers and around our bathing beaches and is adding real time data on water quantity and air quality. We can also keep you up to date with events and news via the LAWA website.

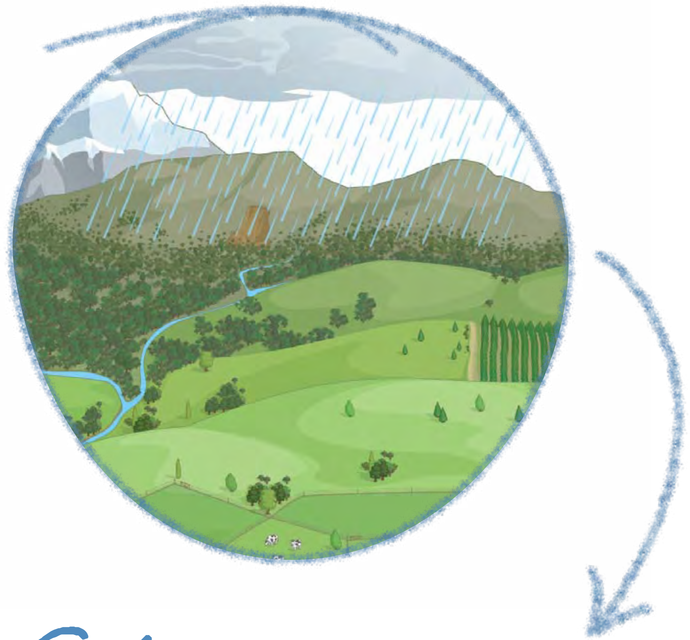
I hope this publication provides you with useful information on aspects of the Hawke's Bay environment that affect you – at home, in your local community, and at work. If you'd like to find out more, a series of more in-depth technical reports are available on our website, or on request.



A sunny day at Pandora Pond.

index

A plume of smoke demonstrates the inversion layer above the Heretaunga Plains early one spring morning.



Climate & Air Quality

Hawke's Bay has a usually temperate climate – neither too cold, nor too wet – but with occasional hot days in summer.

In Napier the number of hot days each year has increased and the number of cold days has decreased in the last 75 years. Notable weather events in the last five years include the drought of 2012-2013, and the April 2011 storm, which affected the southern Hawke's Bay coastline most severely.

Air quality has improved in Hastings and Napier over the last five years, although domestic heating is still the major contributor of fine particulates in the air causing winter pollution.

Open fires have been banned and older wood burners are progressively being replaced with more efficient appliances, and HBRC provides funding assistance through the HeatSmart programme.

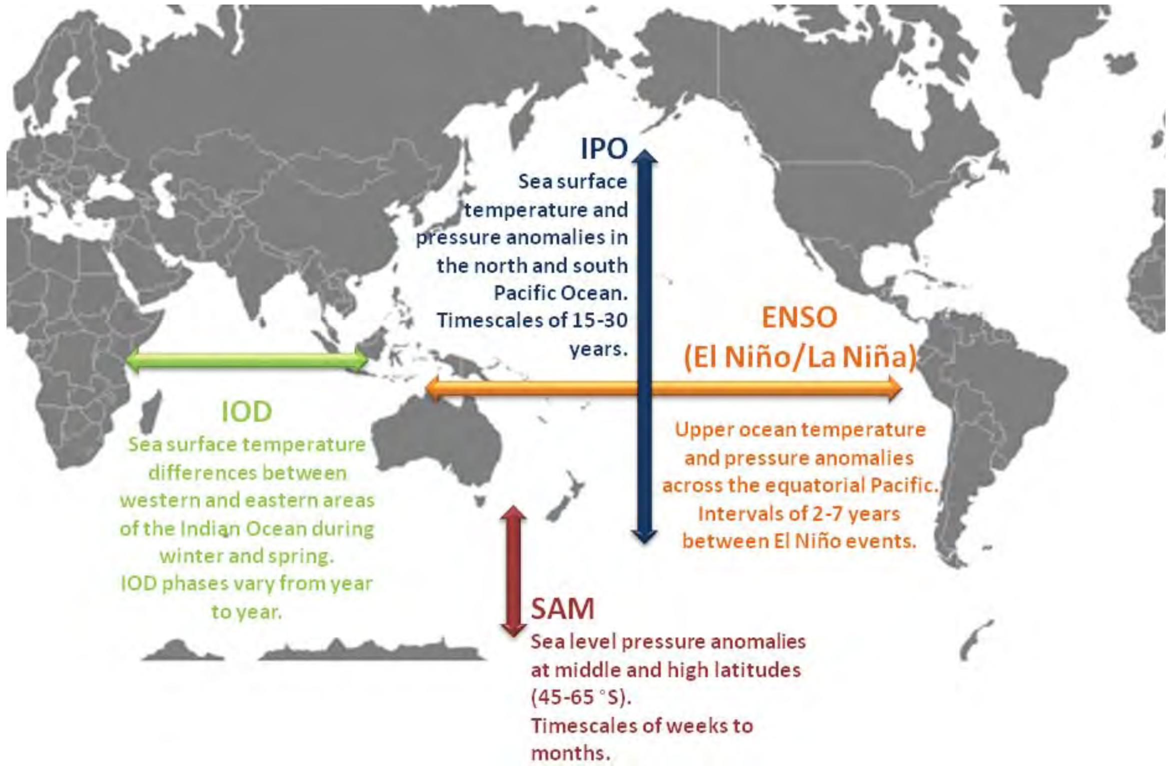
Circulation Patterns & Climate Trends

New Zealand's weather is influenced by cycles in large-scale circulation patterns which affect the strength of the westerly flow that prevails over New Zealand and the track taken by storms around the southern hemisphere.

These cycles are the El Niño-Southern Oscillation (ENSO), the Inter-decadal Pacific Oscillation (IPO), the Southern Annular Mode (SAM) and the Indian Ocean Dipole (IOD), (Figure 1).[1] The influences these circulation patterns have on the climate of Hawke's Bay are briefly summarised in Table 1.

The phases of ENSO are measured by the pressure difference between Tahiti and Darwin. The warm or negative phase is called El Niño and the cool or positive phase is known as La Niña. El Niño events strengthen the westerly flow over New Zealand and this increases the chance of drought in Hawke's Bay. Winds from the northeast, which often bring rain to the east coast, are more prevalent in La Niña phases. El Niño events occur every four and half years on average but the interval between events ranges between two and seven years.

Figure 1: Atmospheric circulation patterns influencing the climate of New Zealand.



The IPO is a 15 to 30 year cycle in atmospheric pressure and sea surface temperature in the central North Pacific Ocean. El Niño events are more likely to occur during positive IPO phases and La Niña events are more common in negative phases. The IPO has been in a negative phase since 1999. In the last five years, ENSO conditions have been mostly neutral, apart from one La Niña event in 2010-11 (Figure 2). Rainfall was higher than usual along coastal parts of Hawke's Bay during that event, especially in April 2011, when parts of our coastline were hit by the Easter storm.

The SAM (also known as the Antarctic Oscillation) refers to the position of the belt of westerly winds that lies around the middle to high latitudes of the southern hemisphere. It moves north during negative phases, bringing more wind to the country and a greater number of rain-bearing fronts. Positive phases shift the westerly belt closer to Antarctica, when New Zealand experiences more settled weather. The SAM changes phase from week to week and in the last five years positive phases were more common than negative phases. Positive phases are associated with less rainfall and higher temperatures over the west coast of the country but its influence on the weather of eastern regions, such as Hawke's Bay, is less clear and not statistically significant.[2]

The IOD relates to patterns in sea surface temperature across the Indian Ocean. Its phases are thought to influence the track that storms take over New Zealand, mainly during winter and spring. The positive phase of the IOD suppresses storm activity over northern New Zealand and the opposite is true for the negative phase[1]. Over the past five years there was one negative phase, two positive phases and two years of neutral conditions. The negative phase coincided with the La Niña event in 2010 and this was a period of high rainfall for parts of Hawke's Bay. The two positive phases were in 2011 and 2012. The spring season in each year was drier than usual across most of the region.

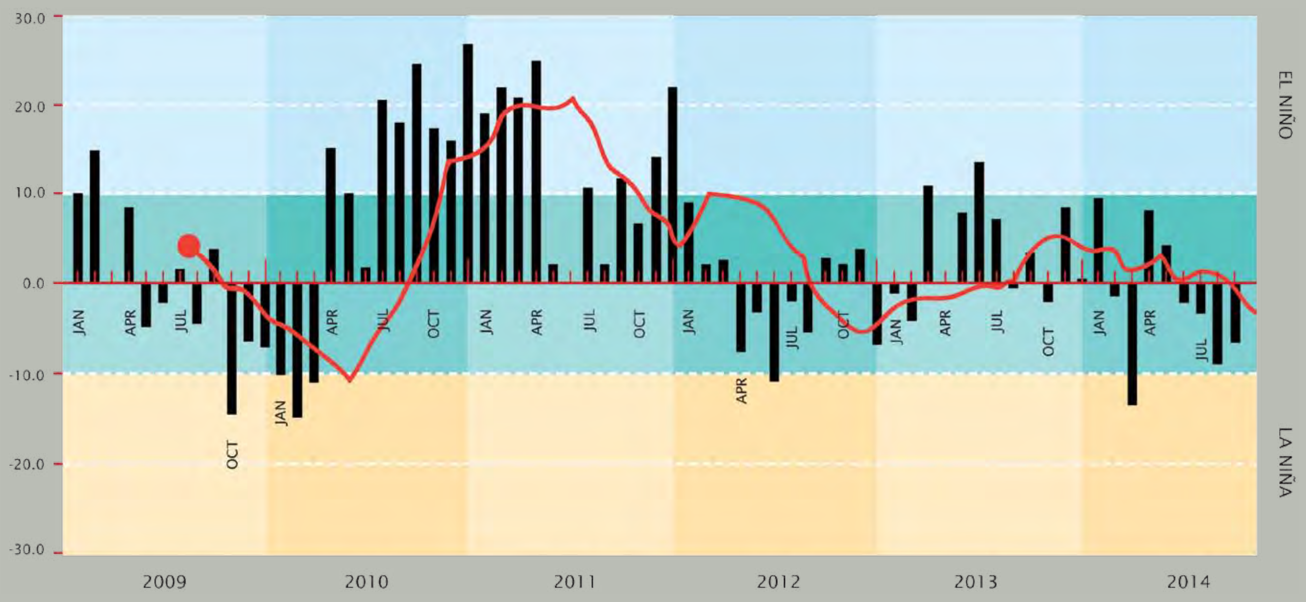
Table 1: Typical relationships between the state of large-scale circulation patterns and regional climate. The relationships described do not occur with every event but occur 'on average'.

CIRCULATION PATTERN	CLIMATE CONDITIONS
IPO	Higher annual average rainfall in Hawke's Bay during negative phases than in positive phases.
ENSO	Cooler than normal winters and drier than normal summers in Hawke's Bay during El Niño (negative phase). Warmer, wetter conditions in La Niña (positive phase).
SAM	The influence on east coast regions is unclear and a stronger relationship exists with west coast weather.
IOD	May bring drier spring weather to Hawke's Bay in positive phases and higher rainfall in negative phases but the relationship is not well established.

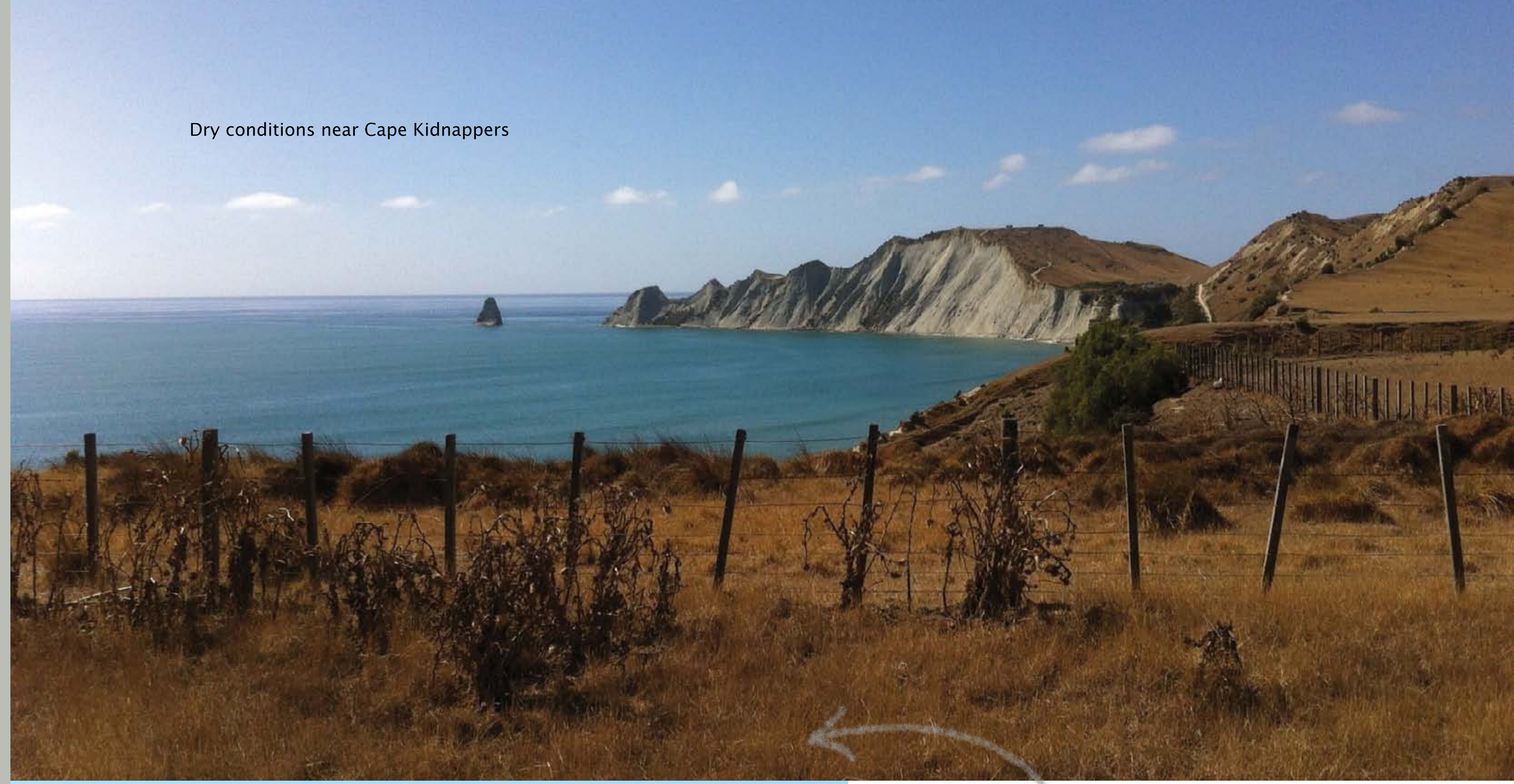
Trends

Seasonal and year to year changes in weather can mask long-term trends in climate. Climate records from the weather station in Napier's Nelson Park since 1940 were analysed for trends in temperature and rainfall. A total of 27 temperature and rainfall indices were examined and only a few showed small but statistically significant changes over time. The annual number of hot days (temperatures over 25˚C), warm spell duration and the diurnal (day-night) temperature range appear to be increasing. The annual number of cold days (maximum temperature less than 10˚C) is decreasing. Trends are not as obvious in the rainfall record and only a weak upward trend in rainfall intensity was detected.

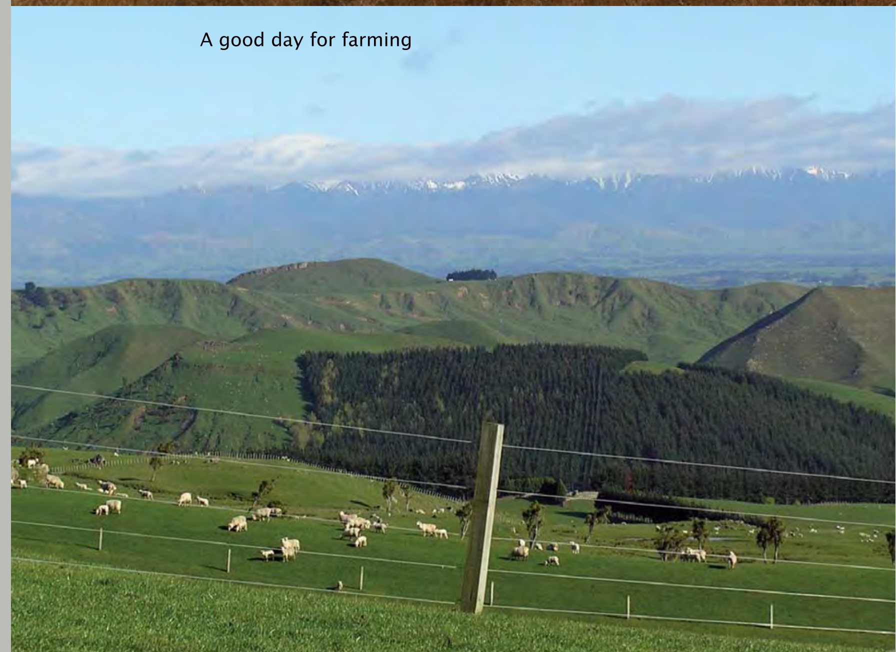
Figure 2: Monthly averages of the Southern Oscillation Index since 2009 and the six month running mean (red line). Sustained positive values above 10 indicate a La Niña event and sustained negative values below -10 indicate an El Niño event. A strong La Niña event occurred from 2010-2011. The monthly values were sourced from the Bureau of Meteorology, Australia.



[1] Griffiths, G., 2011. Drivers of extreme daily rainfalls in New Zealand. Weather and Climate, 31, p24-49.
[2] Renwick, J., and Thompson, D., 2006. The Southern Annular Mode and New Zealand climate. Water and Atmosphere, 14(2), p24-25.



Dry conditions near Cape Kidnappers

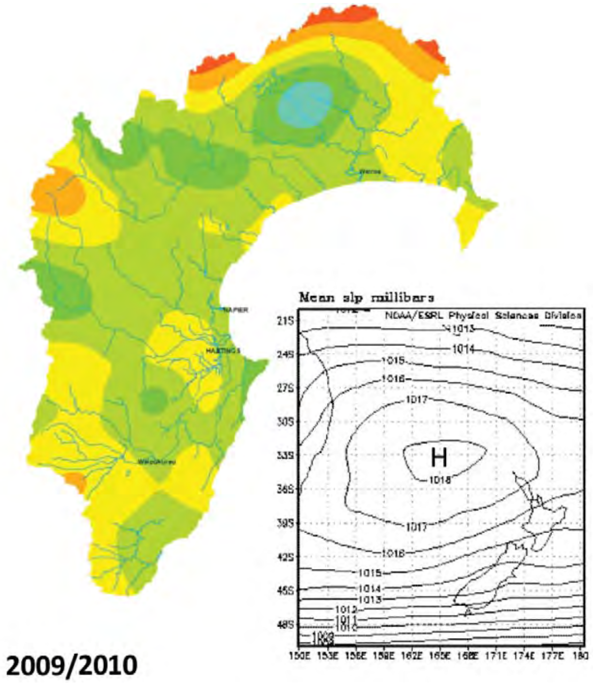


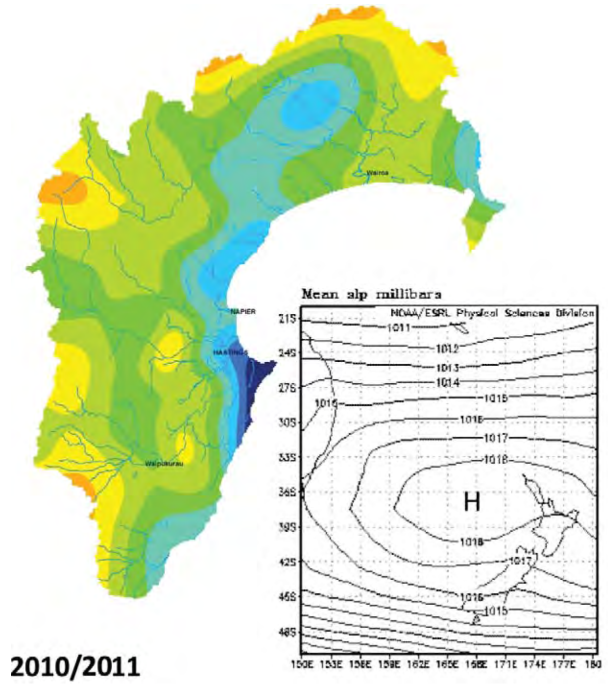
A good day for farming

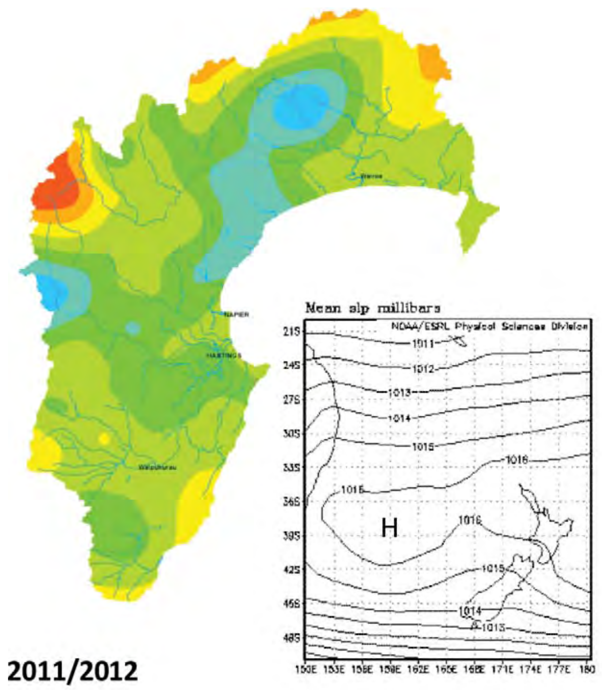
Seasonal and year to year changes in weather can mask long-term trends in the climate.

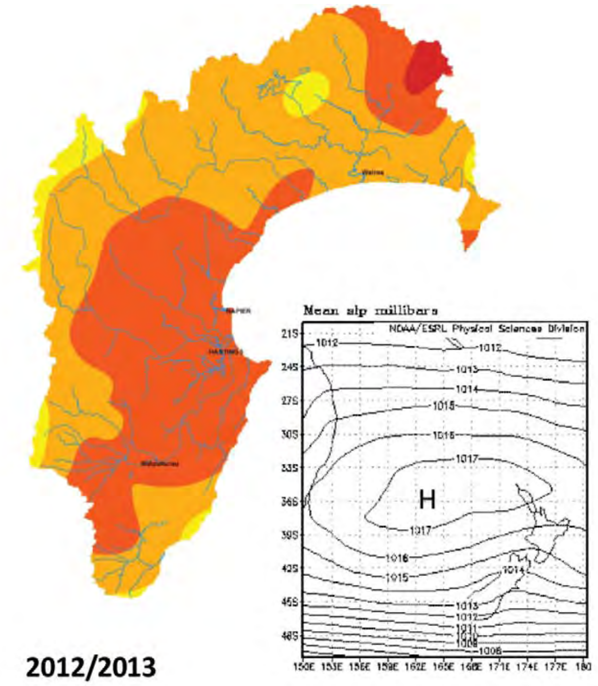
Wet days on the plains - flooding of the Ngaruroro River

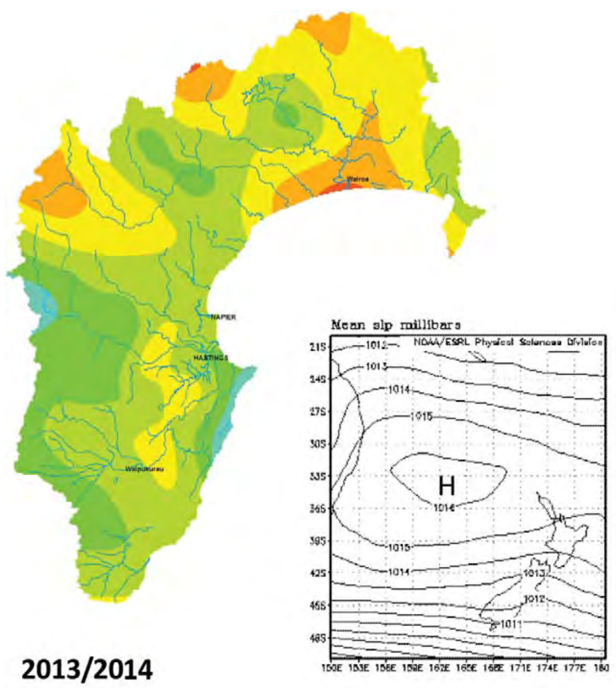
Winter snowfall











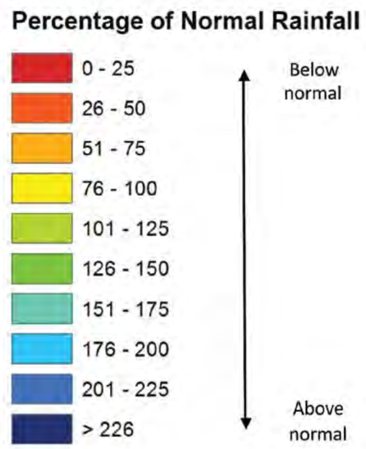


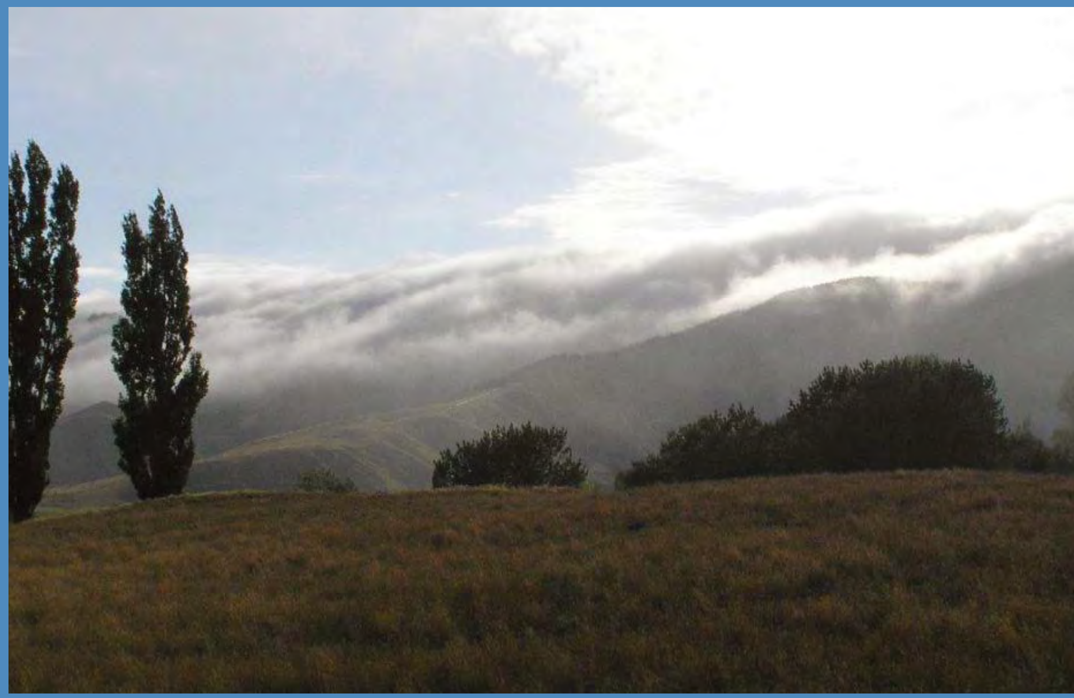
Figure 3: Regional rainfall summary and mean sea pressure level charts (1 October to 30 April) 2009-2014. Rainfall totals are compared to a 30 year average (1970-2000). Mean sea level pressure is averaged over the October to April period.

Rainfall

Annual rainfall totals during 2009-2014 were very close to the thirty year average. Rainfall during the peak irrigation season, which typically runs from October through to April the following year, was mostly near to above normal (Figure 3). The notable exception was a widespread drought in 2012/2013, with only 50 percent of the annual average rainfall recorded. Drier than usual weather affected northern Hawke's Bay again in 2013/2014.

Coastal areas, especially Cape Kidnappers southward, experienced well-above normal rainfall in 2010/2011 and 2013/2014. Severe weather (greater than 100 mm in 24 hours) occurred in October 2010 and again when ex-tropical Cyclone Wilma hit the country in January 2011, but the heaviest rain fell in April 2011 (see the case study page 14).

In the 2013/2014 irrigation season, severe weather occurred in November but then not again until April, when ex-tropical cyclones Lusi and Ita both brought significant rainfall to the southern coast.



EXTREMES 2009-2013

Temperature

HOTTEST
37.3 ˚C

Wairoa town
- North Clyde
(NIWA)
2 Feb 2009

COLDEST
-10.1 ˚C

Taharua
5 June 2009

Wind

STRONGEST AVERAGE WIND SPEED
80 km/h

Cricklewood
(inland of
Wairoa town)
11 Sept 2013

STRONGEST WIND GUST
143 km/h

Cricklewood
11 Sept 2013

Temperature & Wind

Annual average maximum and minimum air temperatures across Hawke's Bay in the last five years were mostly near the long term average (within 0.5˚C), except in 2013 when they were warmer than usual and in 2012 when maximum temperature was below average (Figure 5).

Wind speed and wind direction are measured at HBRC's climate stations; the example shown in Figure 6 is for the Marewa climate station in Napier.   Warmer weather in 2013 can be attributed to few southerly and southwest winds and an increase in typically warmer northwesterlies.

Figure 4: Location of climate monitoring sites - Taharua, Cricklewood and Wairoa North Clyde (see box, left).

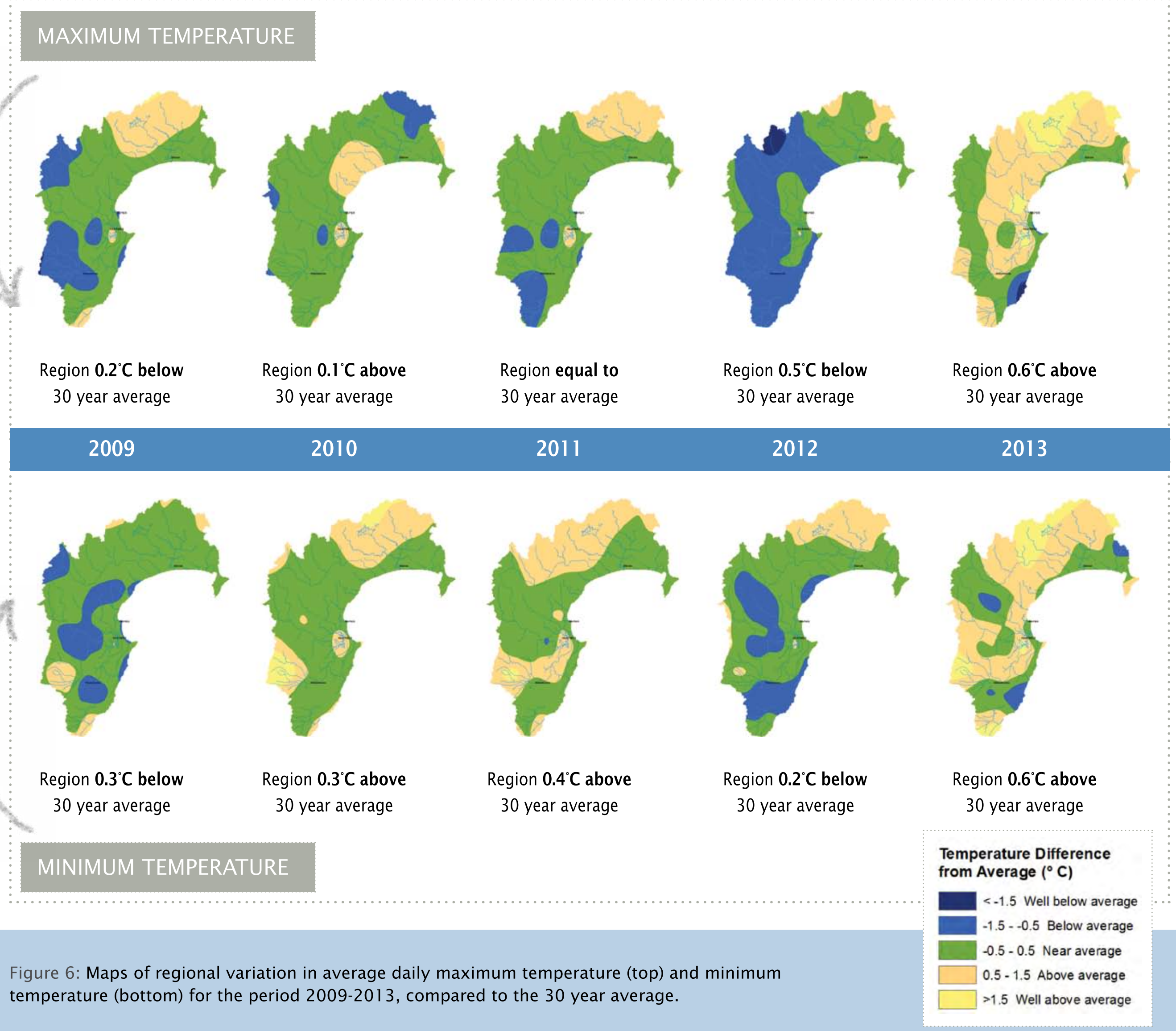


Figure 6: Maps of regional variation in average daily maximum temperature (top) and minimum temperature (bottom) for the period 2009-2013, compared to the 30 year average.

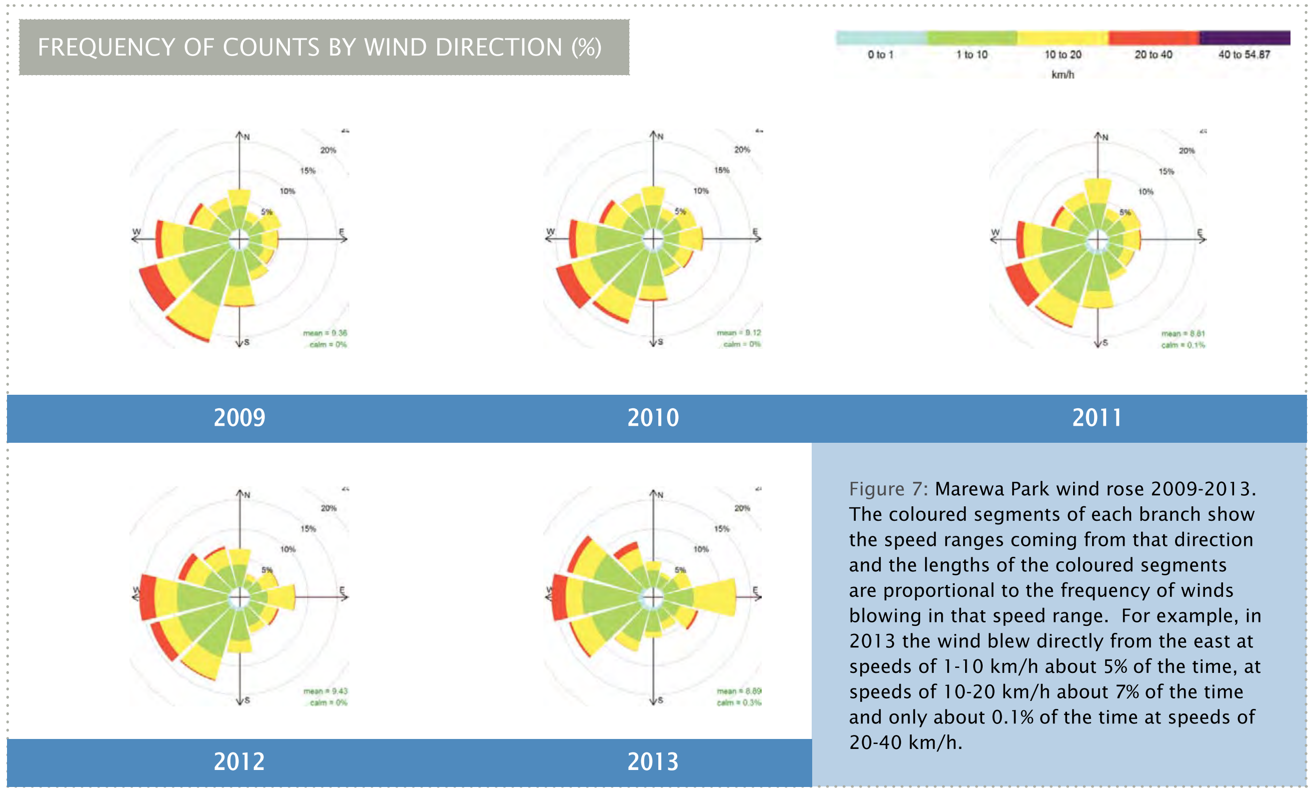


Figure 7: Marewa Park wind rose 2009-2013. The coloured segments of each branch show the speed ranges coming from that direction and the lengths of the coloured segments are proportional to the frequency of winds blowing in that speed range. For example, in 2013 the wind blew directly from the east at speeds of 1-10 km/h about 5% of the time, at speeds of 10-20 km/h about 7% of the time and only about 0.1% of the time at speeds of 20-40 km/h.

Case Study

2012/2013

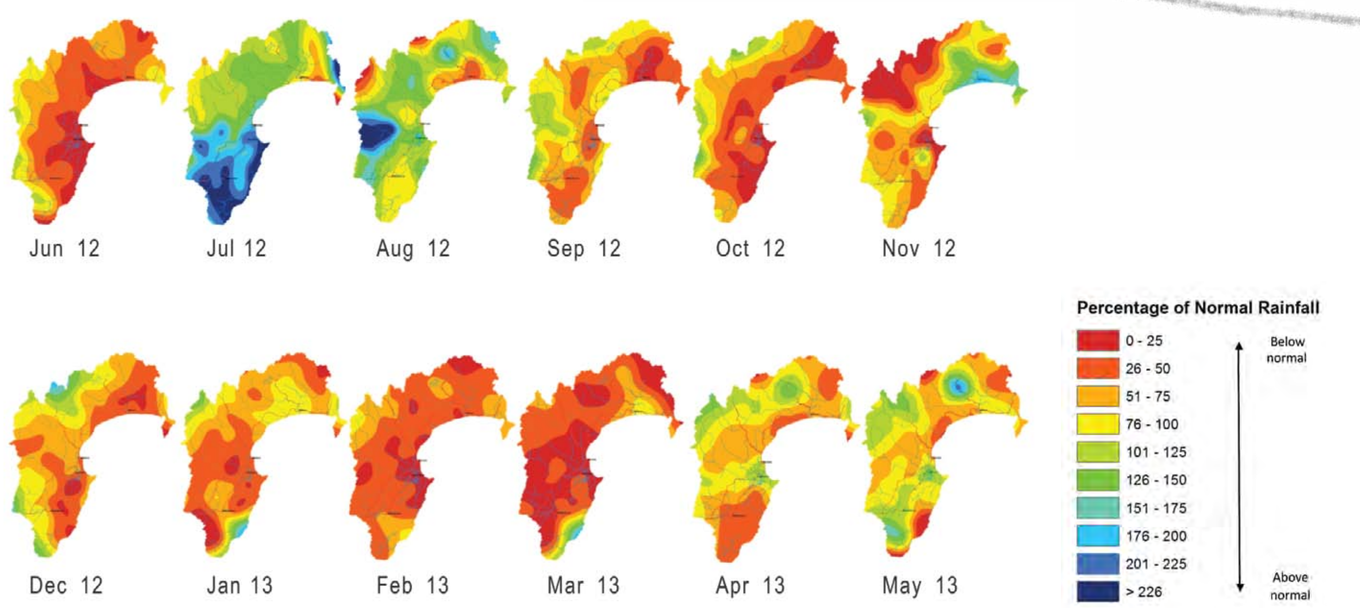


Figure 7: Regional monthly rainfall 2012/2013 compared to a 30 year average.

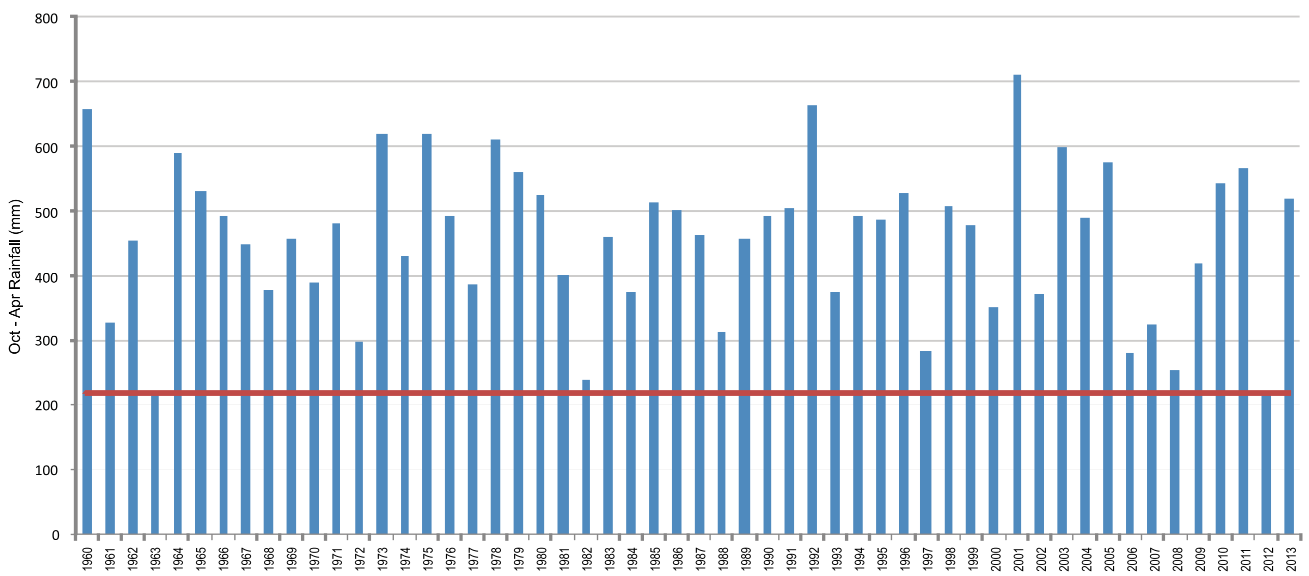


Figure 8: 1 October to 30 April rainfall at Mt Vernon, Waipukurau, from 1960/1961 to 2013/2014. The x-axis is labelled with the year each period starts. The line represents the 2012/2013 total (219 mm). Lower rainfall than this was recorded only in 1963/1964 (217 mm).

THE DROUGHT OF 2012/2013

Drought conditions affected many areas across New Zealand over the spring to autumn period of 2012 to 2013. The Minister for Primary Industries officially declared a drought in Hawke's Bay in March 2013 after six consecutive months of below normal rainfall (Figure 7).

The drought was widespread across the region and some rainfall gauges, such as at Mt Vernon in Waipukurau and at the Hawke's Bay Airport near Napier, recorded the second lowest October to April rainfall totals in the last 50 years (Figure 8).

Soil moisture measured at HBRC climate sites was very low from mid-November to mid-April (Figure 9) and reached levels where pasture growth would normally have stopped throughout this time, without irrigation. Soil moisture levels recovered to close to normal through April and May following a number of rain events that each delivered more than 10 mm of water.

RAIN EVENT
This is a term commonly used to describe a period of rainfall of a particular signifance.

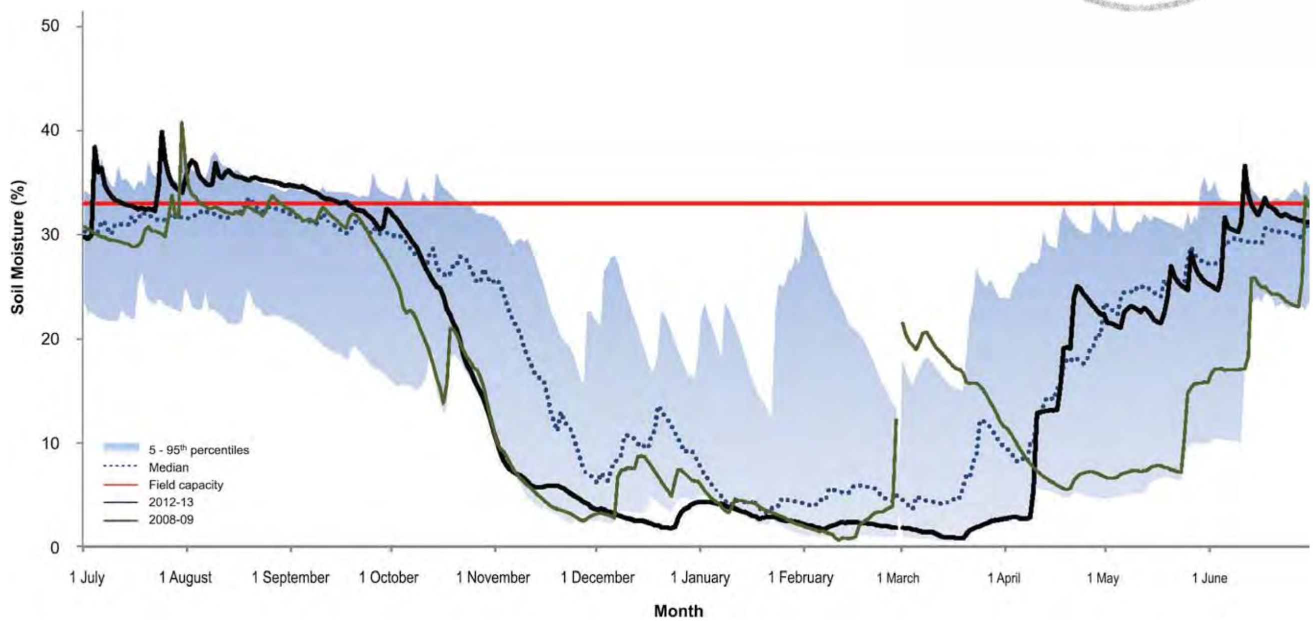


Figure 9: Average daily soil moisture levels (%) at HBRC's climate monitoring site at Bridge Pa, Hastings in 2012-2013. The previous last drought was in 2008-2009 and this is shown for comparison. Soil moisture has been monitored at the site for ten years. The upper and lower bounds of the shaded area represent the 5th and 95th percentiles of the soil moisture measurements over the ten year period and the dashed line represents the median value. Field capacity (straight line) is the maximum amount of water held by the soil once excess water has drained away.

Case Study


Erosion CHB coast area. *Photo: Peter Scott*


Peach Gully Bridge


Kopuawhara


Damage to Te Angiangi Marine Reserve

APRIL 2011 STORM

The most significant rain event over the last five years occurred during the Easter holidays in late April 2011. A low crossed the country from the northwest bringing with it moist humid air. The low was centred near Hawke's Bay during 26 and 27 April and a slow moving front developed as the moist air met colder air coming up from the south (Figure 10). Strong southeast winds developed, bringing heavy rain to eastern areas and especially to the coast south of Napier, where rainfall totals exceeded a 1 in 100 year event (Figure 11), and were greater than those during Cyclone Bola in 1988.

HBRC's rainfall site at Waipoapoa recorded the most rain during the event. The one, two and three day totals measured 432 mm, 626 mm and 658 mm respectively. The total for April at Waipoapoa was 706 mm, which is four times the April average at that site.

For more information on the impact of this storm on the coastal area, see Case Study page 146.

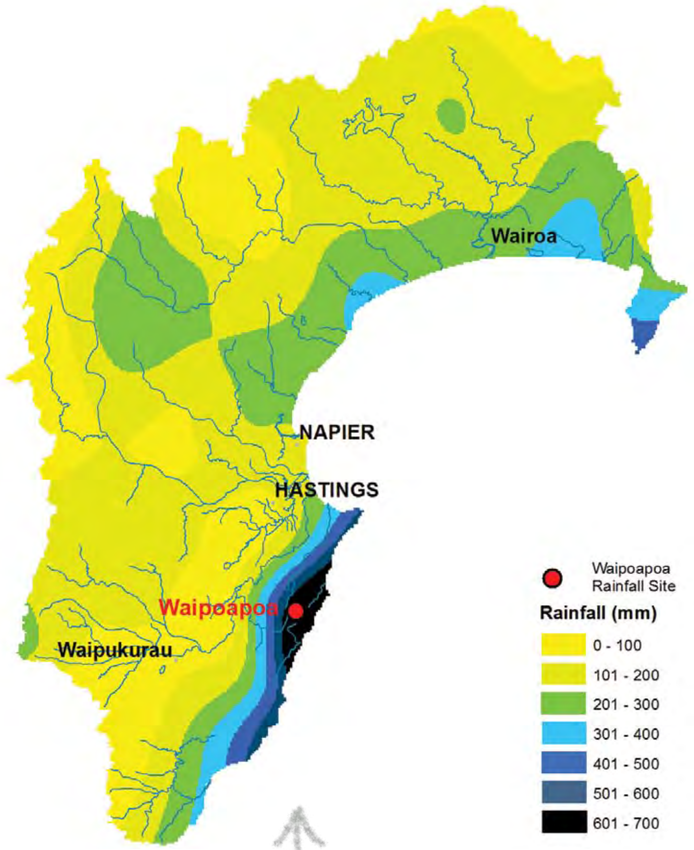


Figure 11: Forty-eight hour rainfall totals (mm) across the region during the Easter storm.

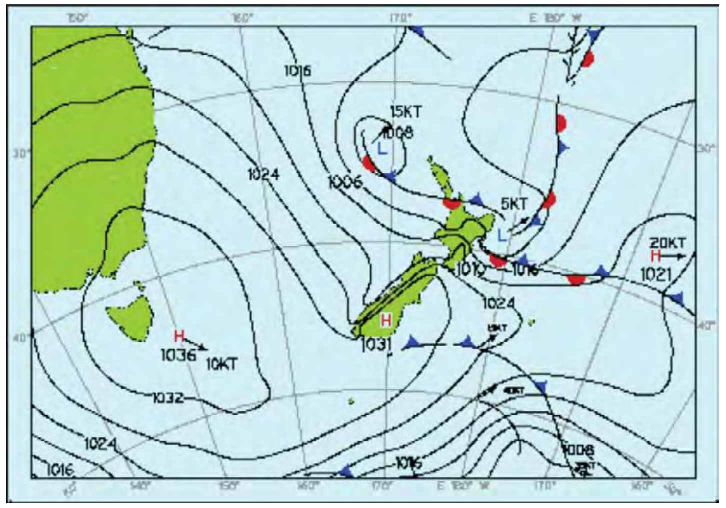


Figure 10: NZ Metservice Mean Sea Level Pressure Analysis at midday 27th April 2011 (screen shot).

HBRC staff involved in the Mohaka longitudinal study.

Surface Water

We monitor stream flows, water quality and ecology at sites across Hawke's Bay.

Although the rate of improvement for phosphorus is worse than the national rate, when it comes to nitrogen our water quality monitoring shows we have fewer sites deteriorating than has occurred nationally.

The drought of 2012-2013 was a low flow anomaly in an otherwise average to above average five years of river flows. However more Hawke's Bay rivers are getting muddier than is the case nationally, and no improvement was seen in the last five years at any site monitored.

Seventeen native fish species spend time in the ocean, migrating to and from freshwater streams during their lives. To make it easier for fish to migrate upstream, barriers to their movement are being identified and improvements made.

The headwaters of most Hawke's Bay streams are healthy places for aquatic bugs – macroinvertebrates - but the modified lower catchments are often poor habitats, particularly where water temperatures are high and dissolved oxygen low. Lower catchments experience high volumes of aquatic plant growth more frequently, while some of our lakes also have high levels of nutrients resulting in occasional algal blooms.

We also monitor water quality at 37 fresh water and coastal sites that are popular for recreation.

Tukituki river mouth.
Peter Scott,
www.abovehawkesbay.co.nz

Water Quality and Ecology

Mai i te kāhui maunga ki Tangaroa
From the mountains to the sea

Our science monitoring

The surface water and ecology State of Environment (SoE) programme encompasses regular monitoring in our rivers, lakes and near-shore coastal environment at a wide range of sites (Figure 31). The programme is designed to measure the state and trends of key water quality parameters so we can assess our performance against national and regional environmental benchmarks, and to detect changes in environmental conditions.

We monitor key nutrients including nitrogen (N) and phosphorus (P), faecal bacteria indicators (*Escherichia coli* and Enterococci), sediment (turbidity) and other environmental variables such as algae and the freshwater aquatic Macroinvertebrate Community Index (MCI – see pages 53).

Sampling Sites

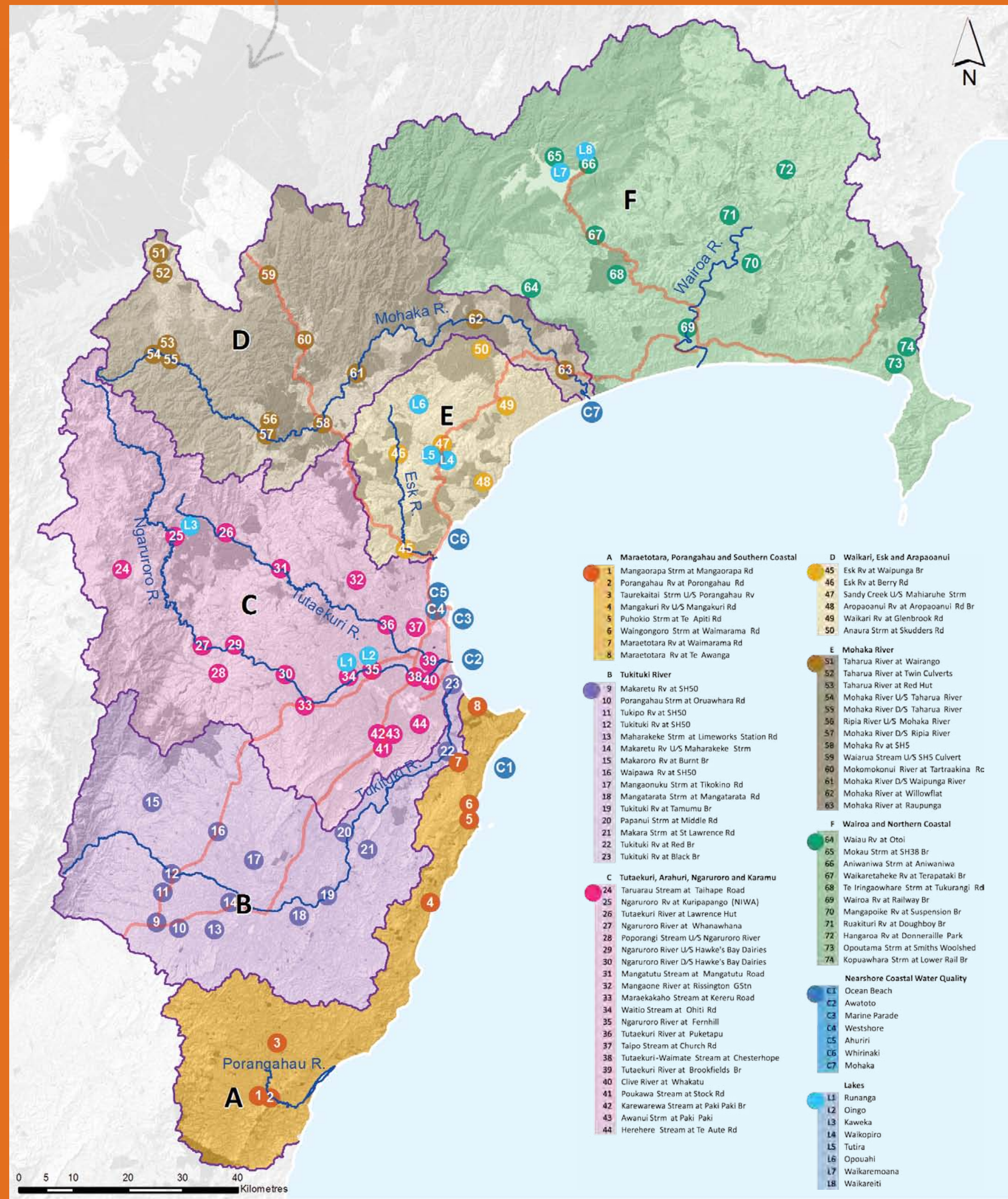


Figure 31: Sampling Sites. Detailed technical reports for each sub-region (A-F) are available (from November 2015).

HBRC staff get their hands wet collecting bugs.

Monitoring and investigations

The rivers monitoring programme consists of monthly water quality testing and observations of periphyton cover, as well as annual fish surveys, stream habitat assessments and macroinvertebrate sampling. We monitor more than 70 sites across the region from Mahia to Porangahau.

The lakes monitoring programme investigates the health of 7 lakes.

Marine water quality is monitored at 7 long-term sites from Ocean Beach to Mohaka, and four more sites have recently been added north of Mohaka to the Mahia peninsula.

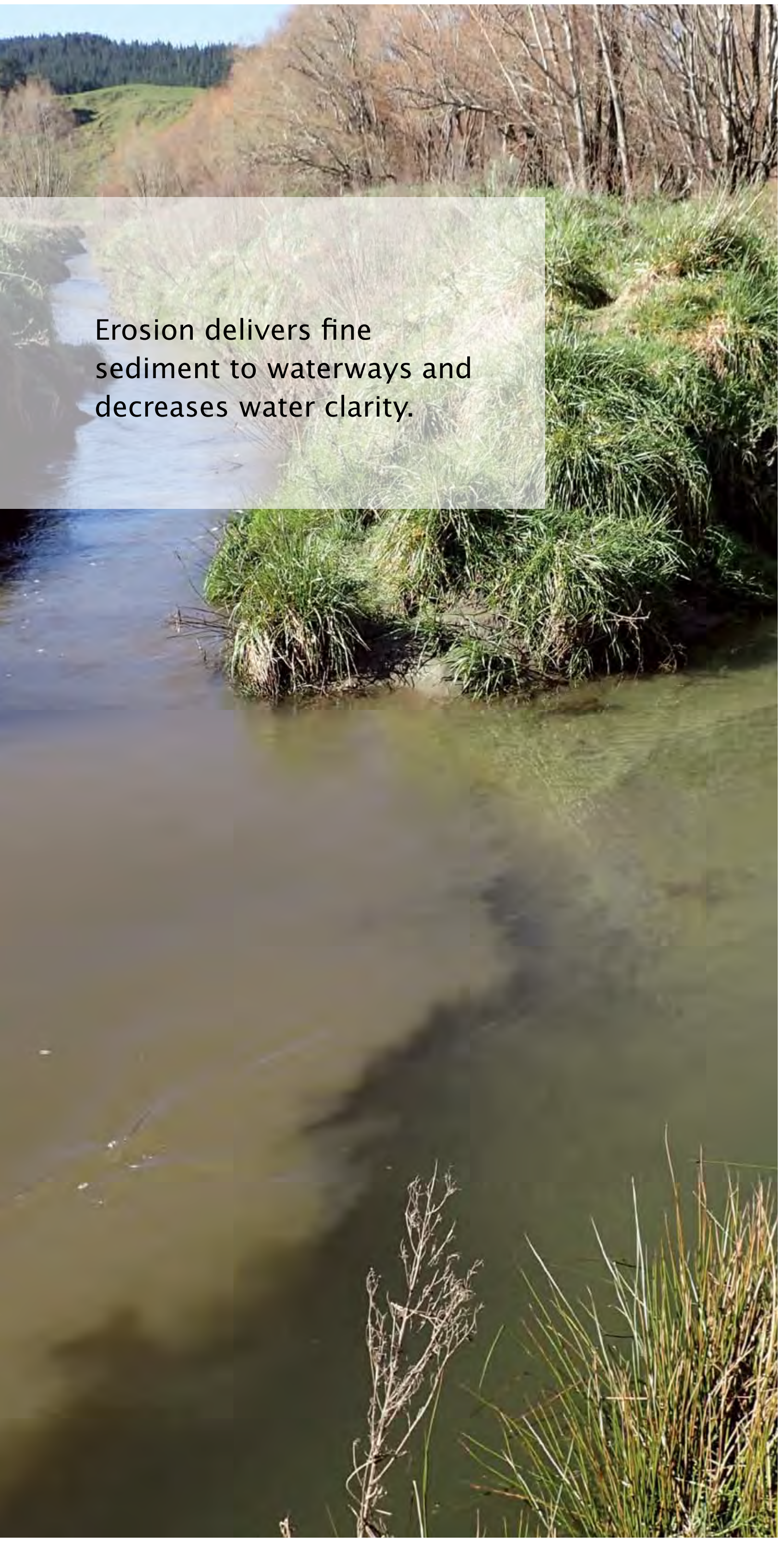
We monitor recreational water quality over the summer months (November – March), which helps inform the public where it is safe and healthy to swim. Several short-term investigations are also undertaken and are targeted at providing solutions to problems identified during routine monitoring. For example, see the Papanui and Taharua case studies on pages 49 and 95.

How can you view the results

To view the results of our long term river monitoring programme you can visit www.lawa.org.nz
LAWA is a national site for sharing water quality data and our results are uploaded to the site regularly. Here you can compare water quality in Hawke's Bay with other regions of New Zealand, and find out about the latest fresh water information, news and events.

LAWA
LAND AIR WATER AOTEAROA

HBRC staff take water samples off the Nuhaka River mouth using a Van Dorn water sampler.



Turbidity

Light is vital for aquatic plants to grow, and high light levels allow aquatic animals to see, forage and avoid predators. People also prefer clear water for recreational and sporting use of rivers and streams. When very fine sediment or other particles are suspended in the water column, less light can pass through the water.

We report on how much turbidity – sediment particles stirred up – is in a waterway by reference to a standard, known as the nephelometric turbidity unit (NTU), which tells us how much light is scattered by particles in the water.

High turbidity often indicates lots of fine-grained sediment is present in the river, usually sourced from erosion. Both geology and land-use affect rates of erosion. Soft sedimentary rocks found in the lower Mohaka catchment and around Wairoa are more easily eroded, and some of the highest turbidity in our region is found here (see Figure 32). By contrast, low turbidity is found in forested catchment headwaters, where the root structure of dense vegetation helps to hold sediment together.

Hawke's Bay is more likely to experience deteriorating trends in turbidity than the rest of New Zealand (see Table 2). Having clearer water is feasible in Hawke's Bay, with improvements in riparian management and application of tailored land management solutions, particularly in catchments that are highly susceptible to erosion.

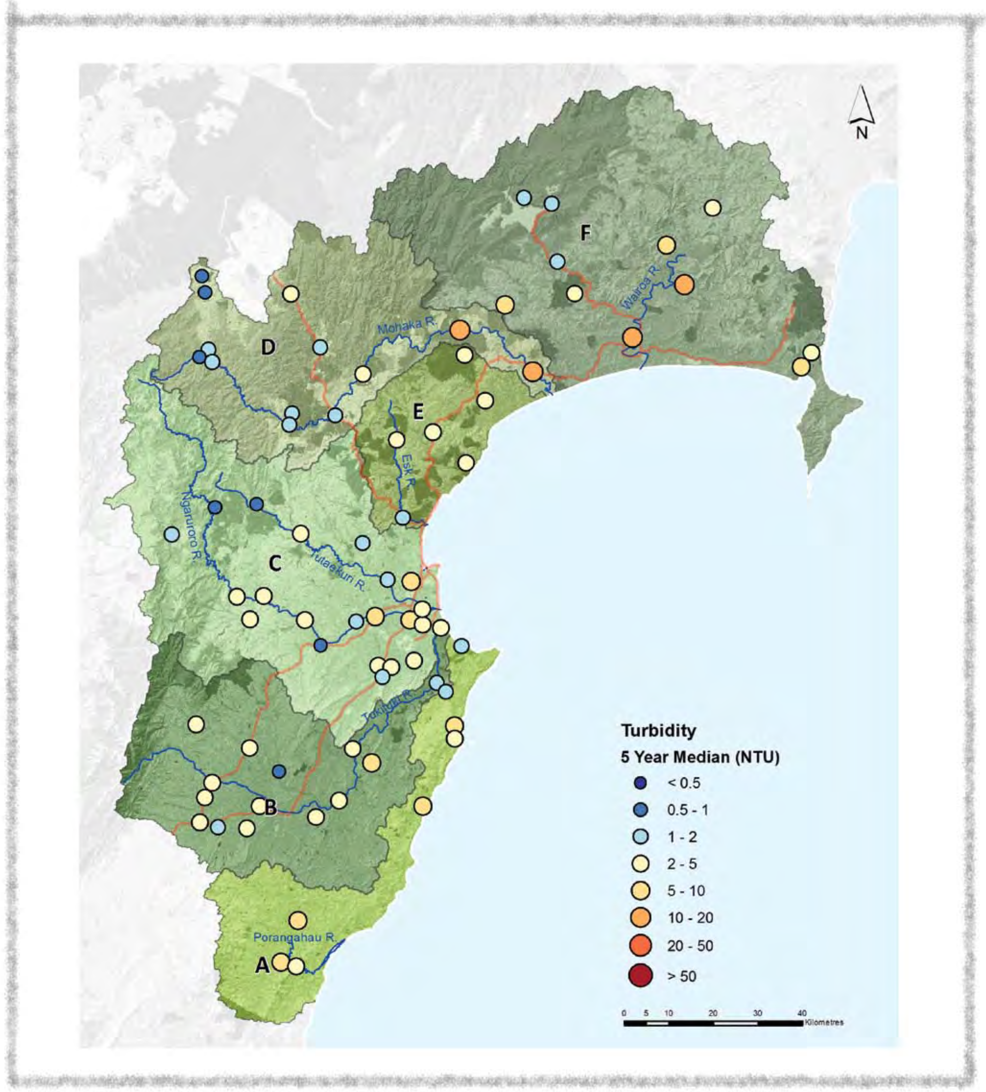


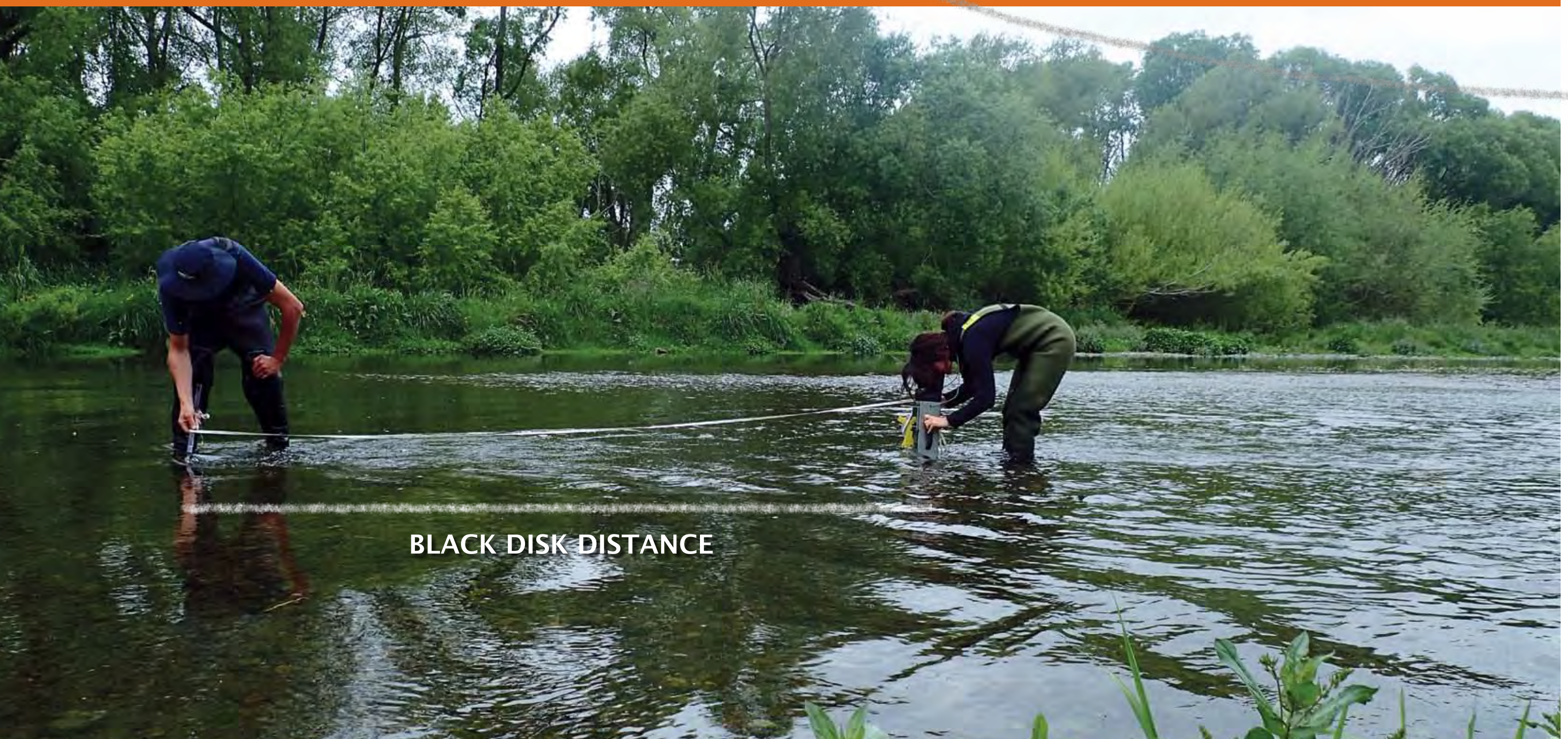
Figure 32: Median turbidity levels in Hawke's Bay rivers 2009-2013.

Table 2: Turbidity trends in Hawke's Bay, over 10 years.

Sub region	Sites analysed	Sites improving	Sites deteriorating	Sites no trend
A PORANGAHAU AND SOUTHERN COASTAL CATCHMENTS	8	0	0	8
B TUKITUKI	9	0	3	6
C TANK (TUTAEKURI, AHURIRI, NGARURORO, KARAMU)	15	0	6	9
D MOHAKA	6	0	4	2
E ESK, WAIKARE, AROPAOANUI	5	0	2	3
F WAIROA	5	0	2	3
OVERALL HAWKE'S BAY	48	0 (0%)	17 (35%)	31 (65%)
OVERALL NEW ZEALAND	530	83 (16%)	78 (15%)	369 (70%)

TRENDS MAY BE DUE TO NATURAL AND/OR HUMAN CAUSES. SEE TECHNICAL REPORTS FOR EXPLANATIONS.

Case Study



Measuring water clarity using the black disk method.

Clear water - high black disk value.

Murky water - low black disk value.

WATER CLARITY:

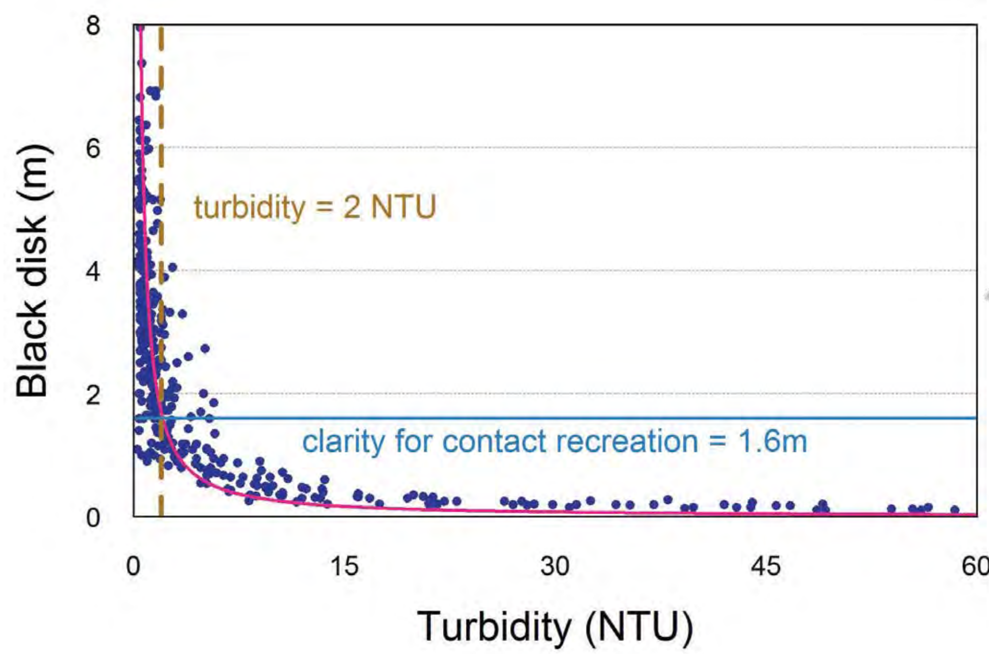
What's that black disk all about?

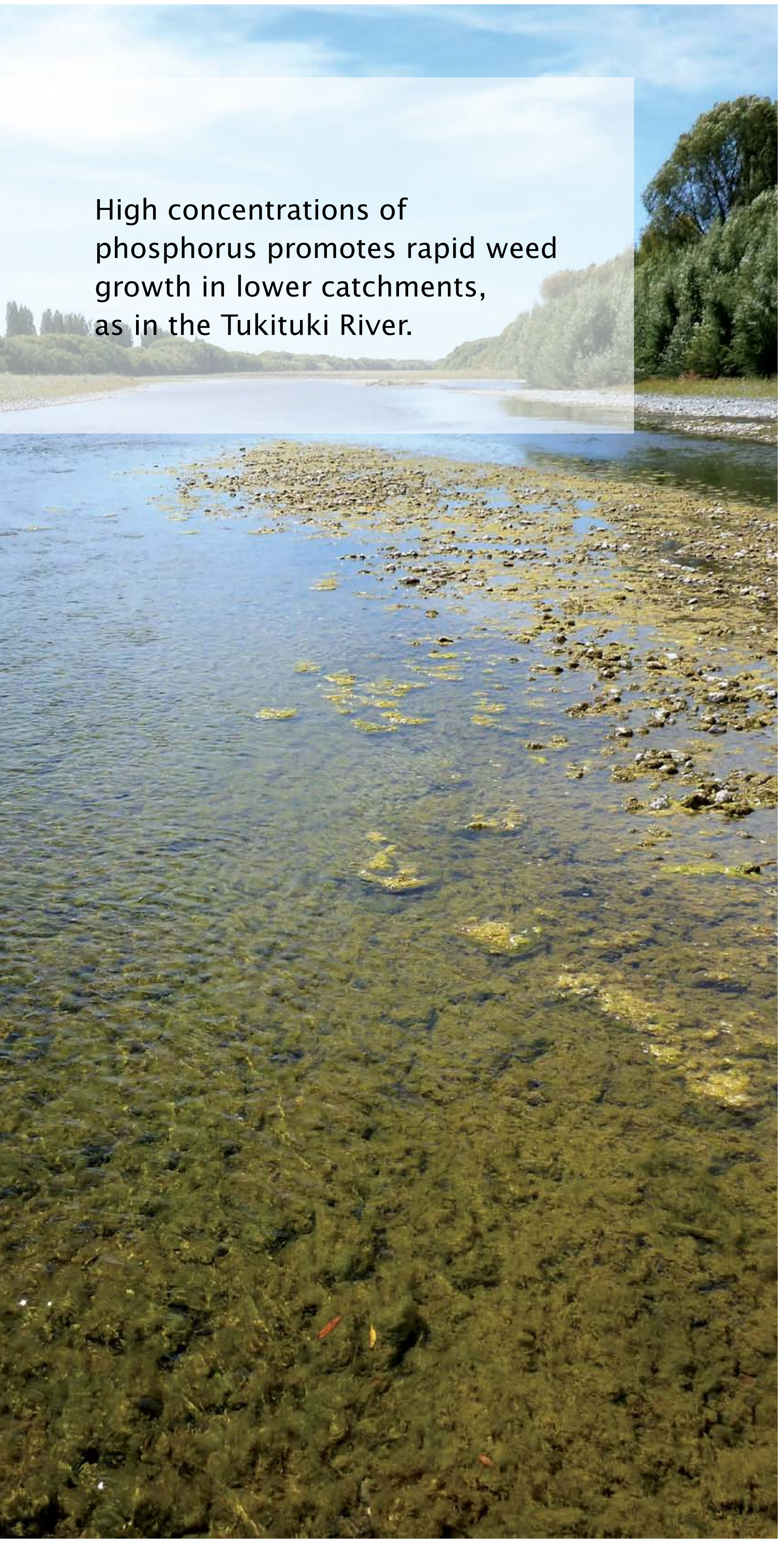
Water clarity in rivers is measured by determining the horizontal distance that a black disk can be seen underwater (see photo left).

Visual clarity in rivers is strongly influenced by the amount of suspended material in the water column. There is a direct relationship between the two (Figure 33). Under clear conditions in a river, a small increase in turbidity will result in a large reduction in visual clarity. A river usually appears ‘clear’ to the human eye at a turbidity of less than 2 NTU (see page 42 for explanation of NTU). Sites on the map [previous page] with yellow markers would appear cloudy most of the time. ‘Blue’ sites would appear clear.

When it rains, increased amounts of sediment often end up washed into our rivers. The more sediment transported from the land into the river, the more turbid the river becomes and the lower the clarity is. Reducing the amount of sediment entering our waterways has many benefits including keeping water clarity high and contributing to improved ecological and recreational values.

Figure 33: Relationship between water clarity and turbidity.





High concentrations of phosphorus promotes rapid weed growth in lower catchments, as in the Tukituki River.

Phosphorus

Phosphorus (P) is an element that's essential for plant and algae growth. It occurs naturally in soils, but high concentrations of dissolved phosphorus (Dissolved Reactive Phosphorus – DRP) in Hawke's Bay water bodies promotes rapid weed growth and algal blooms, and can affect ecosystem health.

We monitor for high levels of P in water bodies, potentially caused by activities such as topdressing with fertiliser, erosion, intensive farming and discharges from sewage treatment works. Stream P levels in the upper parts of Hawke's Bay catchments are mostly less than 0.01 mg/L. This level of P limits algal growth. However, high levels of P have been found in lower catchments, including in urban areas, parts of the Tukituki River and on the Heretaunga Plains.

Over the last ten years P levels have improved at 5 sites and deteriorated at 1 site. However, P levels remain high in many places across the region, and Hawke's Bay lags behind the rate of national improvement in P levels in streams.

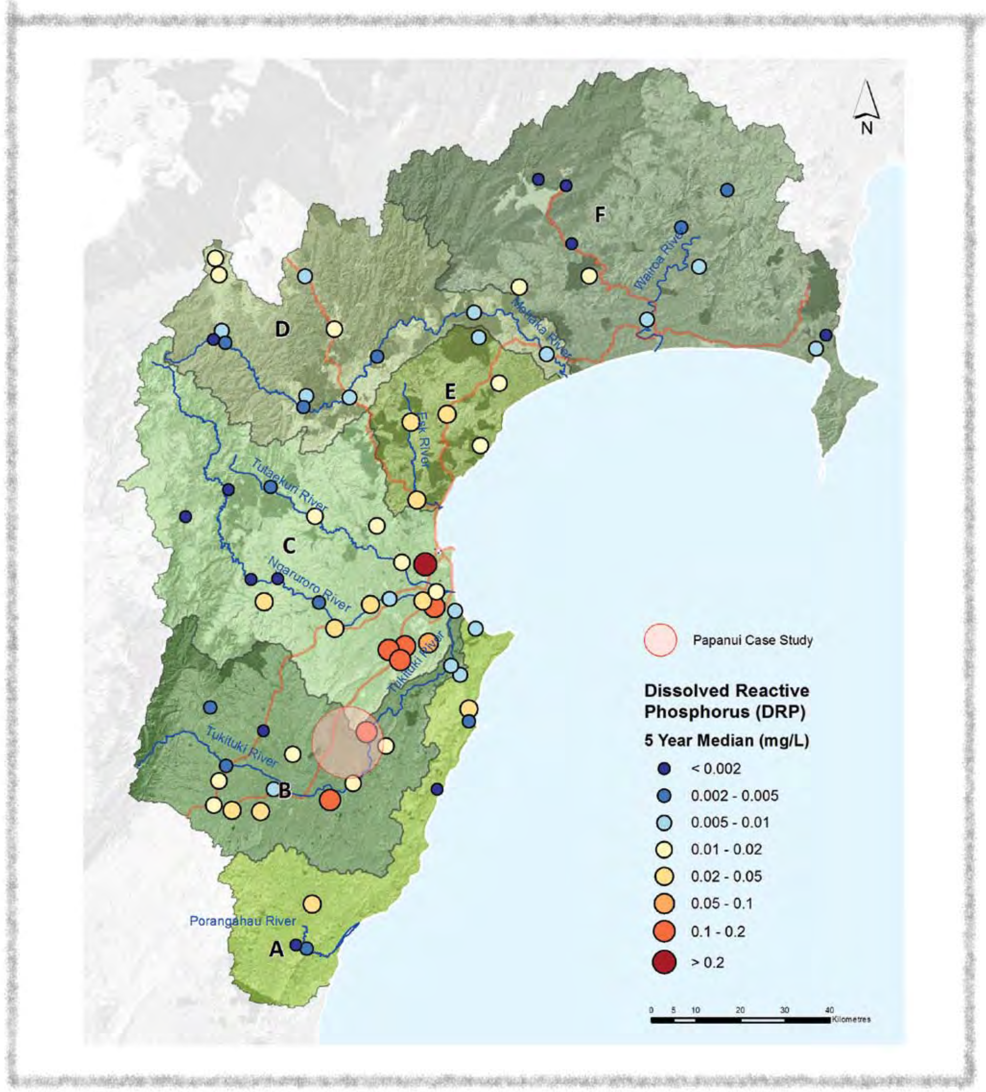


Figure 34: Median Phosphorus levels across Hawke's Bay 2009-2013.

Table 3: Dissolved Reactive Phosphorus trends in Hawke's Bay, over 10 years.

Sub region	Sites analysed	Sites improving	Sites deteriorating	Sites no trend
A PORANGAHAU AND SOUTHERN COASTAL CATCHMENTS	8	2	0	6
B TUKITUKI	9	0	1	8
C TANK (TUTAEKURI, AHURIRI, NGARURORO, KARAMU)	14	1	0	13
D MOHAKA	6	2	0	4
E ESK, WAIKARE, AROPAOANUI	5	0	0	5
F WAIROA	5	0	0	5
OVERALL HAWKE'S BAY	47	5 (11%)	1 (2%)	41 (87%)
OVERALL NEW ZEALAND	501	207 (41%)	26 (5%)	268 (53%)

TRENDS MAY BE DUE TO NATURAL AND/OR HUMAN CAUSES. SEE TECHNICAL REPORTS FOR EXPLANATIONS.

Case Study

Median in-stream P levels measured at sites throughout the Papanui catchment are above PC6 target levels.

The Papanui catchment

Members of the Taiwhenua and Papanui landowners hosting HBRC councillors and staff at Tapairu Marae for discussions about the sub-catchment.

HOW DID THE PAPANUI GET ITS 'P'?

Tukituki Plan Change 6 (PC6) requires reductions in phosphorus levels in streams and rivers in the catchment to meet environmental objectives. Papanui is a hotspot, with P levels consistently above the target of 0.015mg/l.

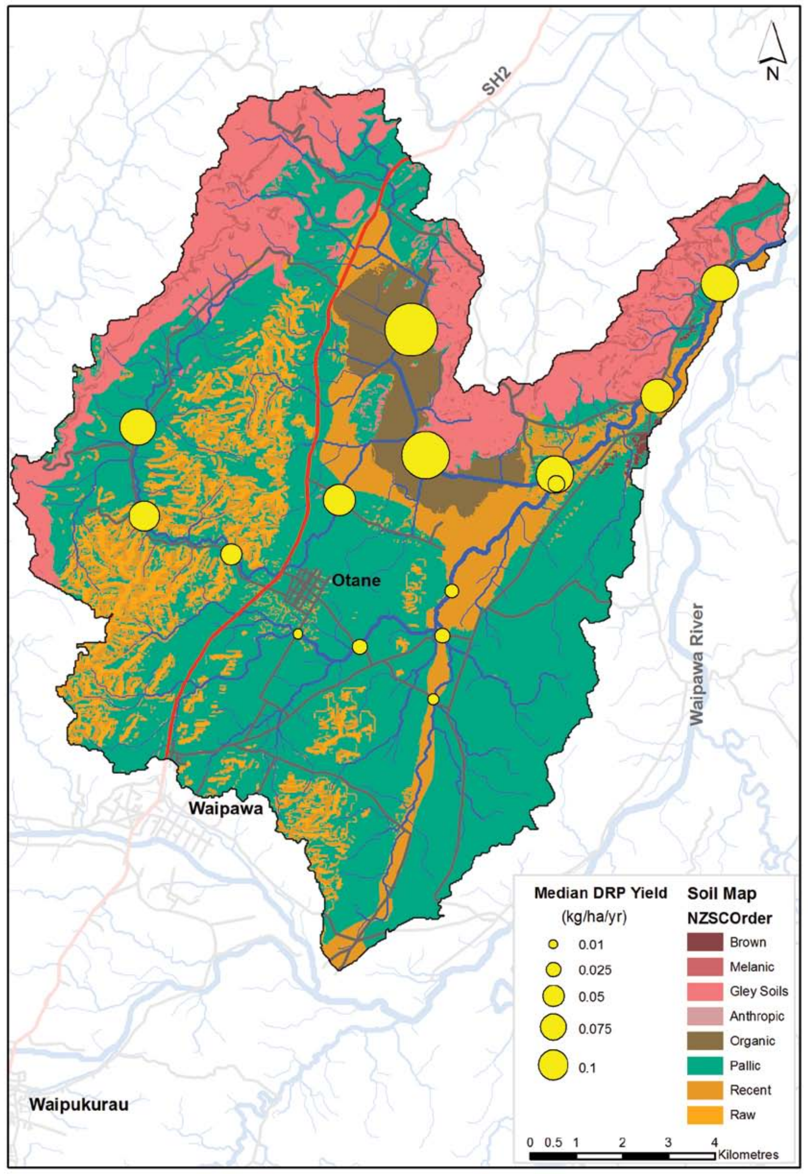
HBRC teams are working to identify where P is coming from in the sub-catchment and how to reduce it. The Land Science team is identifying the origin of P in the landscape, while our Hydrology, Surface Water and Groundwater teams are examining how P moves through the hydrological system. With this information, the Land Management team considers how to reduce P levels from land-use activities, without huge economic costs for farms and the wider community.

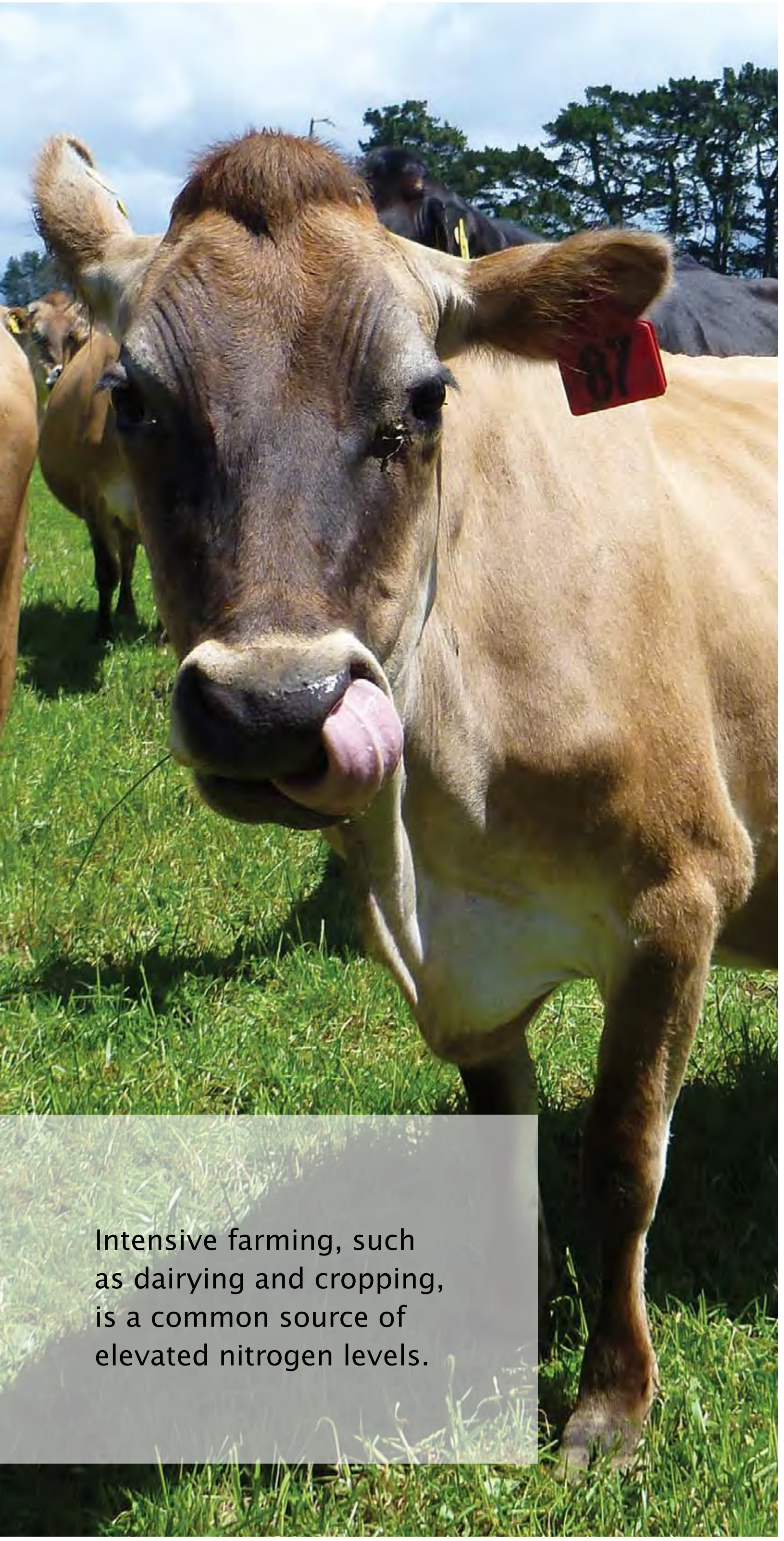
Certain types of soil increase the risk that P will be lost from the land. Pallic soils (green on Figure 35) are found over a wide area of the Papanui catchment, and are fine, windblown sediments highly susceptible to erosion. When soil is eroded, it can transport P into the stream, which may explain why in-stream P concentrations are high throughout the catchment.

Organic soils (brown on the map) have particularly high levels of P loss and this is reflected in high P yields in streams in this part of the catchment. Another source of P is the Otane wastewater plant and Central Hawke's Bay District Council is investigating what contribution this makes to the Papanui specifically, and the Tukituki catchment more broadly.

These science investigations underpin the Papanui Catchment Management Strategy which is being developed by a focus group of catchment landowners and Taiwhenua. This strategy is due for completion in 2015 and will guide investment to improve water quality, including integrated and non-regulatory programmes.

Figure 35: Soil type influences the risk of P loss in the Papanui catchment.





Intensive farming, such as dairying and cropping, is a common source of elevated nitrogen levels.

Nitrogen

Nitrogen (N) is an essential element for plant and algal growth.

However too much dissolved inorganic N (DIN) in our waterways can cause problematic weed growth if other necessary nutrients are also available and environmental conditions are favourable.

Nitrate and ammonium are different forms of DIN and can be toxic to fish and macroinvertebrates. Common sources of nitrogen are fertiliser, septic tanks, sewage treatment works, animal effluent, and industrial discharges.

Waterways in intensively modified areas of Hawke's Bay have DIN levels of more than 0.2 mg/l, which can promote rapid algal growth. Catchment headwaters and other less intensively modified areas tend to have DIN levels less than 0.2 mg/l which would limit potential algal growth.

In Hawke's Bay most DIN is in the form of nitrate and although DIN levels are sometimes high enough to be a factor in nuisance algal growth in our rivers, they typically remain below toxicity thresholds.

In the last ten years, nitrogen levels (measured as total oxidised nitrogen which is nitrate-nitrogen and nitrite-nitrogen) have improved at 17% of the sites HBRC monitors, while they've deteriorated at 10% of the sites (Figure 36). The worsening trends in nitrogen in the Taharua River are discussed (page 95). However, a smaller proportion of Hawke's Bay sites have deteriorated compared to national trends (Table 4).

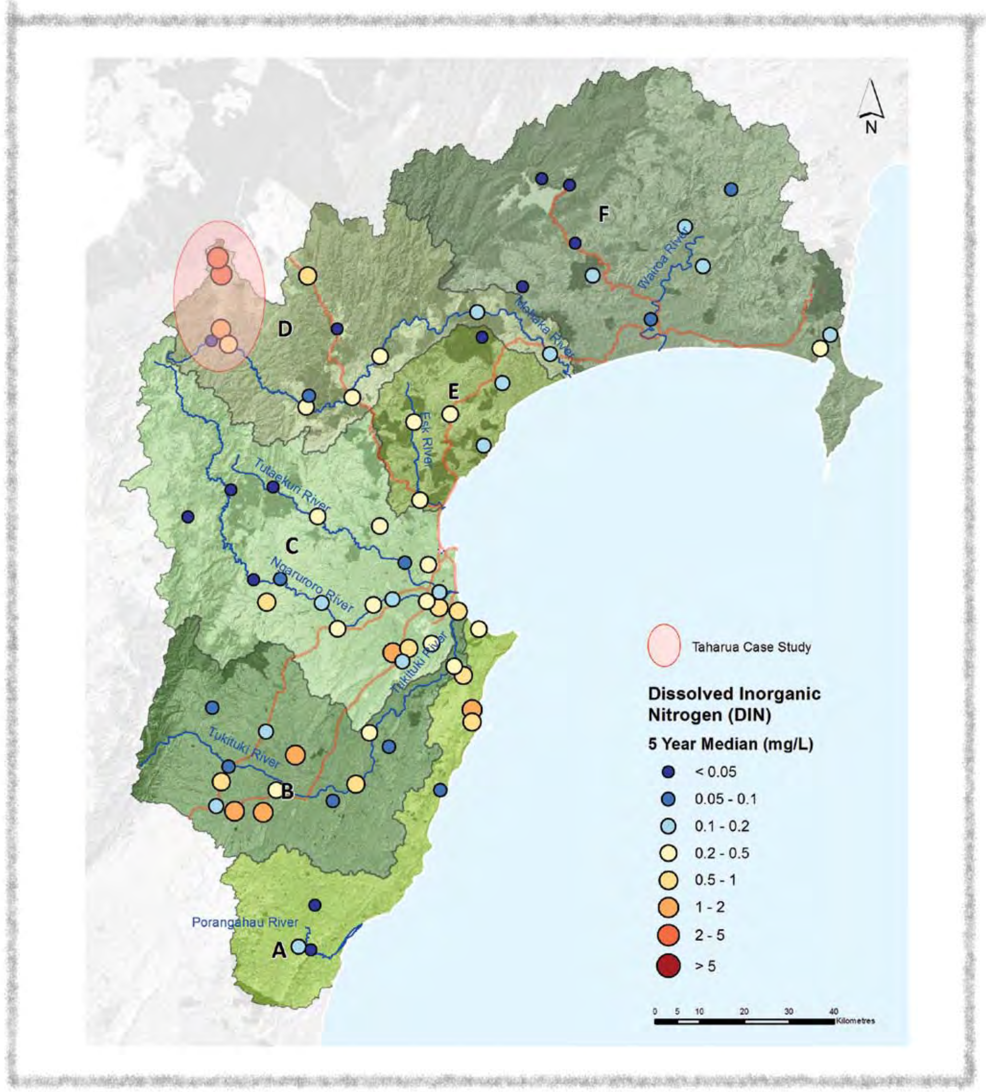


Figure 36: Median nitrogen levels across Hawke's Bay 2009-2013.
The Taharua Case Study is on page 95.

Table 4: Total oxidised nitrogen trends in Hawke's Bay, over 10 years.

Sub region		Sites analysed	Sites improving	Sites deteriorating	Sites no trend
A	PORANGAHAU AND SOUTHERN COASTAL CATCHMENTS	8	1	0	7
B	TUKITUKI	9	4	0	5
C	TANK (TUTAEKURI, AHURIRI, NGARURORO, KARAMU)	15	1	1	13
D	MOHAKA	6	0	4	2
E	ESK, WAIKARE, AROPAOANUI	5	1	0	4
F	WAIROA	5	1	0	4
	OVERALL HAWKE'S BAY	48	8 (17%)	5 (10%)	35 (73%)
	OVERALL NEW ZEALAND	504	86 (17%)	123 (24%)	295 (59%)

TRENDS MAY BE DUE TO NATURAL AND/OR HUMAN CAUSES. SEE TECHNICAL REPORTS FOR EXPLANATIONS.


Mayfly larvae

Stonefly larvae (right) and mayfly larvae (above) are sensitive to pollution and MCI scores are high when they are present. Midge larvae (middle left) and worms (bottom left) are tolerant of pollution, and have correspondingly low MCI scores.


Midge larvae


Worms


Stonefly larvae

Macroinvertebrate Community Index

Macroinvertebrates are aquatic bugs large enough to be seen without a microscope and are sensitive to organic pollution.

We use the occurrence of these in waterways to monitor and report on stream health.

Traditionally, stream quality or ‘health’ assessments were based on analysing water quality from discrete samples and focused on chemical data. Discrete water samples in rivers often miss ‘pulses’ of stress like pollution events, because the change in water chemistry is short-lived. The composition of the macroinvertebrate community, however, can ‘record’ a pulse of stress because the diversity and abundance of the biotic community will take longer to recover. Hence the biotic indicator is more time-integrated and can be a better measure of overall stream health.

The Macroinvertebrate Community Index (MCI) is a national scoring system which has allocated a score from 1 to 10 for each species or taxon of macroinvertebrate, depending on their tolerance to (low score) or sensitivity to (high score) organic pollution. By adding these scores together we get a picture of stream health - MCI scores of 120 or greater are ‘excellent’, while scores lower than 80 are ’poor’.

In general, MCI scores in the headwaters of Hawke’s Bay streams are ‘good’ to ‘excellent’, while MCI scores in more modified parts of our region are ‘fair’ to ‘poor’ (Figure 37). MCI scores in the Karamu/Clive catchment were frequently ‘poor’, which prompted HBRC to undertake a targeted investigation (see page 54).

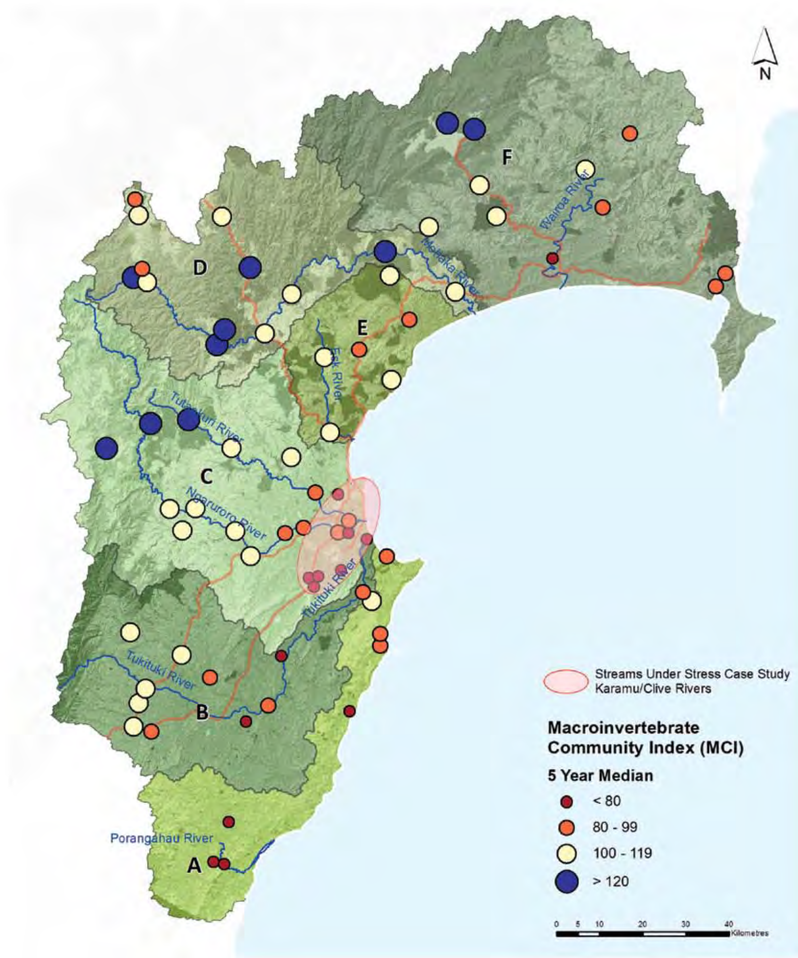


Figure 37: Median MCI scores across Hawke’s Bay 2009-2013.
The Streams Under Stress Case Study is on page 54.

Case Study

NO SHADE
- Awanui at the
Flume sampling site
during the summer
2014 field study.

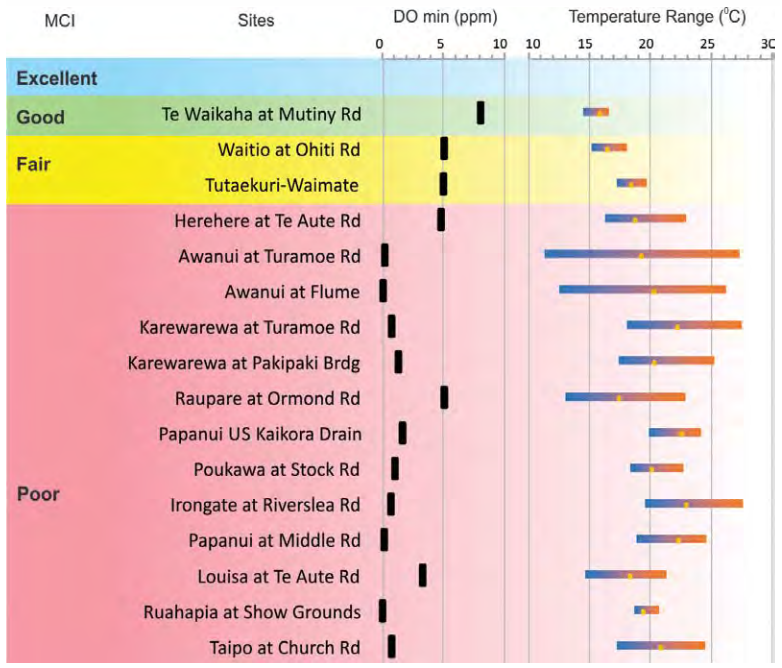


Figure 38: Macroinvertebrate indicator class at study sites (MCI), dissolved oxygen minima (vertical purple dash in the centre of the figure) and temperature ranges (blue to red band to the right of the figure) at sampling sites, 13 February - 4 March 2014.

STREAMS UNDER STRESS

The Karamu/Clive catchment flows through the Heretaunga Plains, one of New Zealand's most productive horticultural areas. Streams in the catchment have a low gradient and sandy/silty substrates, which provide ideal growing conditions for aquatic plants (macrophytes). The streams have been extensively modified, channelled and straightened for drainage and flood protection, and are currently suffering from nuisance macrophyte and algal growth. MCI scores here are amongst the lowest in Hawke's Bay, indicating the life supporting capacity in these streams is compromised.

In the summer of 2013/14 we investigated what particular factors were most damaging to the ecological health of these streams so we could recommend ways to improve their state. Sixteen lowland stream sites with a range of environmental conditions were chosen for this study. Macroinvertebrates were sampled, along with water quality parameters, and stream habitat and macrophytes were assessed. Dissolved oxygen and water temperature were recorded continuously at the sites for several days (Figure 38).

At many sites, macrophytes blocked more than half of the stream channel and habitat quality was degraded. Temperature in some streams increased above 27˚C and dissolved oxygen was extremely low for several hours each day. In these situations, macrophyte respiration consumes more oxygen in the stream than is produced by photosynthesis or derived from the atmosphere, leading to low dissolved oxygen levels.

Our analysis showed that it was the maximum water temperature and minimum dissolved oxygen concentration that strongly affected the macroinvertebrate community composition. MCI was lowest at sites with high maximum temperature and low daily oxygen levels (Figure 38).

Given these results, the most effective way to increase the life supporting capacity of these streams is to provide shade over the water with suitable riparian (river-side) vegetation. Macrophytes grow less prolifically under shade, resulting in fewer low oxygen events. Shade cools down streams by reducing direct heating by sunlight and by creating a micro-climate with lower air temperature above the stream channel. Riparian vegetation also improves bank stability, reduces sediment and nutrient inputs, and improves invertebrate and fish habitat.

GOOD SHADE
- Shaded section of
Te Waikaha upstream
of the sampling site at
Mutiny Road, part of
the summer
2014 study.

You will read the terms PM10, NES, clean heat and airsheds frequently in this section on air quality.

PM10

High concentrations of tiny airborne particles smaller than 10 micro-metres in size are in the smoke from fires and increase the risk of respiratory and cardiovascular illnesses, including cancer. These are referred to as PM10. These particles are produced by burning wood and other fuels, as well as coming from natural sources, such as dust and sea salt.

NES

The Government has set a National Environmental Standard (NES) for PM10 at an average concentration of no more than 50 µg/m³ measured in open air over 24 hours. Only one exceedance of this level will be allowed in an airshed in a twelve month period. Airsheds are air quality management areas designated by regional councils and they are typically where levels of pollutants are known to or are likely to exceed the NES. The airsheds in Hawke's Bay are shown in Figure 18.

ACTIONS

There is no known 'safe' threshold for PM10. So while the NES aims to reduce the harm caused by these particles, communities are encouraged to keep working towards lower concentrations. HBRC initiatives, like the HeatSmart programme is designed to help achieve the NES requirements and at the same time improve the quality of air our community breathes, so reducing the health impacts.

HEATSMART

The Heatsmart programme is Hawke's Bay Regional Council's insulation and clean heat funding assistance programme to help residents get warmer, healthier homes. Grants and loans assist with the cost of fitting ceiling and underfloor insulation and replacing non-compliant burners and open fireplaces within air sheds.

Air Quality Pressures

Both human activities and natural processes affect air quality in our region, and poor air quality can pose a risk to people's health.

Domestic heating fires, outdoor burning of vegetation, combustion engines and some industrial processes all release pollutants into the air. These pollutants include fine particulates (PM10 and PM2.5), carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x), sulphur oxides (SO_x) and volatile organic compounds (VOC).

Emissions inventory

An emissions inventory for Hawke's Bay was completed by HBRC in 2005[1] and updated for the Napier and Hastings airsheds in 2010[2]. The emissions inventory lists the main sources of non-natural contaminants within an airshed and quantifies the amount being emitted. Updating the inventory every five years helps HBRC identify whether emissions are changing over time. The inventory also categorises potential sources of emissions from domestic heating, motor vehicles, outdoor burning, shipping, aviation and industry. Outdoor burning was not included in the 2010 update because regional rules limiting contributions from that activity were about to come into effect.

In 2005 the inventory showed that domestic heating was the largest source of PM10 in the region, accounting for 78-92% of daily winter emissions across the region. By 2010, 92-95% of PM10 emissions in urban centres came from domestic heating (Figures 14 and 15). Domestic heating is the main source of CO, SO_x, VOC and CO_2 during winter, while motor vehicles emit the most NO_x and high proportions of CO and CO_2.

Decline in Emissions

Total PM10 emissions declined between 2005 and 2010 in the region's main urban centres (Figure 12). The decline is a result of changes to home heating methods (Figure 13), improved vehicle technology, industry switching their boiler fuels, and schools converting to heat pumps. Emissions of all other contaminants also decreased. Notably, SO_x emissions probably declined because sulphur content in petrol and diesel fuels was reduced by the government in 2008 and 2009.

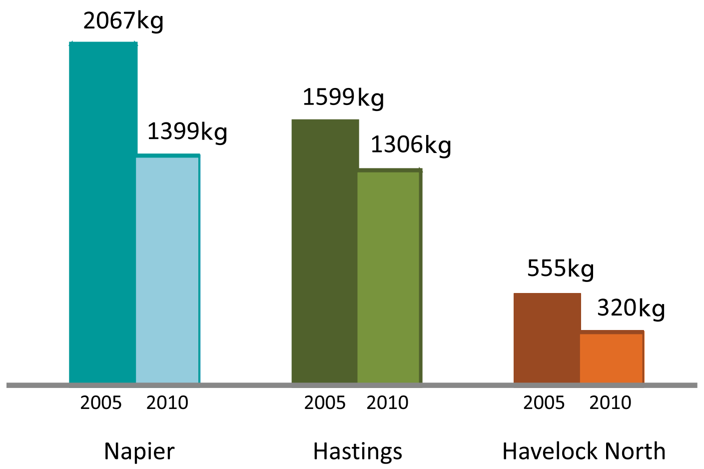
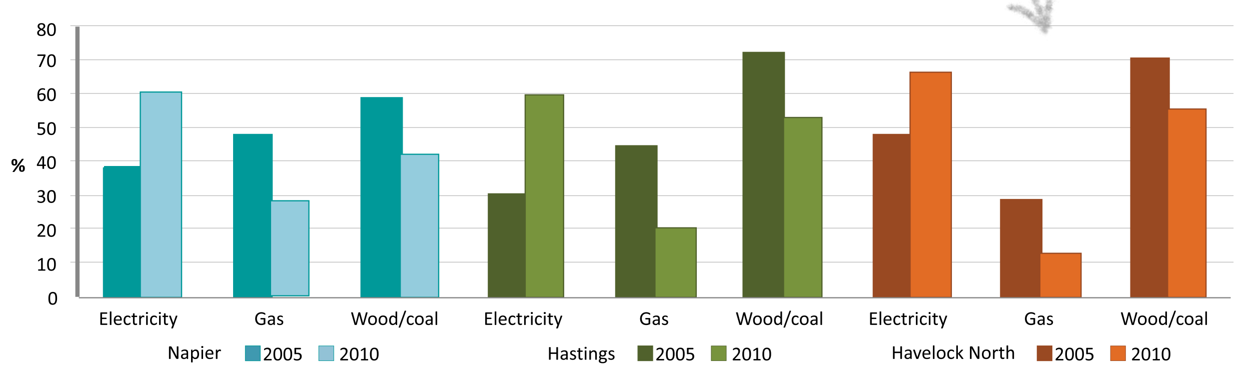


Figure 12: Total daily winter PM10 emissions (kg) in Napier, Hastings and Havelock North in 2005 and 2010. The number of households included in the 2010 results for Napier was 20,315 (20,154 in 2005), in Hastings it was 13,914 (13,641 in 2005) and in Havelock North it was 4,140 (4059 in 2005).

Figure 13: Proportion of households using electricity, gas, wood and coal to heat their homes in 2005 and 2010 in Napier, Hastings and Havelock North. The changes in home heating methods have helped reduce domestic heating emissions by approximately 32% in Napier, 18% in Hastings and 42% in Havelock North.



[1] Wilton, E. (2005). Air Emissions Inventory Hawke's Bay 2005. A report prepared for the Hawke's Bay Regional Council, EMT 05/04, Plan No. 3773. Environet Ltd, Christchurch.

[2] Wilton, E., and Baynes, M. (2010). Air Emission Inventory – Napier, Hastings and Havelock North 2010. A report prepared for Hawke's Bay Regional Council. Environet Ltd, Christchurch.

[3] Wilton, E., Baynes, M., Reza, P. (2010). Source apportionment of particulate in Napier. A report prepared for Hawke's Bay Regional Council. Environet Ltd and University of Canterbury, Christchurch.

[4] Wilton, E., Davy, P., Smith, J. (2007). Source identification and apportionment of PM10 and PM2.5 in Hastings and Auckland. Prepared for the Foundation for Science, Research and Technology. NIWA, Christchurch.

Source apportionment studies

Additional information about sources of PM10 can be obtained through source apportionment studies, which involve analysing collected PM10 material to identify its source. These studies help measure the amount of material coming from natural sources, such as dust and sea spray, which are not normally included in emission inventories.

A source apportionment study was completed in Napier in 2010[3], following a similar study in Hastings[4] in 2007. This work identified that the most significant contributor to PM10 collected in winter in both Hastings and Napier was domestic heating (Figures 16 and 17), while natural sources such as soil and sea spray contributed 13% in Hastings and 30% in Napier. The contribution from natural sources dropped to 8% in Hastings and 21% in Napier on days when the NES for PM10 was exceeded, which suggests the cause of exceedances is non-natural emissions. The natural component of PM10 emissions often cannot be managed, but needs to be accounted for when developing strategies for reducing PM10 concentrations.

Figure 14: Relative contribution from a range of sources to daily winter emissions in Napier in 2010.

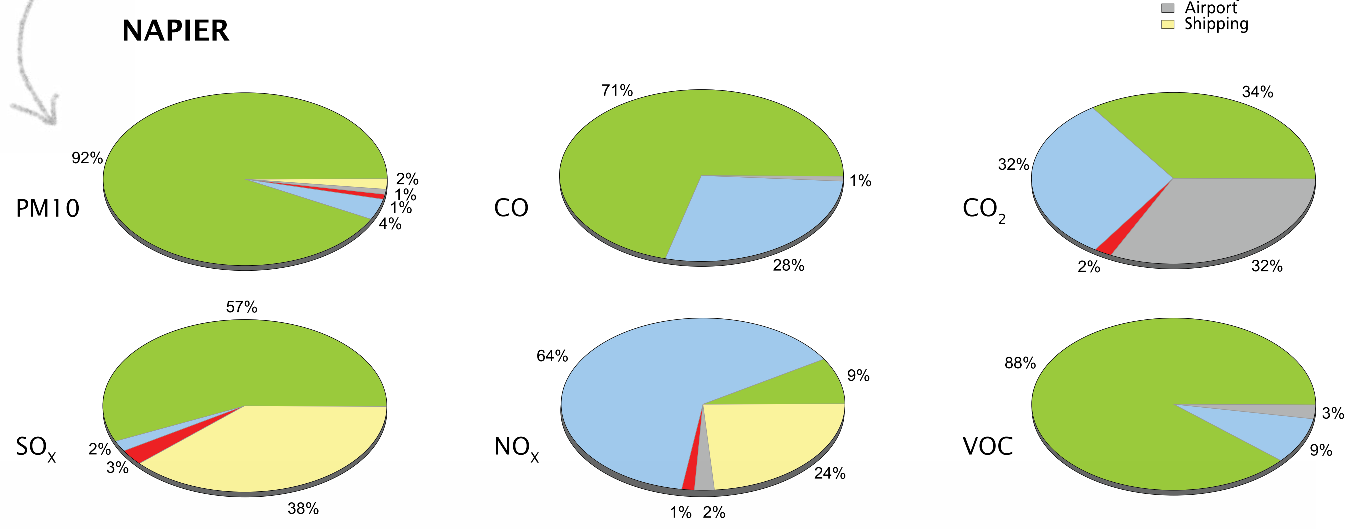
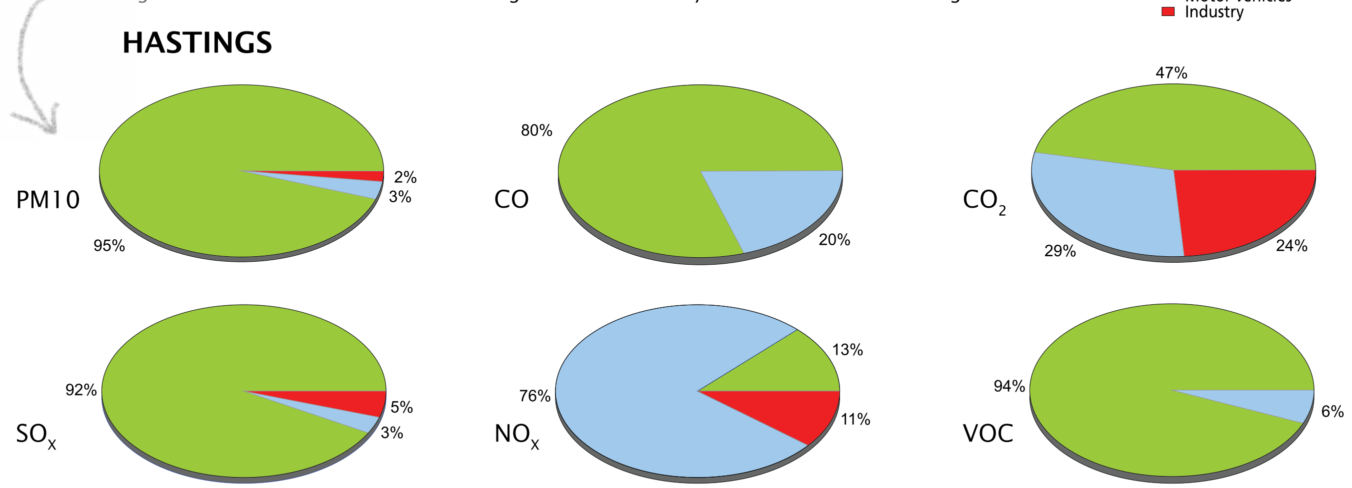


Figure 15: Relative contribution from a range of sources to daily winter emissions in Hastings in 2010.



In 2007 NIWA and Environet Ltd jointly studied PM10 source contributions in Hastings and Auckland. The source contributions for Hastings are shown in the graphs below. Three years later in 2010, Environet Ltd looked at source contributions in Napier. The Napier graphs include a category called 'secondary', meaning particulates that form in the air through chemical processes rather than being emitted directly.

Figure 16: The proportional contribution of sources to PM10 concentrations for each season in Hastings. Seasonally averaged 24 hour PM10 concentrations are shown alongside the season at the top left of each pie chart (Wilton et al., 2007).

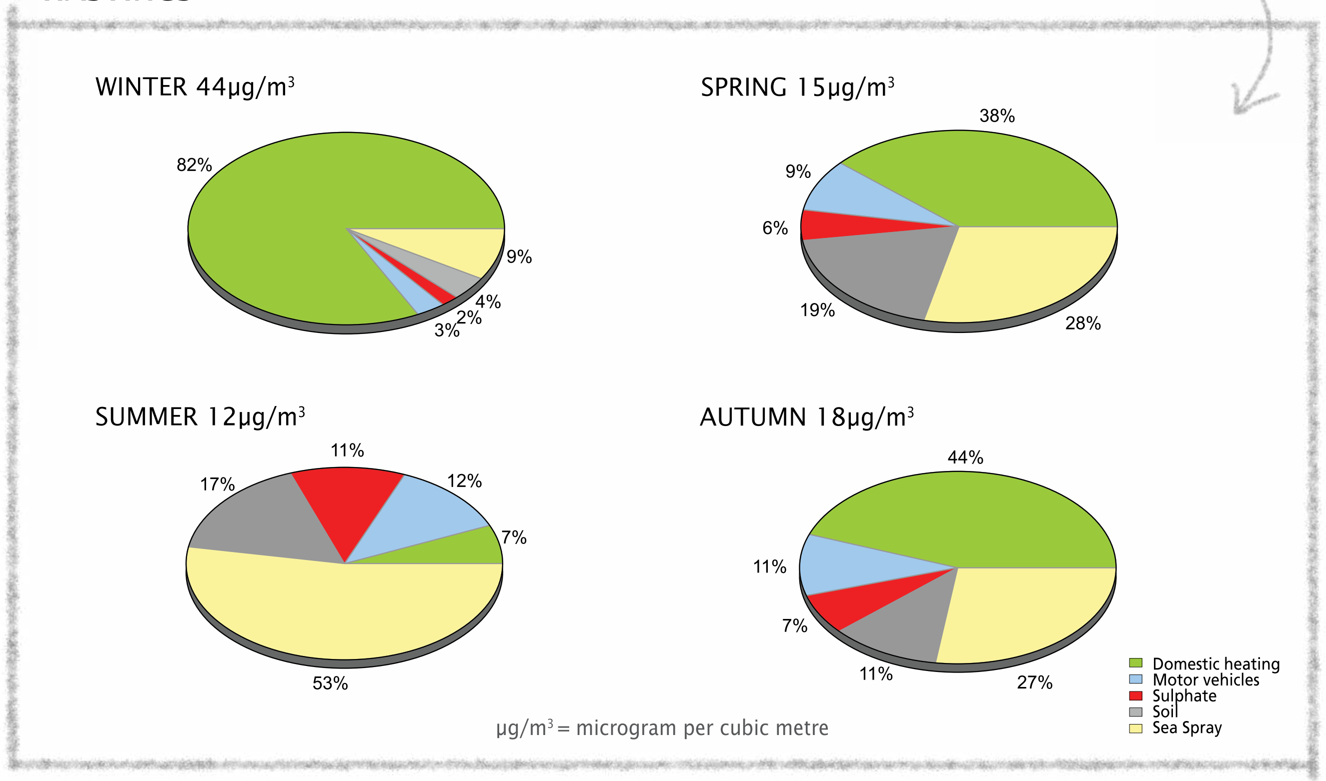
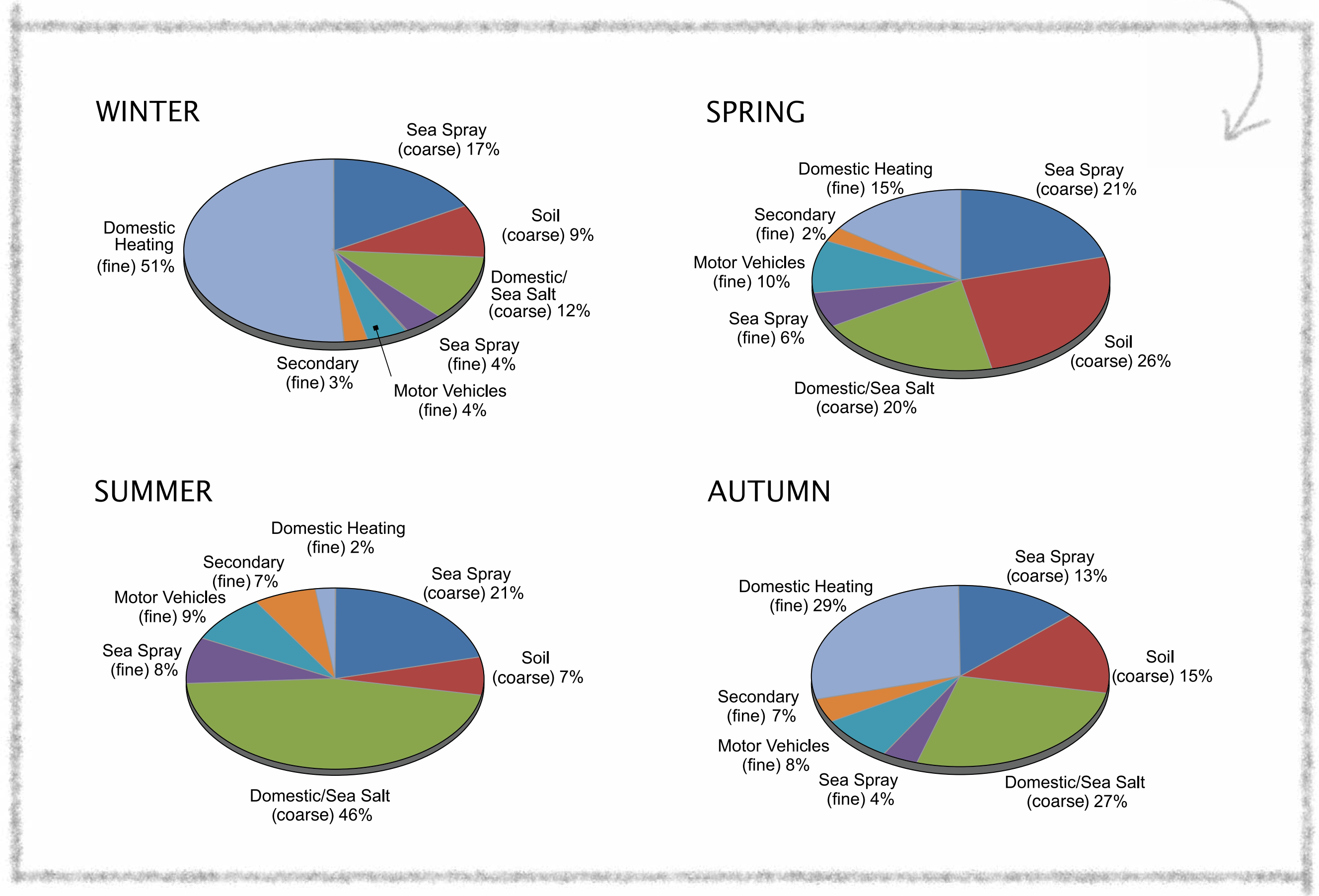


Figure 17: Seasonal variations in the relative contributions of sources to PM10 in Napier. (Wilton et al., 2010).



Although smoke from fires is the main reason for poor air quality, weather conditions also play a role.

Urban Air Quality

Each minute, every one of us inhales about 10 litres of air, so it's important that the air we breathe won't harm our health. In winter Napier and Hastings occasionally have poor air quality, just like many other New Zealand cities and towns, where fires are used to heat homes on cold days.

To assess progress towards achieving the National Environmental Standard (NES), HBRC monitors PM10 continuously in the Napier and Hastings airsheds (Figure 18). The NES has been exceeded in Hastings every year and in Napier most years since continuous monitoring began in 2006 (Figure 19). The monitoring sites are in Marewa Park in Napier and at St John's College in Hastings (Figures 20 and 21). Late autumn and winter are the only times when the NES is exceeded, as people light fires (in woodburners, since open fireplaces have been banned since 2011) to keep warm.

When it's cold and calm more fires are lit. Those conditions also encourage temperature inversions to develop at night, when air is colder close to the ground and warmer further up, which is the reverse of normal temperatures. This inversion traps cold air and smoke from fires close to the Earth's surface. The weather pattern that most often causes the inversion and high NES exceedences is when cold southerly winds are followed by a ridge of high pressure with its clear skies and frosts (Figure 22).

Weather conditions vary from winter to winter, making it difficult to analyse trends in PM10 concentrations. To remove the influence of changing weather conditions, we analyse air quality trends only for days when poor air quality is expected – we call these 'characteristic days'. On a 'characteristic day' daily average temperature must be below 11˚C and the mean wind speed must be less than 5 km/h (Figure 23). The minimum temperature and the numbers of hours of light winds are also important.

Averaged PM10 concentrations from characteristic days (referred to as normalised PM10), have improved over time, reaching their lowest value in 2014 (Figure 24). The number of characteristic days on which poor air quality occurs is also improving, as fewer pollution days occur. These trends need to continue if good air quality is to be achieved in Napier and Hastings throughout winter. The only way this can happen is to continue to reduce PM10 emissions from all man-made sources.

Sunset and clear skies over Ahuriri estuary

(Photo: Trevor Rynhart)

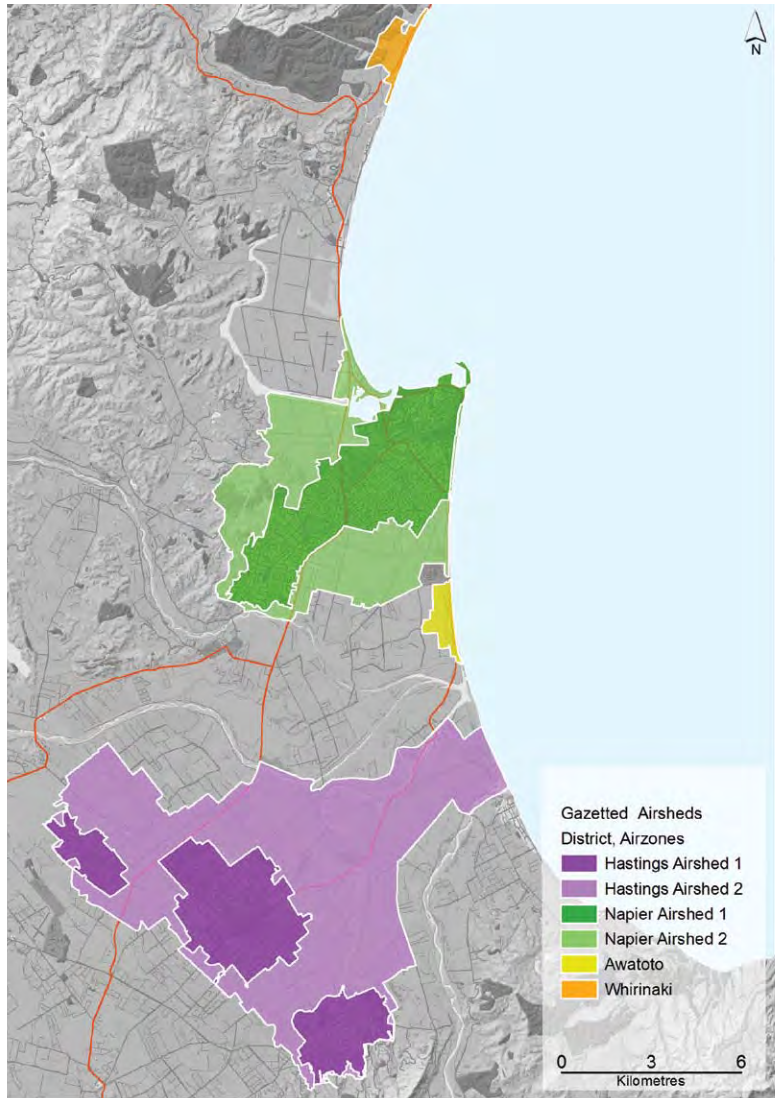


Figure 18: Airsheds in Hawke's Bay.

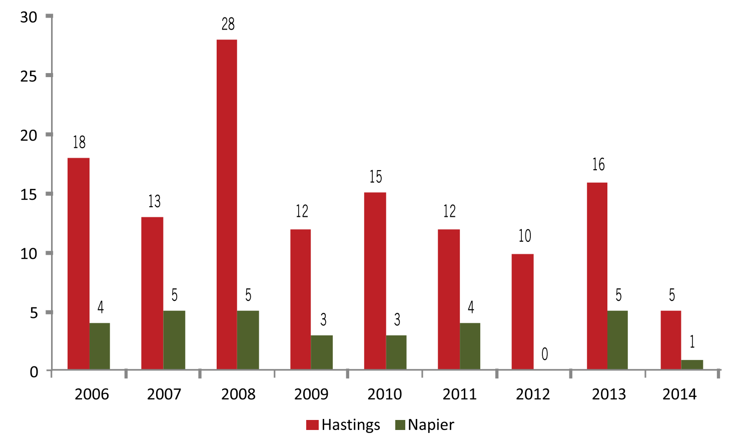


Figure 19: The number of times the 24 hour average PM10 concentration, measured at Marewa Park in Napier and St John's College in Hastings, has exceeded the NES of 50 µg/m³, 2006 to 2014.

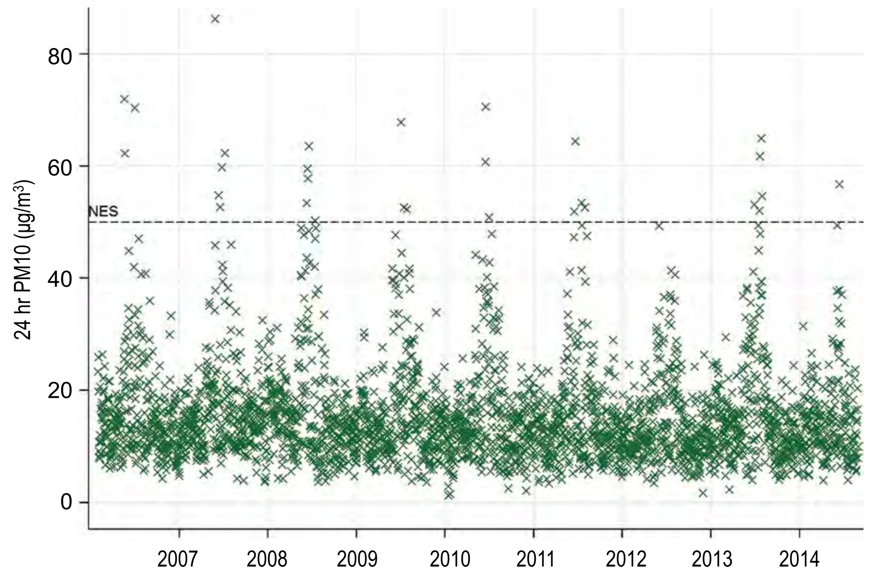


Figure 20: 24 hour average PM10 concentrations recorded at Marewa Park in Napier from 2006 to 2014.

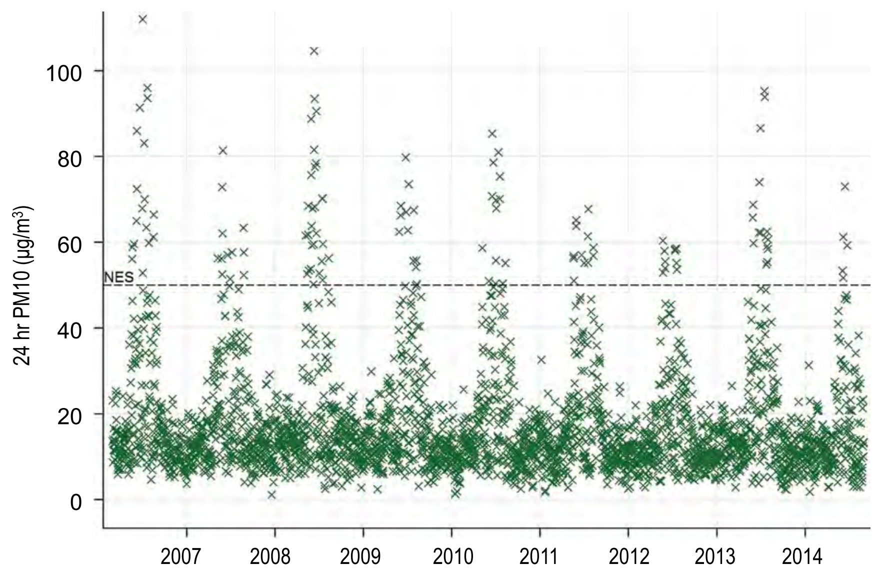


Figure 21: 24 hour average PM10 concentrations recorded at St John's College in Hastings from 2006 to 2014.

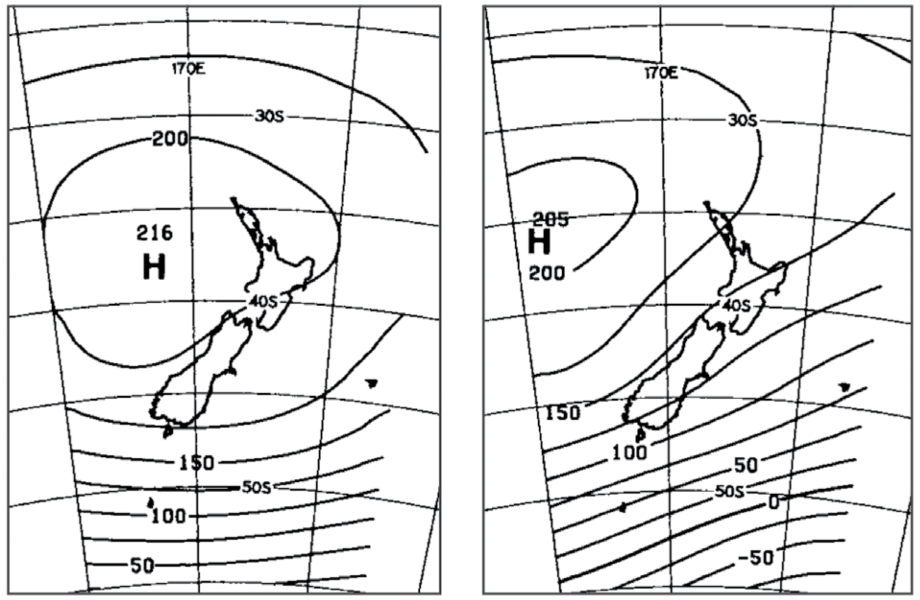


Figure 22: Typical weather patterns associated with 52% of the exceedances recorded at St John's College since 2006 (Kidson, 2000[1]). The images show a high pressure system centred in the Tasman Sea extending a ridge over New Zealand. The units displayed are the geopotential height (m) of the 1000 hPa pressure level.

[1] Kidson, J.W. 2000. An analysis of New Zealand synoptic types and their use in defining weather regimes. International Journal of Climatology 20: 299-316

μg/m³ = micrograms per cubic metre

Figure 23: St John's College winter daily average PM10 concentrations plotted against daily average wind speed and coloured coded by daily average temperature.

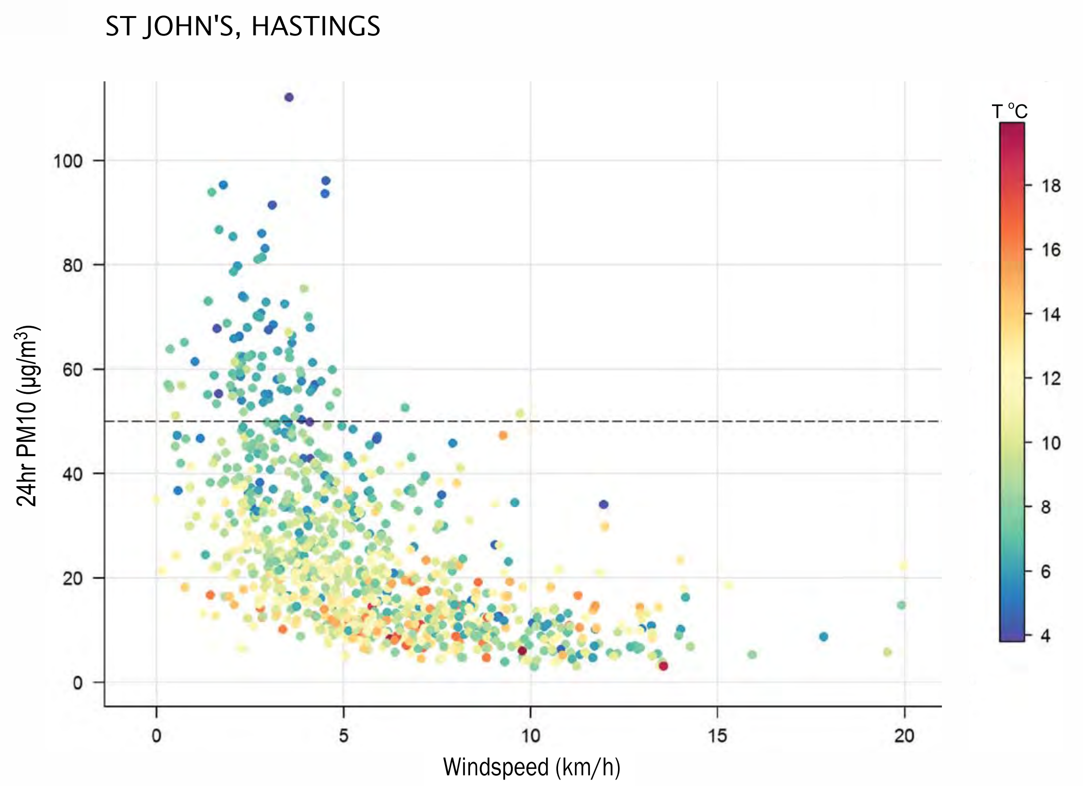
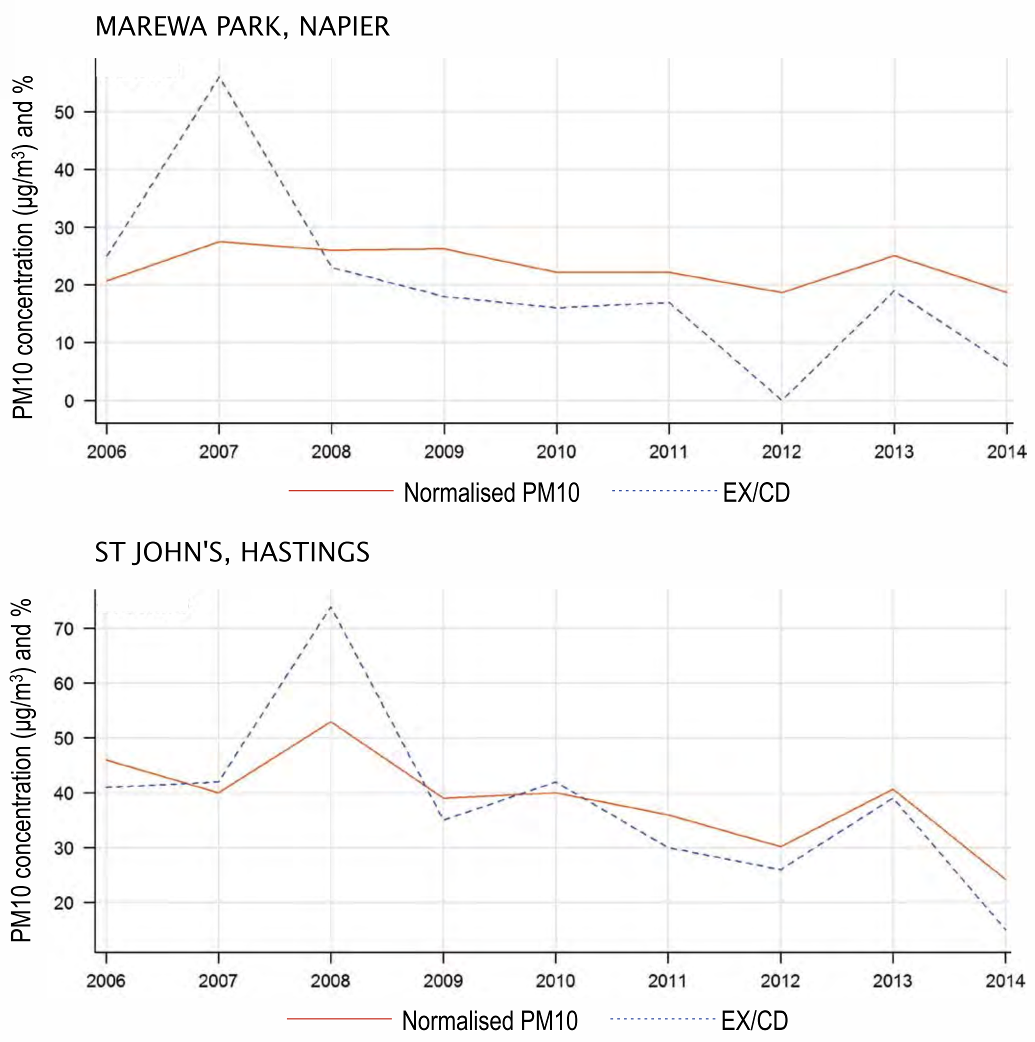


Figure 24: Normalised PM10 concentrations and the proportion of characteristic days that exceed the NES (EX/CD), for Marewa Park (top) and St John's College (bottom) from 2006 to 2014. A 'characteristic day' occurs when weather conditions might lead to an exceedance of the NES.



View from Te Mata Peak of air pollution around Napier and Hastings.

The monitoring site in Napier for the 2013 was on the corner of Hyderabad and Taradale Roads. This site has been used for the last two monitoring periods and previously the monitoring took place in Vigor Brown Street.

Roadside Monitoring

HBRC periodically monitors air quality at roadside locations that have high traffic volumes.

Continuous monitoring is undertaken for a period of eight weeks at sites in Napier and in Hastings every four to five years (Figures 25 & 26). The most recent monitoring was during July and August 2013 (and previously in 1994, 1998 and 2008). On each occasion, we have measured nitrogen dioxide (NO_2) and carbon monoxide (CO), while sulphur dioxide (SO_2), ozone (O_3) and PM10 have been monitored occasionally.

The results show that air quality at some of our busiest intersections meets health standards and is mostly 'Good' when compared to National Environmental Standards (NES). However direct comparisons between each monitoring period are difficult because of changes in location, the time of year and the pollutants being monitored.

The only pollutant that has exceeded the NES during roadside monitoring was PM10 during the 2013 monitoring period. Elevated PM10 concentrations occurred in the evening, mostly after the rush-hour peak, which suggests that domestic heating sources were contributing to the air quality measured.

The monitoring site in Hastings for 2013 was on the corner of Heretaunga Street West and Tomoana Road. In 2008 the site was located near the corner of Omahu and Maraekakaho Roads and before that in York Street.

Figure 25: Maximum 1 hour average carbon monoxide (CO) concentrations (top) and 8 hour average concentrations (bottom) compared to Environmental Performance Indicators (EPI) and the National Environmental Standards.

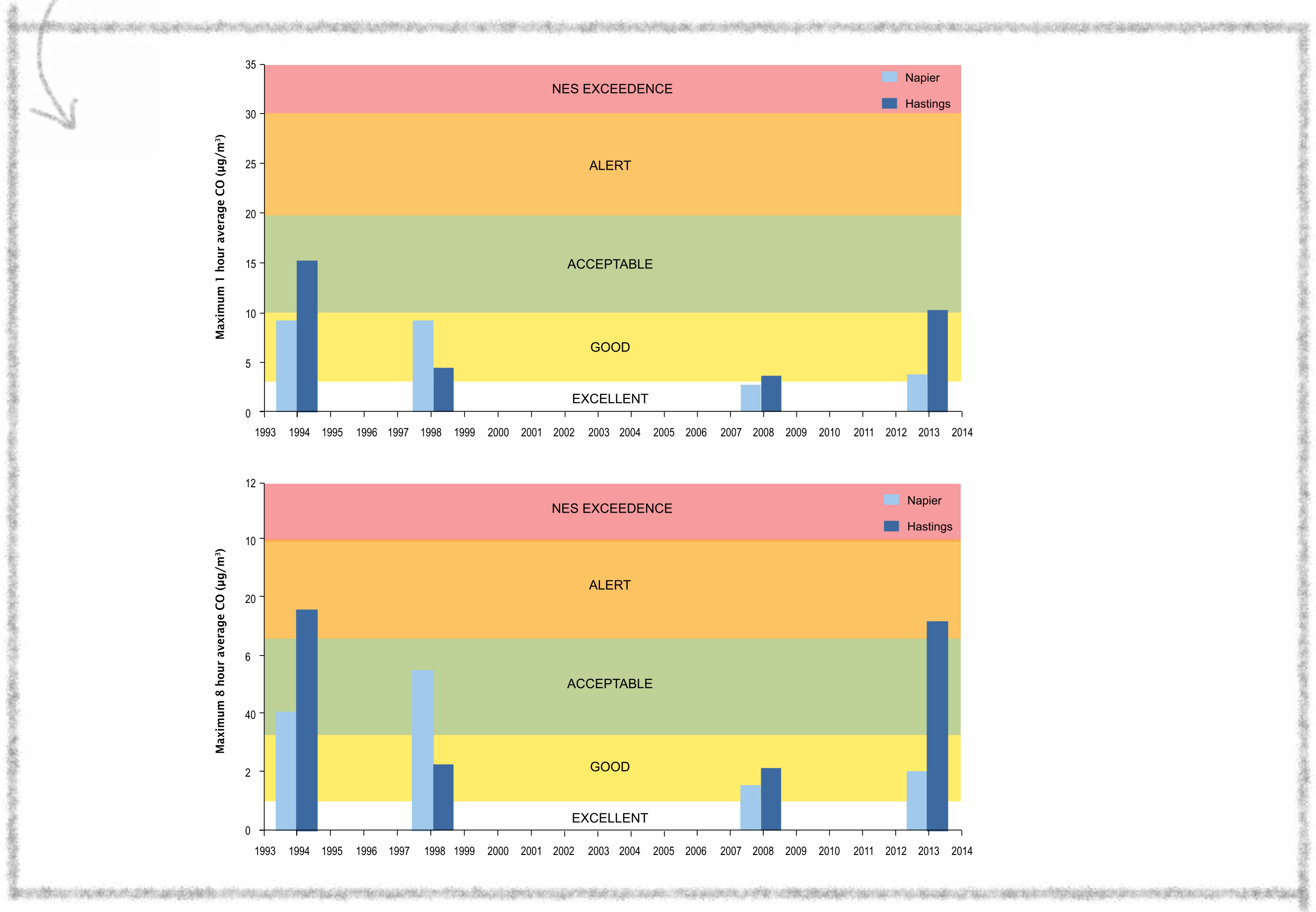
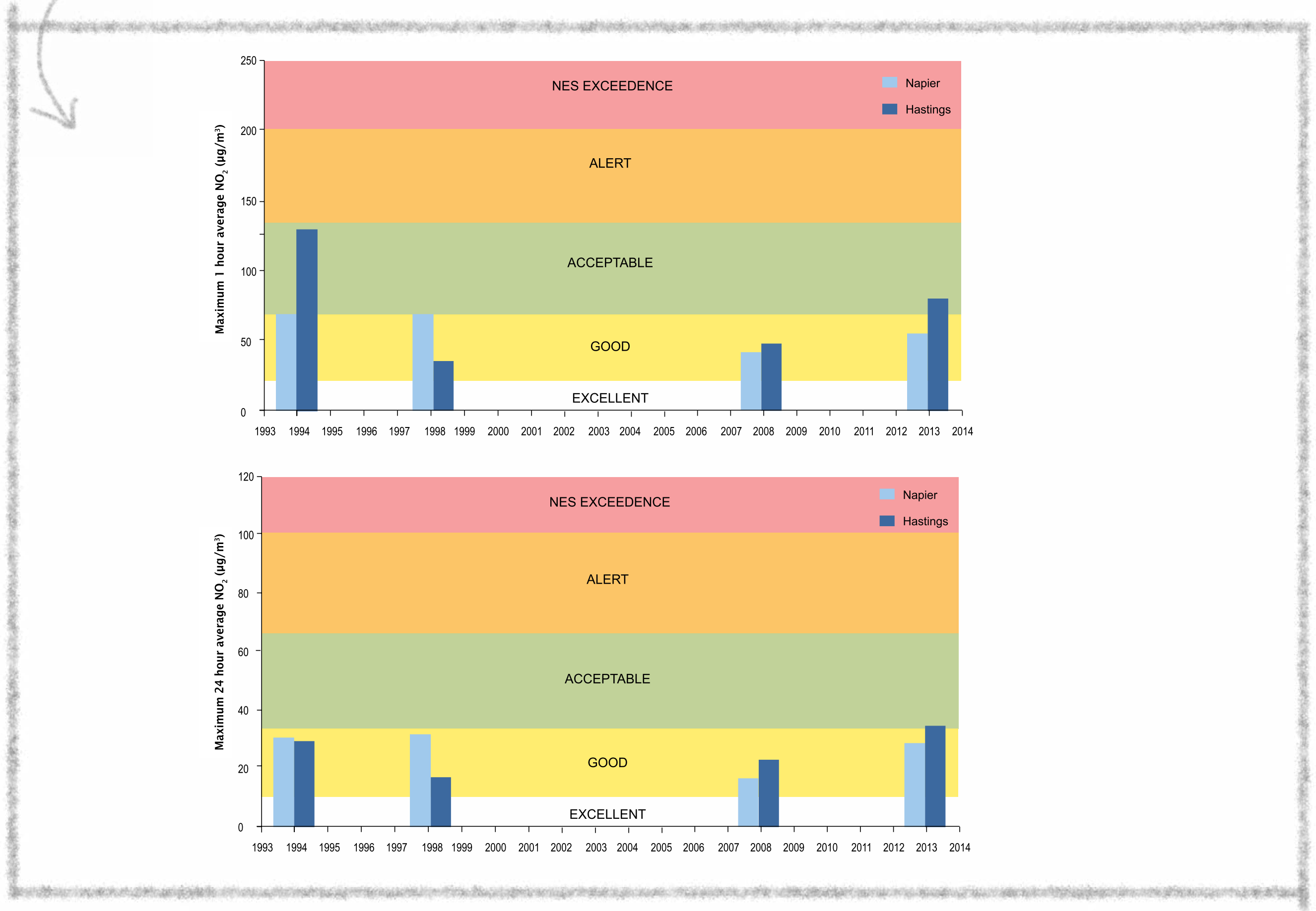


Figure 26: Maximum 1 hour average NO_2 concentrations (top) and 8 hour average concentrations (bottom) compared to Environmental Performance Indicators (EPI) and the National Environmental Standards.



Case Study

Winter air over the Heretaunga Plains

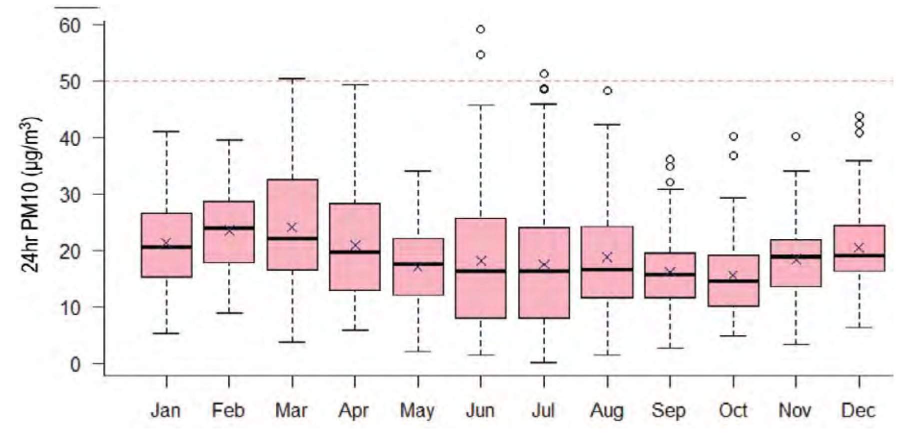


Figure 27: The distribution of daily mean PM10 concentrations by month at Awatoto. Thick black lines are the median and the cross is the mean. Upper and lower quartiles are represented by the upper and lower borders of the box respectively. Whiskers extend to 1.57 times the inter-quartile range and circles are outliers.

AWATOTO INDUSTRIAL AIRSHED PM10

Since 2012 HBRC has monitored PM10 in the Awatoto airshed at a site 200 metres from the shore. Land-use in the airshed includes industry and rural activities. The airshed receives a high level of PM10 from natural sources including wind-blown soil and sea spray. PM10 concentrations are higher when sea breezes carry salt into the airshed in summer and early autumn (Figure 27). This contrasts with urban areas (see page 21) where peak PM10 concentrations occur in winter, mostly due to smoke from wood burners.

At Awatoto it is windy weather that increases PM10 concentrations (associated with salt and soil), in contrast to Napier and Hastings where it's calm conditions that are associated with poor air quality.

The NES for PM10 has been exceeded four times at Awatoto since monitoring began. Two of these exceedances seem to be associated with local earthworks, while the other two were due to higher than normal levels of salt particulates during days of strong onshore winds and high seas (Figure 28). The Minister for the Environment recognised the last of these as an 'exceptional event' and acknowledged that the exceedance of the NES on that occasion was not within HBRC's control.

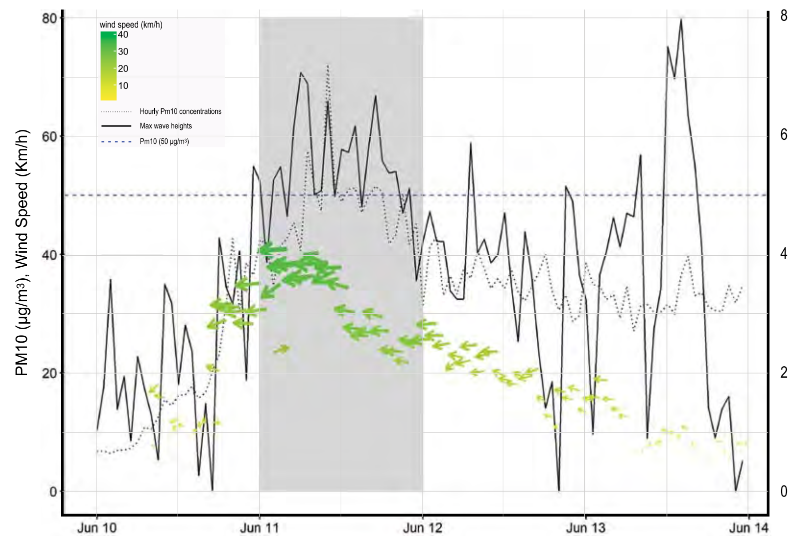
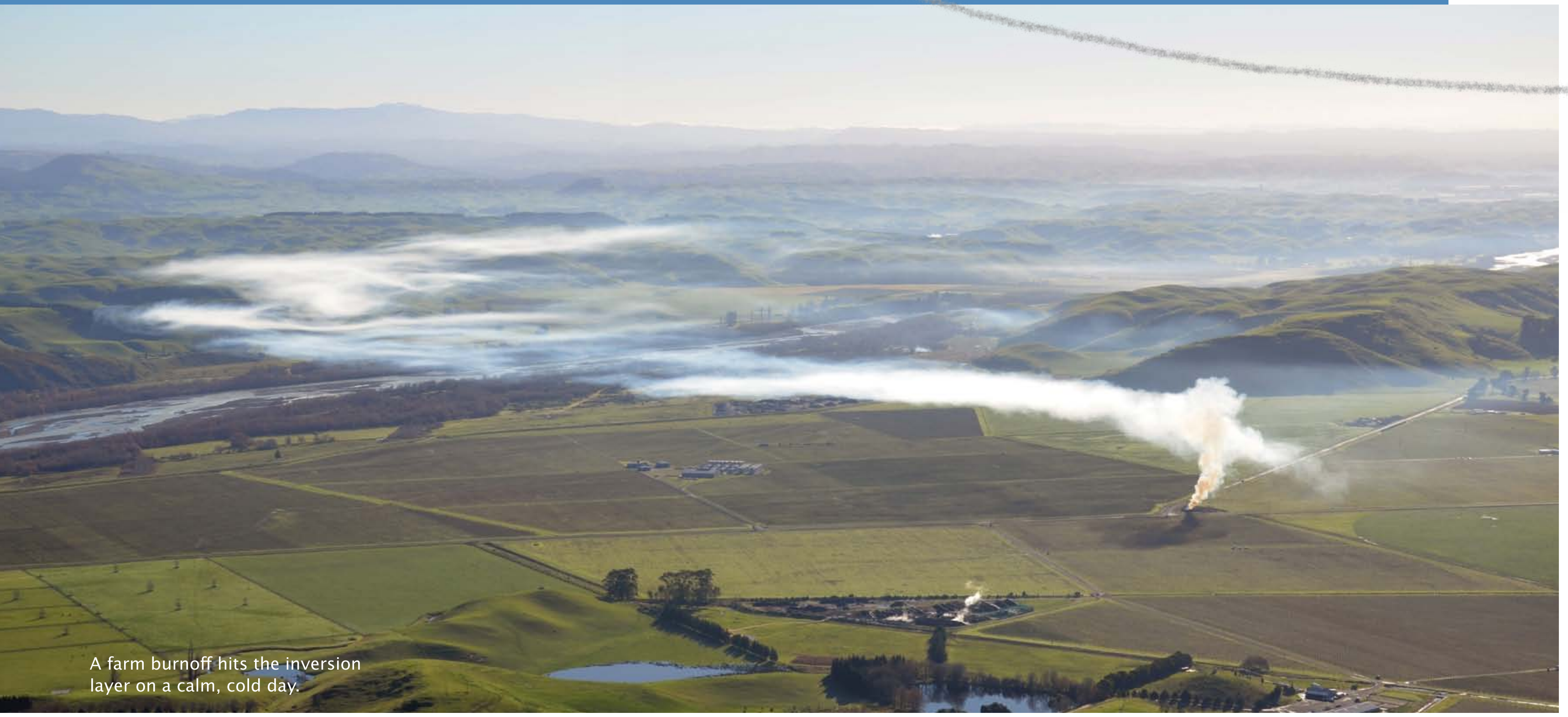


Figure 28: Hourly PM10 concentrations at Awatoto and maximum wave heights (hmax) at Port of Napier from 10 - 14 June 2014. The arrows show the direction of the hourly average wind. The speed of the wind is indicated by the colour and size of the arrows as well as their position relative to the y-axis. On 11 June (grey box) there was a strong onshore easterly wind and wave heights were higher than usual, and hourly PM10 concentrations were elevated throughout the day resulting in a 24 hour average that exceeded the NES for PM10 of 50 µg/m³.

Case Study



A farm burnoff hits the inversion layer on a calm, cold day.

RURAL PM10

Concentrations of PM10 are occasionally high during winter in Napier and Hastings, but how do our rural towns fare?

To find out, HBRC monitored PM10 in Wairoa, Waipukurau and Waipawa using a small mobile instrument called a Microvol. Air quality was monitored every third day on a school site in each town for one year. This 'screening' monitoring helps to identify whether more intensive monitoring should be undertaken.

Neither Waipukurau nor Waipawa exceeded the NES for PM10 during the period of monitoring (Figure 29). However, in Wairoa the NES was exceeded three times although, interestingly, these exceedances occurred in three different seasons – spring, summer and winter. HBRC is now monitoring air quality in Wairoa continuously to see whether those results were unusual or a regular pattern.

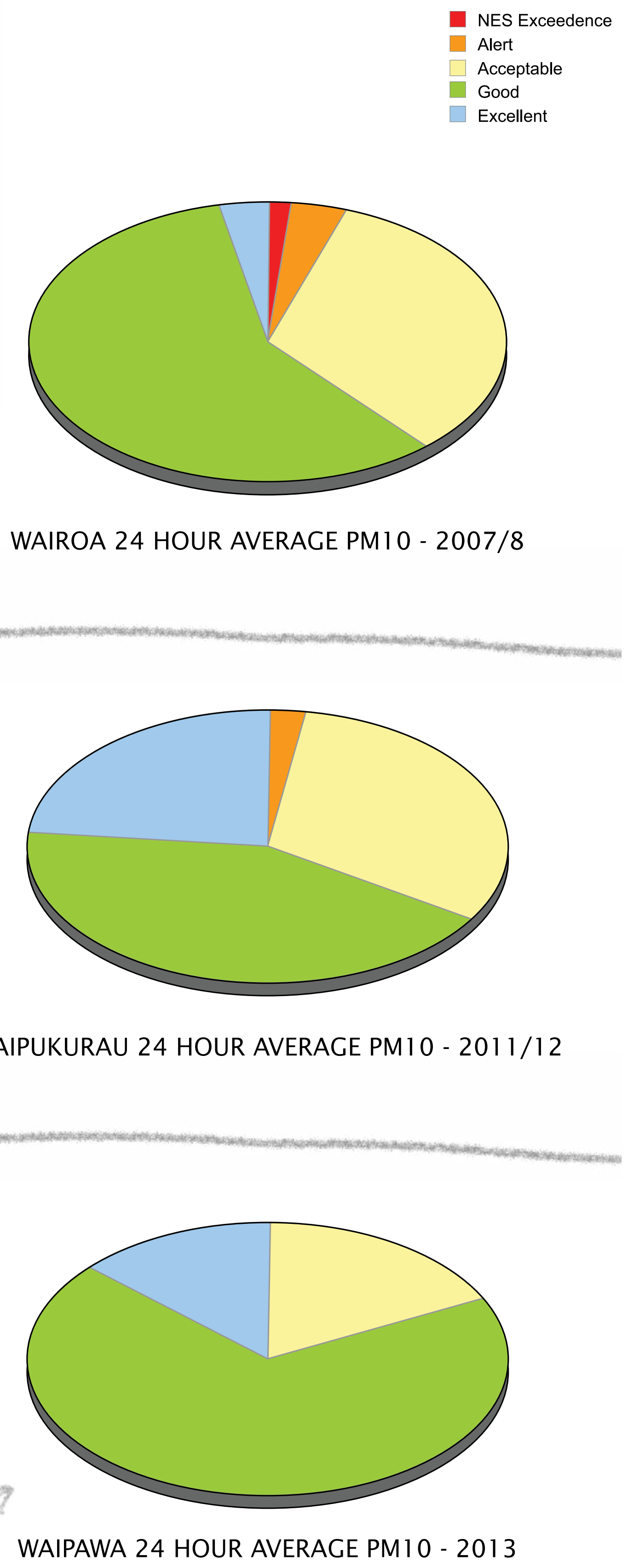


Figure 29: A summary of results from year-long PM10 monitoring campaigns in Wairoa, Waipukurau and Waipawa.

The 24 hour averages in these pie charts are categorised into Environmental Performance Indicators (EPI) and exceedances of the National Environmental Standards for Air Quality set at 50 micrograms PM10 in a cubic metre of air.

The EPI categories are:

- EXCELLENT AIR QUALITY (particles per cubic metre of air are less than 10% of the NES, less than 5 micrograms)
- GOOD (between 10-33% of the NES)
- ACCEPTABLE (between 33-66% of the NES)
- ALERT (between 66-100% of the NES).

An Exceedance is when PM10 is over the NES limit.

Case Study


A clear day over Ahuriri


A haze of air pollution hangs over the Heretaunga Plains

MOBILE MONITORING

Our understanding of spatial variations in air quality has been improved through mobile monitoring, which involves driving around the cities taking measurements of air quality at regular intervals.

HBRC's two permanent PM10 monitoring sites - in the Napier airshed at Marewa, and in the Hastings airshed at Mayfair - provide good long-term records of ambient air quality, which we use to investigate trends, but they don't give us a complete picture of air quality variations across the airsheds.

Mobile monitoring is useful for highlighting relative differences in air quality between suburbs, but it only provides a snapshot in time, and the results can't be compared with the NES of 50 µg/m³ which is a 24 hour average.

On the evening of 23 June 2014, when conditions were cold and calm, we completed mobile monitoring around the Heretaunga Plains, taking measurements every minute along a route through Clive, Hastings and Napier.

The highest concentrations in Hastings were found near the permanent monitor in Mayfair. In Napier high concentrations were found at a range of locations from Greenmeadows to Maraenui (Figure 30). This information helps HBRC to know where help may be needed to reduce emissions, including increasing the use of clean forms of heating.

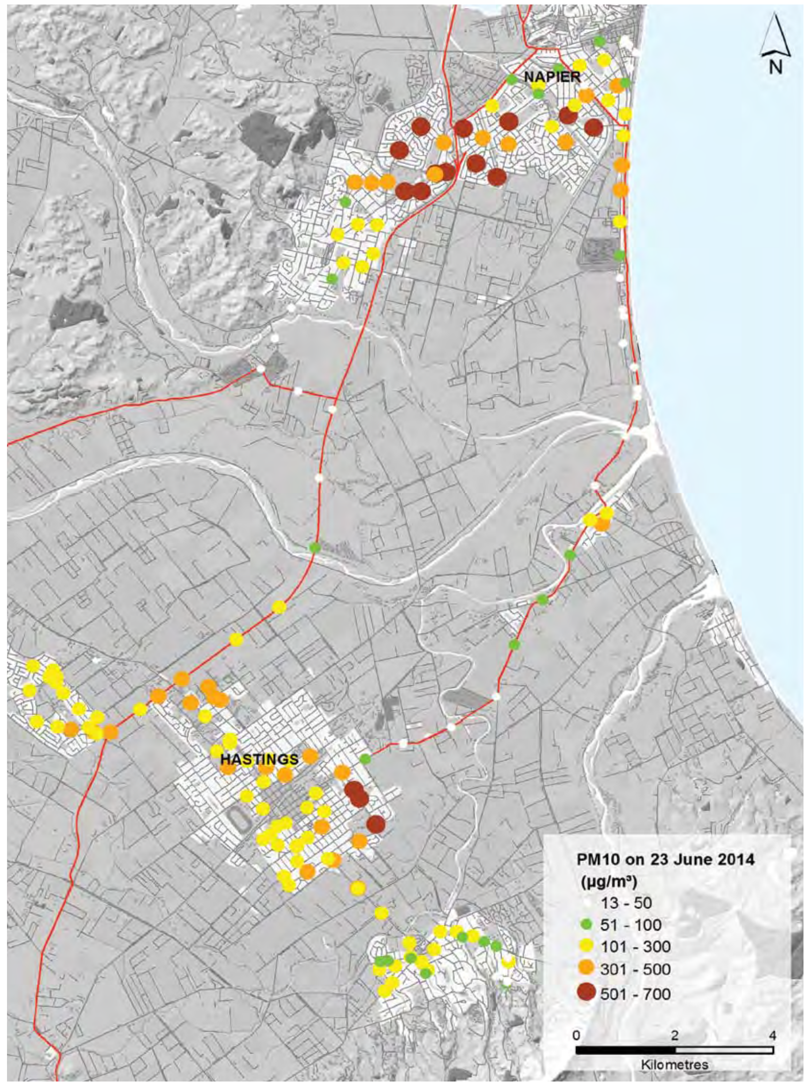


Figure 30: PM10 concentrations measured at 1 minute intervals on the evening of 23 June 2014.

Fish

Helping our Native Freshwater Fish

There are 19 species of native fish found in the streams and lakes around Hawke's Bay. Most are secretive and shy and may be swimming around in your local creek without you realising. But ***8 of these native species are threatened*** and all need our help to thrive. Hawke's Bay Regional Council scientists monitor native fish populations around the region to determine abundance and trends, and to identify potential problems, like barriers to fish migration.

The 3 migratory Galaxias species (whitebait) found in Hawke's Bay, with a non-migratory cousin (top left). The dwarf Galaxias evolved from a koaro-like ancestor. The transparent juvenile stage of inanga (and less commonly koaro and banded kokopu) can be found in your whitebait patty!

Please help us find barriers

We are trying to identify barriers to fish passage in streams around the region so we can prioritise our fish barrier remediation programme.

There's a lot of streams to look at, so we would appreciate the help of landowners, fishers and other river users. If you know of a barrier in your area, please enter details on **www.fishbarrier.co.nz** and upload a photo. We are particularly interested in barriers within 40 km of the coast, because fish species diversity is highest in this zone and many poor climbing species live here.

Even small drains running through your property are important habitat for these species. See full details on the website.

Providing Passage for our Migratory Fish

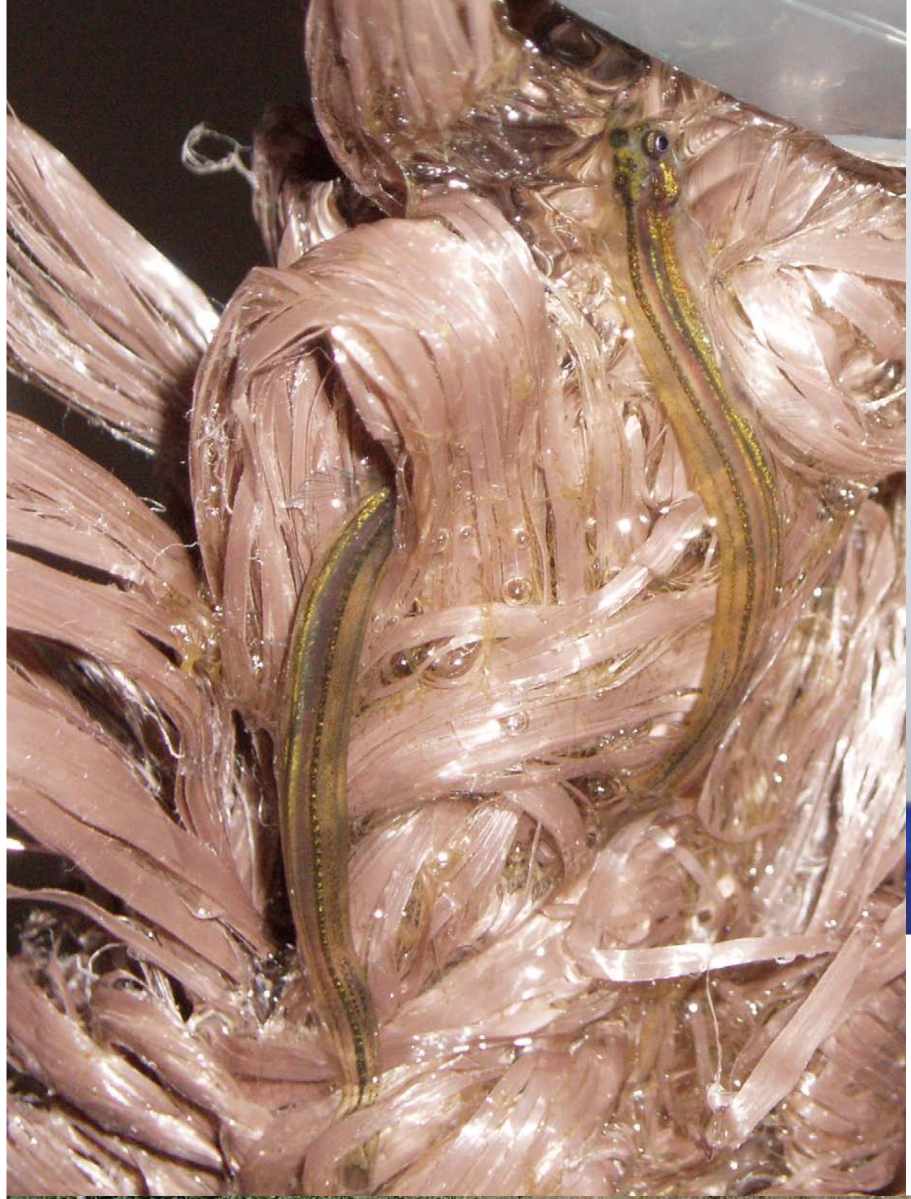
From the Sea to the Mountains

Our native freshwater fish can be divided into 'migratory' and 'non-migratory' groups. The migratory group, which includes whitebait and tuna (eels), need access to and from the ocean. Most of our freshwater fish species are migratory because freshwater habitats in New Zealand have been disturbed repeatedly over millions of years by volcanic eruptions, glaciers and sea level change. Freshwater populations were wiped out, and it was only species that could swim through the sea that were able to access New Zealand and repopulate rivers and lakes. Because of this history, 17 of the 19 native species in Hawke's Bay still spend time in the ocean. However, now these fish face the modern challenge of roads, dams and other obstacles blocking rivers and streams, preventing migratory species from accessing their freshwater habitats. If we don't provide for fish passage, stream biodiversity will decline.

Providing fish passage

Fixing fish barriers around the region is a priority to ensure fish can find their way upstream to suitable habitat, and HBRC is working with iwi, interested organisations and landowners. Some of our native fish are excellent climbers and don't need much help. Elvers, koaro and banded kokopu can use their specialised fins to wriggle their way up damp vertical surfaces. For these fish, we are installing mussel spat rope (photos, upper right).

Other species like inanga, torrentfish and bullies need a bit more help. There is currently no cheap fix for helping these species up and over difficult barriers, and so we are working with specialists around the country to develop a fish ramp that would be suitable, robust and cheap. We trialled prototypes during the summer of 2014/15 (photo, lower right).



Perched culverts are a common problem in hilly terrain. The mussel spat rope above provides elvers and other 'climbers with a navigable surface to help them over the barrier. *Photos Bruno David*

Experimenting with prototype fish ramps at an HBRC pumping station.

Bluegill bully

Actual Size = 15mm

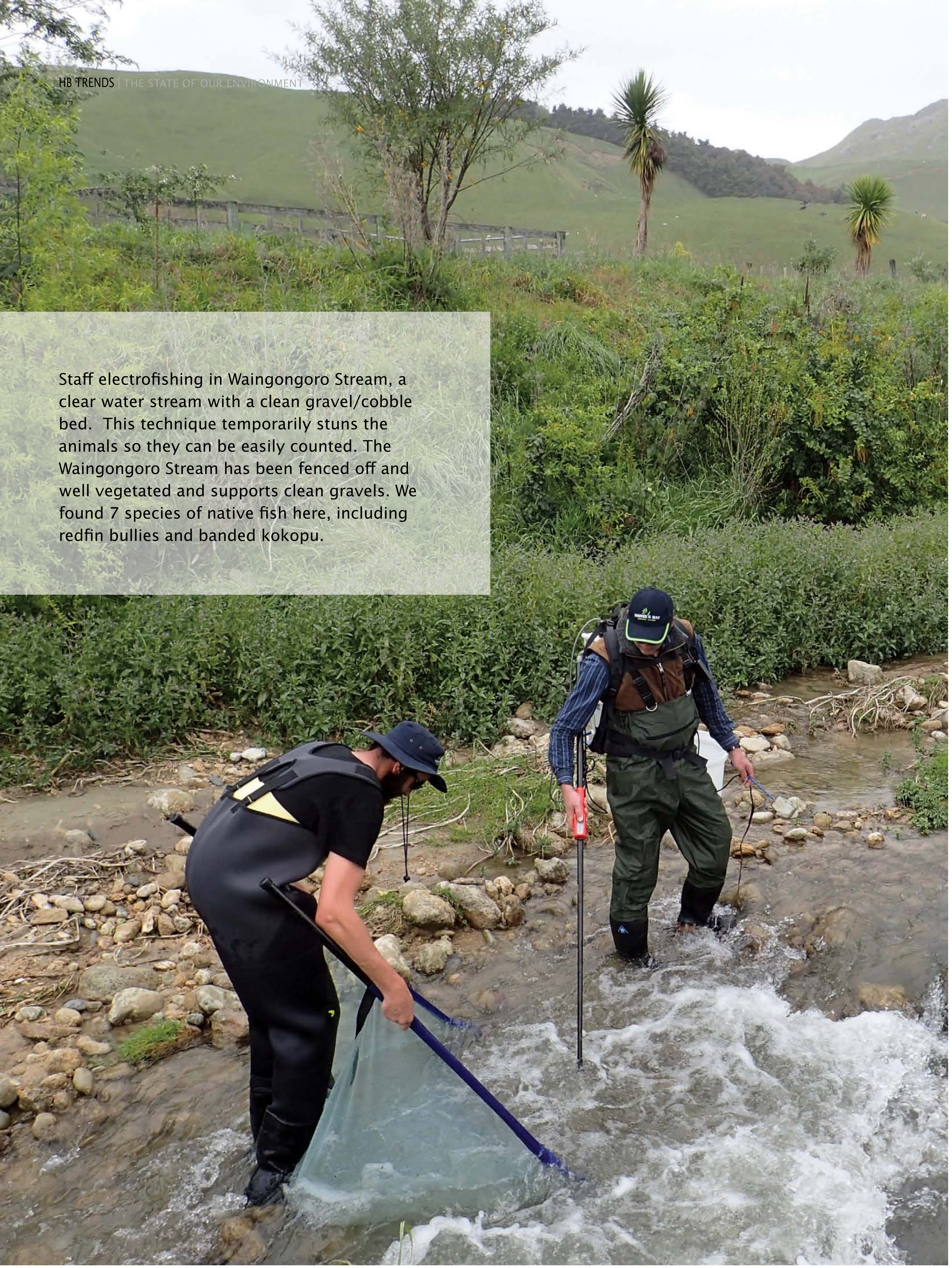
HBRC checking fish below a weir and upstream (fish barrier).

Minimum flow and fish

Torrentfish and bluegill bullies prefer faster water in riffles and rapids and are most commonly found in the lower reaches of our larger rivers. The bluegill (above) was caught in the Mohaka River, and the torrentfish (right) was caught in the Tutaekuri River. During dry conditions HBRC needs to temporarily stop irrigators and other water users from extracting water, otherwise the fast water habitat needed by these species dries up and disappears.

The unique torrentfish is found only in New Zealand and is common in our braided Hawke's Bay rivers. This fish is closely related to blue cod, but has evolved into a flattened form with specialised fins to help anchor it to the riverbed in fast flowing rapids.

Actual Size = 15mm



Staff electrofishing in Waingongoro Stream, a clear water stream with a clean gravel/cobble bed. This technique temporarily stuns the animals so they can be easily counted. The Waingongoro Stream has been fenced off and well vegetated and supports clean gravels. We found 7 species of native fish here, including redfin bullies and banded kokopu.

Male redfin bully in breeding colours.

Sedimentation and fish

The male redfin bully uses his bright colours to attract the less colourful females to a favoured rock or log. The female will attach her eggs to the underside of the site the male is guarding. After fertilising the eggs, the male stands guard and uses his fins to gently sweep away any mud or sand that would otherwise smother the eggs, as well as chasing away potential predators.

When too much fine sediment enters our waterways, it smothers all the nooks and crannies that would normally be suitable for eggs, and the bullies cannot reproduce successfully. Stopping sediment from surrounding land getting into our waterways will really help our native fish, and is a high priority for HBRC (page 42).

Less colourful female redfin bully.

Juvenile kahawai caught in the Waitangi Estuary

Actual Size = 12mm

Juvenile stages of black (pātiki), yellow belly and sand flounder all spend time in our estuaries

Monitoring fish communities in the Ahuriri Estuary

Estuary Fish

Estuaries host many fish species. Some of these, such as the estuarine triplefin, spend their entire lives in the estuaries. However, most fish found in the region's estuaries are either juveniles or adults migrating between rivers and the sea.

Estuaries are critical nursery habitats for many fish, particularly for juvenile black (pātiki), yellow belly and sand flounder. These juvenile fish are vulnerable to changes in water quality and salinity associated with changes in land use.

We are surveying estuaries around Hawke's Bay to create an inventory of species present and to see which species are becoming more or less abundant.

Estuaries are critical nursery habitats for many fish and are especially vulnerable to impacts from land use.

Photo: Sjaan Bowie

Inanga lay their eggs in our estuaries near the upstream penetration of the salt wedge. The saline intrusion study will help locate these critical reproductive habitats so they can be managed accordingly. *Photo: Mike Hickford.*

Conductivity/temperature logger used in salinity surveys. These instruments are installed at sites around our estuaries to monitor changes in salinity.

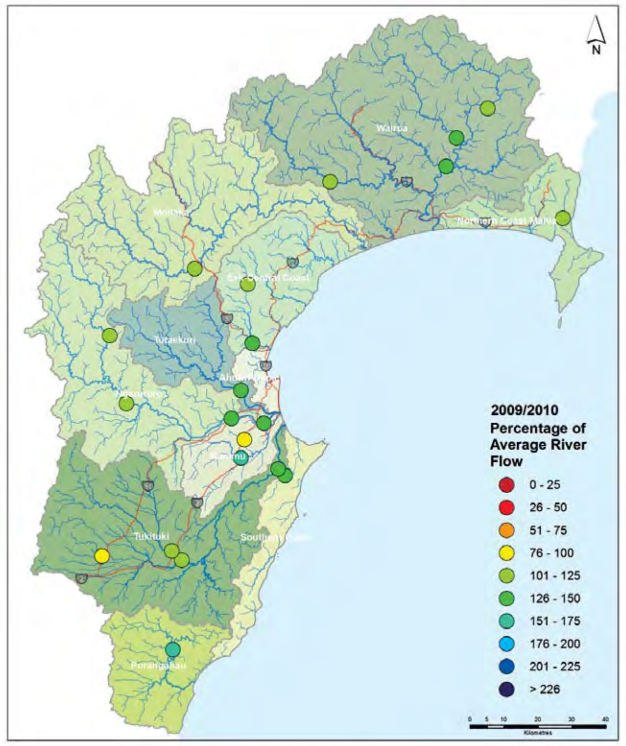
Salinity Mapping

Fish and other organisms favour particular estuarine habitats and salinities. Mapping these habitats is critical for understanding our estuaries. We have mapped the extent of saline influence in most of the region's large estuaries, as well as sediment and habitats in the Waitangi estuary (see case study page 137).

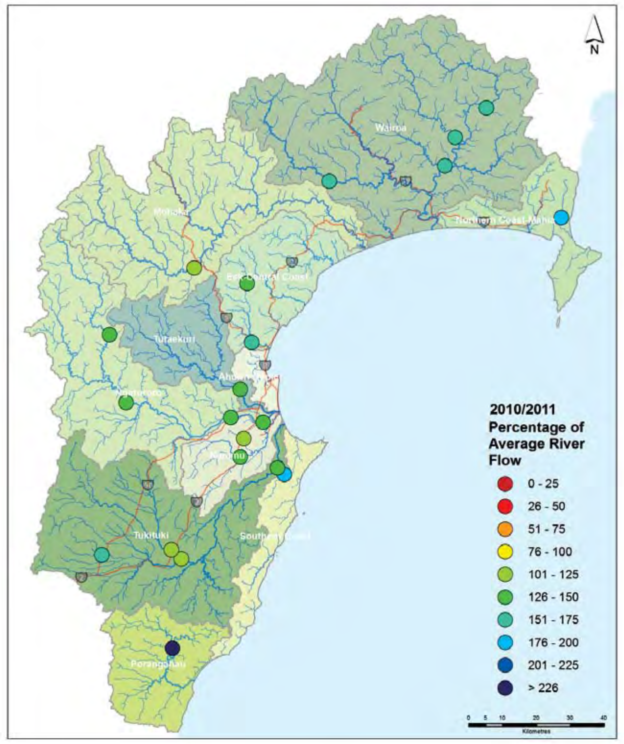
Mapping where the saline influence occurs provides a baseline we can use to assess the changes over time associated with changing river flow and changing sea levels related to climate change.

Some fish species are sensitive to where saline water extends into estuaries. Inanga lay their eggs on the banks of our estuaries on spring tides, near the maximum extent of saline influence. By mapping the maximum extent of saline water, HBRC improves its ability to find these important reproductive habitats. This helps us protect these areas to ensure more whitebait occur in future seasons.

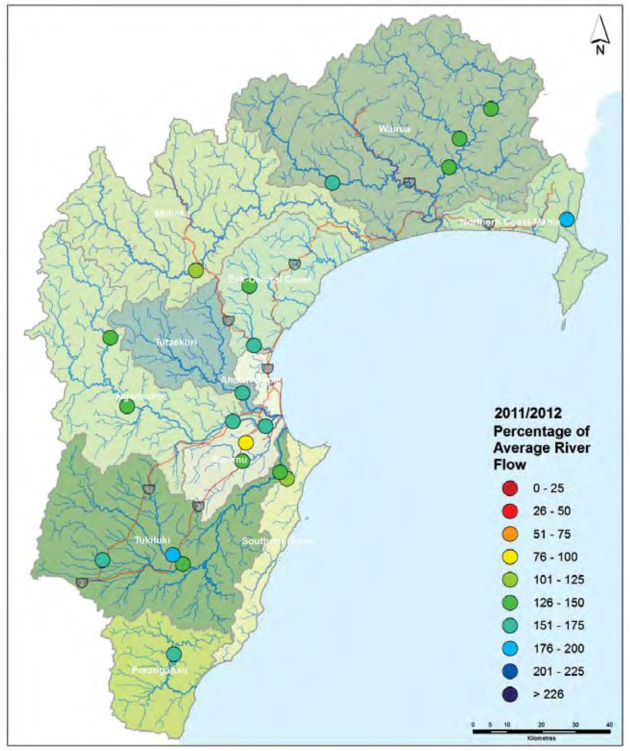
Figure 39: Extent of maximum saltwater influence in the Clive River (lower), Ngaruroro River (middle) and Tutaekuri River (top). Dark blue is saltwater, light blue is freshwater.



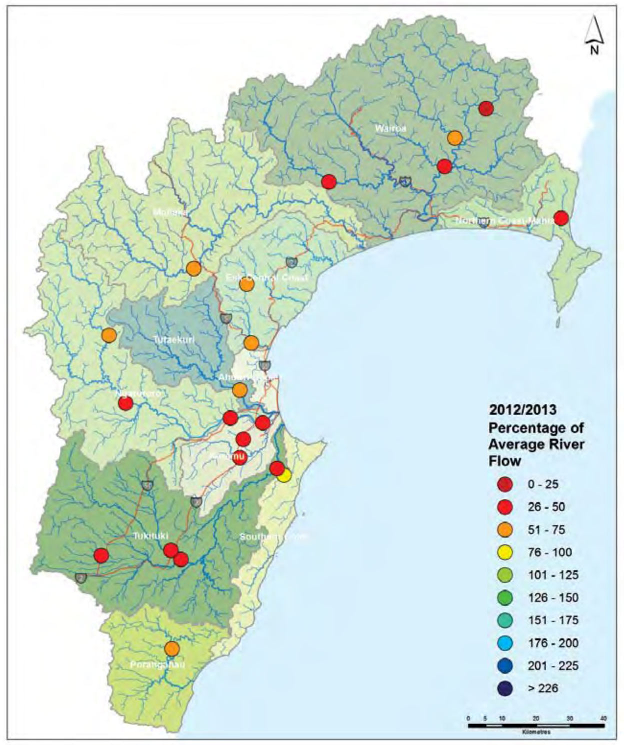
2009/2010
PERCENTAGE OF AVERAGE RIVER FLOW



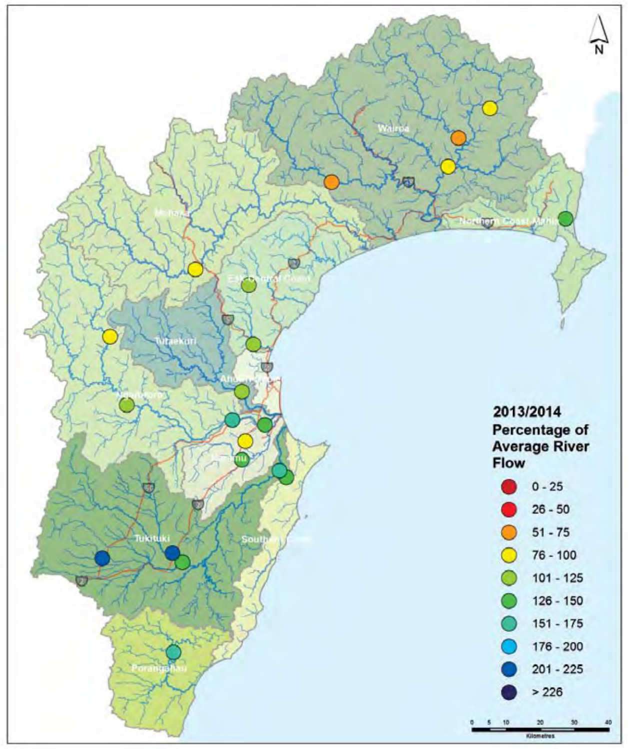
2010/2011
PERCENTAGE OF AVERAGE RIVER FLOW



2011/2012
PERCENTAGE OF AVERAGE RIVER FLOW



2012/2013
PERCENTAGE OF AVERAGE RIVER FLOW



2013/2014
PERCENTAGE OF AVERAGE RIVER FLOW

Figure 40: Regional river flow summary - Percentage of average river flow (1st October to 30th April) 2009-2014.

River Flows

River flows across the Hawke's Bay region have mostly been average or above average during the last five years, except during the summer of 2012/2013.

The 'percentage of average flow' statistic at 21 river sites was calculated by comparing river flows during the dry season of each year (from 1 October to 30 April) with long-term average river flows (see Figure 40).

From 2009 to 2012, river flows at all sites were either close to average or above average (Figure 40). Over the last five years the highest seasonal flows occurred during 2010/2011. During this year, flows at representative sites in the north of the region (Kopuawhara Stream) and south of the region (Taurekaitai Stream) were between 100 and 183 percent of average. Heavy rain during the Easter holidays in late April 2011 caused severe flooding and damage around the northern and southern coastal areas of Hawke's Bay. The climate case study on page 147 describes this event in more detail.

The region experienced drought conditions during 2012/2013, which is described in the climate case study on page 12. As a result, river flows at all sites during that year were well below the long-term average, with flows at 21 to 76 percent of the average.

During 2013/2014, river flows across the region were generally close to average or above average. However sites in Northern Hawke's Bay and the Mohaka Catchment experienced drier than usual conditions (see Rainfall chapter, page 9).

Mahanga Beach is one of the popular recreational spots where water quality is monitored.

Recreational Water Quality

Hawke's Bay's coastal waters, freshwater lakes and rivers are used for a range of recreation activities such as swimming, surfing, water skiing, fishing, kayaking, shellfish gathering and diving.

Water quality in the coastal environment throughout Hawke's Bay is generally very good and suitable for recreational activities. Water quality at freshwater sites can be more heavily affected by land use and discharges in the catchment than marine waters. Estuarine or coastal lagoon areas are the receiving environment for the entire freshwater drainage network and as these areas typically have slow-flowing, warmer waters they can have consistently higher numbers of bacteria than freshwater and marine areas.

What affects water quality?

At times, particularly after heavy rain, rivers and coastal waters can have animal and even human faecal material in them. The water may carry pathogens (germs, including viruses and bacteria) that can cause illness or infections for some people or stock.

Although it is not possible to monitor for all of these pathogens, those that commonly cause illnesses are associated with enterococci and *Escherichia coli* (known as *E.coli*) bacteria and can be monitored. Measuring the concentration of these bacteria gives an indication of the health risk associated with contact with the water.

Figure 41: Recreational water quality monitoring sites in Hawke's Bay.

Summer weekly monitoring

Each week during summer HBRC's science team collects samples at 37 popular sites where people swim, kayak, surf or enjoy other activities on or in the water – termed 'contact recreation' (Figure 41). When bacteria levels in a sample exceed Ministry of Health guideline values for two consecutive days, signs are put up at that site by councils and the Public Health Unit of the Hawke's Bay District Health Board advising people to stay out of the water until bacteria levels return to normal, low-risk levels. The information is also on HBRC's website.

Long term monitoring

The Suitability for Recreation Grade (SFRG) is a general guide to the water quality of a site based on 5 years of weekly monitoring data with information about the catchment. The SFRG grade descriptions indicate how suitable a site is for contact recreation (Table 5).

Our monitoring programme

HBRC's science team focuses on 'hot spots', those sites where water quality has deteriorated or which have consistently poor water quality. We aim to discover the source of the contamination and find management options that can improve water quality by reducing bacteria levels. Investigations include catchment inspections and 'faecal source tracking' that use Faecal Sterol and Polymerase Chain Reaction (a type of DNA analysis) measurement techniques. These analyses help identify whether contamination comes from human, ruminant (cow, sheep and deer for example), dog or waterfowl sources (see case study page 74).

Table 5: The Suitability for Recreation Grade (SFRG)

SFRG	SITES	COMMENTS
Very Good	Aramoana Beach Blackhead Beach Kairakau Beach Ocean Beach Porangahau Beach Pourerere Beach	Generally large open coastal beaches of southern Hawke's Bay with high flushing and dilution.
Good	Hardinge Rd Beach Mahanga Beach Marine Parade Waimarama Beach Waipatiki Beach Westshore Beach	Generally urban beaches or beaches with settlements or freshwater inputs.
Fair	Mahia Beach Te Mahia at boat ramp Te Awanga Beach	More work required to understand why these beaches do not have higher gradings.
	Pandora Pond	More work programmed through the TANK Plan Change process to determine sources of faecal contamination.
	Esk River Ngaruroro River Tutaekuri River	Fair grade reflects susceptibility to rainfall related contamination.
Poor	Maraetotara Lagoon	Generally coastal lagoons with limited flushing and warmer temperatures.
	Opoutama Beach	Initial testing results indicate land-use sources. More work required to confirm these results.
	Tukituki River at Blackbridge Tukituki River at SH2	Work programmed to confirm source of faecal contamination. Plan Change in process to address suspected sources.
Very Poor	Clive River Wairoa River Kairakau Lagoon Maungawhio Lagoon Porangahau Estuary	More work required to determine main source of faecal contamination.
	Waipatiki Lagoon Waipuka Stream	Faecal source work has highlighted waterfowl sources.
	Puhokio Lagoon	
	Lake Tutira	Prone to unpredictable cyanobacterial blooms and parasites causing duck itch.
Follow-up	Tukituki River at Walker Rd	More work needed to determine why low *E. coli* levels conflict with high risk identified potential upstream sources. A longer data set is required to grade this site.

Case Study

Ocean Beach at Waipuka Lagoon

WAIPUKA STREAM –

Tracking the origin of faecal contamination

During the summer sampling season 2013/14, our recreational water quality science team investigated the source of contamination in the Waipuka Stream.

Waipuka Stream lies at the eastern end of Ocean Beach Road, 30 km south of Napier. The catchment for Waipuka Stream and Ocean Beach is predominantly in high production pastoral farming, with small sections of exotic forest and one of the most extensive sand dune systems in Hawke's Bay.

Waipuka Stream is used for paddling and wading but it consistently has a 'poor' Suitability for Recreation Grade. The 'poor' SFRG is due to regular high faecal bacteria counts.

This history of poor recreational water quality for the site prompted a special investigation during the 2013/14 season to track the origin of high faecal bacteria counts. On two occasions when the Waipuka Stream samples showed relatively high counts, our science team investigated further.

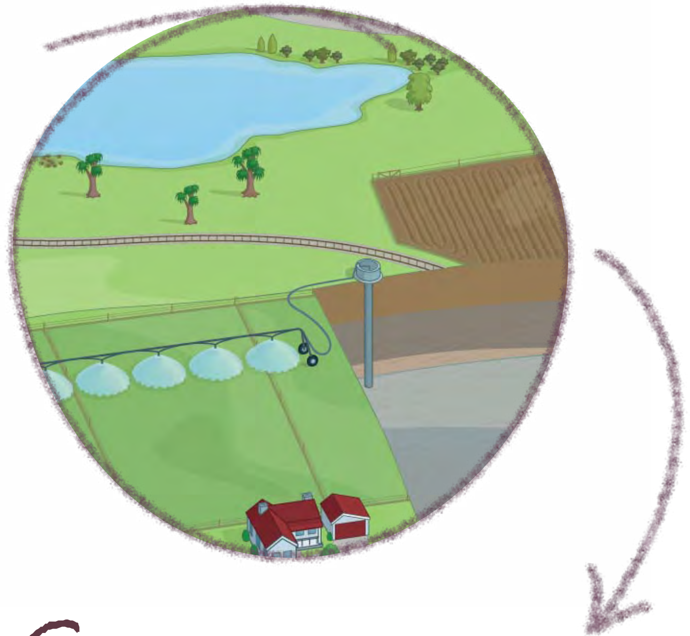
Using Faecal Sterol and Polymerase Chain Reaction (a type of DNA analysis) measurement techniques, we found that most of the bacteria was coming from waterfowl with some faecal contamination also from ruminants (ie cattle, deer, goats or sheep). There was no evidence that any human waste from dysfunctional septic systems was contaminating the stream.

We found further evidence of the cause of the high bacteria counts when we surveyed upstream of the sampling site: a large number of resident geese were depositing their droppings on the stream bank.

We are continuing to explore ways to improve water quality in the Waipuka Stream, working with local landowners and the community, and ensuring the community is aware of the contamination risk and causes.

The mouth of the Waipuka Stream from the air

Groundwater exploration in Hawke's Bay began on the Heretaunga Plains in the mid 19th century and by 1887 the city of Napier was supplied with groundwater from 6 artesian wells.



Groundwater

Groundwater is one of Hawke's Bay's most precious natural resources.

Approximately 90% of all water resource consents are issued for groundwater abstraction. Compared with surface water, there is almost 8 times the number of groundwater consents issued and triple the annual volume of water allocated (excluding consents for hydro electricity).

Most wells and groundwater consents are located on the Ruataniwha and Heretaunga plains (Figure 44). These two areas account for 90% of the region's consented groundwater allocation and approximately 84% of the number of wells drilled.

Today groundwater is mainly used for irrigation and industrial use, with municipal supplies accounting for 25% of the groundwater allocated.

Traditionally, the management of water resources focused on surface water or groundwater as if they were separate resources. Over time, and through a better understanding of the system, it has become apparent the development of either of these resources affects the quantity and quality of the other.

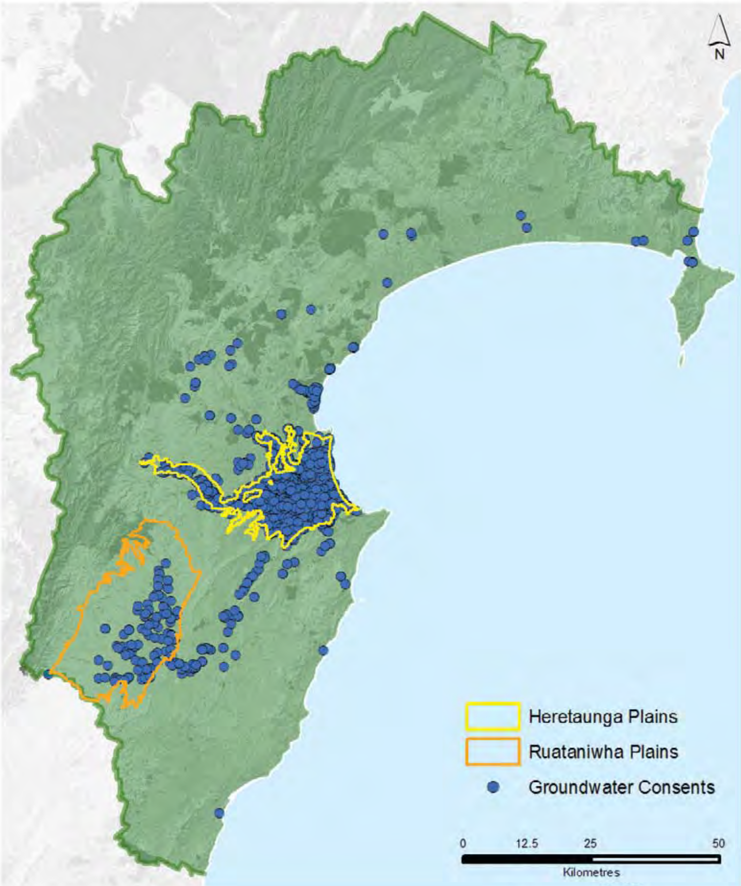


Figure 44: Location of groundwater consents in Hawke's Bay.

Groundwater Monitoring

Long-term systematic monitoring of our groundwater resource has been occurring since the late 1960s.

Many of these older monitoring wells were originally drilled for other purposes than to monitor the State of the Environment. A dedicated State of the Environment groundwater programme was not established until the early 1990s.

Drilling a new monitor well is an expensive process. To reduce the costs involved in establishing a groundwater monitoring network, Hawke's Bay relies on private wells to take groundwater samples and measurements. Access to these wells is provided free of charge by Hawke's Bay land owners. Today, many of our most valuable monitor wells are still privately owned.

MONITOR WELL NETWORK

A network of 112 monitoring wells is used by HBRC to monitor both short-term and long-term changes in groundwater recharge, storage and water quality. Monitoring helps us see how groundwater is affected by groundwater pumping, land use change and climate variability. Information about changes to our groundwater resource helps assess the effectiveness of our current Resource Management Plan and helps us develop policy to manage and protect our groundwater resource

Case Study

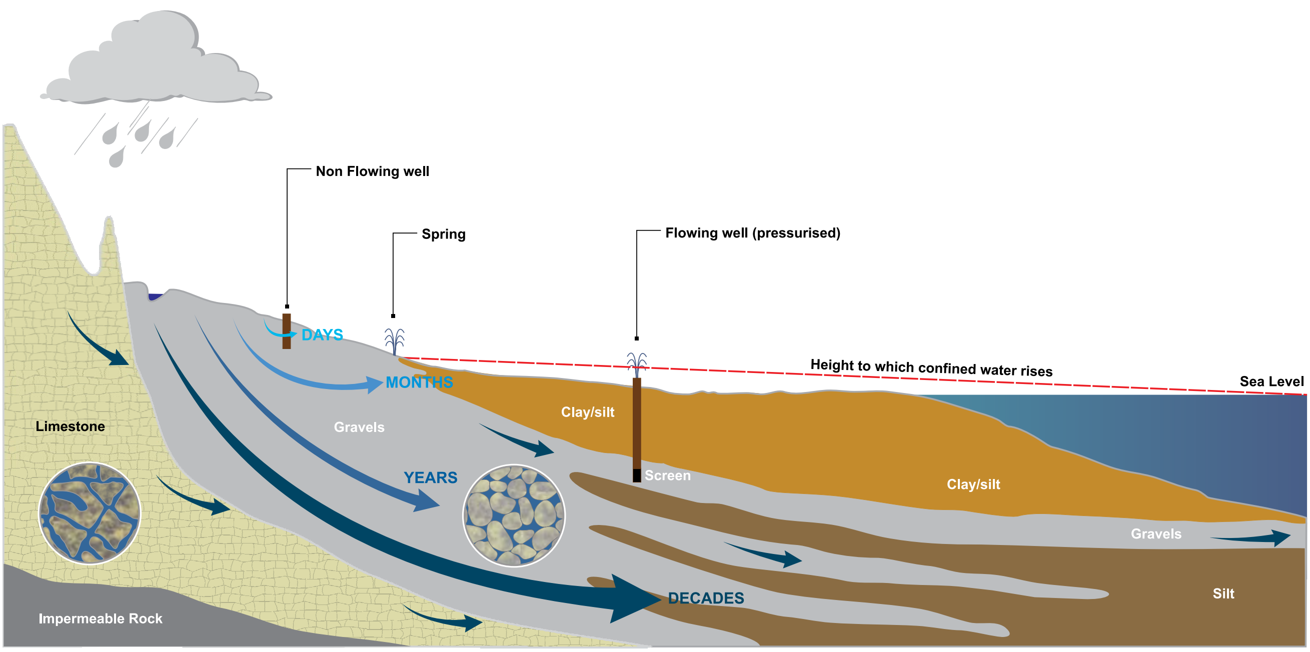
A PLAINS MODEL

A geological model of the catchments of the Heretaunga Plains is being developed. The catchments of the Tutaekuri, Ahuriri, Ngaruroro and Karamu rivers are known collectively as TANK (from the first letters of the river names). These rivers and the groundwater resources underlying the plains are important contributors to nearby surface water bodies and sustain agriculture and horticulture, city water supplies and industry.

The three-dimensional computer model of groundwater and surface water has been developed by HBRC to help sustainably manage the fresh water that is available on the plains. The model allows the effects of proposed water and land use approaches to be understood by Council and by stakeholders during decision-making and before these approaches are implemented.

HBRC works closely with experts to develop our computer models, for example, HBRC worked with GNS to construct a conceptual geological model of the Heretaunga aquifers (Figure 45). This model then helps HBRC develop the groundwater/surface-water model, because groundwater flow is affected by the type of rock through which the water flows.

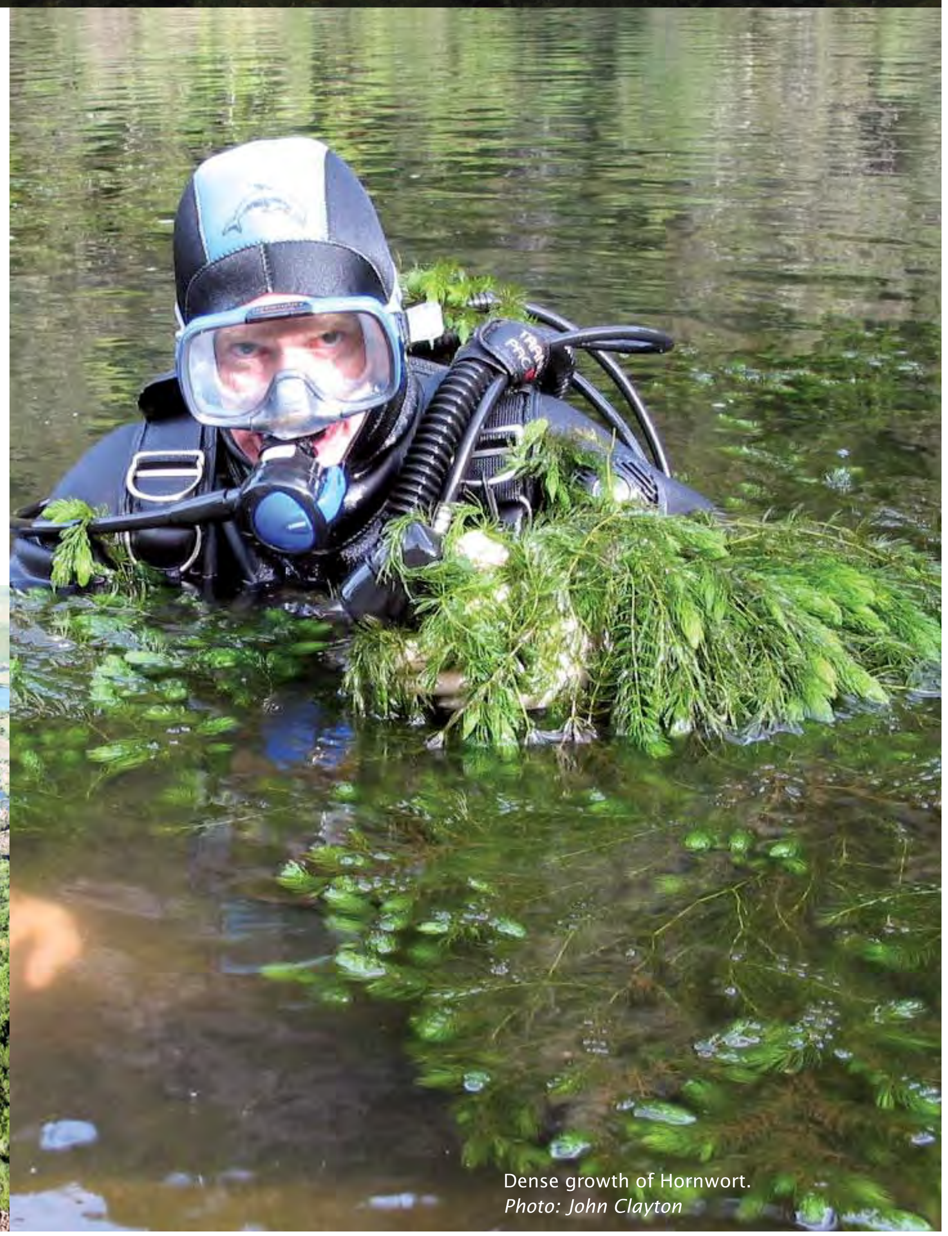
Figure 45: Idealised cross section through the Heretaunga Plains groundwater system from west to east.



Lake Waikaremoana

Hawke's Bay lakes vary substantially in their physical characteristics. Deeper lakes tend to have clear water, whereas our shallow lakes may either be very turbid or dominated by aquatic weeds.

Lake Runanga



Dense growth of Hornwort.
Photo: John Clayton

Our Lakes

The lakes in Hawke's Bay vary substantially in their physical characteristics. Some lakes are shallow, while others are deep; some receive significant inputs of water, sediment and/or nutrients, while others experience more 'closed' conditions where these inputs are limited.

These physical attributes affect the ecology of lakes. For example, in shallow lakes, plants can grow to cover the entire lake bed because plants can root into the sediment and still be close enough to the surface to receive sunlight. In deeper lakes, plants cover less of the lake bed, because light cannot penetrate to those depths. The dominant light-harvesting organisms in deep lakes are usually tiny floating algae that can intercept sunlight in the surface waters.

Lakes are particularly sensitive to sediment and nutrient inputs because particles settle out in the still lake waters. Lakes accumulate sediment and nutrients, which can result in eutrophication.

The eutrophication status of a lake is quantified using the 'trophic level index', or TLI. The TLI combines four separate water quality variables: nitrogen, phosphorous, chlorophyll-*a* (algal biomass), and water clarity. The combination of values for these four variables gives an index reflecting the nutrient enrichment and water quality in a lake (Figure 42).

A TLI above 4 is considered eutrophic, i.e. enriched with excessive nutrients, resulting in increased algal growth and reduced water clarity. Based on the data we have collected, both lakes Tutira and Waikapiro are considered eutrophic, Lake Oingo is considered supertrophic, and Lake Runanga is considered hypertrophic. All the other lakes were 'better' than eutrophic, with low nutrient and algal levels.

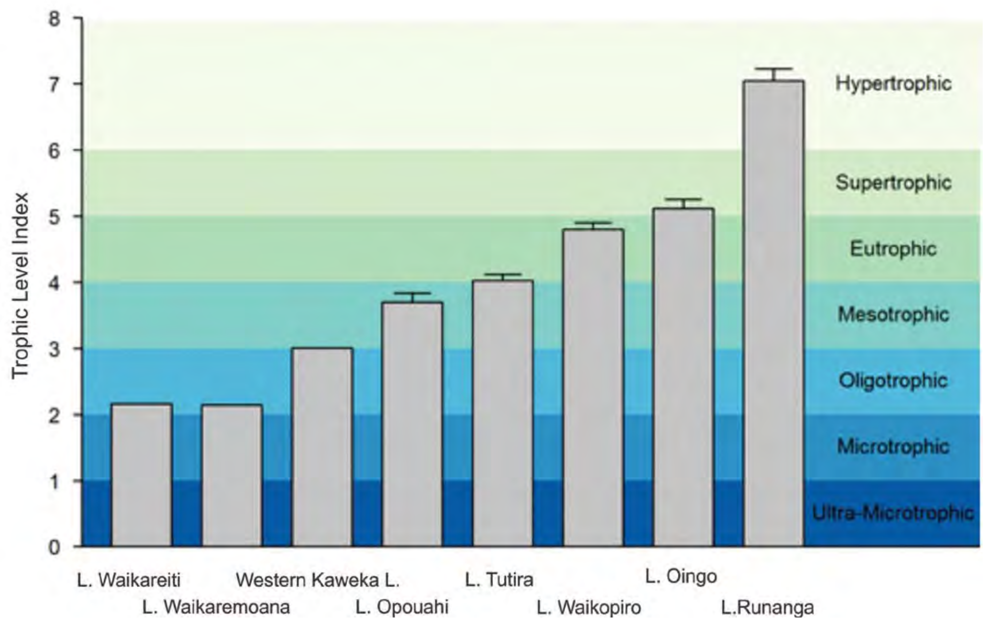
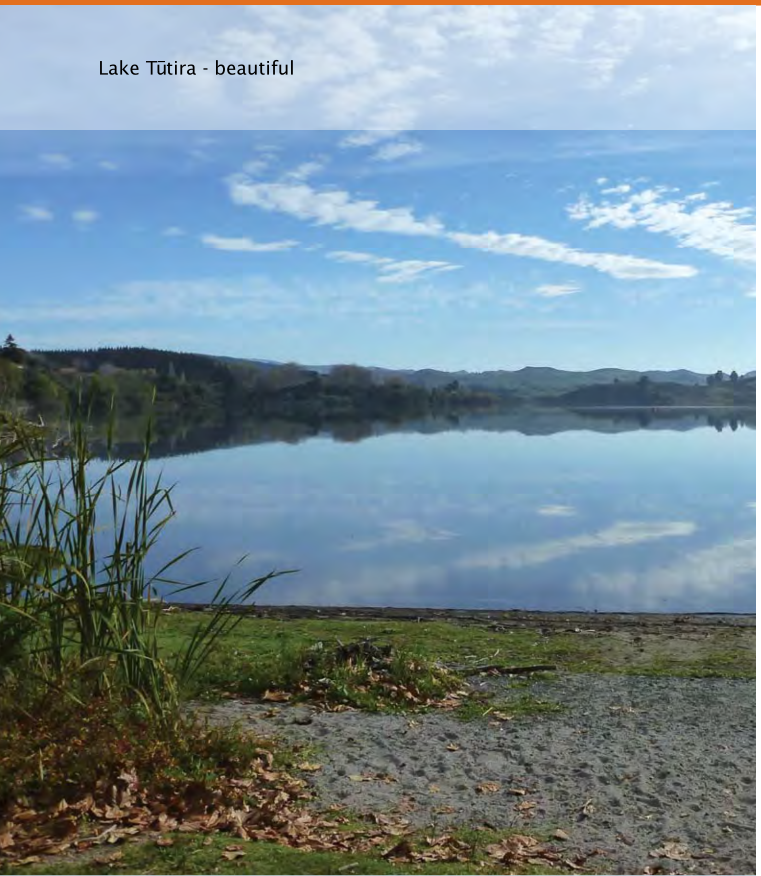


Figure 42: We use a trophic level index (TLI) to assess the eutrophication state of Hawke's Bay lakes.

Case Study



Lake Tūtira - beautiful

Lake Tūtira - not so beautiful

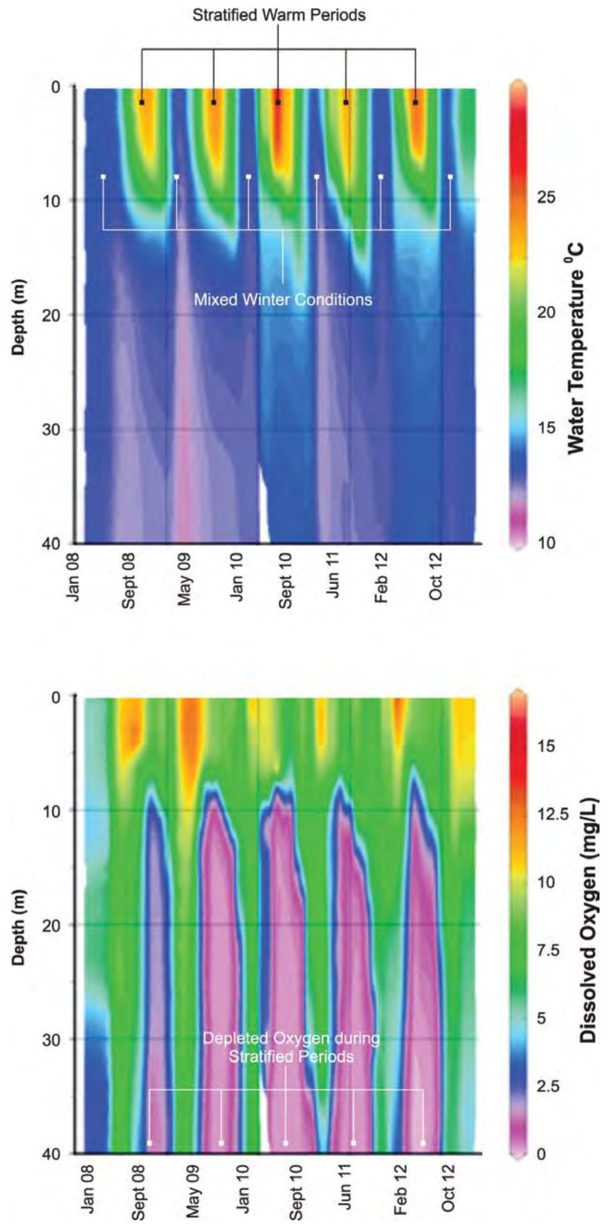


Figure 43: Stratification leads to low oxygen levels in deeper water.

WHAT'S TROUBLING TŪTIRA?

Lake Tūtira is a culturally significant lake located along an ancient Māori travelling trail. The lake was formed when a large landslide about 7,400 years ago dammed the water. A number of pā sites were located around the lake which provided tuna (eels) for local Māori. In more recent decades it has been a popular spot for trout angling, and is regularly stocked by Fish and Game. As it is close to Napier and has pleasant camping sites with excellent amenities (it is in a regional park), Lake Tūtira is a valuable and well used natural asset.

However, algal blooms have adversely affected the lake for at least forty years. HBRC, landowners, local residents and the many people who enjoy the lake would like these algal blooms to stop.

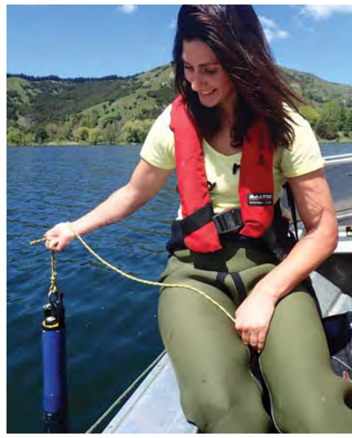
Algal blooms are not consistent at Tūtira – the lake can be clear one week, and smothered with green growth the next. A wide range of environmental variables are monitored by HBRC using a moored buoy in the lake (photo, right), including cyanobacteria, dissolved oxygen, temperature, turbidity, and climate. Water samples are collected from tributaries to understand nutrient inputs to the lake. The University of Waikato are using this information to construct a computer model of the lake ecosystem, to help identify what actions could be taken to improve this special system.

For most of the year Lake Tūtira is stratified, where layers of water do not mix together - as indicated by the temperature and dissolved oxygen profiles shown opposite. This stratification happens because, when the lake surface warms up, the water becomes less dense than the cooler water below it and is less likely to mix; this results in very little circulation between shallow and deeper water.

Stratification leads to low oxygen conditions in deeper water because oxygen consumed by biological activity there is not replenished from the atmosphere through mixing. This effect can be seen in the two plots left. When the surface water warms (red patches in top of upper plot, Figure 43) the dissolved oxygen in the deeper water gets very low (pink patches, lower plot, Figure 43).

Stratification and subsequent mixing may be one factor contributing to algal blooms, and is being investigated using the computer modelling.

Water quality profiling in Lake Tūtira. This instrument gets slowly lowered to the bottom of the lake and then hauled back up. It records temperature, conductivity, dissolved oxygen, chlorophyll *a*, pH and depth as it goes.



Water quality monitoring buoy above the deepest part of Lake Tūtira.

Groundwater Quality

Groundwater quality is monitored quarterly at key groundwater catchments in the region.

Samples are collected and analysed for major physical, chemical and microbiological parameters to assess the state and trends in groundwater quality.

The following parameters monitored are used in various ways for setting both standards and monitoring water in New Zealand:

- Nitrate-nitrogen
- *Escherichia coli (E. coli)*
- Dissolved iron
- Dissolved manganese
- Total hardness

Nitrate-nitrogen concentrations and the occurrence of *E. coli* are key indicators for both environmental and health related reasons, including the New Zealand Drinking Water Standards (NZDWS). Manganese, iron and total hardness are also monitored since they can cause adverse effects to water's taste, odour, colour, clarity or general appearance.

The data shown here was collected from groundwater bores used for irrigation, stock watering, and occasionally for potable water supply. The NZDWS may not apply to the sites reported on here. Because groundwater moves so slowly, the state of groundwater quality is assessed over 5 years, Trends can be assessed when at least two 5 year periods of monitoring have been completed.

Nitrate-nitrogen

Nitrate-nitrogen (NO_3-N) is a naturally occurring nutrient required for plant growth. In undeveloped groundwater catchments, natural levels of nitrate in groundwater are usually less than 1 mg/l. Nitrate may also arrive in groundwater from leaking septic tanks, from animal urine and from fertiliser, so its presence at concentrations higher than 1 mg/l may indicate contributions from these sources.

Groundwater often discharges through springs to rivers, lakes and wetlands, where high nitrate from the groundwater can cause nuisance algal and aquatic plant growth, and even cause nitrate toxicity in animals living in those water bodies. An assessment of nitrate and its effect on rivers, streams and lakes in Hawke's Bay is described in the surface water quality section (page 37-79).

High levels of nitrate in groundwater used for supplying drinking water can be detrimental to human health. The Ministry of Health has set a limit of 11.3 mg/l nitrate in drinking water. This maximum acceptable value (MAV) is set to prevent a blood disorder in infants knows as 'blue baby syndrome'.

Seventy percent of groundwater monitoring sites within the major aquifer systems across the region had low (< 1mg/l) levels of nitrate (Figure 49). Only 10% of sites monitored have levels that are greater than 50% of the NZDWS – between 5.65 mg/l and 11.3 mg/l nitrate. None of the sites monitored had nitrate concentrations above the NZDWS of 11.3 mg/l.

In the last fourteen years nitrate concentrations have increased at 18% of sites, in the Heretaunga Plains gravel aquifer and in the Ruataniwha gravel aquifer. Most monitoring sites had no trend in nitrate and 3% of the sites had a decreasing trend (Figure 48).

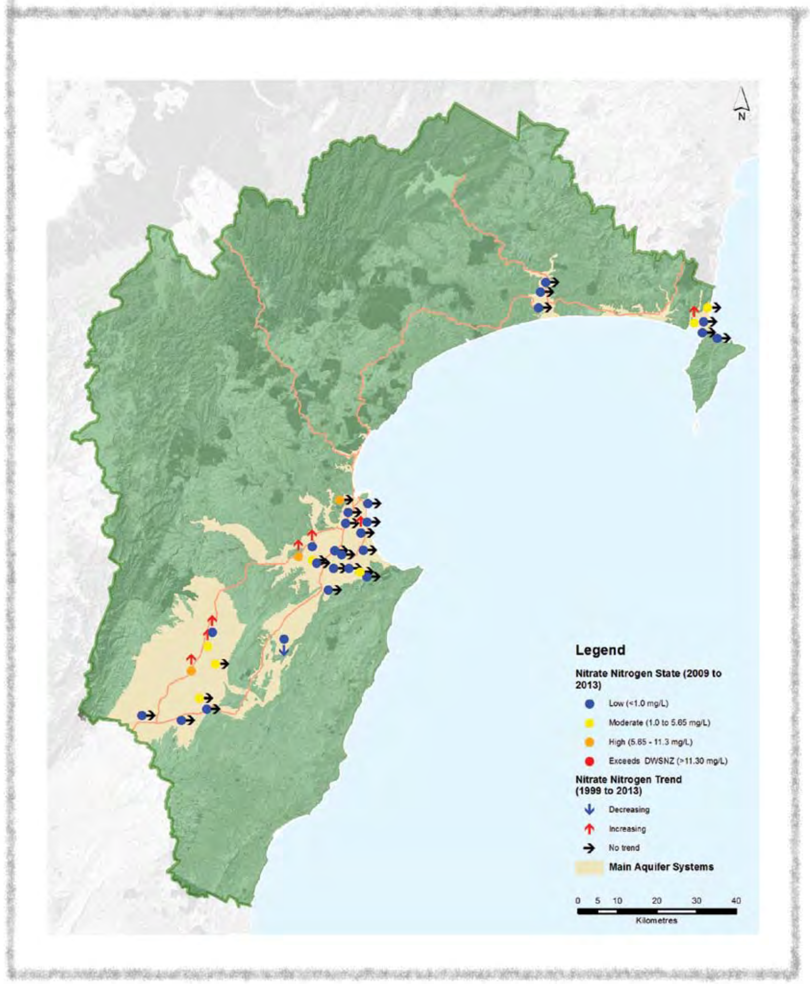


Figure 49: State (2009 to 2013) of nitrate-nitrogen (NO_3-N) levels and trends (1999 to 2013) in nitrate nitrogen at groundwater quality sites in the Hawke's Bay region.

Indicator Bacteria - *Escherichia coli (E. coli)*

E. coli is a naturally occurring indicator of microbial faecal contamination from warm blooded animals. Its presence at elevated levels in groundwater indicates contamination from animal faeces. The contamination may be a point source such as a defective septic tank, or widespread from animal effluent.

The NZ Drinking Water Standards (NZDWS) is less than one *E. coli* count in each 100 ml of water. This is also the limit of detection, which means even very low levels of *E. coli* contamination will exceed the Standards. In the last five years 88% of the sites monitored were 90% to 100% compliant with the NZDWS (Figure 50), however in 2013 all monitored sites complied with the Standards.

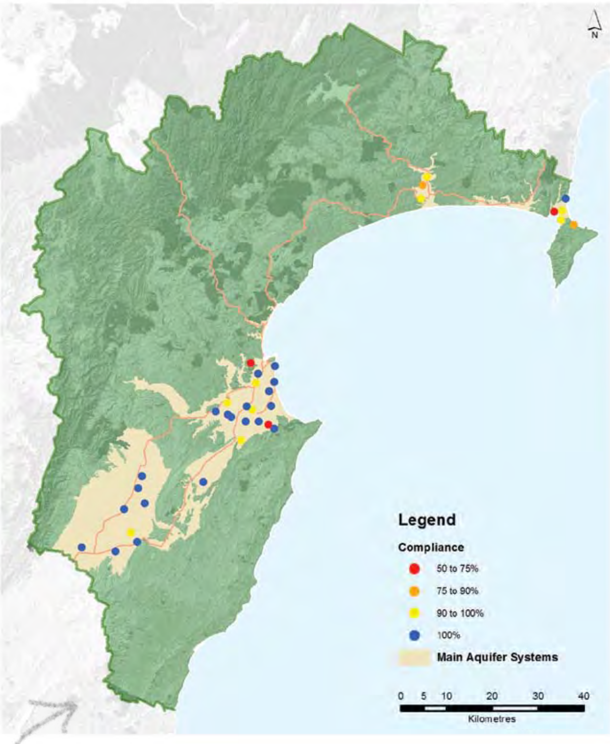


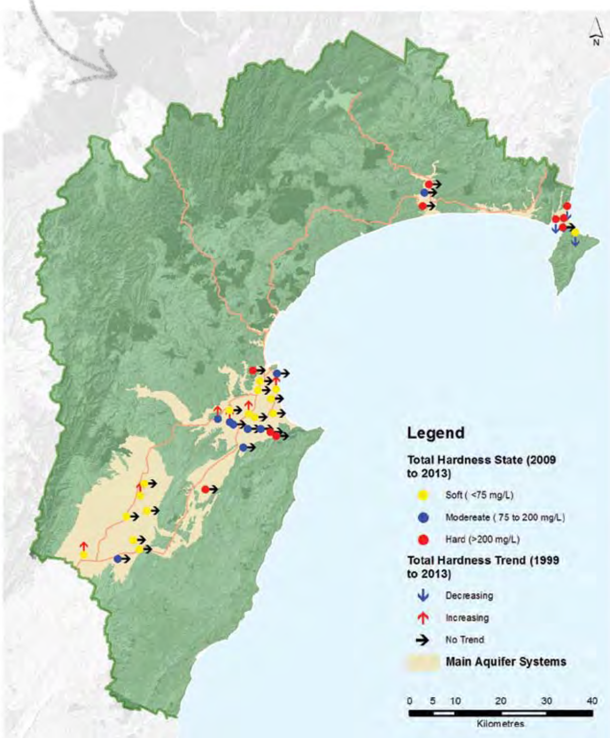
Figure 50: Microbiological indicator compliance of *E. coli* with the New Zealand Drinking Water Standard at groundwater quality monitoring sites in the Hawke's Bay region from 2009 to 2013.

Total Hardness

Total hardness indicates the level of calcium and magnesium salts dissolved in water. Hard water has an unpleasant taste, and hard water may cause scaling to form in pipes, hot water cylinders and kettles. River water generally is soft, but groundwater is more likely to be hard from contact with aquifer rocks.

The NZDWS classifies hard water as 200mg/l total hardness or greater, and soft water as less than 75 mg/l total hardness. Hardness greater than 350 mg/l can clog irrigation equipment, while levels less than 60 mg/l can corrode irrigation equipment. In the last five years only 30% of sites had hardness levels within guidelines. Aquifers with hard groundwater are mostly limestone aquifers in Wairoa and Mahia. Over 14 years 85% of monitoring sites had either no trend or decreasing hardness (Figure 51).

Figure 51: State (2009 to 2013) and trend (1999 to 2013) of total hardness levels at groundwater quality monitoring sites in the Hawke's Bay region.



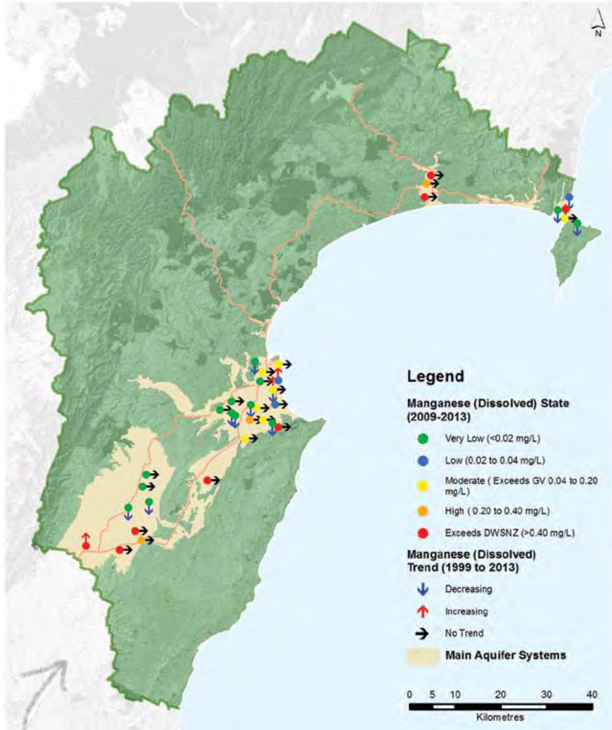


Figure 52: State (2009 to 2013) and trend (1999 to 2013) of dissolved manganese levels at groundwater quality monitoring sites in the Hawke's Bay region.

Iron and manganese

Iron and manganese occur naturally in groundwater, including Hawke's Bay aquifers. These two elements are derived from the rocks and gravels in which the groundwater is found. Iron and manganese are usually present in higher concentrations in deep gravel aquifers because they spend longer in contact with the rocks containing those elements.

The NZDWS maximum acceptable value (MAV) for manganese is 0.4 mg/l to avoid effects on human health. A lower limit (guideline value - GV) of 0.2 mg/l is set to avoid unpleasant taste, and a limit of 0.04 mg/l is set to avoid staining laundry and bathroom fittings. Iron also has an aesthetic GV of 0.2 mg/l to avoid poor tasting water and the staining of laundry and bathroom fittings. Iron and manganese can clog irrigation equipment and cause spotting on plant leaves at concentrations greater than 1.5 mg/l.

In the last five years, 23% of monitored sites exceeded the MAV for manganese and 50% of the sites exceeded aesthetic guidelines (Figure 52). In the same period 28% of sites exceeded the aesthetic guideline value for iron (Figure 53). Overall, 93% of monitoring sites had either no trend or decreasing manganese levels over the last fourteen years and 98% of sites had either no trend or decreasing iron concentrations.

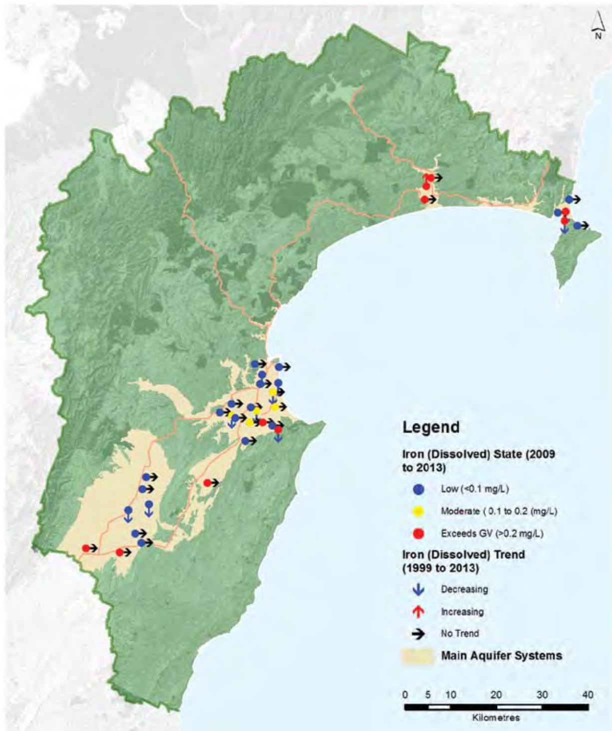
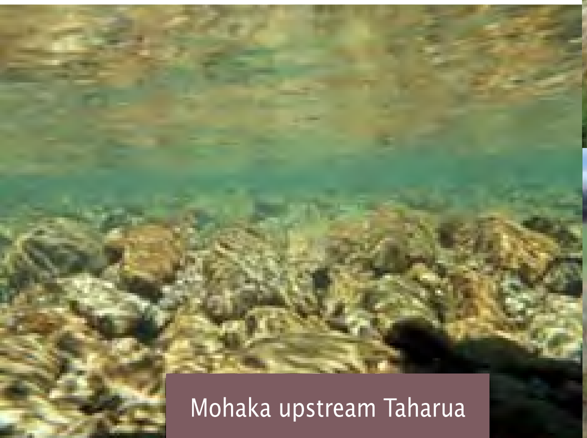


Figure 53: State (2009 to 2013) and trend (1999 to 2013) of dissolved iron levels at groundwater quality monitoring sites in the Hawke's Bay region.

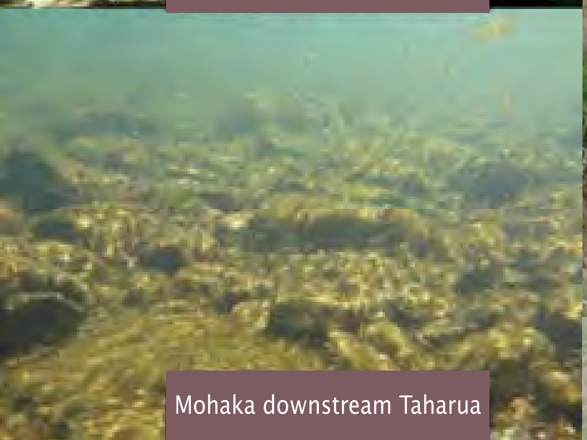
Groundwater quality is monitored quarterly at key groundwater catchments in the region.

Case Study

Water clarity decreases and algal growth increases in the Mohaka River downstream of the Taharua River confluence



Mohaka upstream Taharua



Mohaka downstream Taharua

Riparian fencing and planting helps reduce nutrient runoff to the Taharua River.

UP, UP & DOWN – Nitrogen trends in the Taharua

Some of the highest in-stream nitrogen levels in Hawke's Bay are found in the upper Taharua catchment, which is a tributary of the Mohaka River.

High nutrient concentrations in this tributary threaten the outstanding characteristics and features of the upper Mohaka, which is protected under a Water Conservation Order (SR 2004/397).

Over the summer of 2008/9 nuisance algal growth was found in the upper Mohaka River downstream of the Taharua confluence (photo, lower left). The nuisance algal growth was caused by increased nutrient concentrations - mostly nitrogen – the consequence of a change from sheep and beef to dairy farming in parts of the Taharua catchment during the 1990s. This land-use change was followed by the development of more intensive dairy farming practices in the catchment from 1999 to 2009.

Nitrate travels mostly with groundwater, which takes time to reach the river. Dating the age of the groundwater in the Taharua catchment confirms, on average, it takes approximately three years to travel through the soil, and another three years to travel to the river (Figure 54).

In the last six years Taharua landowners have been implementing a range of improved land-use management practices to target nitrogen and to reduce phosphorus in the Taharua River.

The land-use changes they've made include:

- Reducing dairy cow numbers from a peak of 9500 to 7600
- Reducing the amount of fertiliser applied during each application and avoiding high risk leaching times from May to the end of July
- Establishing riparian fencing, stock exclusion, and buffer zones around grazed crops.

The fact that nitrogen levels are decreasing in the Taharua River suggests the land-use changes of recent years are having the desired effect.

Nitrogen has been decreasing in groundwater for the last five or six years, and improvements in surface water quality began about three or four years ago (Figure 54). This pattern occurs because nitrate travels through the groundwater before entering the river.

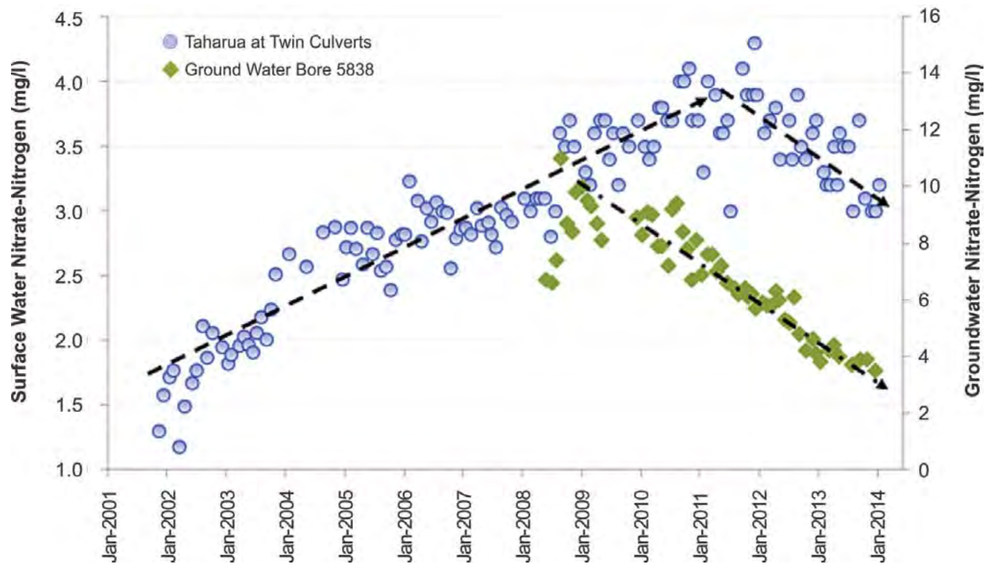
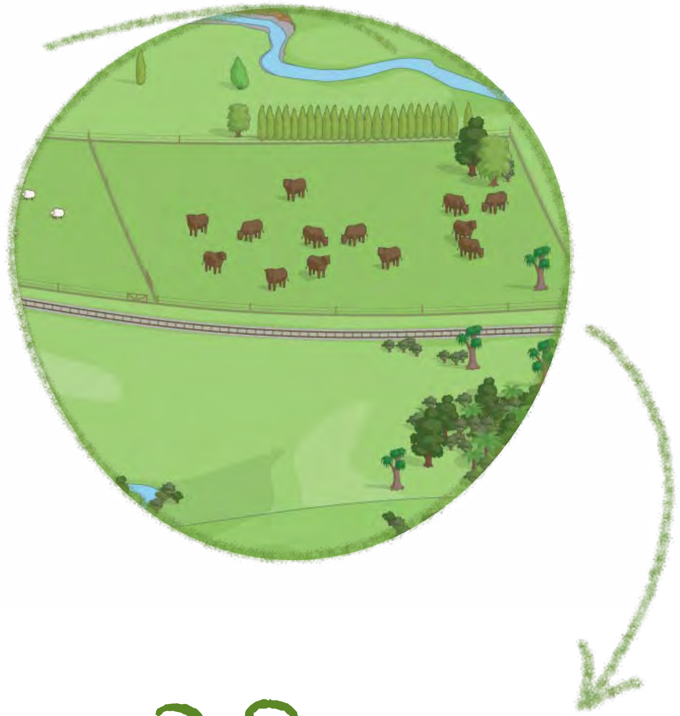


Figure 54: Nitrate-nitrogen concentrations measured in the headwaters of the Taharua River at the Twin Culverts monitoring site and at groundwater monitoring bore 5838. Note there is three years delay between peak nitrate-nitrogen concentrations in groundwater and peak concentrations in the Taharua River.

Panoramic view of Heretaunga Plains. Cropping and viticulture extends around residential and industrial areas (foreground).

Figure 55: Map of Hawke's Bay topography. The land is mostly rolling and steep hill country. The flat Heretaunga and Ruataniwha plains are also shown.



Land Science

Land of Hawke's Bay

The Hawke's Bay region covers approximately 1.4 million hectares or 1,400 km². Approximately 80% of the land is comprised of hill country or mountainous areas while only 12% is flat to gently rolling land. Most of the valuable flat land is found on the Ruataniwha and Heretaunga plains. The remaining land is comprised of steeper rolling country. The varying topography of the region is shown in Figure 55. The Heretaunga Plains is the most productive and intensely farmed area in Hawke's Bay, where a wide variety of crops are grown, including orchards, vegetable cropping, and vineyards.

Figure 56: Land cover in the Hawke's Bay region as of 2012. (Statistics from Land Care Research LandCover Data Base v 4, 2014)

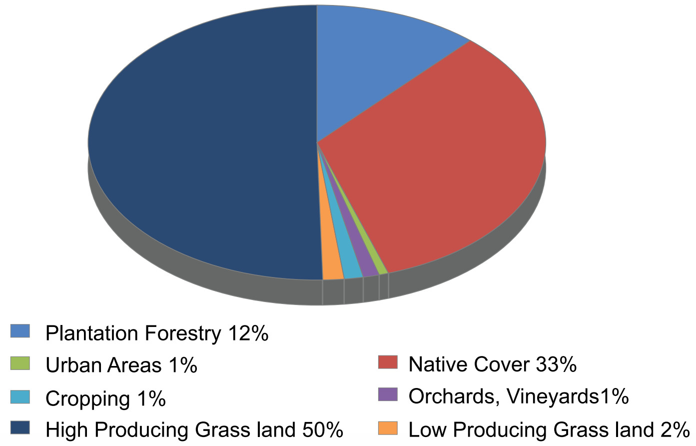


Figure 57: Figure 4. Proportional change in livestock numbers between 2007 and 2012 (information provided by Statistics New Zealand).

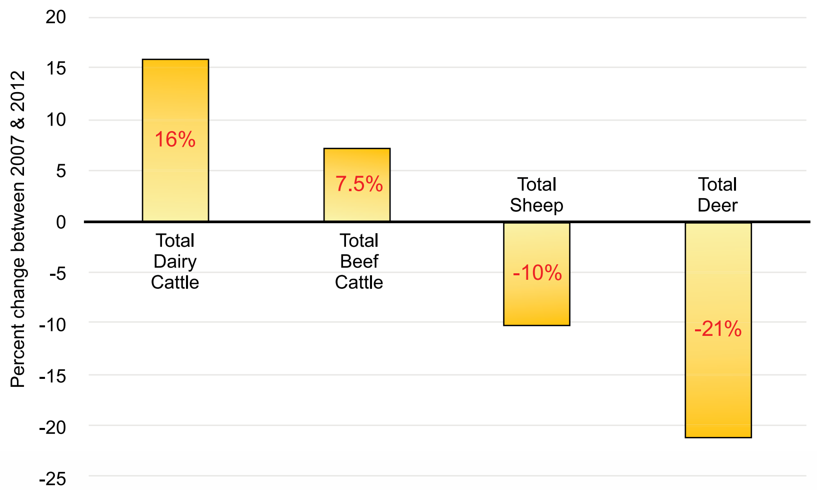


Table 6: Hawke's Bay stock numbers in 2007 and 2012 (information provided by Statistics New Zealand).

Year	2007	2012	%
Total dairy cattle	80,200	93,047	16
Total beef cattle	438,366	471,010	7.5
Total sheep	3,624,018	3,262,468	-10
Total deer	88,408	69,977	-21

Approximately 50% of the land in Hawke's Bay is used for pastoral farming, mainly sheep, beef and dairy farming with some deer. Native bush and scrub covers 33% of the region while commercial forestry covers 12%. The remaining 5% is split between orchards, vineyards, cropping, low producing grass land and urban areas (Statistics from Landcare Research Land Cover Data Base v4). Figure 56 shows the land use of Hawke's Bay as a proportion of the total.

Land cover in 2007 was very similar. However, although land cover is similar, stock numbers increased from 2007 to 2012 (Figure 57), with a 16% increase in dairy cattle and a 7.5% increase in beef cattle. While the numbers of dairy and beef cattle have increased, the numbers of sheep and deer have decreased by 10% and 21% respectively. Table 6 compares the actual numbers of stock in the Hawke's Bay region in 2007 and 2012.

Agriculture, horticulture and forestry all play important roles in the Hawke's Bay's economy. Sustainable land management practices help maintain productivity while avoiding damage to soil structure. Loss of soil structure will result in soil compaction, increased erosion and a reduction in plant growth and productivity.

About 62,000 hectares of land (5%) in the region is used beyond its capability, according to the Land Use Capability (LUC) index (Figure 58). Land used beyond its capability is prone to degradation through soil erosion and nutrient loss. HBRC has allocated between $250,000 and $400,000 each year over the last five years towards soil conservation initiatives to protect the most vulnerable land.

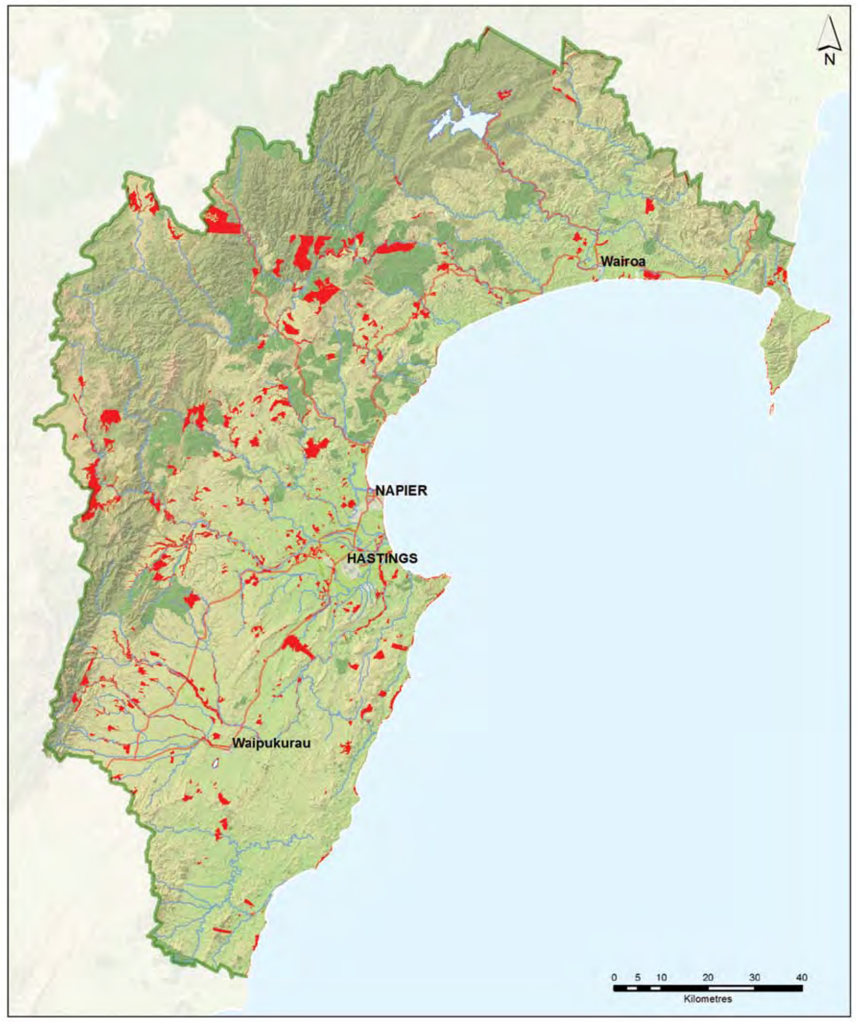


Figure 58: Red areas depict land being used outside of its capability. About 38% of Hawke's Bay's land area may be too steep or otherwise restricted for agricultural activities (excluding forestry).

Equipment for groundwater quality monitoring at a Heretaunga Plains well.

Long-Term Groundwater Quantity

Current state and trends

In its natural, predevelopment state, any groundwater system is in long-term equilibrium. That is over some period of time, the amount of water entering the system is approximately equal to the amount of water leaving the system. Because the system is in equilibrium, the quantity of water stored in the system is constant or varies only a little in response to annual or long-term climatic variations.

Resource development such as irrigation, urban expansion, drainage and other activities affect this natural state. When groundwater is pumped, the aquifer responds by either increasing the amount of water entering the system, reducing water leaving the system, removing water from storage or a combination of these three. Long-term monitoring helps to determine this response.

Long-term trends

Long-term systematic measurements of groundwater levels have been undertaken since 1968. However most monitoring sites weren't installed until the early 1990s so our knowledge of the response to groundwater pumping is primarily limited to the last 20 years.

On the **Heretaunga Plains** (Figure 46, upper), groundwater level declines have mainly occurred west of Hastings, near Flaxmere, and between Roy's Hill and Fernhill in the major recharge area. The rates of declines vary between sites and across seasons.

In general, the greatest rates of decline have occurred over the summer seasons whereas over the winter seasons the declines are more gradual. This response of increasingly lower summer groundwater levels compared with more gradual winter groundwater declines is reflected in an increase in the amplitude of seasonal fluctuation over time. The rates of declines over the summer seasons range between 1-10cm per year. Over winter, the declines range between 1-5cm per year.

Not all sites experience both winter and summer declines, nor are declines the only trends detected. At some monitoring sites, trends for only one season are observed. There are many reasons for this. For example, where only summer trends are detected, some sites may show increasing summer declines due to increased pumping but over winter groundwater levels may recover, season after season, due to the influence of nearby sources of recharge. Some trends may also be too small to detect over the monitoring period, so where summer declines are detected, an absence of a winter groundwater level declines may simply reflect the characteristics of the data, rather than non-existence of a trend.

On the **Ruataniwha Plains** (Figure 46, lower), groundwater declines are mainly detected on the western margins of the Plains near Takapau and Ongaonga. As with the Heretaunga Plains, the rates of decline for monitoring sites on the Ruataniwha Plains vary between sites and seasons. Like the Heretaunga Plains, the greatest declines occur over the summer seasons, and not all sites possess both winter and summer declines, nor are declines the only trends detected. Over the summer seasons, the rates of declines range between 3-28cm per year. Over the winter seasons, the declines range between 11-18cm per year. Groundwater level declines tend to be greater on the Ruataniwha Plains than on the Heretaunga Plains.

The longest monitoring record is for the Heretaunga Plains near Fernhill. Groundwater levels at this site have been measured for approximately 45 years. Because changes in the groundwater resource are slow, this well, with its longer water level record, provides a clearer indication of the changes over time. A strong declining trend can be observed in the record with increasing seasonal variation over time and a total loss of storage of approximately 1.5m since 1968.

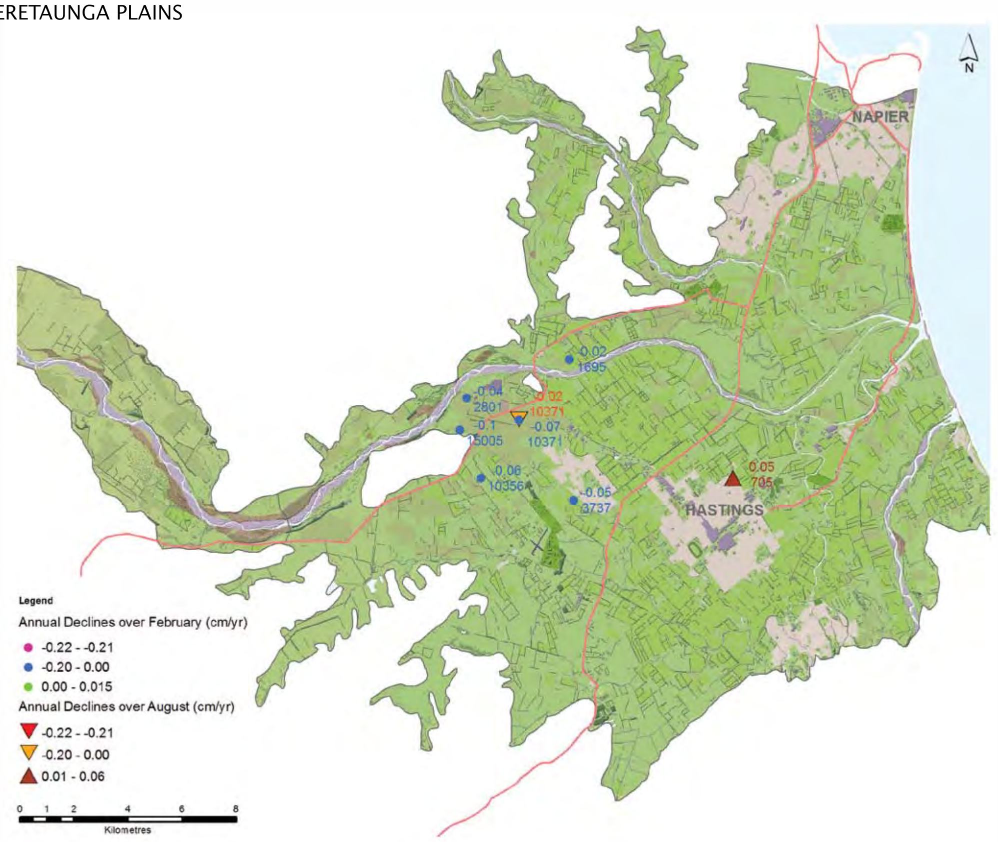
Systematic groundwater monitoring helps us to detect trends but other sources of groundwater level information are also helpful to evaluate changes over time. Drilling records, for example, provide water level records prior to monitoring. Drilling information is often our only source of information prior to the development of our aquifers. The earliest drilling records are for the Heretaunga Plains at Meeanee, 1867. At the time an artesian head of 6.1m above land surface was encountered, not too dissimilar to water levels measured in the same location today. This suggests that artesian pressures in the confined aquifer at this location have not significantly changed over the last 150 years.

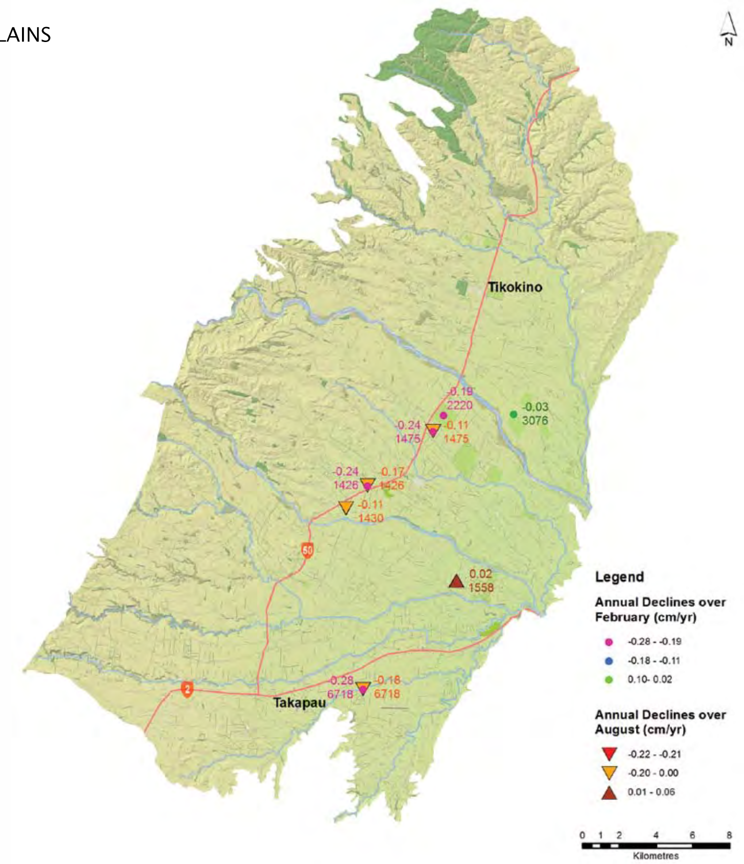
Interaction with surface water

It is easy to think that because groundwater levels haven't undergone significant changes, plenty of groundwater can still be used. What usually isn't well understood is the interaction groundwater has with surface water. When groundwater is abstracted from an aquifer it affects the balance between water entering and leaving the system. To compensate for loss of storage, groundwater pumping may cause reduced surface water flows either by increasing the loss of surface water to groundwater, or by decreasing the volume of groundwater discharged to surface water as base flow.

On a basin-wide scale, pumping and its effects on surface water are complex. HBRC is in the process of building a numerical model – a tool typically used to better understand the impacts of resource activities on the water resources. Information from this model will help to further develop effective resource management.

Figure 46: Location and magnitude of state and trends detected in Hawke's Bay groundwater quality.





Seasonal Groundwater Quantity

Current state and trends

The water balance of groundwater systems adjusts continuously to changes in climate, groundwater pumping, and land use. Water level measurements from observation wells are used to understand how hydrological changes affect aquifers, including recharge, storage, and discharge of water to and from the aquifers. This information is used to monitor changes, to develop groundwater models, to forecast trends, and to design, implement, and monitor the effectiveness of groundwater management and protection programmes

Seasonal changes

Groundwater levels in Hawke's Bay typically decline over spring and summer and rise in autumn and winter, an annual pattern resulting from changes in recharge to and discharge from the aquifer resources.

Over spring and summer, rainfall and river flows are typically lower than in autumn and winter, resulting in less water flowing in and recharging the aquifer. The effects of less recharge are compounded over the summer months by increased aquifer discharge in the form of groundwater pumping. At the end of summer, the demand for groundwater decreases and, due to increased river flows and rainfall, recharge to the aquifer exceeds the rate of discharge. This results in rising groundwater levels and an increase to the base flow of spring-fed streams and rivers.

The magnitude of seasonal fluctuation can vary from season to season and from year to year in response to varying climatic and pumping conditions. The typical seasonal groundwater level fluctuation at most of our groundwater monitoring sites is about 2m. Exceptions occur along the western margins of the Heretaunga and Ruataniwha Plains where the amplitude of the seasonal fluctuation increases to approximately 5m. This increase in amplitude most likely reflects a combination of concentrated pumping and presence of no-flow boundaries. The no-flow boundaries, such as the less permeable hill country, act as barriers to pumping effects resulting in a greater drawdown in adjacent gravels where groundwater is more easily transmitted (see Figures 47 and 48).

The range of seasonal fluctuations in groundwater levels has not changed significantly in the last 20 years at most monitoring sites. In most years groundwater levels have typically declined and recovered to about the same level as in previous years. However, at three sites in the main recharge area of the Heretaunga Plains with records longer than 20 years, seasonal variation has increased at around 4-8 cm each year. This increasing seasonal variation is caused by lower summer groundwater levels.

At monitoring sites with longer records changes in the seasonal groundwater level fluctuation become more apparent. This is because the rate of change is slow and takes time to develop. Our monitoring site with the longest record is located near Fernhill on the Heretaunga Plains and indicates the seasonal groundwater level fluctuation has increased approximately 0.5m over the last 45 years. Before 1968 the effects of climatic and pumping conditions on the groundwater resource were relatively limited.

Figure 47: WELL 10371 GROUNDWATER LEVEL RECORD
Well 10371 is located on the Heretaunga Plains near Fernhill and has the longest record of groundwater levels in Hawke's Bay. Groundwater levels measured since 1968 show the amplitude of seasonal groundwater level fluctuations has increased over the monitoring period. At this site there is also a clear loss of groundwater storage. This site is one of five in this area where statistically significant declines have been observed in the last 20 years.

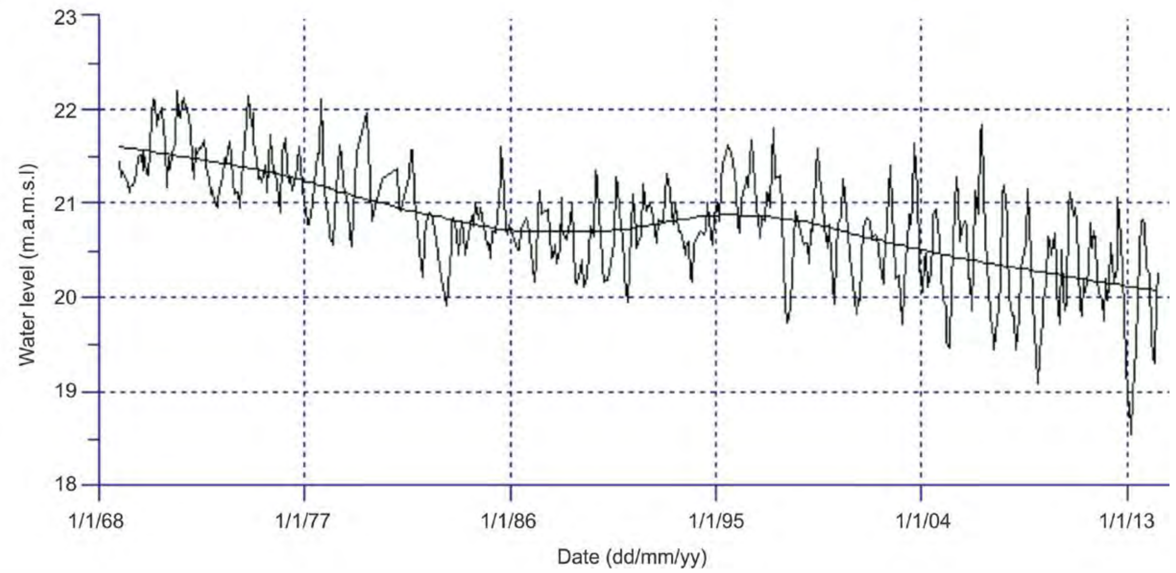
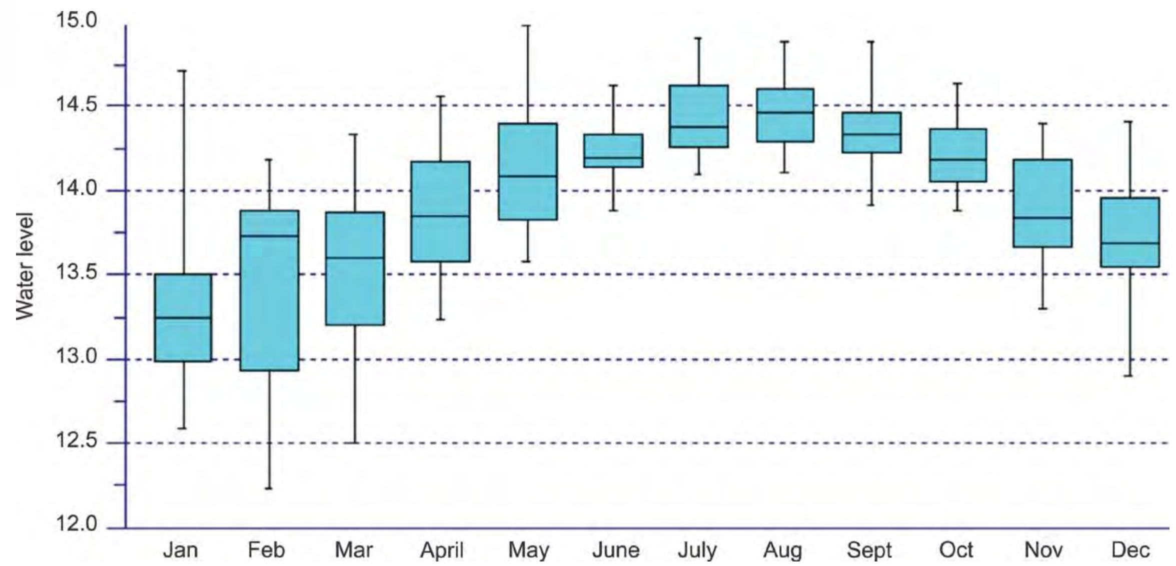


Figure 48: WELL 15006 SEASONAL BOX PLOT
Well 15006 is located on the Heretaunga Plains in Twyford. The box and whisker plots show the range and spread of groundwater levels measured for each month. The lowest groundwater levels and greatest spread of measurements are observed in February. In August groundwater level measurements are more consistent.



Soil profile assessment. Various aspects of soil are assessed on site, including colour, particle size and texture.

Soil Quality Monitoring in Hawke's Bay

One of our most important resources is our land and soil. HBRC monitors the health of our soil through the regional soil quality monitoring programme (SQM). Each year a different land use is examined across a range of soil types. Currently we have established 57 sites across the region, with these set to expand over the next two years (Figure 59).

SQM sites were first established in 2000, but only data obtained since 2010 are used for comparisons at present. By revisiting the SQM sites every three to five years, we will develop a long-term monitoring dataset that can be used to identify and examine any trends in soil quality.

Up to 15 physical parameters and 51 chemical parameters are measured at each SQM site, including 10 metals and 25 indicators of organic pesticides.

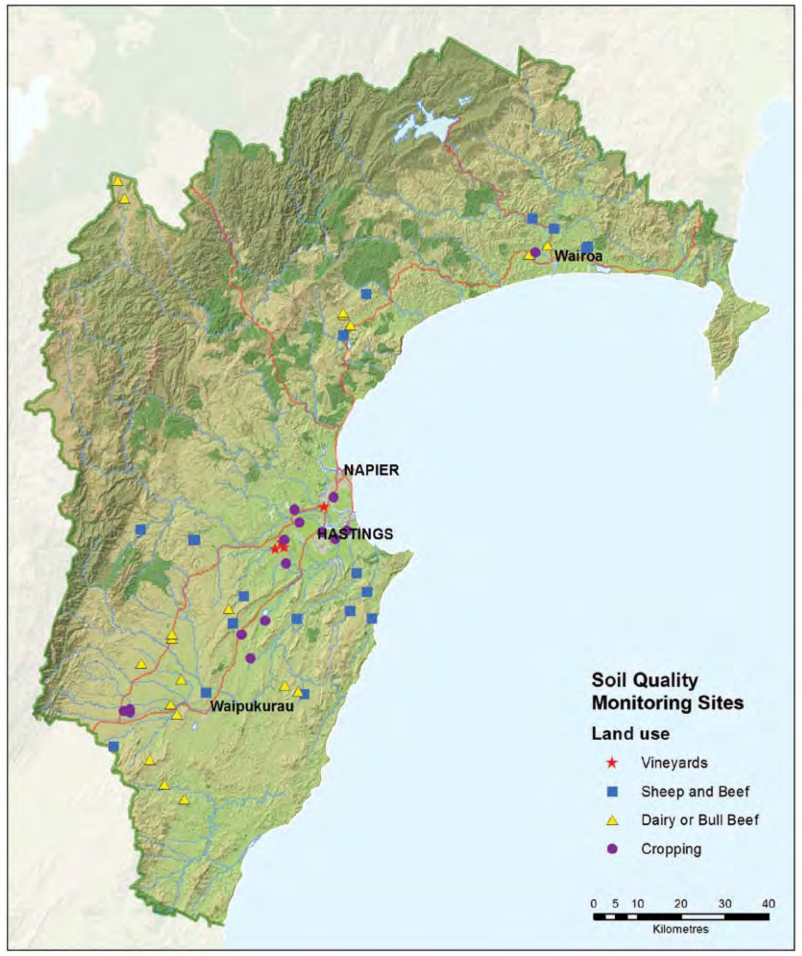


Figure 59: Soil quality monitoring sites across Hawke's Bay.

RESULTS & BOX PLOTS

The levels of several significant parameters measured in the SQM programme are presented here. The results for all SQM parameters are available on www.hbrc.govt.nz.

The data are presented as box plots. The box area contains a band that represents the median or middle value of the results. The bottom of the box represents the 25th percentile while the top of the box represents the 75th percentile, so 50% of the results are within the box area.

The 'whiskers' below and above the box represent the 10th percentile and the 90th percentile, i.e. 80% of all values are between the lower and the top marker.

Olsen Phosphorus (Olsen P)

Olsen P is a measurement of plant available phosphorus in the soil. Too little phosphorus will restrict plant growth while too much can lead to losses from the soil to nearby watercourses, where it may cause excessive algal growth (eutrophication) (see page 77). The loss of phosphorus from the soil will also have an economic impact for the landowner because elevated Olsen P levels indicate over-application of expensive phosphate rich fertilisers.

Figure 60 shows that sampled cropping and intensive pasture sites are above the suggested upper limit. Some extensive pasture sites (mainly sheep and beef farms) and a small proportion of vineyards are below the lower limits. The low Olsen P levels on extensive pasture sites may indicate that pasture on these farms is not growing to its full potential and the addition of a phosphate fertiliser could boost productivity. Conversely, it appears that some of the cropping sites have too much phosphorus in the soil and have a higher risk of losing this phosphorus to surface water and groundwater through run off and infiltration respectively.

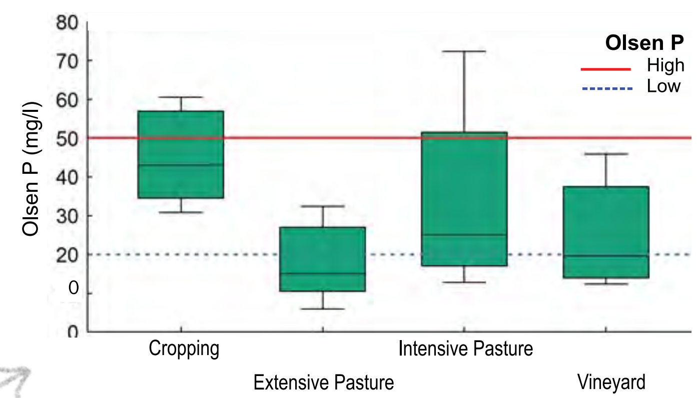


Figure 60: Olsen Phosphorus (Olsen P) across different land uses. Continuous and dashed lines are the high and low threshold of the Olsen P target range. The thresholds for high and low Olsen P were established by work carried out on behalf of the Land Monitoring Forum by Mackay *et al.* (2013).

Total Carbon

Total carbon is an indicator of organic matter content in the soil. Carbon can be separated into two types, organic carbon and inorganic carbon. Organic carbon takes into account carbon from sources such as decaying vegetation or bacterial growth, while inorganic carbon is comprised of carbonates and bicarbonates, which form the mineral fraction of the soil.

Generally there is very little inorganic carbon found in New Zealand soils, so measuring total carbon gives a good indication of organic carbon levels in the soil. Organic matter helps soils retain moisture and nutrients and gives good soil structure for water movement and root growth.

Total carbon is also an indicator for biological activity in the soil. High total carbon can indicate that the microbiological community is healthy, because total carbon indicates how much organic matter there is in a soil, and organic matter is a food source for microbes.

In general, soil samples taken from intensive pasture contained the highest levels of total carbon, while cropping soils showed the lowest levels of carbon (Figure 61). The high levels of carbon and associated organic matter found at intensive pasture sites are probably due to high manure input and permanent pasture cover. The low carbon/organic matter levels found at the cropping sites could be due to excessive tillage and machinery soil compaction, which cause the organic matter to breakdown and, under certain conditions, be lost through soil erosion. Significantly, vineyards are usually grown on soils with low organic content as that is what the grapevines prefer.

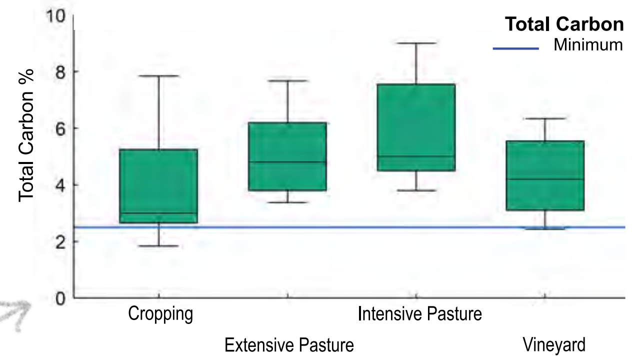


Figure 61: Total carbon. There is no upper threshold for the total carbon content. As total carbon levels increase, the soil changes from a mineral soil to an organic soil, before finally becoming a peat soil.

HBRC staff taking a bulk density sample.

Anaerobically Mineralisable Nitrogen (AMN)

Anaerobically mineralisable nitrogen (AMN) is a measure of organic nitrogen in soil, which can be broken down to make nitrogen available to plants and microbes. It's used as an indicator of biological activity and soil fertility. When soil nitrogen levels are too high, it can increase the risk that nitrogen will be lost to waterways, but too little nitrogen may limit plant growth. There are several ways for nitrogen to be lost from soils, including leaching, crop removal, soil erosion and runoff.

Median values of AMN observed in soil under a range of land-uses all fall within the guideline range (Mackay et al., 2013) shown in Figure 62. Soils under extensive and intensive farming generally contained higher AMN. Some sites in these land uses exceeded the upper threshold for AMN (the upper error bars in Figure 62). These sites may have an elevated risk of nitrogen loss to waterways.

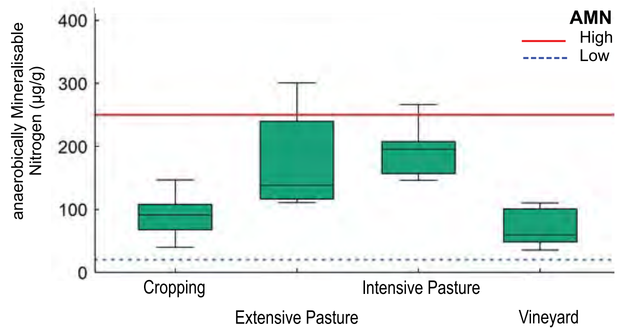


Figure 62: Anaerobically mineralisable nitrogen (AMN) in soils under various land uses.

Macroporosity

Macroporosity indicates the volume of larger pore spaces between soil particles (macro-pores), which provide space for root growth and encourage soil aeration, biological activity and water flow. Macro-pores are the first pores to collapse when soil is compacted, so their volume is an indicator for the degree of soil compaction. Highly compacted soil doesn't drain well, which increases the risk of overland flow, which leads to soil and nutrient loss. It can also affect root growth as the roots can find it difficult to penetrate compacted soil.

Soils from vineyard sites had higher macroporosity than soil from other land uses (Figure 63). However, the strips of land between the vines where mechanical harvesters travel had lower macroporosity than the actual vine row areas where machine impact was not a factor. These two results give an excellent example of how machinery can compact soils.

Median values (the dark line across the middle of the shaded area) for macroporosity on cropping, extensive and intensive pastures were similar to each other and very close or below the low level for a healthy soil (Mackay *et al*., 2013). This may be caused by compaction from high stocking rates, lack of pasture renewal and/or conventional tillage.

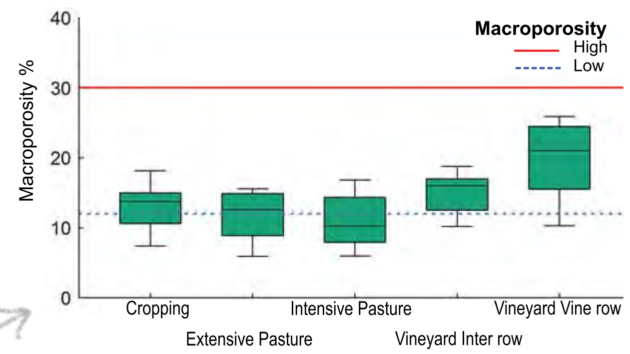


Figure 63: Macroporosity in soils under various land uses.

Aggregate Stability

Soils naturally form small clumps or aggregates when they are undisturbed. Aggregate stability is a measure of how stable these aggregates are. Ideally the aggregates need to be of desirable size, and be able to resist compaction and breakage. A stable and crumbly texture lets water soak into soils quickly, doesn't dry out too rapidly and allows roots to spread easily. Cultivation for cropping affects aggregate stability by mechanically breaking up these aggregates. Once the aggregates are broken down into smaller particles, they will be vulnerable to compaction and erosion. The only way to repair the soil structure once it has been broken down is to 'rest' it. Given time microbial and other soil fauna (worms and burrowing insects) activity will bring structure back to a degraded soil.

Only cropping sites were investigated for aggregate stability as cropping is the land use that will cause the most damage to soil aggregates. Most of the sampled cropping sites (Figure 64) showed aggregate stability lower than the minimum suggested value of 1.5mm (Mackay *et al*, 2013). This indicates that current or historical practices have caused structural damage to the soils, and may limit productivity in the future.

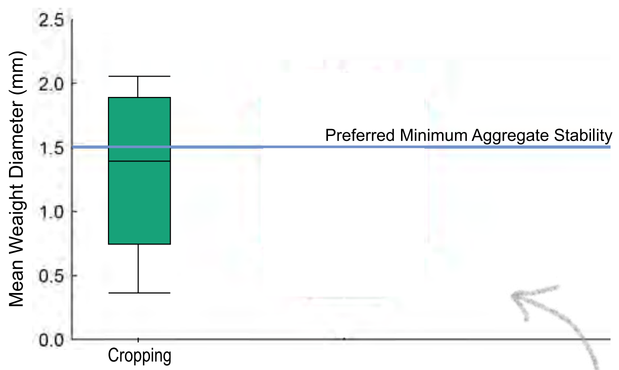


Figure 64: Aggregate stability. Note that only cropping sites were measured for this parameter due to the unique management of cropping soils.

Cadmium (Cd)

There was no exceedance of the 1mg/kg guideline limit for cadmium in soil (Figure 65) (New Zealand Water & Waste Association and Ministry for the Environment, 2003). Cadmium is a heavy metal and a contaminant found in phosphate rock. When phosphate rock is used to produce phosphate fertiliser and applied to land, a very small amount of cadmium also is applied. Cadmium is readily taken up by plants/pasture and if, that plant/pasture is eaten by stock, cadmium accumulates in the liver and kidneys of those animals. If people then eat a small amount of that meat, the cadmium can then be passed on, potentially accumulating in human liver or kidneys, possibly causing damage.

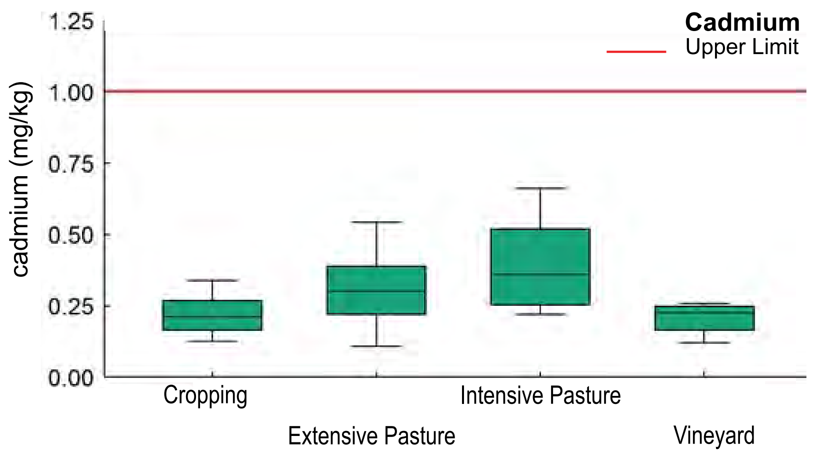


Figure 65: Cadmium. All samples tested had cadmium concentrations below guideline values.

HBRC staff collecting soil samples across a 50 m transect on an intensive pasture site.

Conclusion

Soils at most sites sampled are within target ranges for most of the indicators measured. However, individual parameters such as Olsen P – which may indicate increased risk of transport of phosphorous to surface waters – give cause for concern. Also, soil compaction – as monitored through macroporosity and aggregate stability – will need to be carefully monitored in the future.

FURTHER READING:

HBRC soil quality annual reports (available at http://www.hbrc.govt.nz/Services/Environment/SOE/Pages/SOE-Annual-Reports.aspx)

Soil Quality Monitoring - Vineyards on the Heretaunga Plains - 2010

Soil Quality in Hawke's Bay Extensive Pasture - 2011

Soil Quality of Intensive Pasture in Hawke's Bay - 2012/13

Soil Quality of Cropping Soils in Hawke's Bay – 2013/2014

New Zealand Water & Waste Association and Ministry for the Environment (2003). Guidelines for the safe application of biosolids to land in New Zealand.

Alec Mackay *et al*., (2013), *Soil Quality indicators: The Next Generation*, Agresearch, report No RE500/2012/025.

Case Study

SEDIMENT LOSS IN THE TUKITUKI CATCHMENT

Soil erosion on east coast hill country following the April 2011 storm

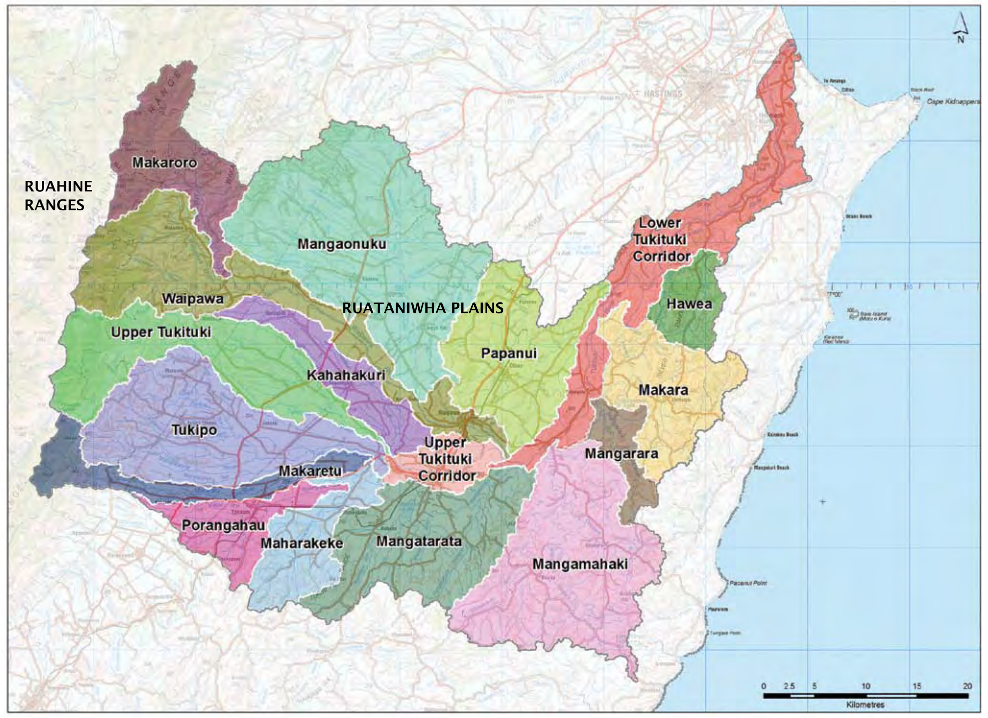


Figure 66: Tukituki catchment and its 17 sub-catchments.

Computer modelling has identified areas in the Tukituki catchment at high risk of hillslope soil loss and stream bank erosion.

The catchment of the Tukituki River covers approximately 250,000 ha. It bounded by the Ruahine ranges to the west and by farmed hill country to the north, south, and east. The catchment drains to Hawke Bay at Haumoana and includes the intensively farmed Ruataniwha Plains in the centre of the catchment (Figure 66).

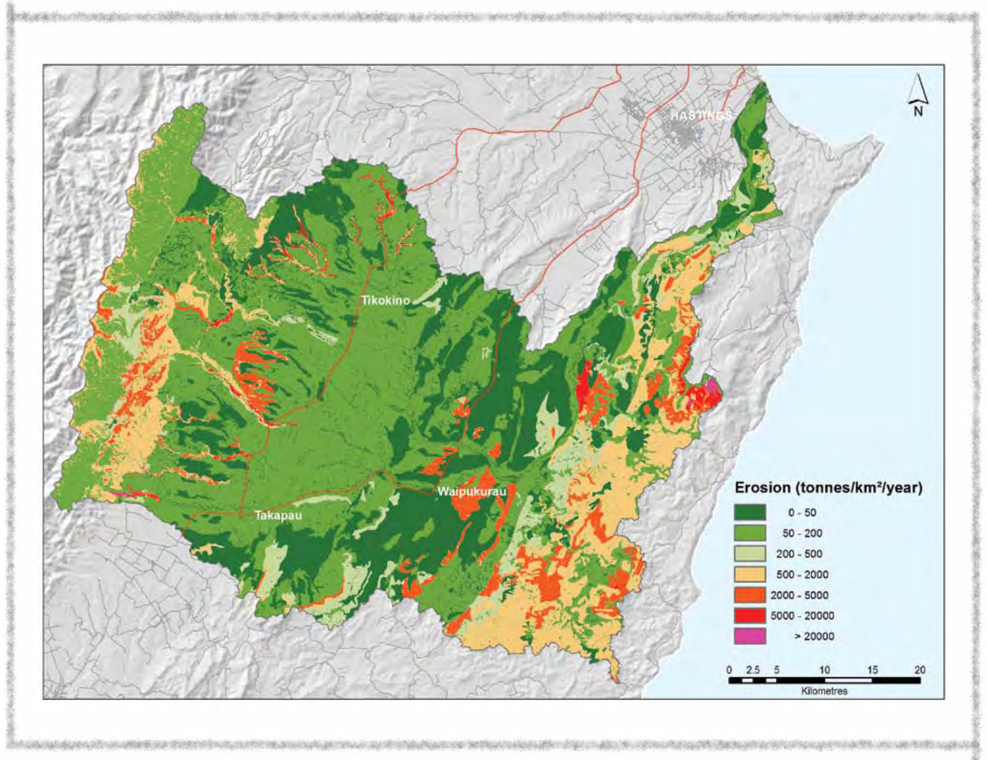
In general, the catchment geology includes harder greywacke rock in the west, and softer mudstones in the east. The relative 'hardness' of the surface rocks can affect erosion rates and the volume of sediment delivered to streams each year, although other factors such as received rainfall and type of land cover also affect rates of erosion.

Like much of the North Island hill country, the Tukituki catchment was converted from indigenous forest to pastoral agriculture following European settlement. In some cases, removal of native vegetation in areas of 'softer' rock has led to accelerated rates of erosion, associated slope failures, and river bed aggradation. These processes can result in loss of productive land, an increase in flood risk and detrimental impacts on aquatic ecology.

Areas at high risk of hillslope soil loss, and stream bank erosion were identified in the Tukituki catchment, and an assessment was made of where measures to deal with erosion might be required to reduce the amount of sediment reaching streams and rivers.

Case Study

Figure 67: Estimated levels of hillslope erosion across the Tukituki catchment.



The highest rates of slope erosion occur in the east and west of the catchment, where predicted maximum erosion rates could be more than 20,000 tonnes from each square kilometre of land in particular areas each year (Figure 67). The high erosion rates in the eastern part of the catchment are the result of a combination of deforestation on the hills and the soft rock geology found in the area. The high erosion in the western side of the catchment is a consequence of the steep gullies and the significant area of land exposed above the tree line on the Ruahine Ranges. The Ruahine Ranges are also exposed to high rainfall and the East Coast experiences regular storm events.

The vulnerability of these eastern areas was evident during a significant storm event in 2011, when heavy rains caused severe erosion in the eastern Tukituki Catchment and neighbouring coastal catchments (see photo previous page and opposite).

It is not just hill country that contributes towards sediment loads in our rivers.

A large amount of sediment reaches rivers from stream bank erosion. Where livestock have access to rivers the rate of stream bank erosion is usually higher. The river reaches contributing the most sediment from bank erosion were identified in the Tukituki catchment using a computer-based model (Figure 68). It is estimated from the model that 282,000 tonnes of sediment are generated from stream banks in the Tukituki catchment each year. This compares with approximately 597,000 tonnes of sediment produced from hillslope erosion each year.

The model can also be used to predict what would happen if particular land management practices were implemented. If livestock were excluded from all small to medium streams in the Tukituki catchment using fences or other means, it is estimated that sediment contributed by stream bank erosion each year could be reduced from 282,000 tonnes to 75,000 tonnes.

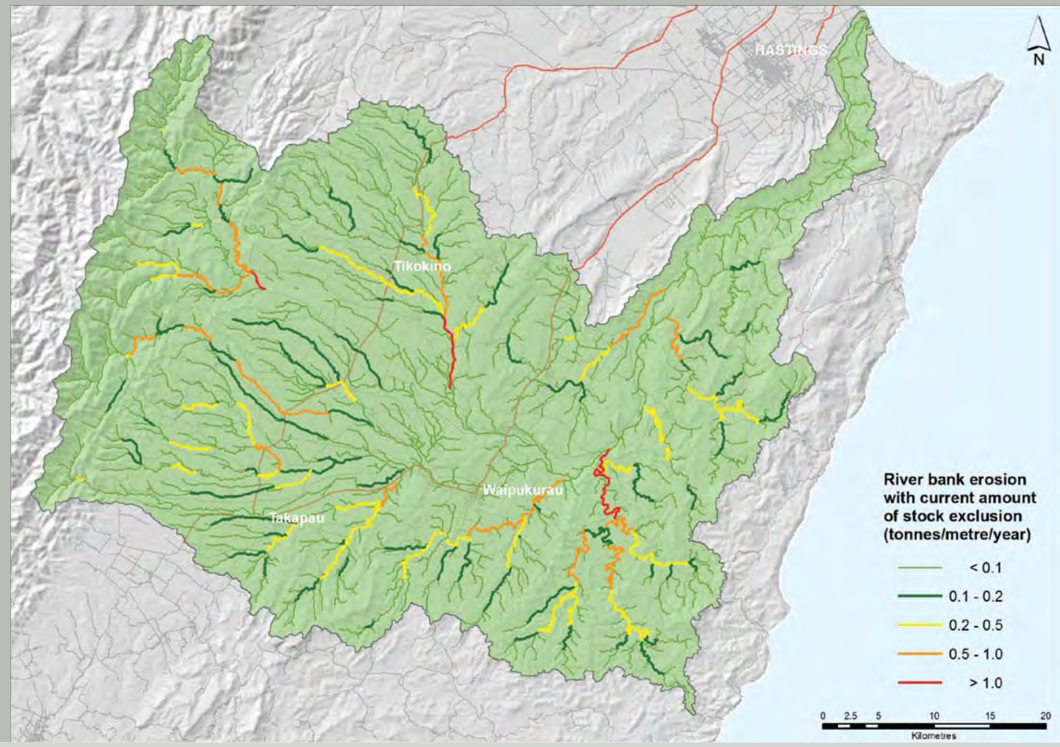


Figure 68: Modelled river bank erosion rates for each metre long length of bank, under current levels of stock exclusion.

Erosion on east coast hill country following the 2011 storm

Long term beach surveys play an important part in understanding the coast, as well as assisting with its long term coastal hazard planning.

A large half crab *(Petrolisthes elongates)* on Te Mahia Reef.

The Coast

The diverse 360km Hawke's Bay coastline stretches from the sandy beaches and reef platforms of the Mahia Peninsula in the north, to the ecologically significant estuary at Porangahau in the south. This diversity provides a wide variety of habitats, including undulating coastal cliffs, sandy beaches, extensive dune systems, rock platforms, gravel beaches and associated herb fields.

One of Hawke's Bay's best known landmarks is the distinctive Cape Kidnappers, which forms the southernmost tip of the curving Hawke Bay. The region's geological history is plain to see here in the fractured and contorted layers of sedimentary rock. In Māori mythology, Cape Kidnappers is Te Matau-a-Maui, the hook of the jaw bone that Maui used to haul up the North Island, which is Te Ika-a-Maui, the fish of Maui. Cape Kidnappers is also home to the largest mainland gannet colony in the world.

The range of habitats in the Hawke's Bay coastal environment support a diverse range of species ranging in size from microscopic animals living in the sand and mud of our estuaries and beaches, through a diversity of marine plants and animals to huge Southern Right Whales which use the coastal waters of Hawke's Bay as an invaluable nursery area.

Opoutama Beach on the Mahia Peninsula

There are many significant areas within Hawke's Bay's coastal waters. These include estuaries like Porangahau and Ahuriri, sand dunes at Ocean Beach and Rangaiika and varied reef systems such as the southern Hawke's Bay intertidal platforms and subtidal Pania Reef. These are ecologically important areas that provide habitats for many plant and animal species, including reef herons, katipo spiders and many species of triple-fin fish.

HBRC monitors the state and trends of many of the region's estuarine, beach and intertidal reef environments, as well as the quality of our near-shore coastal waters.

The coastal environment is highly valued for recreation so during the summer we also monitor popular recreational sites to check that water quality is suitable for water activities. Our beaches have mostly great water quality so people can enjoy their swimming, fishing, surfing, diving and boating.

Coastal Water Quality

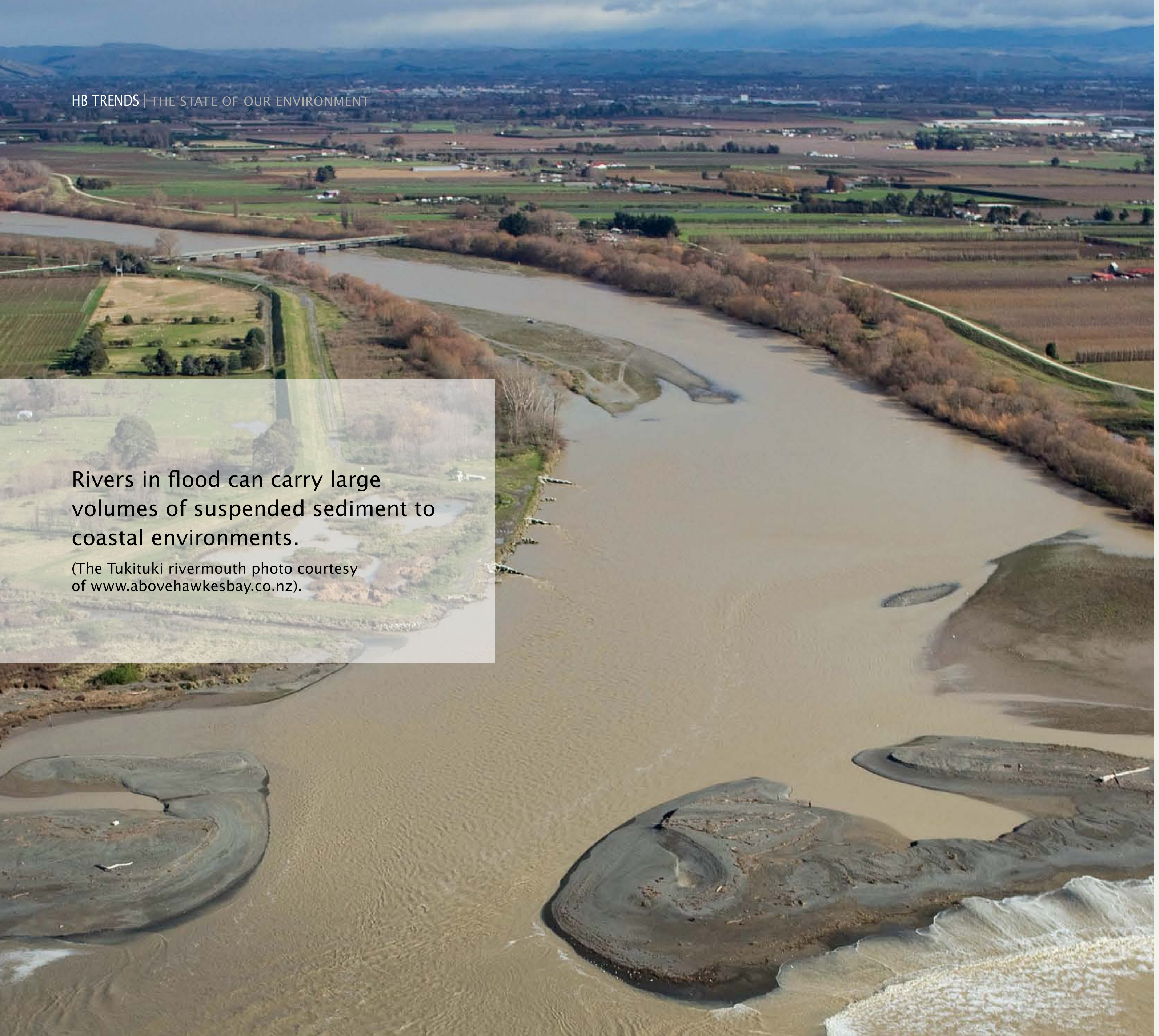
A wide range of biological, social, economic and recreational activities depends upon good water quality in the coastal environment. However, discharges of contaminants associated with land-based activities can affect coastal water quality.

Since 2006, near-shore water quality has been monitored every six weeks at seven sites from Ocean Beach northwards. The programme has recently been extended to Wairoa and the Mahia Peninsula (Figure 73). Samples are collected by boat about 1 km from shore. Sites are located adjacent to possible sources of land-based discharges such as rivers and harbours. The samples are tested for nutrients, faecal contamination, sediment, physico-chemical parameters and chlorophyll-*a*, which is an indicator of the amount of algae in the water.

Monitoring using samples from the coast is augmented by data collected offshore by the HAWQi water quality monitoring buoy (see Case study page 125) and the summer recreational water sampling programme (see Recreational water quality page 71).

Concentrations of contaminants observed in the coastal environment are generally lower than in fresh water because they are rapidly diluted in the ocean. This effect can be seen in the elevated concentrations of dissolved reactive phosphorus (Figure 74) in the Ahuriri Estuary, which has a small tidal volume, compared to the other sites measured which are all in open water.

Figure 73: Coastal monitoring sites.



Rivers in flood can carry large volumes of suspended sediment to coastal environments.

(The Tukituki rivermouth photo courtesy of www.abovehawkesbay.co.nz).

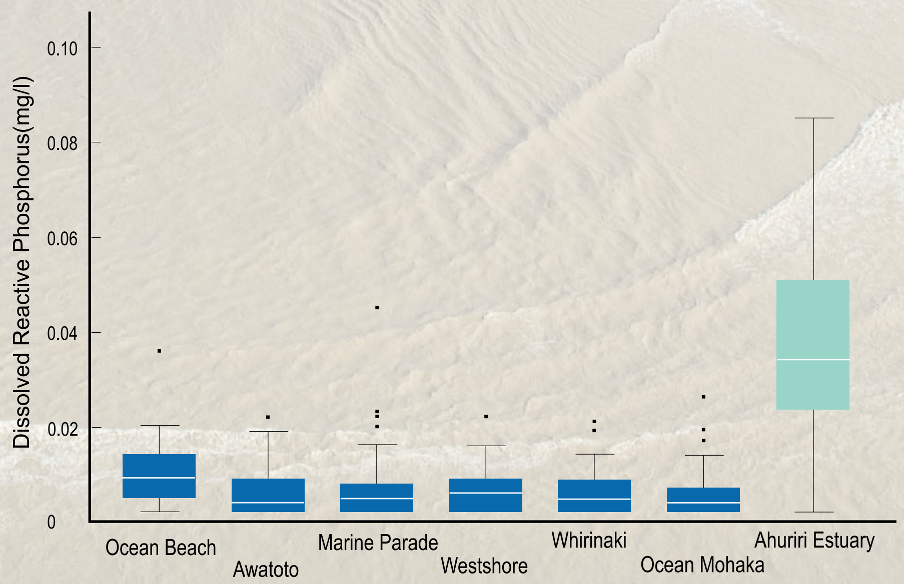


Figure 74: Boxplot showing the ranges of dissolved reactive phosphorus concentrations at nearshore water quality monitoring sites between June 2006 and December 2013.

The water quality at most sampling sites is stable and shows no trend. There is an improving trend in water quality at the Ahuriri Estuary site in terms of turbidity and phosphorus concentrations, and an increasing trend in turbidity at Marine Parade (Table 7).

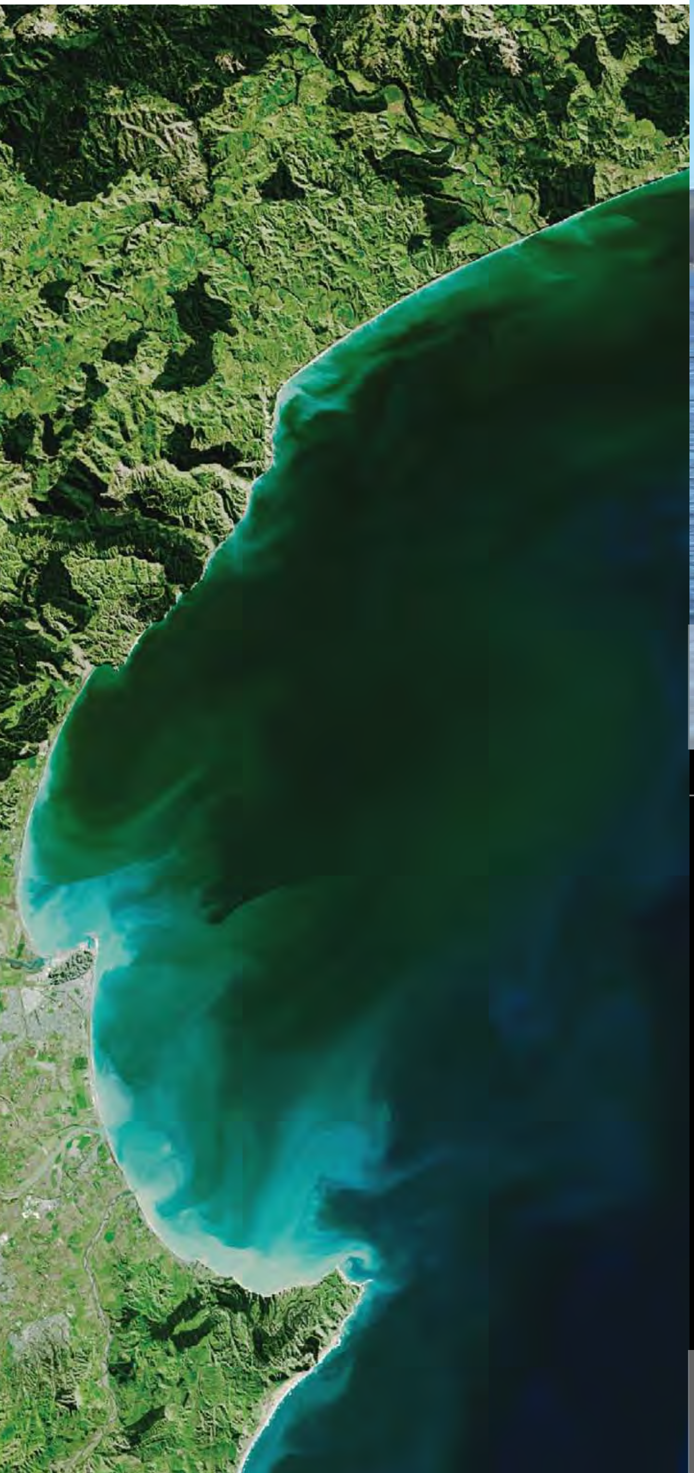
Table 7: Summary of trends in the main contaminants measured at nearshore water quality sampling sites.

Analyte/Contaminant	No. sites analysed	No. sites better	No. sites worse	No. sites no trend
TURBIDITY	7	1 (AHURIRI ESTUARY)	1 (MARINE PARADE)	5
SUSPENDED SOLIDS	7	0	0	7
ENTEROCOCCI	7	0	0	7
CHLOROPHYLL-*a*	7	0	0	7
DISSOLVED REACTIVE PHOSPHORUS	7	1 (AHURIRI ESTUARY)	0	6
TOTAL PHOSPHORUS	7	1 (AHURIRI ESTUARY)	0	6
DISSOLVED INORGANIC NITROGEN	7	0	0	7
TOTAL NITROGEN	7	0	0	7

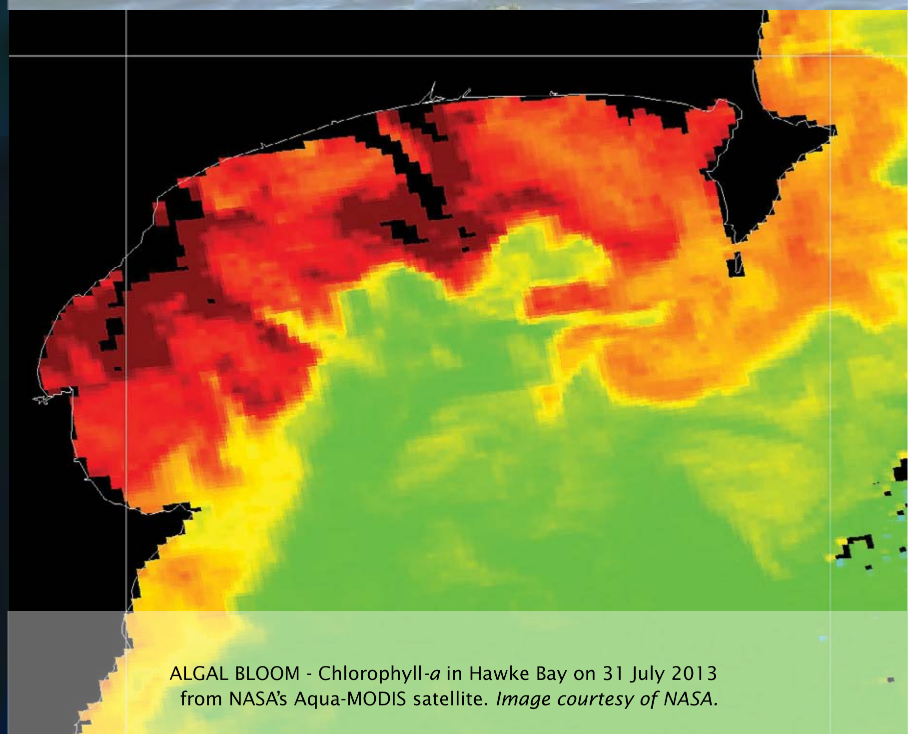
River plumes carry suspended sediment and other materials into the coastal environment *(Photo courtesy of www.abovehawkesbay.co.nz).*

Case Study

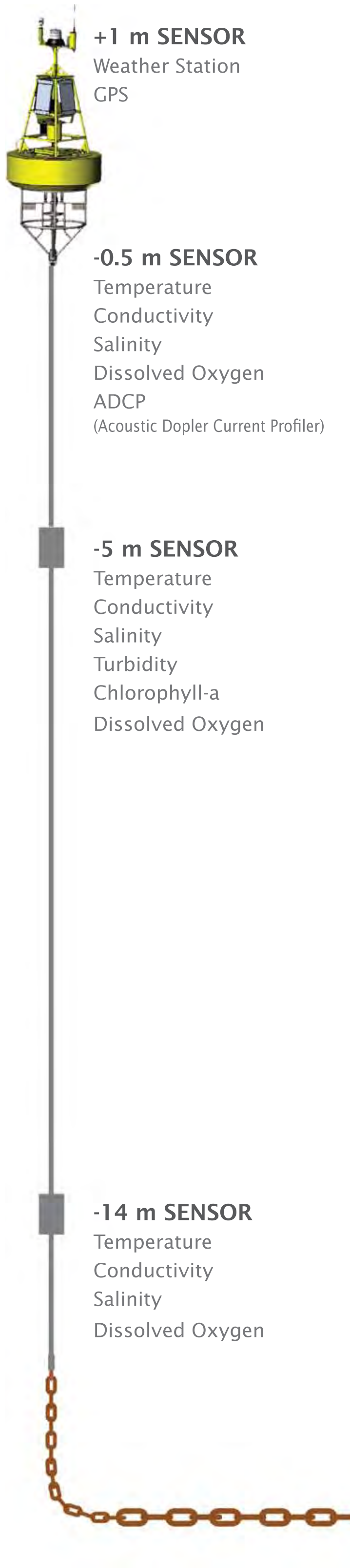
Sediment plumes and algal bloom in Hawke Bay 31 July 2013, natural colour Landsat 8 image, *courtesy of USGS.*



HAWQi buoy off the coast of Tangoio



ALGAL BLOOM - Chlorophyll-*a* in Hawke Bay on 31 July 2013 from NASA's Aqua-MODIS satellite. *Image courtesy of NASA.*



HAWQi - IT'S A BUOY!

Background

New Zealand's near-shore coastal waters are affected by activities in river and lake catchments that drain to the sea. However coastal waters are difficult and costly to monitor and are generally monitored less than river catchments. This means long-term, continuous monitoring of the coast is of considerable value.

In December 2012, with the assistance of the Cawthron Institute, we moored Hawke's Bay's first coastal water quality buoy, called HAWQi (Hawke's Bay Water Quality information), approximately 5 km off Tangoio Bluff in Hawke Bay (see photo at left). HAWQi collects continuous temperature, conductivity, turbidity and chlorophyll-*a* data.

How HAWQi works

HAWQi has temperature and conductivity sensors at the surface and at depths of 5 m and 14 m, and an optical chlorophyll-*a* and turbidity sensor at 5m. An ultrasonic weather station and GPS sensor are also situated on the buoy, 1 m above sea level. An independent GPS lets HBRC know if the buoy becomes detached from its mooring, and allows it to be tracked and recovered.

The software used to control the hardware and electronic settings remotely was developed by the Monterey Bay Aquarium Research Institute (MBARI) in California, and provided to us by MBARI for this project.

Case Study

HAWQi buoy being returned to the water with the help of Coastguard Hawke's Bay and divers who secured the buoy to the seabed.

In 2014 the buoy was taken out of the water for servicing and had new equipment added. The new gear is an ADCP (Acoustic Doppler Current Profiler) which will provide important information on ocean currents within Hawke Bay plus new sensors to collect data on dissolved oxygen to provide information on the dynamics of algal blooms.

Data is transmitted back to HBRC via UHF radio telemetry, and is quality checked using HBRC's normal data management systems.

Data may be accessed by the public on HBRC's HAWQI website www.hawqi.co.nz, and on our main council website at www.hbrc.govt.nz too. Boaties and others can use the data to check weather and sea conditions.

What are we using HAWQi for?

Coastal conditions were previously only monitored during 'one-off' sampling missions by boat. HAWQi now provides continuous, real-time data, which provides context to those one-off samples.

The continuously-collected data allows us to identify short-lived coastal water quality events as they develop in Hawke Bay. For example, an algal bloom in July 2013 in Hawke Bay was detected early by HAWQi, which allowed us to study the event with a wide range of coastal water samples.

Because we knew a significant event had occurred, we obtained satellite imagery to support our analysis of the data.

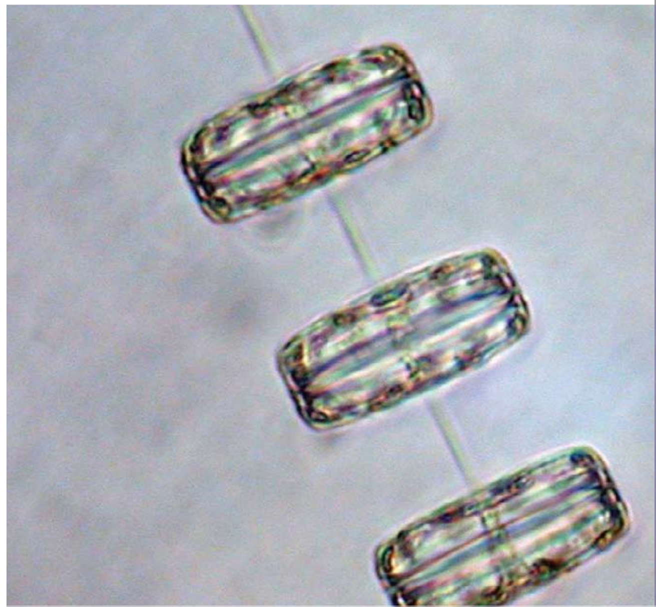
Data from HAWQi will also allow us to make better use of satellite imagery (see image on page 124) to help us detect any changes in water quality throughout the bay, and understand the drivers behind these changes.

The data is used to provide information on coastal water quality for science investigations and for policy development.

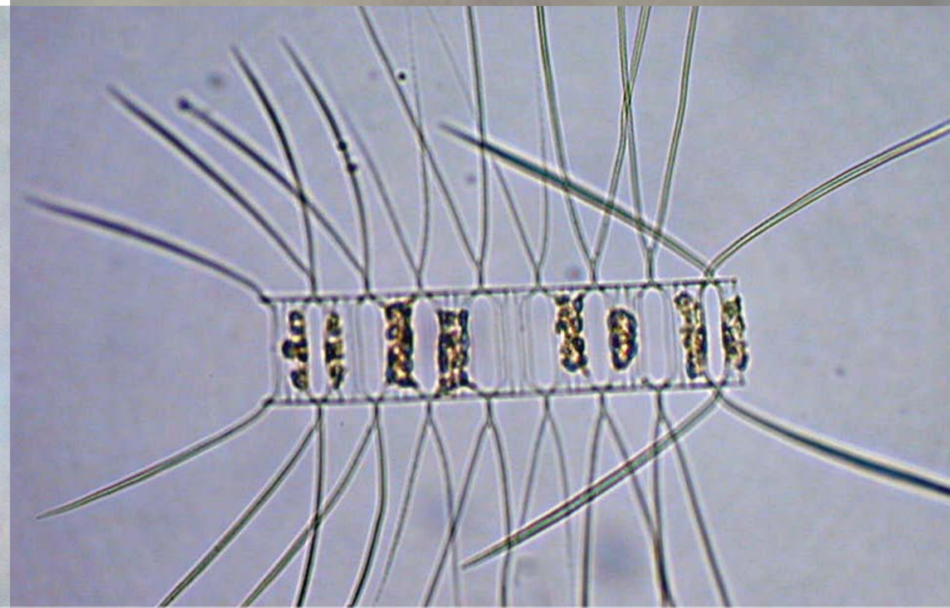
In future, the buoy will help us analyse satellite imagery to provide robust, monitoring data with high spatial coverage.

Chaetoceros sp.
courtesy Cawthron Institute

Algal blooms are made up of billions of microscopic organisms called phytoplankton.



Thalassiosira sp.
courtesy Cawthron Institute



Chaetoceros sp.
courtesy Cawthron Institute

Southern North Island Forest Gecko, found in indigenous forest, scrub and shrubland. The species is just one of many that are classified by the Department of Conservation as 'At Risk – Declining'. Lizards such as this cannot travel long distances, so they are prone to habitat loss and fragmentation. They are also vulnerable to predators such as cats and mice. New Zealand lizards are distinctive from overseas species – they live unusually long lives, and produce few young.

Hawke's Bay Biodiversity

Current State of Our Knowledge

New Zealand has been separated from other land masses for about 80 million years. As a consequence, our endemic land-based species have evolved in isolation. Several aspects of New Zealand's isolation are key to its biological diversity, or biodiversity. For example, until a thousand years ago, only land mammals present in New Zealand were bats. Land-based mammal predators such as humans and rats (kiore) arrived only relatively recently. Birds evolved to fill ecological niches occupied elsewhere by mammals.

New Zealand's biodiversity is important because our plants and animals provide 'services' such as the purification of water and air, the cycling of nutrients and the creation and maintenance of soils. Many people consider that there is also intrinsic value in biodiversity. Indeed, for Māori, biodiversity is an integral part of mauri.

Biodiversity in New Zealand has declined since human settlement, through species extinction, habitat loss and degradation, and the effects of introduced plants and animal pests.

Biodiversity has also declined in Hawke's Bay. An examination of the state of Hawke's Bay biodiversity was initiated in 2013. The resulting report – *Hawke's Bay Biodiversity Inventory – Current State of Knowledge* – identified what further investigations would be required to fill knowledge gaps about regional biodiversity.

FURTHER READING:

DoC and MfE (2000). The New Zealand Biodiversity Strategy: Our chance to turn the tide. Wellington, Ministry for the Environment.

Hashiba, K., O. Wade and W. Hesketh (2014). Hawke's Bay Biodiversity Inventory - Current state of knowledge. *HBRC Report No. RM 13/23 - 4554.* Napier, Hawke's Bay, Hawke's Bay Regional Council.

Hawke's Bay biodiversity - past and present

Indigenous forest once dominated most of Hawke's Bay (Figure 71). Kahikatea forest covered the region's alluvial plains, while most of the middle-hill country was clothed in podocarp forest. Mountain beech forests dominated the higher country.

Indigenous forest in Hawke's Bay has been reduced to approximately 20% of its original cover (Figure 72). Lowland and middle-hill forests such as kahikatea-dominated alluvial forests and podocarp forests have seen the largest decline over the last 1000 years. These forests are some of the most threatened indigenous habitats in the region.

As well as our indigenous forests, a significant area of wetlands has been lost over the last 200 years, particularly around river mouths and on alluvial plains. Wetlands have been drained over that period to allow farming, and only 2% of the original wetland extent remains in the region.

Changes in land use and the removal of riparian (river bank) vegetation cover over time has also contributed to the decline of aquatic biodiversity in many streams and rivers in lowlands and middle-hill country.

Our 360km coastline supports a diverse range of habitats such as coastal cliffs, sand dunes and rock platforms. Some of these habitats are naturally confined to small areas but some, such as sand dunes, have been lost to land use change and coastal developments.

Changes in the extent and condition of indigenous habitats affect resident indigenous species. For example, habitat fragmentation affects lizards and some bird species incapable of moving to other habitat sites. Predation and competition from introduced species such as cats, possums, rats and mice have also played a big part in habitat degradation and species decline. Over half of the native bat, bird, reptile and plant species ever recorded in the region are now threatened. Forty percent of native freshwater fish are also threatened. Several species have disappeared from the region, including kakapo, stitchbird, Duvacel's gecko, robust skinks, Hochstetter's frog, and Hector's tree daisy. It is suspected that numerous other species have also disappeared, unnoticed.

Rifleman or titipounamu, the smallest bird species in New Zealand, is mainly found in mature forest, especially beech, kamahi and podocarp forest. They are relatively poor flyers and typically move through forest using short flights. Once found across most of New Zealand's indigenous forest, the population is now highly fragmented and restricted to high-altitude mountain ranges where mature forest remains. It is classified by DoC as At Risk – Declining *(Photograph taken by Tamsin Ward-Smith, Cape Sanctuary).*

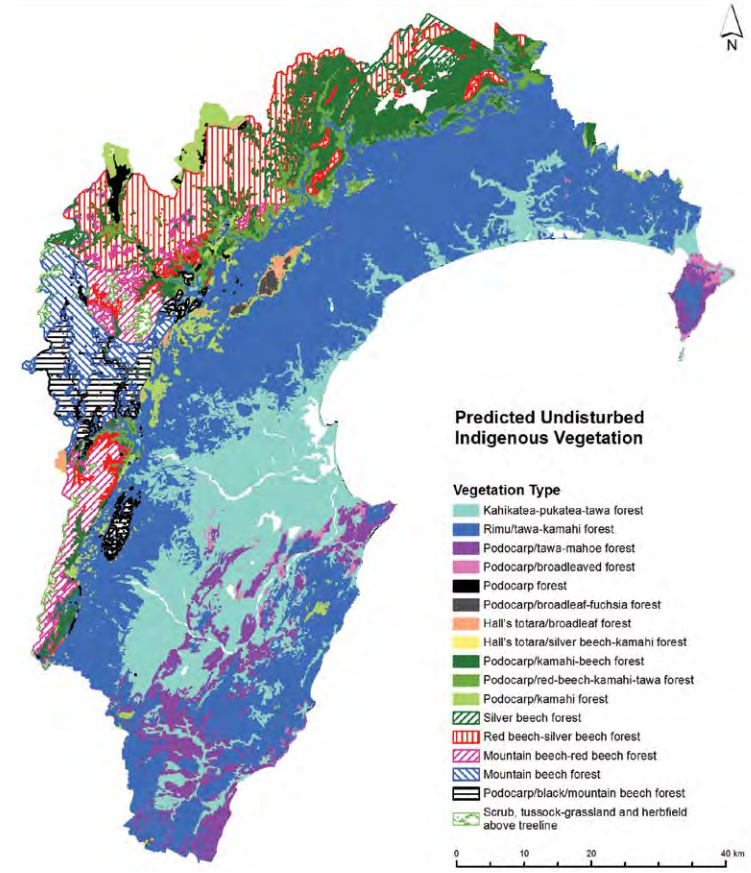


Figure 71: The predicted extent of indigenous forest and scrub in the absence of large-scale disturbance. Different colours and shades represents different forest types. The area without any colour (displayed as white) in this figure is unclassified and consists of open water including lakes and main channels of braided rivers.

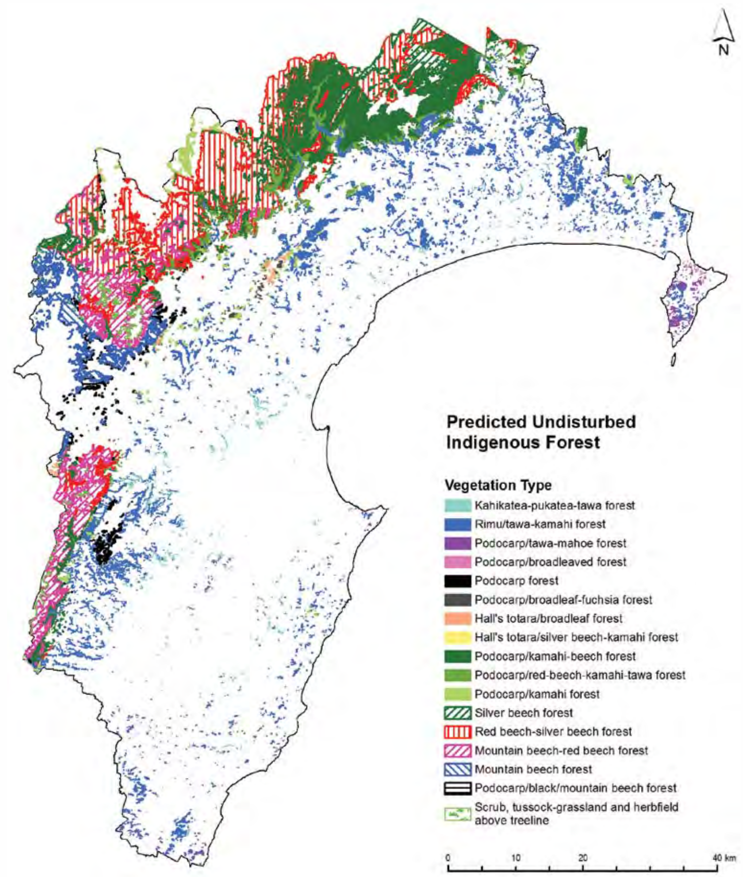


Figure 72: The current extent of indigenous forest and scrub in Hawke's Bay. Note that manuka/kanuka shrubland and other shrubland are not displayed in this map. Only non-forest vegetation shown in this map occurs above the treeline ('Scrub, tussock-grassland and herbfield above treeline').

The speckled whelk or kawari *(Cominella adspersa)* hunts in a rockpool.

Intertidal Reef and Sandy Beach Ecology

Our coastal ecological monitoring programme looks at intertidal reefs, sandy beaches and estuaries (Figure 75).

Ecosystem health is examined using indicators, like the level of contaminants in soft shore sediments and ecological community characteristics. It is important to monitor coastal ecology because natural variability can be exacerbated or altered by human influences, particularly land use changes and coastal management. Our long term monitoring programmes help us identify the effects of land-use change, climate change and ocean acidification.

Sandy beaches are popular recreational areas for swimming, surfing and fishing. They are also ecologically significant, supporting a diverse range of microscopic animals which help remove excess nutrients and other contaminants from the water. Some of our beaches host large shellfish beds, which feed both people and fish.

One of the most significant threats to beach animals is vehicles, particularly on beaches that are readily accessible by four wheel drives. Habitats, food chains, nests and animals are damaged by vehicles.

Figure 75: Map of monitoring sites.


Scutus breviculus, known as the shield shell

Sandy beach ecology

We monitor the condition of our region's sandy beach ecology and each ecological community is influenced by the environment at the beach where it is found. For example, the ecological community at Opoutama beach is dominated by marine worms. Large amounts of organic material wash ashore at Opoutama beach and marine worms are particularly adept at breaking this down. Crustaceans and bivalves are more prevalent at southern beaches, where the rates of deposition are lower (Figure 76).

Intertidal reefs

Intertidal reefs are some of the most biologically diverse habitats in the region. These are areas which are exposed at low tide and underwater at high tide. They provide habitat for many algal, invertebrate and fish species, and they are particularly important as nursery areas for juvenile fish and shellfish spat.

We currently monitor the intertidal community on reefs at Kairakau, Hardinge Road and Te Mahia as part of the long-term State of the Environment monitoring programme. This programme focuses on identifying what species are found on our region's reefs, and monitoring seasonal, annual and long-term variations in the structure of the ecological community of the reef. This includes identifying whereabouts species live on our reefs, and how the structure of the ecological community changes over time.

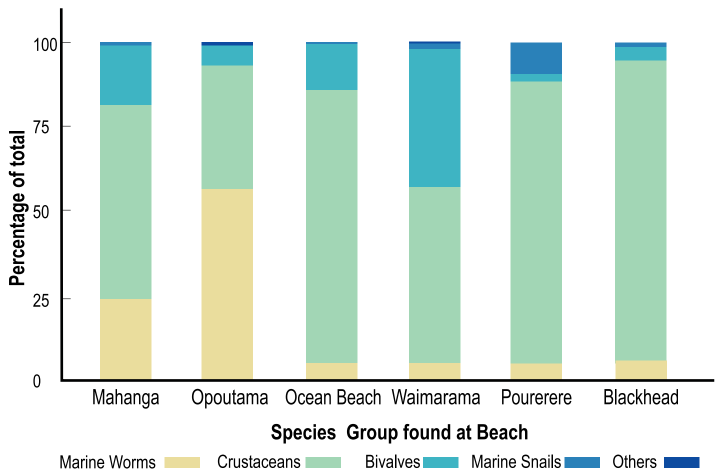


Figure 76: The different community characteristics of animals found around the beaches of Hawke's Bay.


A mud crab (*Helice crassa*)


The New Zealand octopus (*Pinnoctopus cordiformis*) hunting on Hardinge Road

Mohaka estuary

Ahuriri estuary

Porongahau estuary mudflats with many mud snails *(Amphibola crenata)*

Estuaries

At the interface of land and sea, estuarine habitats are distinctive and dynamic environments.

Estuaries have many functions. They are invaluable habitat for bird roosting, feeding and breeding, and they provide important spawning and nursery grounds for fish. Nutrient and sediment processes in estuaries help to buffer the effects of land-use activities on the open ocean. They also buffer the impacts of ocean processes, such as wave action and swells on the land, as estuarine processes form new land and new habitats.

In Hawke's Bay, HBRC monitors estuarine water quality at the Tukituki, Waitangi and Mohaka estuaries, as well as sediment quality, and the macroinvertebrate communities that live within and on the sediment at the Porongahau, Waitangi, Ahuriri and Wairoa estuaries. To further our local knowledge of these valuable environments, we also map the habitats associated with the region's estuaries (see case study page 137).

Estuaries are the downstream receiving environment for streams and rivers. This means they're one of the most at risk coastal environments for deposition of suspended sediment and accumulated contaminants from the catchment upstream.

The input of sediments from the land is probably the greatest threat to the health and sustainability of estuaries and the ecological services they provide. In some areas of New Zealand, land-use changes have increased sedimentation rates in estuaries from about 1mm each year to ten times this rate. Increased sedimentation rates can kill estuarine plants and animals, and changes in fine sediment deposition affect biological communities that live in marine and estuarine ecosystems.

Sediment texture in estuaries can be used to indicate the capacity of sediments to retain contaminants. Contaminants such as heavy metals, hydrocarbons, pesticides and excess nutrients mostly attach to fine sediments. Estuaries with fine muds are vulnerable to urban and rural contaminants washed down streams and rivers and discharged from stormwater outlets.

The Tutaekuri blind arm at Waitangi Estuary.

Waitangi Wetland, looking toward Awatoto.

Ahuriri estuary sampling sites

Sediments in the Ahuriri estuary are a good example of vulnerability to contamination, and show evidence of contamination from stormwater and land-based activities (Figure 77). HBRC has 4 monitoring sampling sites in the Ahuriri estuary (see map). Sampling site Ahuriri D is at the mouth of the Tyne Street drain, which drains an urban industrial catchment. The sediments at this site have elevated levels of copper, lead and zinc. These heavy metals are common contaminants associated with urban environments.

HBRC staff monitoring sediment and macroinvertebrates in the Ahuriri estuary.

Sediment contamination levels, Ahuriri

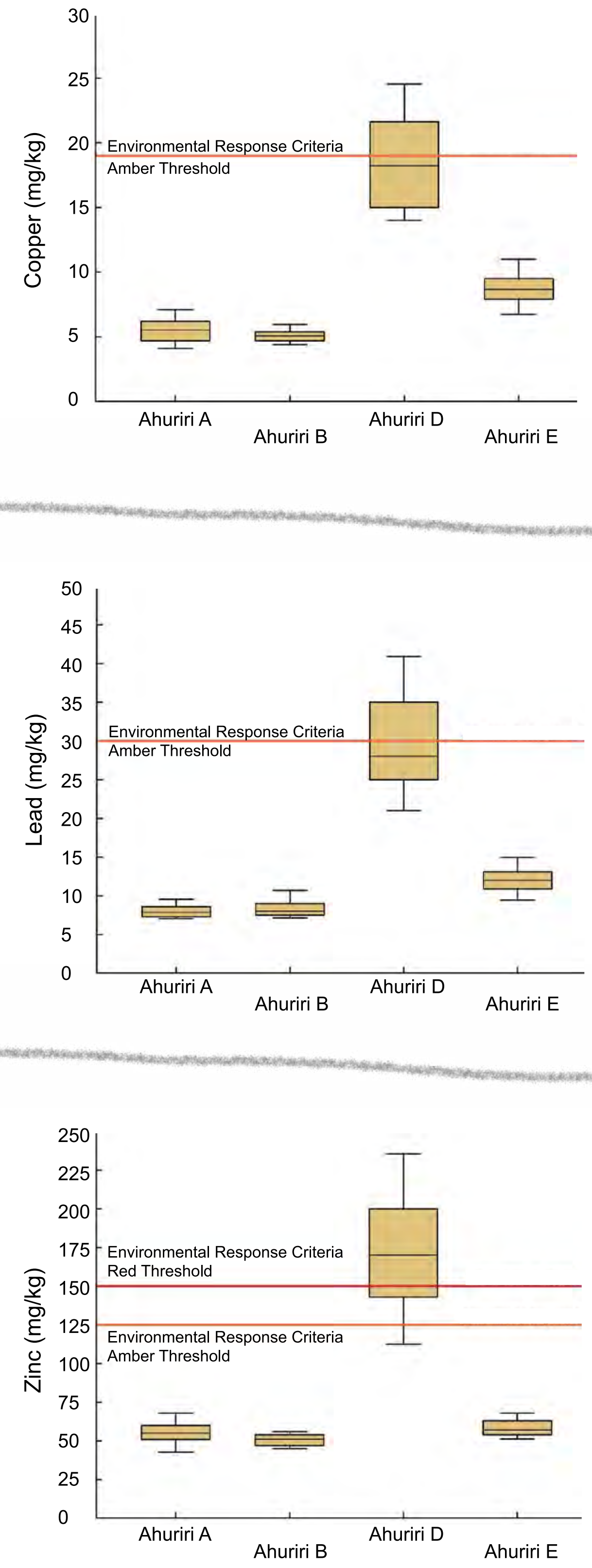


Figure 77: Using the Environmental Response Criteria developed by Auckland Council, the amber threshold is an indication that contaminant levels are elevated and the biology of the site is possibly affected. The red threshold indicates that the biology of the site is likely to be affected.

Case Study

HBRC staff mapping sediments in the Waitangi estuary

Juvenile NZ Fur Seal/Kekeno (*Arctocephalus forster*) resting on the Ahuriri Estuary

Mudsnails *(Amphibola crenata)* grazing on sandy mudflats in the Waitangi Estuary

WAITANGI ESTUARINE HABITAT MAPPING

Knowing what can be found within Hawke's Bay's coastal environments is an important part of managing these areas. Monitoring change over time also helps us recognise the most valuable and vulnerable habitats that require our continued attention.

HBRC is mapping plant habitats and intertidal sediment habitats in the region's estuaries (Figure 78). In 2013 and 2014 the wetland vegetation and sediment zones of the Waitangi Estuary at the combined mouth of the Clive, Ngaruroro and Tutaekuri rivers were mapped using recent colour aerial photographs, combined with broad-scale habitat mapping and field visits to confirm our findings. We mapped the dominant types of vegetation and sediment using standard approaches defined in the National Estuary Monitoring Protocol (Cawthron 2002).

This baseline information on estuary habitats helps us identify where it will be most useful to carry out targeted studies on specific habitats and key areas within the estuary. This baseline information also allows us to see where the distribution of plant species and the location of different sediment types is changing in future.

The survey shows that the most extensive area of estuarine vegetation is in the southern part of the Waitangi estuary. Most of the remaining estuary contains no native vegetation and is dominated by grassland. The south side of the estuary is where sediment is deposited and where it generally is softer. The relatively slow flow of the Clive River means that more sediment is deposited in this area, while the Ngaruroro and Tutaekuri rivers convey their sediment to the sea.

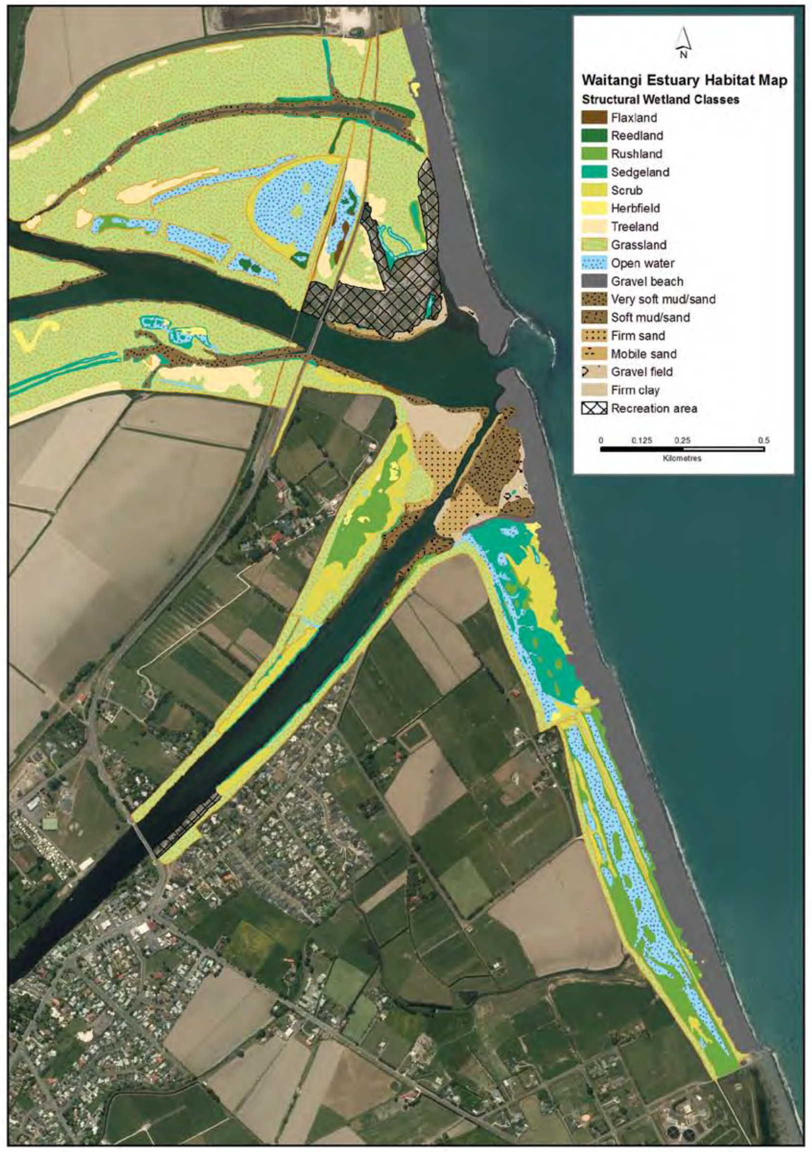
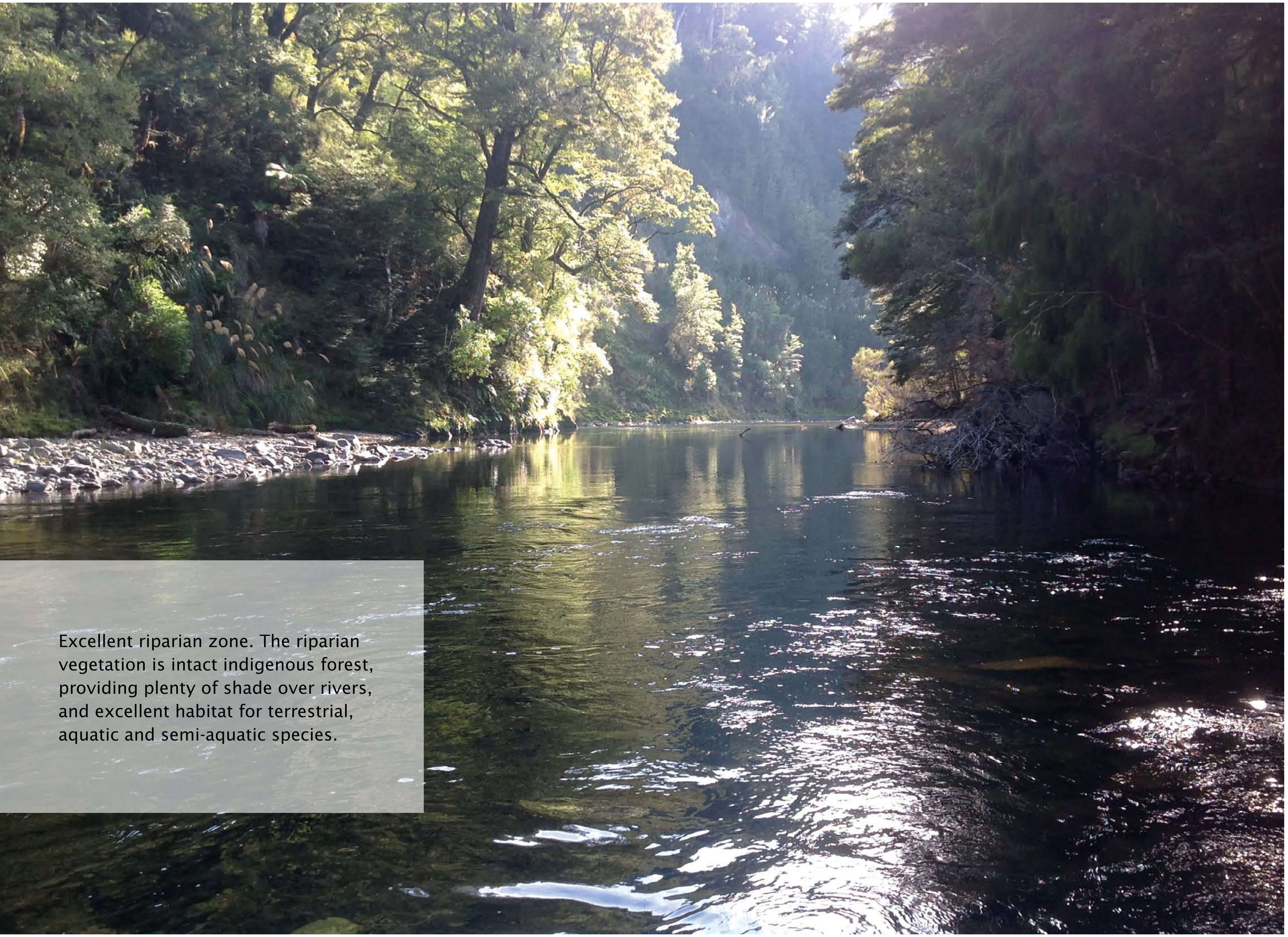


Figure 78: Waitangi Estuary Habitat map.



Excellent riparian zone. The riparian vegetation is intact indigenous forest, providing plenty of shade over rivers, and excellent habitat for terrestrial, aquatic and semi-aquatic species.

Our Riparian Environment

What is the riparian zone and why is it important?

The riparian zone is the area along the edges of streams and rivers - the interface between land and water. This zone is subject to seasonal flooding, so it provides a diverse habitat for terrestrial and semi-aquatic flora and fauna.

Phosphorus and nitrate are both valuable plant nutrients which are widely used in agriculture. However, they can become pollutants when they leave the paddock and enter waterways. When excessive amounts of nutrients enter waterways, they can change water chemistry and create toxicity problems. Excess nutrients can also cause excessive growth of plants including weed and algae, which in turn can remove oxygen from the water and make it less suitable for many fish species. These pollutants can arrive in waterways from surface run-off, soil erosion, and leaching into groundwater.

Riparian zone vegetation benefits in-stream habitats in many ways. For example, it acts as a buffer for surface and sub-surface flows of contaminants derived from land use activities. Root masses and branches overhanging waterways and leaf litter can also provide food and habitat for many fish and insects living in the water and on adjacent land. Shading from trees and shrubs maintains water temperature in streams.

When stock are prevented from accessing riparian zones and streams, this limits the potential damage they do to stream banks and the amount of associated soil erosion. Riparian vegetation can be effective in reducing nutrient input to the stream by reducing surface runoff and sub-surface leaching, and through denitrification, which is the process of nitrate reduction by bacteria living in root zones.

Riparian management by excluding stock and re-vegetating with appropriate plants improves water quality, in-stream and stream bank habitat conditions, and also improves regional terrestrial and aquatic biodiversity.

Case Study

RIPARIAN CONDITION –

Heretaunga and Tukituki

We conducted a desk-top assessment of riparian conditions in the Tukituki, Tutaekuri, Ahuriri, Ngaruroro, and Karamu catchments. The level of stock access to small and medium streams and the extent of riparian vegetation were assessed using aerial imagery (Figure 3).

High-altitude sub-catchments in the Tukituki Catchment such as Makaroro (T17 in Figure 69) have low levels of stock access. This is largely due to most of the catchment being managed by Department of Conservation or under QEII National Trust covenant. About 80% of the streams assessed have no or very low levels of stock access, while 20% of streams have a very low level of stock access. The riparian vegetation of these catchments is mostly indigenous forest and scrub, which provides sufficient shade to the stream.

In some areas where plantation forestry and steep gully systems act as barriers for stock access, stock disturbance is relatively limited. When trees are older, before they are harvested, the commercial plantations can provide a good amount of shade to streams.

Porangahau (T7), Maharakeke (T8), Mangatarata (T10) and Upper Tukituki Corridor (T15) sub-catchments (Figure 69) showed high levels of stock disturbance. Over 50% of the streams assessed appeared to lack fencing or any other measures to limit stock from accessing waterways. Riparian vegetation in these catchments is predominantly pasture grass, which provides very limited shading.

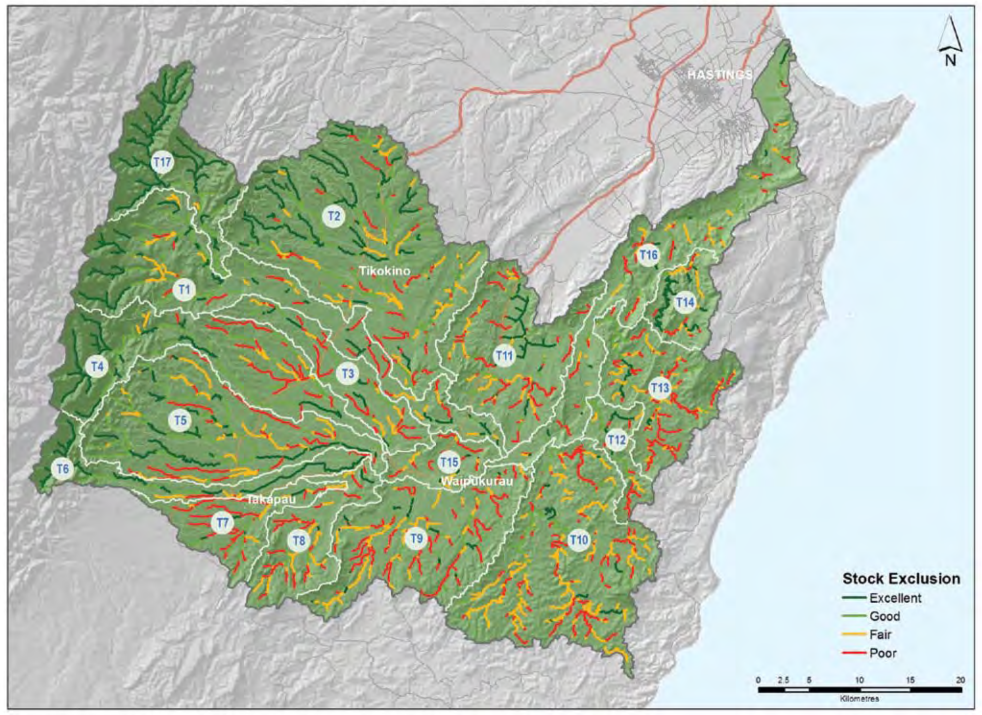
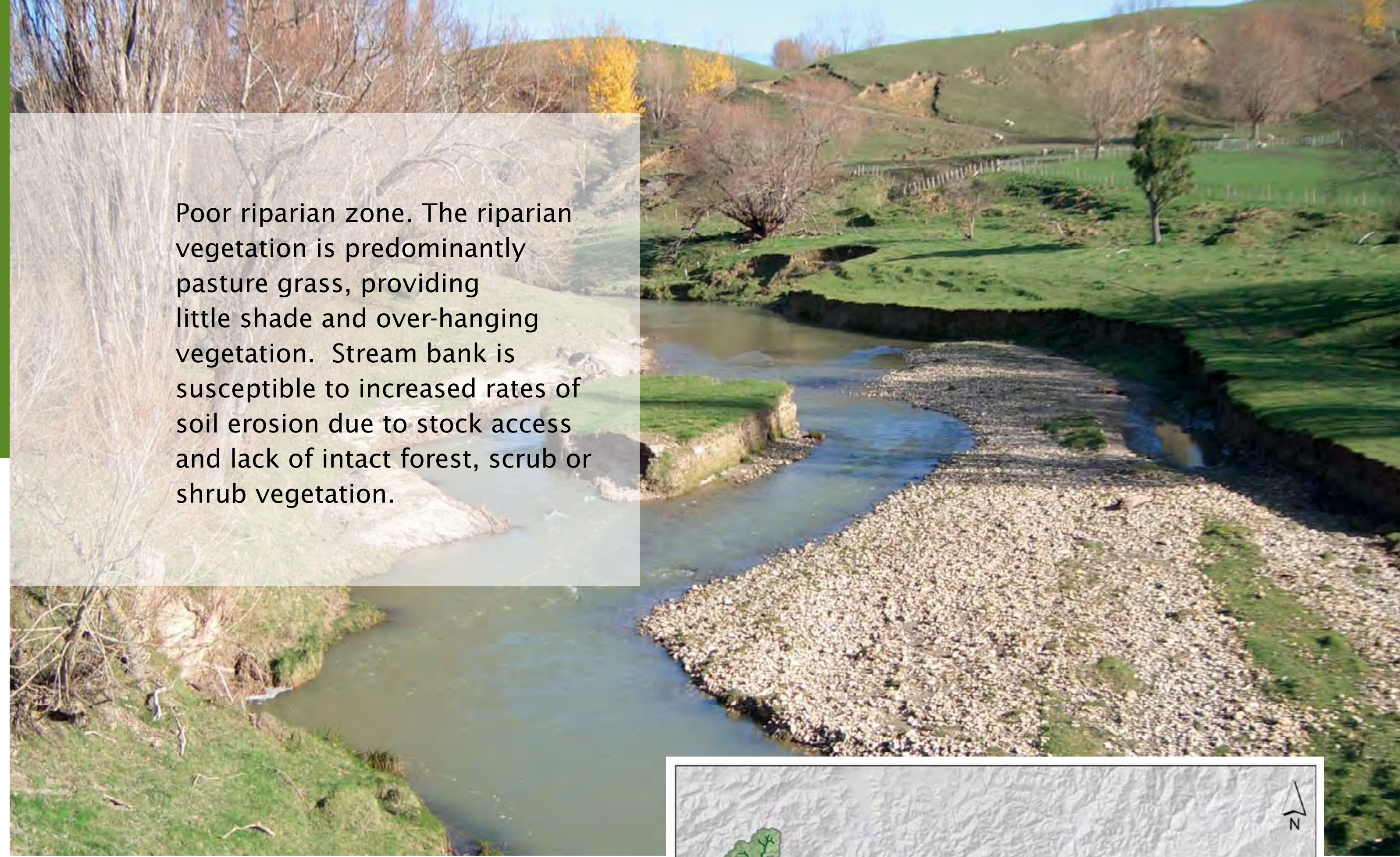


Figure 69: Stock disturbance level in Tukituki Catchment. The catchment is divided into seventeen sub-catchments (T1 – T17). The four categories used are: 'Excellent' (no stock access or damage to riparian habitats and waterways), 'Good' (stock access and damage is present but minimal in extent), 'Fair' (stock access and damage is evident), and 'Poor' (stock access and damage is significant). The condition of riparian vegetation showed a very similar pattern to the pattern of stock disturbance across the catchment.



Poor riparian zone. The riparian vegetation is predominantly pasture grass, providing little shade and over-hanging vegetation. Stream bank is susceptible to increased rates of soil erosion due to stock access and lack of intact forest, scrub or shrub vegetation.

The Ngaruroro and Tutaekuri catchments showed similar patterns of riparian condition to the Tukituki catchment. Overall riparian conditions were good in the headwater sub-catchments, such as Upper Ngaruroro (NG1) and Upper Tutaekuri (TK1), where stock have minimal access to the streams. The state of the riparian zone becomes poorer in lowlands, where land used mostly for agriculture has stream banks that can suffer damage from stock access, and lacks shade from tall vegetation (Figure 70).

The Karamu and Ahuriri catchments showed distinctive patterns where riparian conditions of many streams were not necessarily influenced by the levels of stock access (Figure 70). These two catchments include three major urban areas, Napier, Hastings and Havelock North. Many streams in the Karamu catchment flow through cropping and horticultural land. While waterways in urban areas and cropping/horticultural land aren't usually accessed by stock, other activities, such as cultivation, occur right up to the edge of waterways and can damage the riparian zone and trigger bank erosion. Nearly 70% of streams assessed in the Karamu Catchment and 40% of streams in the Ahuriri Catchment have poor, or are completely lacking in, riparian vegetation and these streams receive very little shading or other benefits from riparian vegetation.

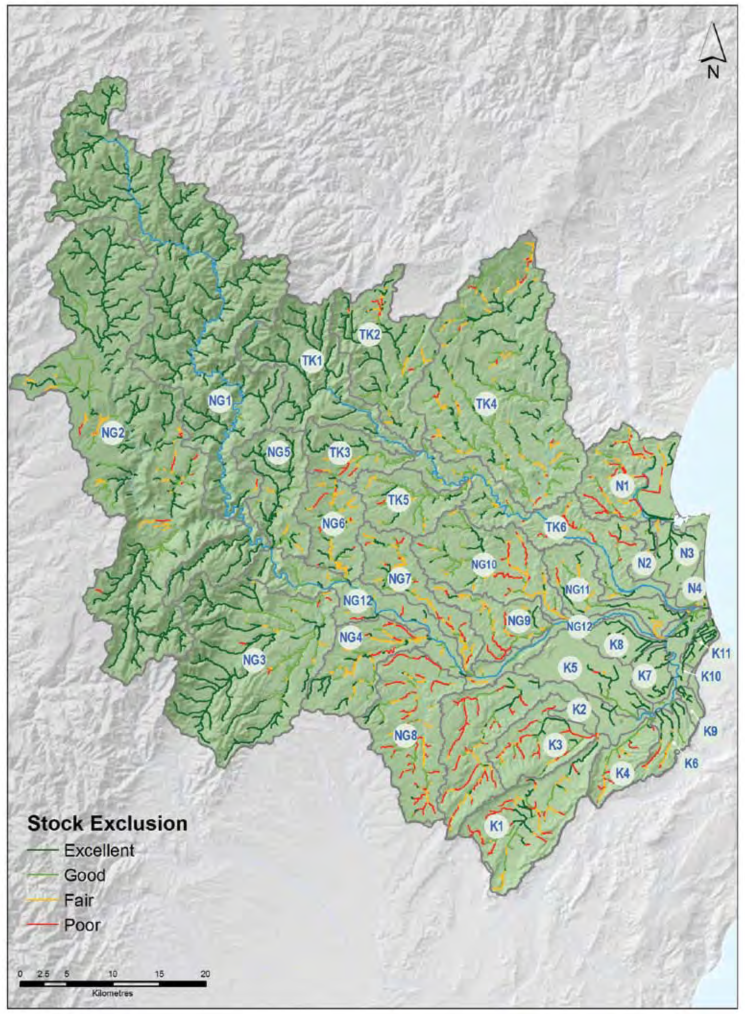


Figure 70: Stock disturbance level in Tutaekuri (TK), Ahuriri (N), Ngaruroro (NG), and Karamu (K) catchments. In the same way as the Tukituki case study, four categories were used: 'Excellent' (no stock access or damage to riparian and waterway), 'Good' (stock access and damage is present but minimal in extent), 'Fair' (stock access and damage is evident), and 'Poor' (stock access and damage is significant).

Hardinge Road reef in a winter low tide.

Coastal Processes

Our coastline and beaches are constantly on the move. The position of the coastline changes gradually all along the Hawke's Bay coast. Coastal landforms are the result of water-driven and wind-driven processes, where waves, currents, tides and wind erode, move and deposit rocks and sediment.

Many of these changes happen where temporary or permanent erosion of the shoreline is taking place, or where the shoreline builds out over time through deposition of new materials. Some of these sediments may be shifted along the coast by waves in a process known as longshore drift.

The speed at which changes in the position of the coastline occur depends on many factors: the geology of the rocks involved; whether the landform being affected is 'soft' like sand-dunes or 'hard' like cliffs; and the supply of new sediments to the coast from rivers.

Over recent centuries the Hawke's Bay coastline has experienced many cycles of erosion, accretion, and flooding caused by the sea. In particular, Haumoana, Te Awanga and Clifton have suffered from erosion and flooding over the years (see Case Study on page 142).

We monitor the effects of coastal processes using beach cross-section surveys, to measure where these affect people's activities, infrastructure or settlements. All major beaches across the region are surveyed at least once a year and reported on. The surveys indicate whether beaches are eroding, accreting or stable and is important to our understanding of the coastal processes.

However, the survey work doesn't tell us why these changes take place. To understand the changes involves knowledge and the application of science over a wide range of disciplines including weather, ocean currents, sediment transport (movement) and coastal geomorphology (the study of the characteristics, origin, and development of the form of Earth's features). Long term beach surveys play an important part in this understanding as well as assisting us with long term coastal hazard planning.

Cliff erosion in action at Cape Kidnappers

Coastal Sediments

Around the world, coastal sediments originate mostly from rivers, and it's no different in Hawke's Bay, although here our coastal cliffs also contribute significant amounts of sediment.

At the southern end of Hawke Bay, the Tukituki River and the cliffs of Cape Kidnappers are the dominant sources of the mixed sand and gravel found on the beaches. Swell, waves, tides, currents and storms move this material north along the coast. When rates of sediment supply from the rivers and cliffs change, the rate of coastal erosion or accretion also changes. Generally, coastal areas with low sediment supply rates are more likely to experience erosion, while accretion is more likely in areas experiencing high rates of sediment supply.

In 2011 to 2012, a LIDAR (Light Detection and Ranging) airborne laser survey was carried out along the coastal cliffs of Hawke's Bay. This survey provided a highly precise record of coastal cliff relief, and the nature of cliff landforms. Changes in cliff positions can be assessed by comparing the results of at least two LIDAR surveys to identify coastal cliff erosion rates and potential coastal sediment supply and transport rates. This requires further survey. Aside from isolated coastal cliff landslides, general cliff erosion from year to year is very gradual, and it may be up to a decade before a re-survey will yield reliable results.

Gravel Review

We are currently reviewing the region's river gravel resource. Relationships between gravel source and transport in rivers, and supply to the coast are being examined. HBRC will complete this extensive work in 2017. The study uses a computer model called Gravel Routing and Textural Evolution (GRATE), developed by NIWA to model sediment transport.

Coastal hazards & tsunami

Coastal hazards affecting Hawke's Bay were investigated in early 2014 by Professor Paul Komar, and are the subject of a Council report published in March 2014. The impacts of waves, tides, and changing sea levels on coastal erosion and flooding were assessed. The analysis identified the projected magnitude of future hazards to shore-front properties over the period of the 21st century. This research will assist Hawke's Bay councils to undertake long term coastal hazard planning, particularly considering the impacts of future climate change and predicted sea level rises.

Also in 2014, the potential for inundation from tsunami in less populated areas of Hawke's Bay was mapped. The 2013 National Tsunami Hazard Model was used to determine potential inundation extents, using the national attenuation rule developed by GNS Science.
This work will help in civil defence management and long term coastal hazard planning.

The storm case studies illustrates some of the coastal hazards and impacts on human settlement and the natural environment.

A gravel bar at the mouth of the Tukituki River

Erosion on the cliffs at Ridgemount

Wave climate

As part of our coastal process investigations, we also examine nearshore bathymetry and wave climate. The wave climate of an ocean is created by forces disturbing the ocean's surface, including swell, waves, tides, storm surge, currents, storms and climate variability.

We monitor the wave climate in Hawke Bay using wave data collected by two wave buoys owned by Napier Port, which are located between South Pania Reef and the Port, in water approximately 15 m deep. HBRC has also compiled a dataset of historical wave climate from 1979 to the present, using hindcasting techniques (using data from past events) and relationships between waves and climate. The wave buoy and the historical wave climate datasets are used in wave climate assessment, wave forecasting, swell event analysis and sediment transport analysis.

In 2011 a 1 km wide strip of the sea floor between Cape Kidnappers and the mouth of the Tukituki River was surveyed using side-scan sonar (see Case Study overleaf).

Case Study

Coastal cliffs at Cape Kidnappers

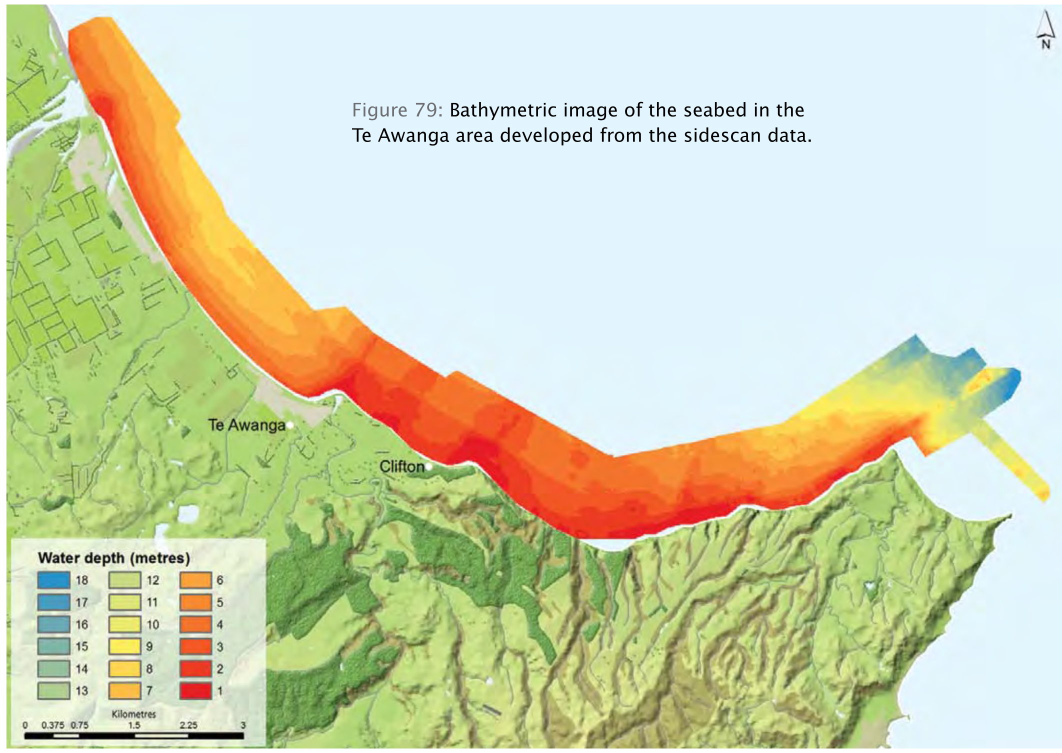


Figure 79: Bathymetric image of the seabed in the Te Awanga area developed from the sidescan data.

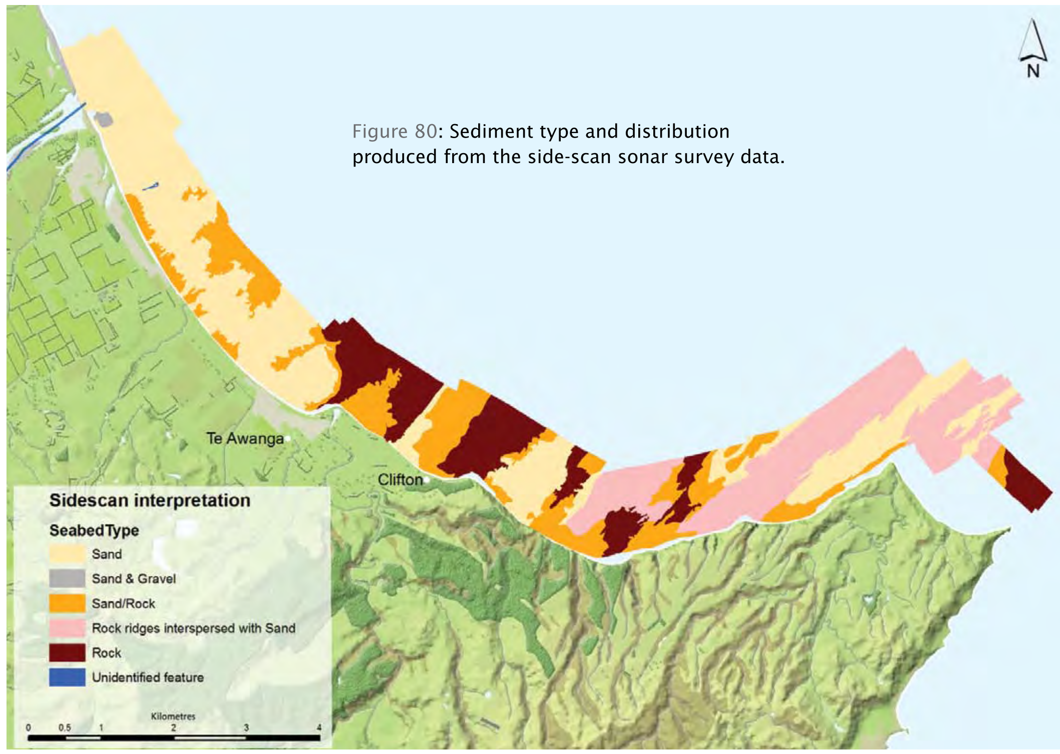


Figure 80: Sediment type and distribution produced from the side-scan sonar survey data.

BATHYMETRY SURVEY

In 2011, Discovery Marine Ltd (DML) hydrographic and coastal management services completed a side-scan sonar bathymetry survey of the sea floor for HBRC. The survey was from Cape Kidnappers to the mouth of the Tukituki River, extending from the beach to 1 km offshore.

The survey provided information on the form and distribution of seabed rock, sand, gravel and other materials, and on water depths. This survey information assists HBRC with sediment transport modelling, to identify transport pathways for material eroding from the cliffs at Cape Kidnappers.

The survey identified six seabed types from the seabed grab samples (Figures 79 and 80). Typically, the water gets deeper moving away from the shoreline, however this survey shows the ridge formation off Te Awanga and Clifton where shallow water colours extend out into deeper water colours. In a similar way to mountains on land, undersea ridges tend to consist of harder rock than the lower surroundings.

Case Study

Erosion on the north side of the seawall (photo looking south)

Temporary concrete blocks to protect the power transformer/pole

Completed limestone rock seawall

Damage at Clifton Motor Camp after high seas

CLIFTON EROSION

Erosion at Clifton has been an ongoing and long term problem, dating back at least to the 1931 earthquake, when this area of the Heretaunga Plains subsided. In recent years, erosion has significantly affected on infrastructure and activities at the Clifton Motor Camp and Marine Fishing Club, including the loss of vehicle access and the temporary loss of mains water supply, which now has been reinstated with a surface pipe.

The adjacent farm owner has allowed limited roading access across their paddocks to access the motor camp but this has had to move inland as more erosion has taken away the driveway. The motor camp leases the narrow strip of reserve land under the cliff from the Department of Conservation and it is mostly used for semi-permanent caravan sites, rather than for casual camping.

Resource consent was granted in 2013 by HBRC for concrete blocks to be temporarily placed on the beach to protect the transformer that provides power to the camp and the fishing club.

That year Hastings District Council (HDC) approved funding to support the construction of an 80 metre long limestone rock seawall at Clifton. The purpose of the seawall was to restore access to the reserve with its campground, the marine club and the boat ramp.

Later in 2013 HDC applied for and was granted a resource consent to construct the seawall. One of the conditions of the consent was that the structure was to be removed after five years or earlier if there is evidence that it is causing significant erosion further along the coast.

The seawall was completed at the end of 2013 using approximately 3000 tonnes of limestone rock, providing temporary vehicle access to what remains of the motor camp and fishing club.

However, despite the seawall, the problems at Clifton Motor Camp have continued. Erosion has continued on the downstream side of the seawall, with effects evident already at the end of the protection works.

Erosion on the north side of the seawall (photo looking north)

Case Study

Mud flow on farmland

Flooding of Te Awanga from Leyland Drain
(Photo courtesy of www.abovehawkesbay.co.nz)

A toilet block succumbing to the Mangakuri River at Kairakau

Coastal Slips, Central Hawke's Bay
(Photo courtesy of www.abovehawkesbay.co.nz)

APRIL 2011 STORM

In the three days after 25 April 2011, a strong easterly storm crossed and covered much of the North Island. The storm caused extensive damage down a narrow strip of Hawke's Bay's coastline, damaging small coastal communities, farms and infrastructure.

This storm produced intense rainfall along most of the Hawke's Bay coastline (Figure 11), the heaviest falls being between Tangoio and Mahanga in the north and between Te Awanga and Porangahau in the south. In Central Hawke's Bay, up to 530 mm of rain fell over thirty hours from 26-27 April, and 657 mm fell over 72 hours.

This intense rainfall caused extensive slips and flood damage to the steep hill country along the coast. In general, the coastal region of Hawke's Bay up to the Mahia Peninsula received 250-400 mm rainfall over 48 hours. The intensive rainfall that saturated 14 coastal Hawke's Bay communities was one of the worst storms to hit the region in decades. At the end of the three day event, several communities remained cut off by slips and floods, and over a hundred people could not return to their homes due to flooding and the threat of landslides. Despite the extensive flooding and damage, no one was badly injured in the event.

In some parts of Central Hawke's Bay the impact of the event was worse than during Cyclone Bola in 1988, even though Cyclone Bola affected more than 1700 farms in Gisborne and Hawke's Bay. For example, 249.5 mm of rain fell in 24 hours during Cyclone Bola at Waipoapoa, just west of Te Apiti Station, significantly less than the 432 mm rain recorded during the April 2011 event at this station.

During the rain event on 26 April, a 4.6 magnitude earthquake occurred 24.5 km deep just off the coast at Pourerere and may have contributed to massive slips on some of the steepest hillsides (page 109). This earthquake had been preceded by 5.2 and 3.6 magnitude events near Porangahau on 11 and 14 April, which may also have shaken the hillsides loose. The soft rocks of marine origin in the area are susceptible to erosion.

One year after the storm event, insurance companies, councils and engineers were still working through issues with property owners. Land damage has left parts of some farms unworkable for the foreseeable future (see page 108).

STORM DAMAGE COSTS

Official figures put the cost of recovery at about $39 million for infrastructure, land and personal and commercial damage claims. This includes:

- $10 million damage to local roads
- $2.5 million to state highways
- $60,000 in benefits and allowances
- $500,000 in labour assistance for farms
- Members of the Insurance Council of New Zealand paid out $6.45 million
- EQC paid out $17.45 million to 339 claimants