Northland River Water Quality Monitoring Network
State and Trends 2010

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NORTHLAND REGIONAL COUNCIL

Executive Summary

This report provides an update on the current water quality state at the 35 Northland River Water Quality Monitoring Network (RWQMN) sites and trends in water quality at 21 sites. Monitoring at these sites was carried out monthly and examines a range of variables including temperature, water clarity, bacteria and nutrient concentrations. Water quality data was compared to the Australian and New Zealand Environmental and Conservation Council guidelines (ANZECC, 2000) for the protection of aquatic ecosystems, the microbiological water quality guidelines for recreational users (MFE, 2003) and the Regional Water and Soil Plan (NRC, 2007).

Formal trend analysis was carried out using Time Trends software (NIWA) on sites with more than five years of data. Trend analysis was carried out on data from October 1996 to June 2010 for all sites when available. For sites that have been added to the network after October 1996, trend analysis included data from when sampling began.

Analysis of water quality state shows that many of Northland's rivers have poor water quality (as assessed against the guidelines) on occasion, even at sites in more pristine environments such as the Waipoua and Waipapa Rivers. Water quality can be strongly influenced by its surrounding land use. Compliance is generally consistently poor at sites in intensive pastoral farming catchments, which includes the Ruakaka, Paparoa and Awanui at Waihue Channel River sites. These sites generally have low water clarity and higher nutrient concentrations. These results are consistent with other national findings (Ballantine et al, 2010. Ballantine & Davies-Colley, 2009. Larned et al, 2004).

Overall there are several positive changes in water quality detected in the trend analysis for 1996 to 2010. Significant improving trends in dissolved reactive phosphorus and total phosphorus were recorded at 11 and 13 sites, respectively. These trends were recorded across all catchment land use types; native forest, exotic forest, urban and pastoral.

Significant improving trends were also observed in all nitrogen species across nine sites; three of these are significant dairying catchments. Improvements in water clarity were detected at seven sites, with the majority of these located in intensive pastoral farming catchments. Eleven improving trends were recorded in the Mangere catchment, which has a large proportion of dairying in the catchment (40% of the 75% pastoral land). NRC has been actively working alongside dairy farmers in this catchment to minimize the impact of discharges.

Contents

1. Introduction

Northland's River Water Quality Monitoring Network was established in September 1996 and initially included nine river sites throughout Northland. Since 1996 a further 22 sites have been added to the network. The four Northland sites in the National River Water Quality Network monitored by National Institute of Water and Atmospheric Research Limited (NIWA) are also incorporated into our regional network. So there are currently 35 sites throughout Northland monitored monthly for water quality. These sites are shown in figure 1 (below).

Sites have been selected to represent different geology, river types and land use found in the Northland Region.

This report looks at the current state of water quality for the 2009/2010 year at all RWQMN sites and compares water quality to the ANZECC guidelines (ANZECC, 2000) for aquatic ecosystems and the recreational bathing guidelines (MFE, 2003). This report also presents the results of a formal trend analysis for 21 sites (sites with 5 years or more data). The state is affected by inter-annual climate variation such as floods and droughts whereas trends give the overall picture of weather water quality is getting better, worse or no changing at all.

Figure 1: Map showing the 35 Regional Water Quality Monitoring Network sites (National River Water Quality Network sites in pink).

2. Methods

All sample and field measurement collection methods follow those documented in the councils Field Monitoring Procedure Manual (NRC, 2010). All laboratory sample analysis was carried out following the procedures in the '*Standard Methods for the Examination of Water and Wastewater*' (APHA, 1998).

2.1 Guidelines used for compliance

The ANZECC guidelines have been used to assess water quality for aquatic ecosystems, while the levels of then indicator bacteria (Escherichia coli) have been used to assess water quality for recreational bathing and drinking water. The water clarity guideline from the Regional Water and Soil Plan (RWSP) for Northland (NRC, 2007) has also been used to assess water quality for recreational bathing.

2.1.1 ANZECC guidelines

The results are compared to the Australian and New Zealand Environmental and Conservation Council (ANZECC) trigger values for the protection of aquatic ecosystems in New Zealand (ANZECC, 2000).

It is important to note that the trigger values are used to assess the risk of adverse effects on the ecosystem and when results are outside trigger values further investigation is recommended to determine whether there is adverse effects on the environment and to what extent. There are two sets of trigger values; one for upland rivers, which only includes one site in the network (Waipoua River), and one for lowland rivers, as shown in table 1 (below).

Table 1: Trigger values for NZ lowland and upland rivers (ANZECC 2000)

Parameter	Trigger values for lowland rivers	Trigger values for upland rivers
Dissolved oxygen (% Saturation)	98 - 105	99 – 103
Water clarity (m)	> 0.6	> 0.8
Turbidity (NTU)	< 5.6	< 4.1
Dissolved reactive phosphorus (mg/L)	< 0.01	< 0.009
Total phosphorus (mg/L)	< 0.033	< 0.026
Nitrate, nitrite nitrogen (mg/L)	<0.444	<0.167
Ammoniacal nitrogen (mg/L)	< 0.021	< 0.01
Total nitrogen (mg/L)	< 0.614	< 0.295
pH	7.2 – 7.8	7.3 – 8.0

2.1.2 *Escherichia coli* (bacteria)

The levels of the bacteria, *Escherichia coli* are used as indicator for the presence of pathogen causing bacteria, which can be a health risk for humans and stock. The levels of *E. coli* can be compared to the microbiological water quality guidelines for recreational users (MFE 2003), to determine whether the water is safe for recreational use. The majority of rivers in Northland are used for recreational purposes. The guideline is less than 550 *E. coli*/100mL of sample.
Similarly the levels of E. coli can be compared to the NZ drinking water standard of less than 1 *E.coli*/100mL (MoH, 2005) to determine whether the water is safe for human consumption. Note this standard is the Maximum Acceptable Value (MAV) for microbiological contamination for drinking water leaving a treatment plant. Untreated water from surface water systems will rarely meet this standard and therefore it is

recommended that surface water is treated to ensure it meets the drinking water standards. On the other hand groundwater is rarely contaminated by harmful pathogens and therefore more likely to be suitable for human consumption without treatment.

2.1.3 Water clarity

Water clarity is also important for recreational users, partly for aesthetic reasons but also because elevated bacterial levels are often associated with turbid water. Water clarity readings can be used as a measure of the aesthetic appeal of water. Public perception of water quality is typically based on colour and clarity. The Resource Management Act (1991) requires that there be no conspicuous change in colour and clarity under sections 70 and 107. The Regional Water and Soil Plan has a guideline for the management of waters for contact recreation purposes of a visual clarity greater than 1.6 m (NRC, 2007, p53). This guideline comes from the *'Water Quality Guidelines No. 2: Colour and Clarity'* (MFE, 1994), which is currently the only water clarity guideline for the purposes of contact recreation and aesthetics in New Zealand.

2.2 Trend analysis

For the trend analysis all values below detection limit or denoted with a less than value, were replaced with half of the detection limit. Because of this, caution should be taken when interpreting results where more than 15% of the samples were below detection (Gilbert, 1987).

The trend analysis was carried out on both the raw water quality data and flow adjusted data. All data was flow adjusted in TimeTrends™. Where there was no flow record for a sample, the sample was deleted from the analysis. The Seasonal Kendal test in TimeTrends™ was used for the trend analysis.

3. Results

3.1 Compliance with ANZECC guidelines

The following maps show the percentage of samples for each site that comply with the ANZECC guidelines for the 2009-2010 financial year. The catchments in the maps are colour coded to reflect good to poor compliance (categories are listed below).

- Dark blue – 81 to 100% of samples comply
- Blue – 61 to 80% of samples comply
- Sky blue – 41 to 60% of samples comply
- Pale blue – 21 to 40% of the sample comply
- Purple – less than 20% of the sample comply

3.1.1 Dissolved oxygen

Compliance with dissolved oxygen (%) guidelines are consistently poor in Northland with only five of the 35 sites achieving a compliance of 50% or more. This poor result is a likely affect of the drought this year with most flows below average. When river flows are low there is less aeration of the water therefore dissolved oxygen levels are lower. Sites with high dissolved oxygen are much more of a concern as those with low dissolved oxygen because dissolved oxygen often has a strong diurnal cycle. Super-saturated oxygen conditions during the day are usually followed by low oxygen (anoxic) levels at night.

Very concerning results were recorded at the Awanui, Hatea, Oruru, Ruakaka, Utakura and Wairua Rivers with no samples complying with the guidelines. Further investigations will be carried out in late 2011, early 2012 to identify the cause of these poor results.

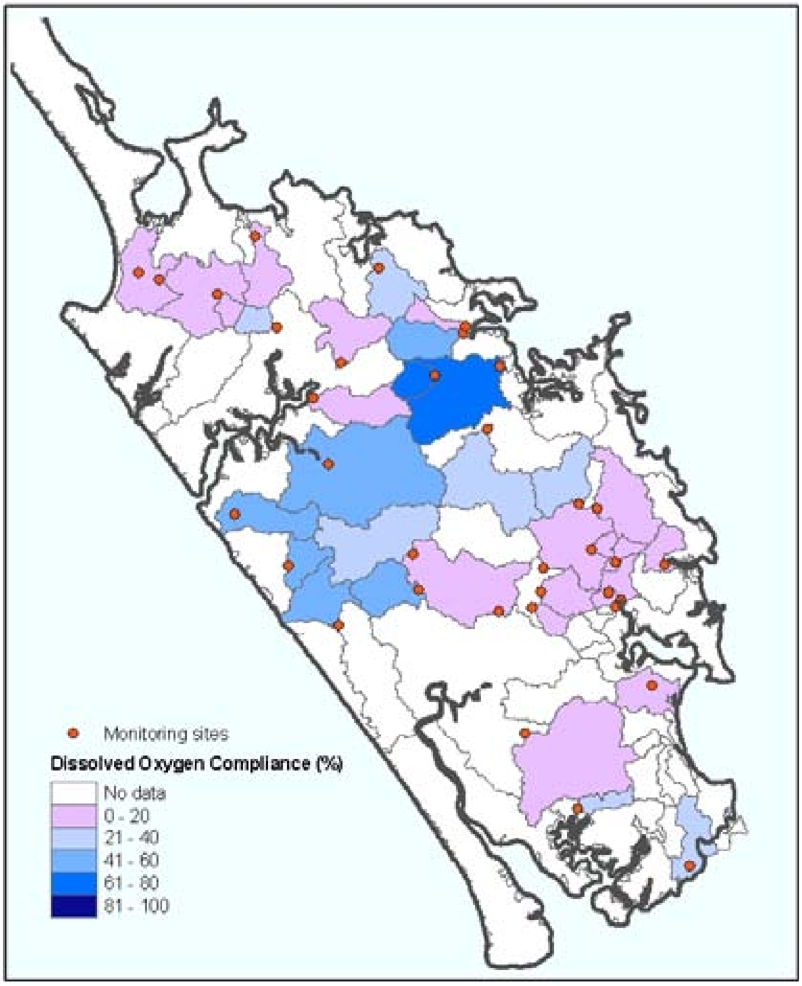


Figure 2: 2009-2010 dissolved oxygen compliance

3.1.2 Water clarity

In 2009-2010 most sites had good compliance with water clarity guidelines. Poorer clarity is displayed in highly erodible catchments, e.g. Utakura, Ruakaka and Paparoa Rivers. When compared to the previous year's data, notable improvements in water clarity are observed in the Awanui, Oruru, Ruakaka and Waiharakeke catchments. It is possible that the changes in water clarity could be as a result of the drought in 2009-2010. With less rainfall runoff fewer sediments would have entered the rivers, and low river levels and higher temperatures encourage weed and algal growth.

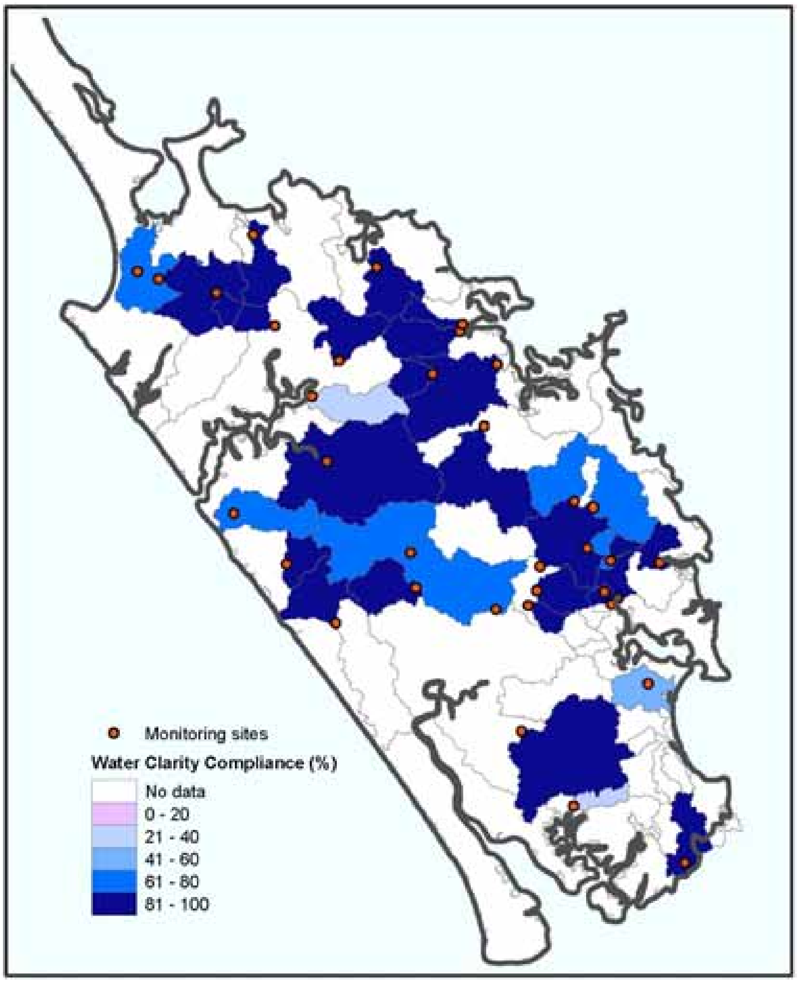


Figure 3: Water clarity compliance map

3.1.3 Turbidity

Majority of the sites had average to good compliance. Three sites, Paparoa, Ruakaka and Utakura Rivers, failed to meet the turbidity guideline on all sampling occasions. These catchments are highly erodible which explains the poor turbidity compliance. Overall compliance is higher than the previous year with notable improvements in the Awanui, Manganui, Oruru and Wairua Rivers which is likely to be due to the drought as there would have been less suspended sediments entering the water ways.

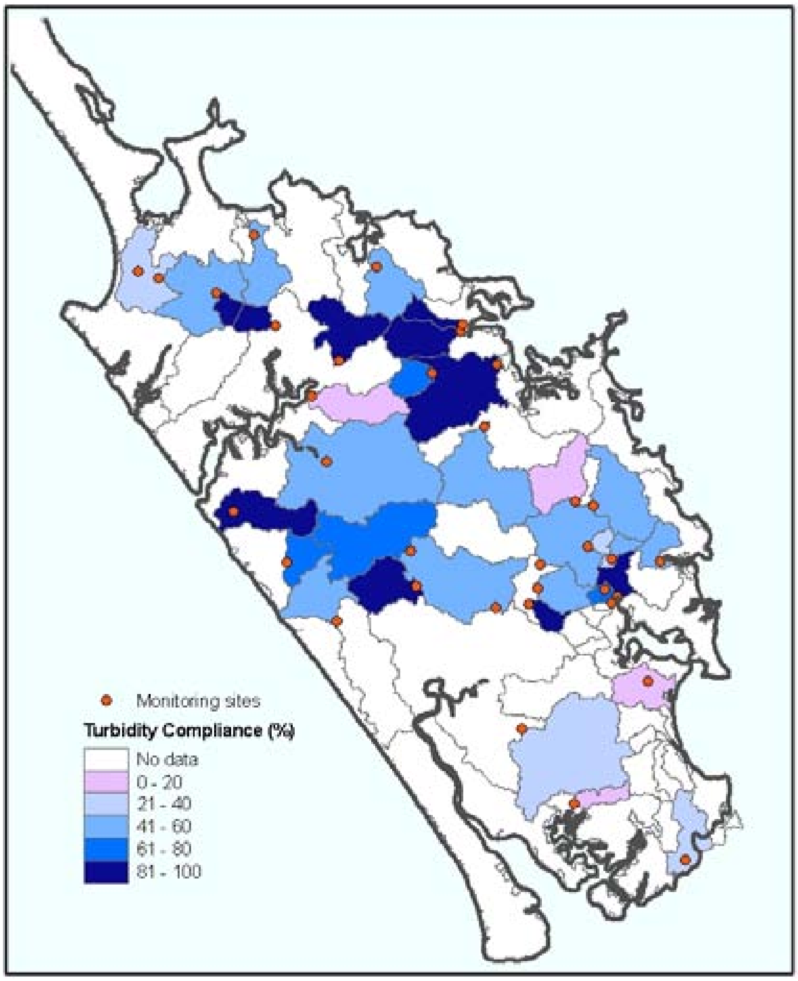


Figure 4: Turbidity compliance map

3.1.4 pH

Most sites had average to good compliance with the pH guidelines for the protection of aquatic ecosystems. When compared to previous year's data, compliance rates have dropped in the Hatea, Kaeo, Mangakahia, Victoria and Wairua catchments. Agriculture run off and changes in land use may have resulted in declines in pH compliance. Improvements were noted in the Paparoa, Ruakaka and Waipoua Rivers.

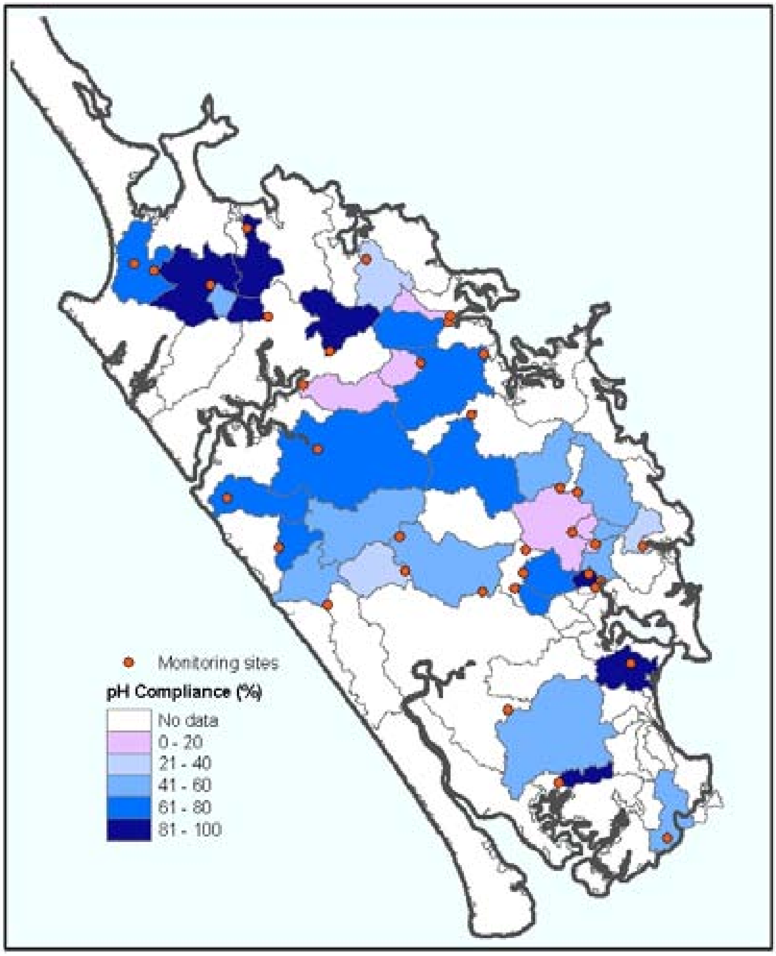


Figure 5: pH compliance map

3.1.5 Total nitrogen

Most sites showed good compliance with the total nitrogen guidelines for the protection of aquatic ecosystems. When compared to the previous year's data notable improvements in total nitrogen water quality were observed at many sites, in particular the Awanui, Mangahahuru and Mangere catchments. It is likely that less rainfall runoff during the drought resulted in fewer nutrients being delivered to the rivers and streams. Also algal growths within the streams would have taken up a lot of the nitrogen. Both of these effects resulted in lower total nitrogen concentrations in the rivers.

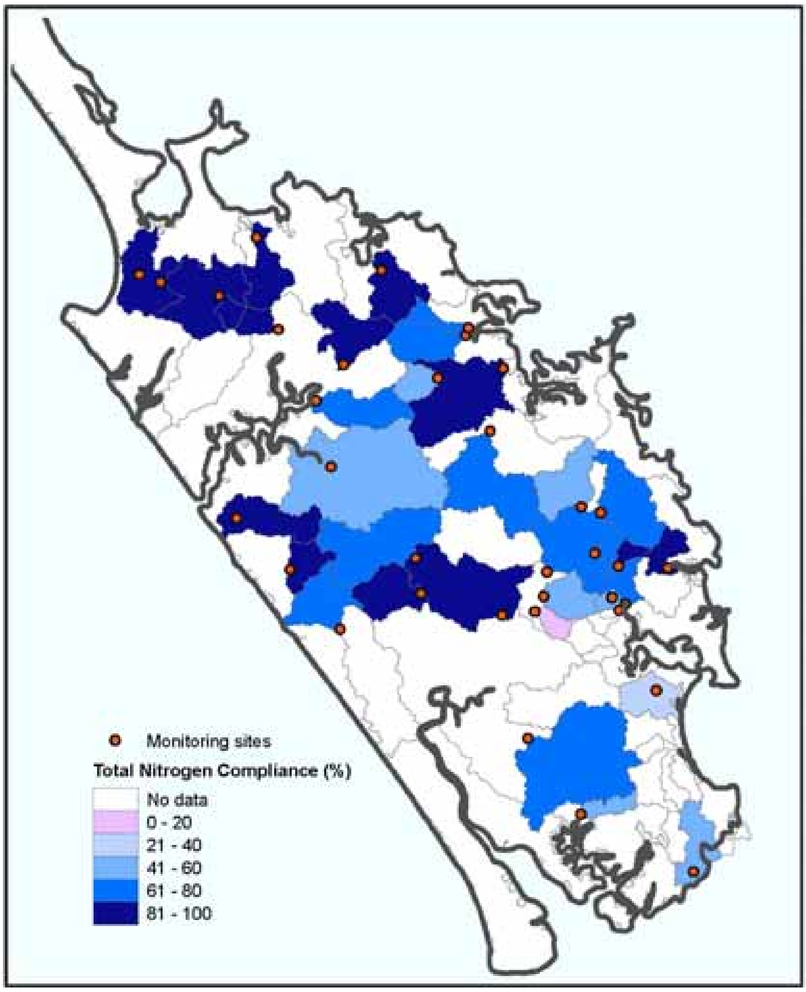


Figure 6: Total nitrogen compliance map

3.1.6 Ammoniacal nitrogen

In 2009-2010 most sites had good to excellent compliance with the ammoniacal nitrogen guideline which is recommended to remain below <0.021 mg/L. Fourteen river network sites complied with the guideline on all sampling occasions. Only one site, Ruakaka River, had less than 50% compliance with ammoniacal nitrogen guideline. When compared to last year's results notable improvements were observed in the Mangahahuru, Manganui, Mangere, Waiotu and Wairua catchments with compliance at all sites increasing by at least 25%. As with total nitrogen, it is likely that less rainfall runoff during the drought resulted in a reduction of nutrients entering the water ways.

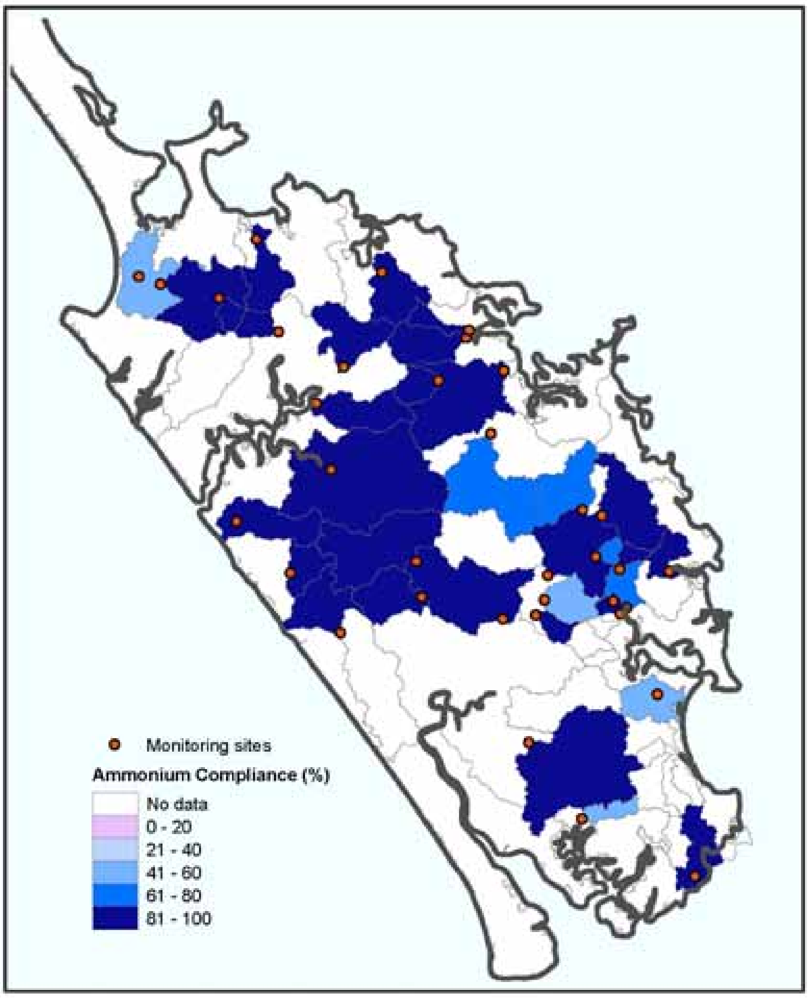


Figure 7: Ammonium compliance map

3.1.7 Total phosphorus

Most sites show poor compliance with the total phosphorus guidelines for protection of aquatic ecosystems. This is partly due to Northland's phosphorus rich sandstone and mudstone catchment geology which provides a high background level of phosphorus to streams naturally. Only two sites, Waipapa River and Waipapa Stream, had 100% compliance with the total phosphorus guideline. Hakaru, Mangere, Paparoa, Ruakaka and Utakura river sites failed to met the guideline of <0.033 mg/l on all sampling occasions. These catchments are highly erodible which explains the poor compliance at these sites.

When compared to the previous year's data notable improvements in total phosphorus water quality are observed at many sites. Big improvements were recorded in the Awanui River (FNDC take site), Mangahahuru Stream (Apotu Rd site) and Waiharakeke River with compliance rates increasing by 50%. Like nitrogen, it is likely that less rainfall runoff during the drought resulted in fewer nutrients being delivered to the rivers and streams. Also algal growths within the streams would have taken up a lot of the phosphorus. Both of these effects resulted in lower total phosphorus concentrations in the rivers.

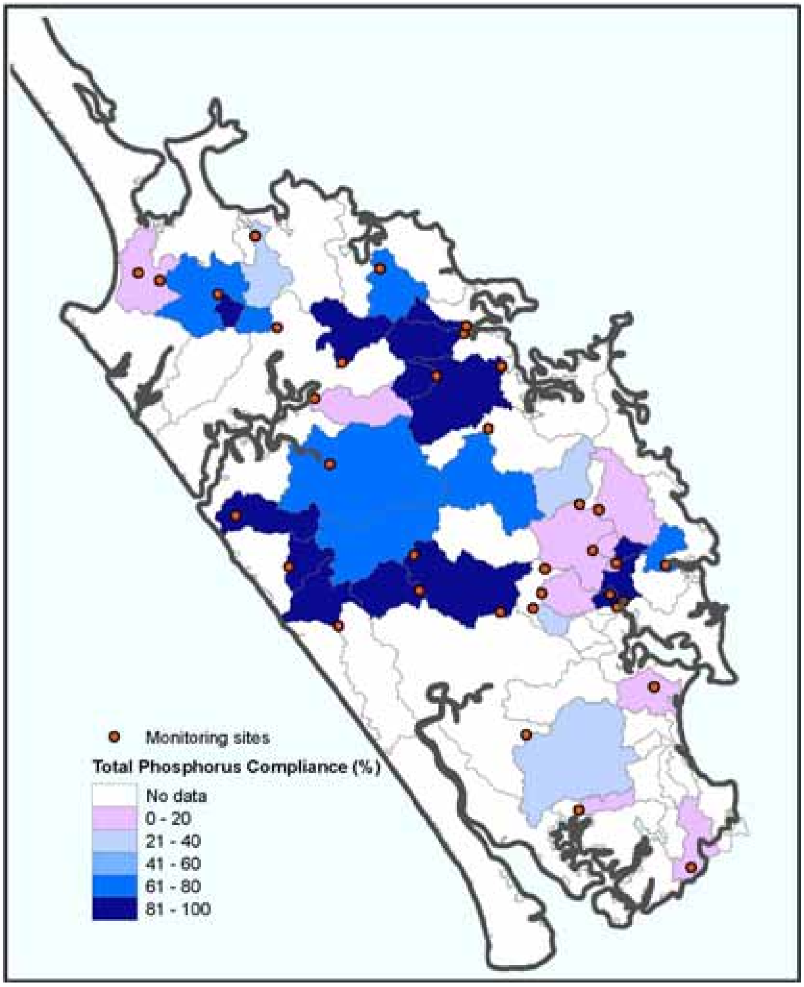


Figure 8: Total phosphorus compliance map

3.1.8 Dissolved reactive phosphorus

Dissolved reactive phosphorus compliance was poor this year at half of the 35 sites, with eight sites failing to meet the guideline of <0.01 mg/l on all sampling occasions. These results are similar to previous years with consistently poor compliance observed in the Hakaru, Mangamuka and Ruakaka Rivers. High dissolved reactive phosphorus compliance in the Mangamuka River is of concern as the catchment is predominately native forest. This indicates that the source of phosphorus is from eroding soils in the catchment.

Eight sites met the dissolved reactive phosphorus guidelines on all sampling occasions. Improvements were observed in the Kerikeri, Waiarohia, Waiharakeke and Waipoua catchments. These improvements are the likely result of the drought conditions seen over the past year.

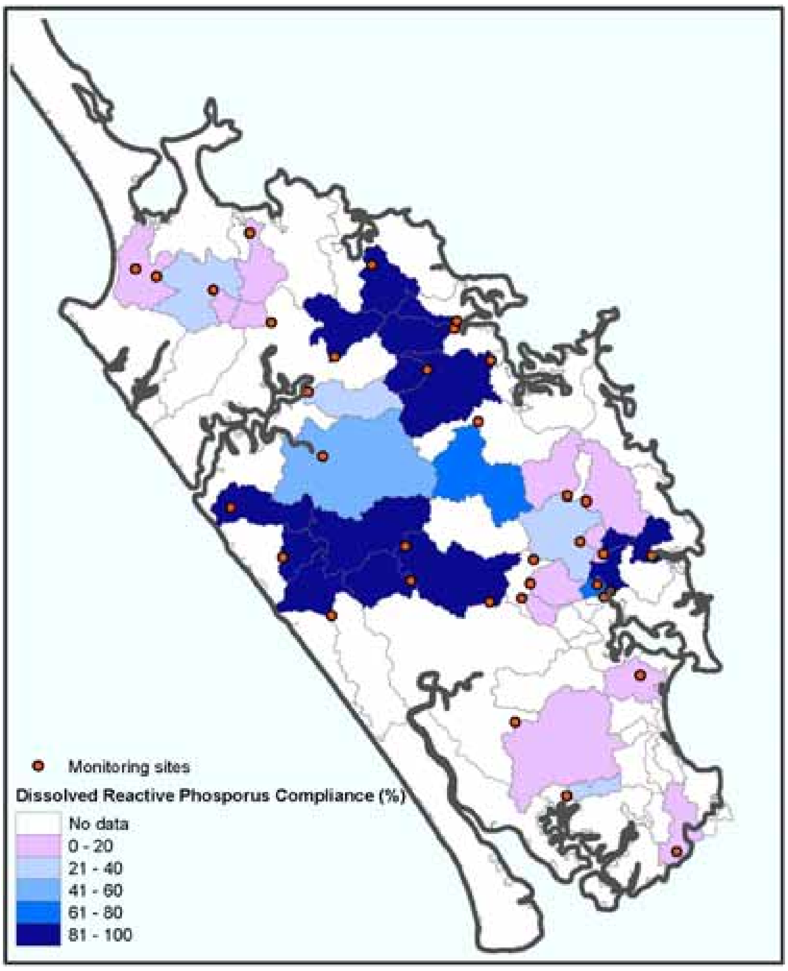


Figure 9: Dissolved reactive phosphorus compliance map

3.2 Compliance with recreational bathing guidelines

The following maps show the percentage of samples for each site that comply with the microbiological water quality guideline (MFE, 2002) and water clarity guideline from the RWSP (NRC, 2007) for the 2009-2010 financial year. The catchments in the maps are colour coded to reflect good to poor compliance.

3.2.1 *E. coli* (bacteria)

Most sites had average to good compliance with the water quality guidelines for recreational bathing. When compared to the previous year's data notable declines in bacteriological water quality are observed at most sites. These declines could be due to the drought in 2009-2010. With below average rainfall, river and stream levels became very low compared to normal flows in summer. The low flows of the rivers and streams may have provided less dilution of inputs and could help explain the observed declines in 2009-2010. Further work is being done to determine the source of *E.coli* in rivers.

Most concerning *E. coli* compliance results were observed in the Mangamuka, Ngunguru, Waimamaku and Waiotu Rivers with compliance rates falling from 92% in 2008/09 year to 50% of samples this year. *E. coli* compliance improved at Waiarohia Stream (Whau Valley), rising from 8% last year to 58% this year.

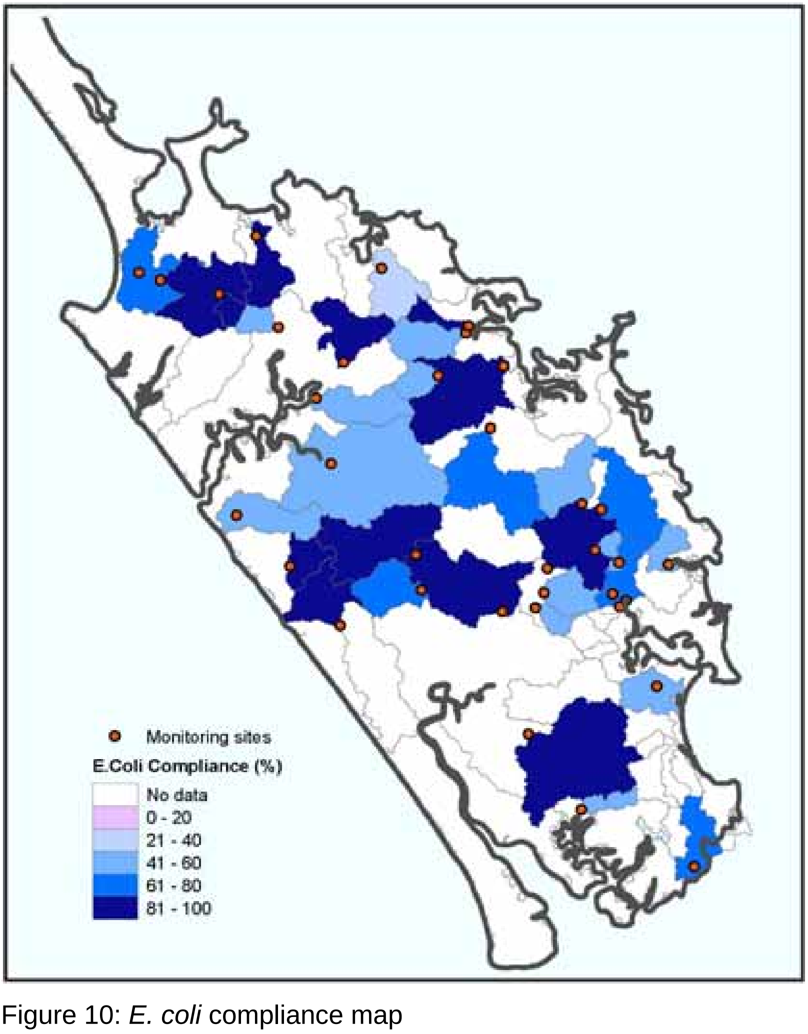


Figure 10: *E. coli* compliance map

3.2.2 Water clarity

Overall recreational bathing water clarity compliance is poor with 11 of the 35 sites failing to meet the guideline of 1.6m on all sampling occasions. Only three sites met the guideline of 1.6m on at least 80% of sampling occasions; Waiarohia Stream at Second Ave, Waipao Stream and Waipapa River and only a further seven sites comply with the guideline at least 50% of the time.

There are improvements in the Waiarohia Stream, Wairua and Waipapa Rivers when comparing data to the results from the 2006 State and Trend report (NRC, 2007). However there are a number of declines in compliance rates, especially in the Mangahahuru, Victoria, Waipoua and Whakapara catchments. Of most concern is the decline in the Waipoua River with compliance dropping from 82% in 2006 to 50% this year.

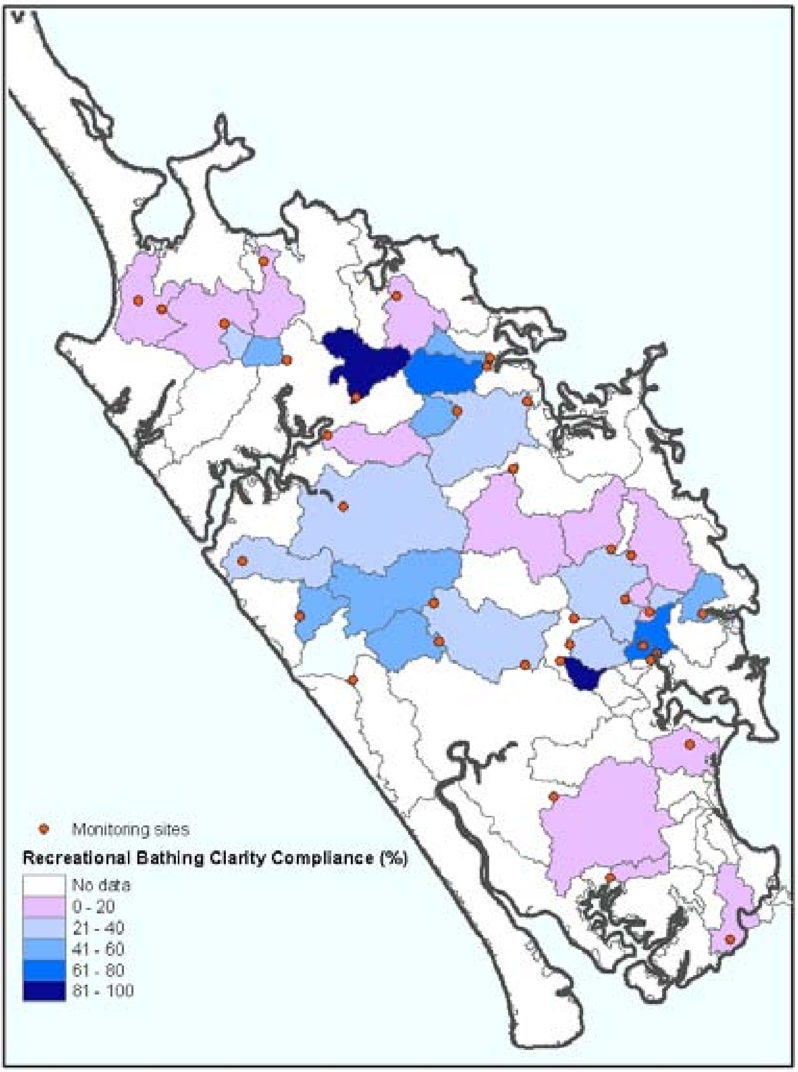


Figure 11: Map of recreational clarity compliance

4. Formal trend analysis

All trends are based on flow adjusted data except for two sites; Waiarohia Stream at Whau Valley and Waipoua River at SH12. Currently there is only three years of flow data for the Waipoua River which is not enough for trend analysis and there is no data yet for the Waiarohia Stream at Whau Valley.

It should be noted that the number of samples for each site and parameter varies because sampling was started in different years for each site and there are some missing results. The trend analysis was done on data from October 1996 to June 2010 for all sites where this data was available (including the national network sites). However, for sites that were added to the network later that October 1996, the trend analysis included data from when sampling began at these sites.

Table 2: Trend results for the 21 RWQMN sites (red arrows indicate deteriorating trend, green arrow indicates improving trend, ID = insufficient data, BD = more than 10% of the samples are below detection limit).

Site	Cond	DO%	DO	Ecoli	pH	Clarity	Turb	Temp	TKN	NH4	NNN	TN	DRP	TP
Awanui Waihue channel (Oct 1996)	↑ (red)	↓ (red)	↓ (red)					↓ (green)		BD ↓ (green)			↓ (green)	↓ (green)
Awanui FNDC take (Oct 1996)	↑ (red)	↓ (red)												
Kaihu (Jul 2002)		↓ (red)	↓ (red)							BD ↓ (green)				
Mangahahuru Apotu Rd (Oct 1996)	↑ (red)	↑ (red)			↑ (green)	↑ (green)				↓ (green)			↓ (green)	↓ (green)
Mangahahuru Main Rd (Jun 2005)							↑ (red)							
Mangakahia Titoki bridge (Oct 1996)		↓ (red)								↓ (green)	↓ (green)	↓ (green)	↑ (red)	
Mangakahia Twin Bridges (Oct 1996)	↑ (red)		ID		↑ (red)					BD ↓ (green)			↓ (green)	↓ (green)
Manganui (Aug 2001)					↑ (red)							↓ (green)		↓ (green)
Mangere (Oct 1996)		↑ (green)	↑ (green)		↑ (green)	↑ (green)	↓ (green)	↓ (green)		↓ (green)	↓ (green)	↓ (green)	↓ (green)	↓ (green)
Opouteke (Oct 1996)	↑ (red)		ID	↑ (red)	↑ (red)					BD ↓ (green)	BD ↓ (green)		BD ↓ (green)	↓ (green)
Punakitere (Aug 2001)					↑ (red)	↑ (green)			↓ (green)	BD ↓ (green)		↓ (green)	↓ (green)	↓ (green)
Victoria (Oct 1996)					↑ (green)	↓ (red)	BD ↑ (red)	↓ (green)		BD ↓ (green)			↓ (green)	↓ (green)
Waiarohia Second Ave					↑ (green)	↑ (green)	↓ (green)		↓ (green)				↓ (green)	↓ (green)

(Jul 2005)														
Waiarohia Whau Valley (Jul 2005)					↑	↑	↓		↓		↑			↓
Waiotu (March 2000)									↓					
Waipapa (Oct 1996)	↑				↑	↑	↓			↓	↓	↓	↓	↓
Waipoua (Jul 2002)		↓	↓		↓					BD -				
Wairua (Oct 1996)	↑	↑	↑		↑	↑				↓	↓		↓	
Waitangi Waimate North (Aug 1999)										BD ↓				
Waitangi Watea (Oct 1996)		↑	↑		↑				↑				↓	↓
Whakapara (Oct 1996)		↑			↑						↓		↓	↓

4.1 Maps showing trends

The results from the formal trend analysis have been summarised into the maps below in the following way:

- Insufficient data for this particular parameter at this site
- No significant change (P >0.05)
- Significant increase or decrease (P ≤0.05)
- Meaningful increase or decrease (P ≤0.05) and the magnitude of the trend is greater than 1% per annum of the raw data median

4.1.1 Temperature

Three sites had significant trends for temperature, all of which were a meaningful and decreasing trend. At this stage, these trends for all sites (Awanui River at Waihue channel, Mangere River and Victoria River) are seen as improvements. These trends are consistent with trends reported by Larned et al (2004) which found that there were positive decreasing trends in temperature at a national scale.

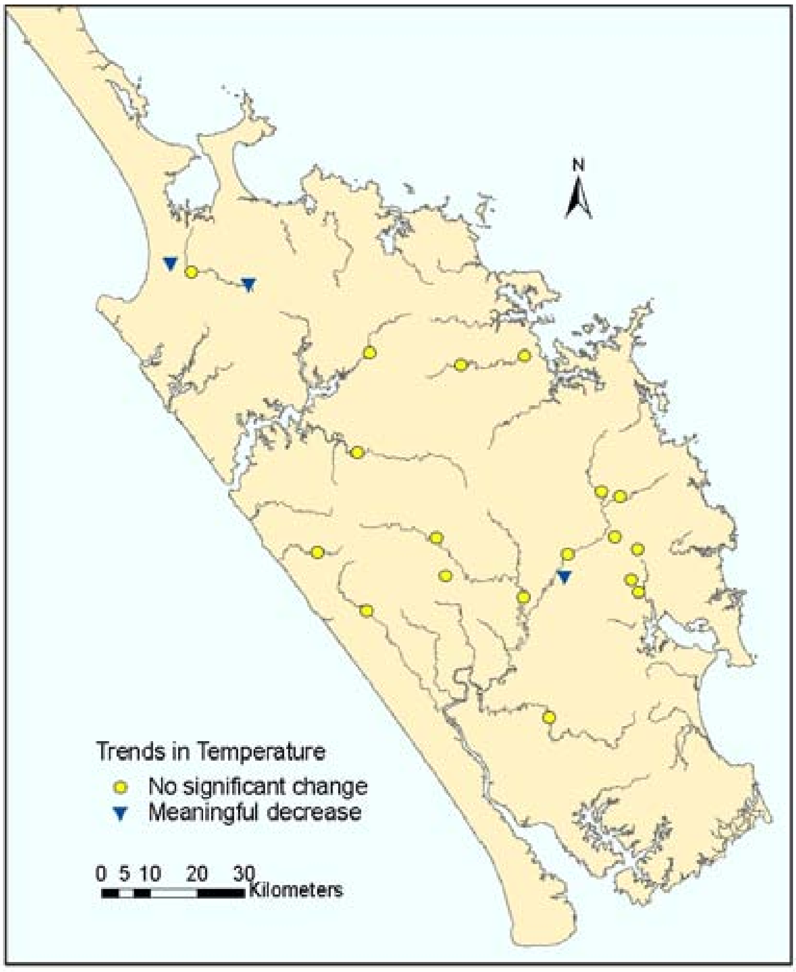


Figure 12: Trends in temperature (°C) at 21 RWQMN sites

4.1.2 Dissolved oxygen

There were ten sites with significant trends for dissolved oxygen, nine of which were meaningful. Decreasing trends were observed in the Awanui, Kaihu, Mangakahia (Titoki Bridge) and Waipoua Rivers, all of which are deteriorating trends as dissolved oxygen levels are often below the recommended guideline range. Ballantine and Davies-Colley (2009) also recorded a significant decreasing trend at Mangakahia at Titoki Bridge.

Five sites had increasing trends in dissolved oxygen. Two of these sites (Mangere River and Waitangi River at Watea) had an improving trend as levels are often below the guideline range. Ballantine and Davies-Colley (2009) did not find any significant increasing trends in dissolved oxygen (%) at any other the four Northland National River Water Quality Network (NRWQN) sites. The time period used for the analysis of the data may explain the different results

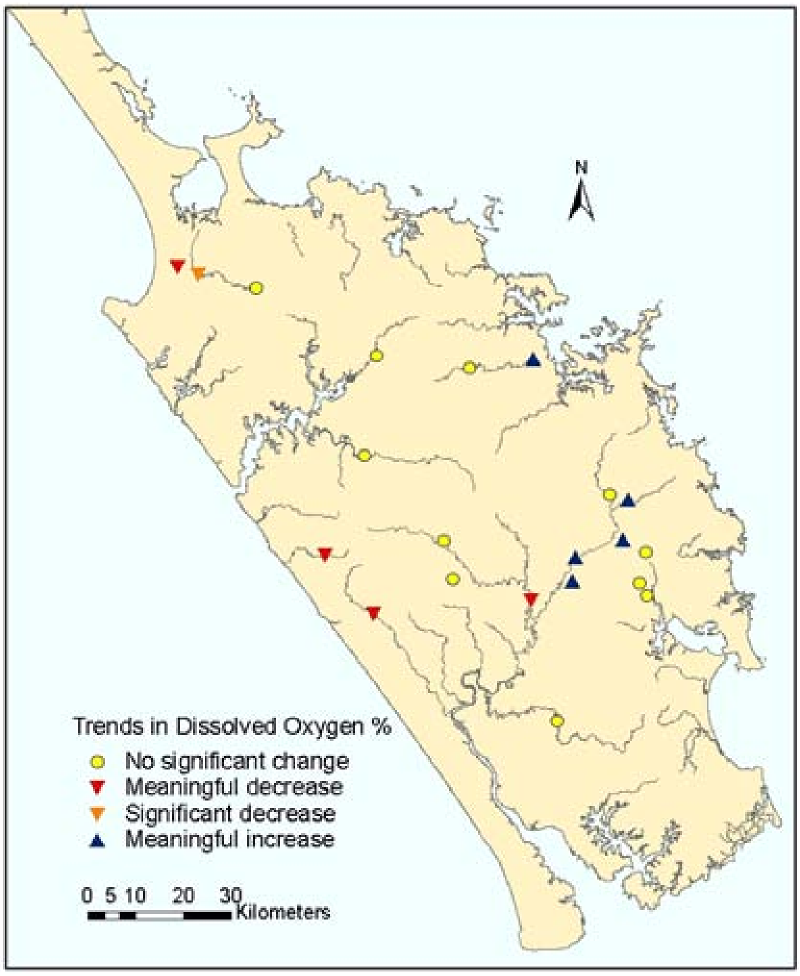


Figure 13: Trends in dissolved oxygen (% saturation) at 21 RWQMN sites

4.1.3 Conductivity

Seven sites had significant increasing trends in conductivity, all of which were meaningful as well. Ballantine et al (2010) also reported an overall increasing trend in conductivity in the Northland regions and at a national scale.

These trends are all likely to be deterioration in water quality at these sites as conductivity is generally used as an indicator of water pollution. However, as conductivity is increasing in both pastoral (Awanui, Mangahahuru (Apotu Rd) and Wairua Rivers) and native/plantation forest classes (Mangakahia (Twin Bridges), Opouteke and Waipapa Rivers) it indicates that intensification may not be the major cause of this trend. Temporal changes in air temperature and precipitation may have influenced these trends (Larned et al, 2004).

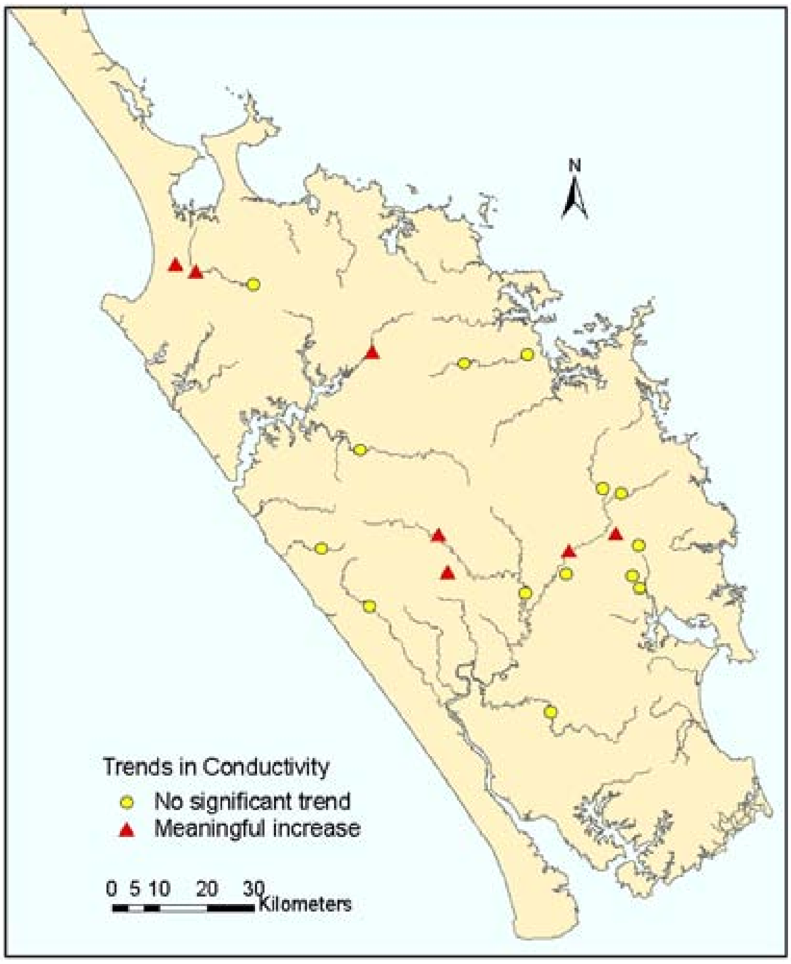


Figure 14: Trends in conductivity (mSm) at 21 RWQMN sites

4.1.4 PH

Fourteen sites showed significant changes in pH, of which all were meaningful trends. The Waipoua River was the only site to have a decreasing trend which is seen as a positive trend as the median pH is 7.35 for the 2009/2010 year which is slightly alkaline. Five of the 13 increasing trends are regarded as a negative trend as the pH is often falling above the guideline range (becoming more alkaline). Other New Zealand studies have typically found decreasing trends in pH (Vant and Smith, 2004. Scarsbrook, 2006).

Improvements were seen in the Mangahahuru, Mangere, Victoria, Waiarohia, Waipapa and Whakapara catchments (all increasing pH trends). Factors such as geology, climatic conditions and changes in nutrient levels can all affect the pH of water. It is likely that improvements seen in the highly modified catchments (Mangahahuru, Mangere and Whakapara Rivers) are linked to decreases in nutrient concentrations (see trends table on pg 16).

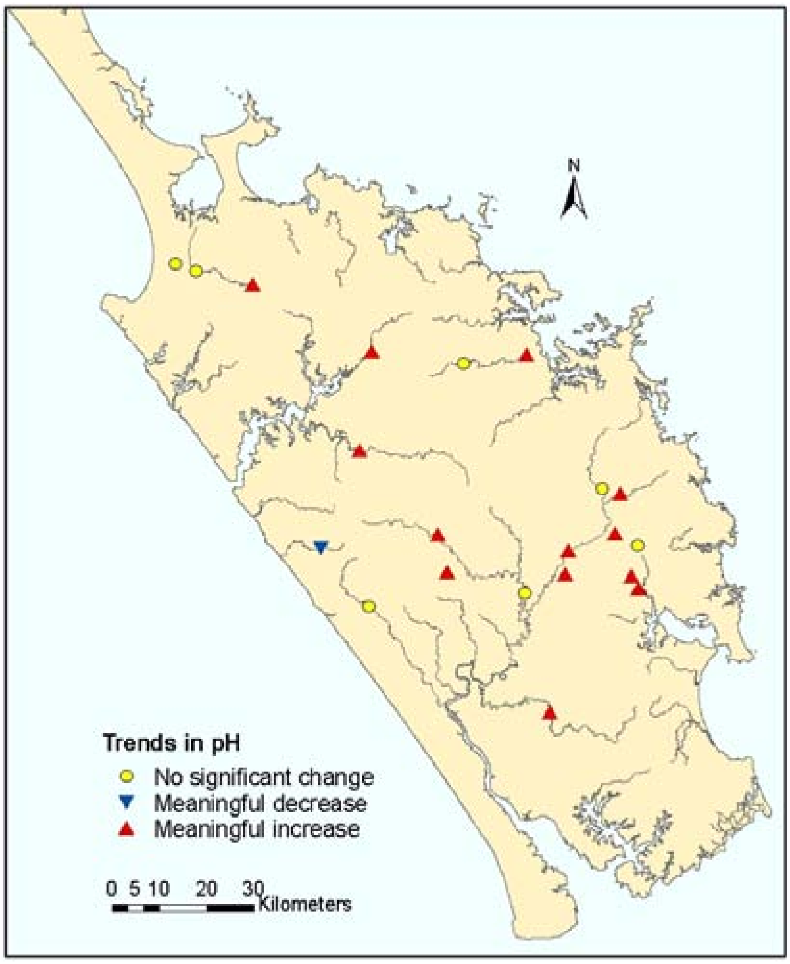


Figure 15: Trends in pH at 21 RWQMN sites

4.1.5 Turbidity

Significant turbidity trends were observed in six of the 21 sites. The only negative trend was seen in the Mangahahuru Stream at Main Rd which has increase in turbidity at a rate of 0.43 NTU per year. The Victoria River also had an increasing turbidity trend however more than 15% of the samples were below the detection limit therefore the trend is not valid. Positive decreasing trends were seen in the Mangere, Waiarohia and Waipapa catchments. Corresponding increases in water clarity were also observed at these sites which indicates that there has been a reduction in suspended sediments entering the streams.

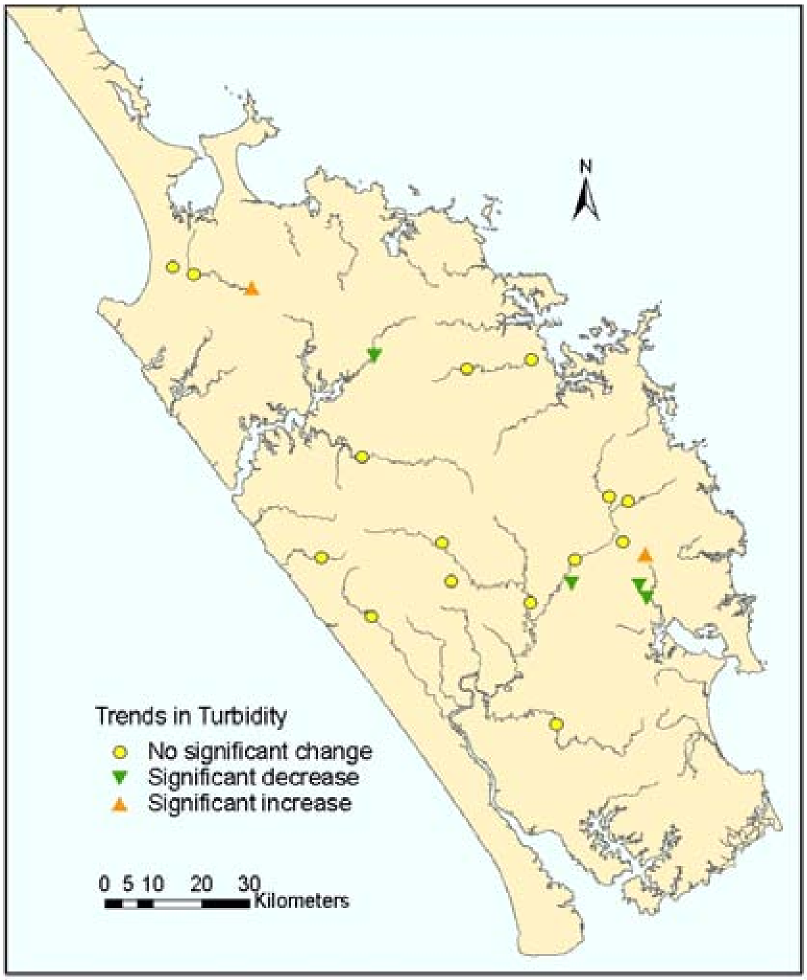


Figure 16: Trends in turbidity (NTU) at 21 RWQMN sites

4.1.6 Water clarity

Eight of the 21 sites had significant changes in water clarity, of which only one site, Victoria River, had a decreasing trend. The rest had positive increasing trends in water clarity. There are correlating trends in turbidity at four of these sites (Mangahahuru at Apotu Rd, Mangere and both Waiarohia sites). Ballantine and Davies-Colley (2009) and Larned et al (2004) found a positive trend in clarity at a national scale. However, Ballantine and Davies-Colley (2009) also found a decreasing trend at three of the four Northland NRWQN sites which is inconsistent with our findings. A difference in the time period used for data analysis explains the different results in water clarity trends.

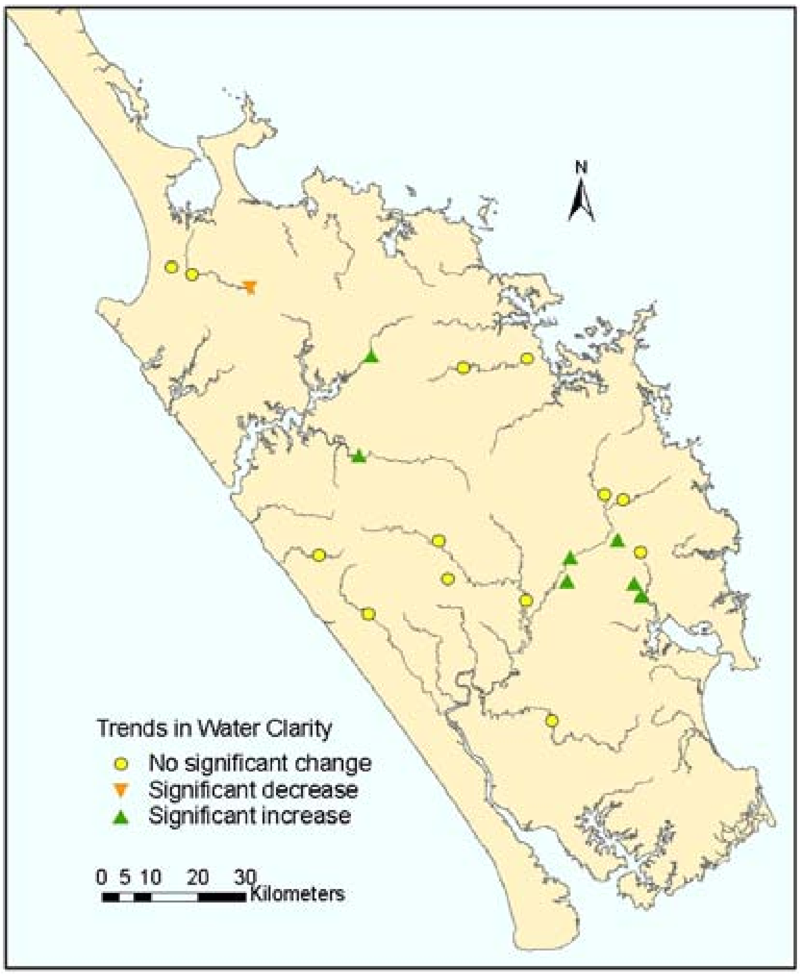


Figure 17: Trends in water clarity (m) at 21 RWQMN sites

4.1.7 *Escherichia coli*

Only one site, Opouteke River, had a significant trend in *E. coli*. It is only a small increase of 12 MPN/100ml/year and the median of 160 is well below the recreational guideline of 550 *E. coli*/100ml. The cause of this increase is unknown at this stage. Faecal source tracking investigations are being carried out to look at the potential source of bacteria in this catchment.

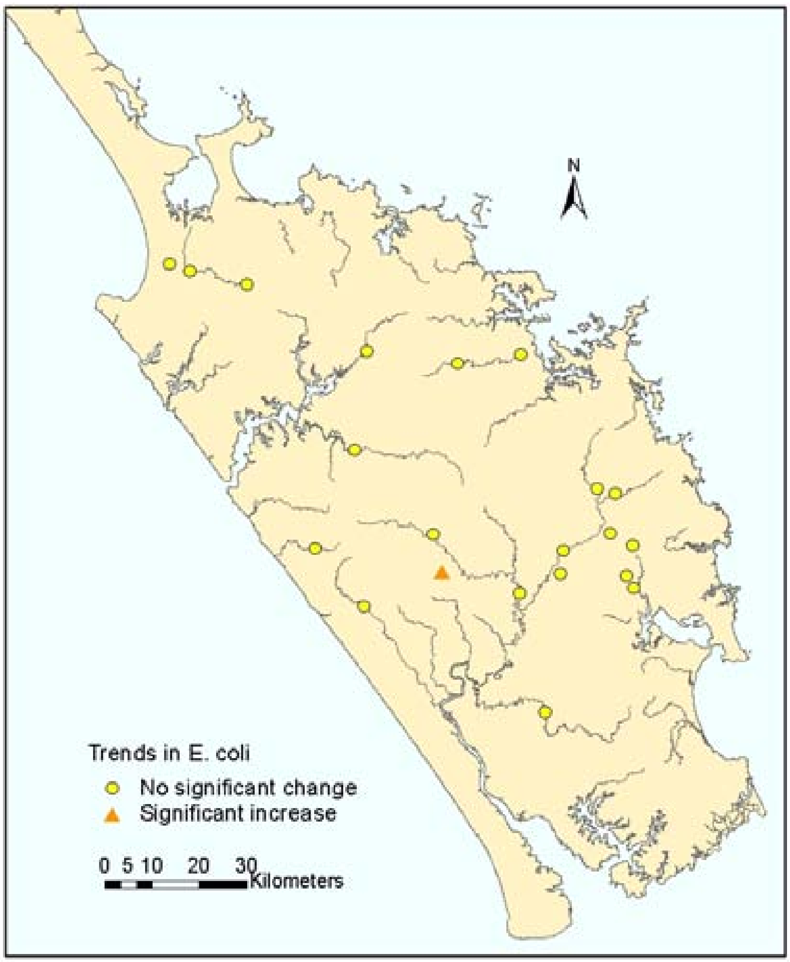
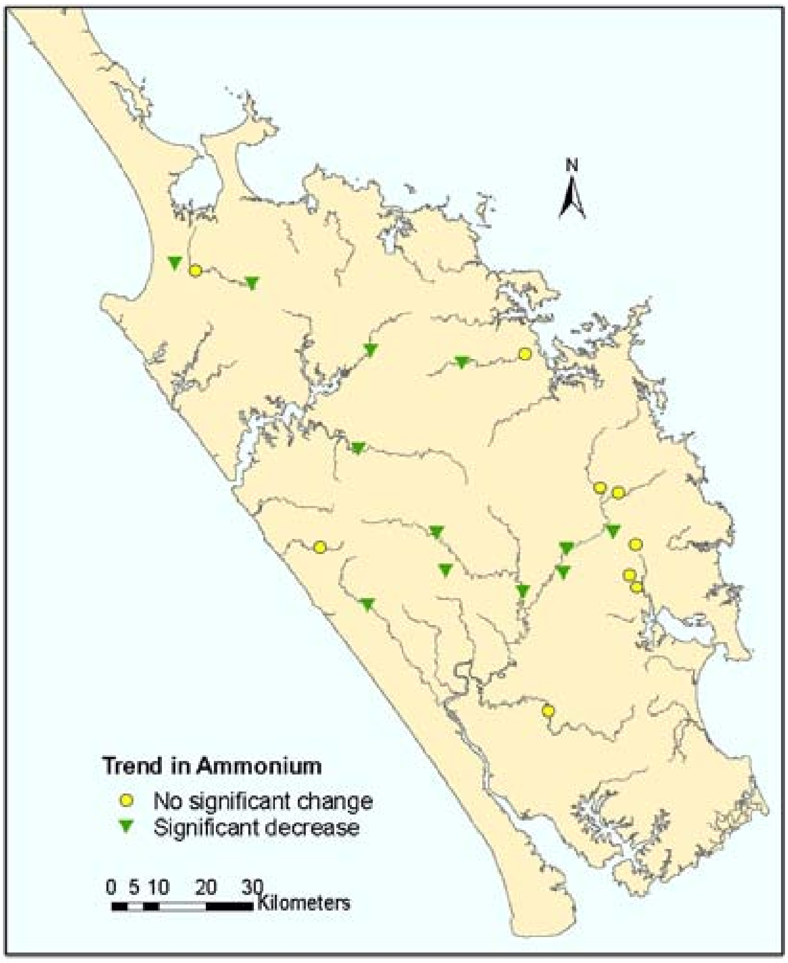


Figure 18: Trends in *E. coli* at 21 RWQMN sites

4.1.8 Ammoniacal nitrogen

Thirteen sites showed significant decreases in ammoniacal nitrogen. However, eight of these sites had more than 15% of samples below the detection limit therefore the decreasing trend is likely to be a result of changes in the detection limit rather than an actual change in ammoniacal nitrogen levels. The other five sites (Mangahahuru Stream at Apotu Rd, Mangakahia River at Titoki, Mangere River, Waipapa River and Wairua River) had less than 15% of the samples below the detection limit so therefore the trend is valid. These results are consistent with a report compiled by Ballantine et al (2010) who found an overall decreasing trend in ammoniacal nitrogen for Northland.



Map 19: Trends in Ammoniacal nitrogen at 21 RWQMN sites.

4.1.9 Nitrate/nitrite nitrogen

Seven sites had significant trends in nitrate/nitrite nitrogen. Only one site, Waiarohia Stream at Whau Valley, had a significant but not meaningful increasing trend. The trend for Opouteke River is deemed invalid as more than 15% of samples were below the detection limit. Decreasing trends were observed in the Mangakahia (Titoki site), Mangere, Waipapa, Wairua and Whakapara catchments. An overall decreasing trend for oxidised nitrogen for the Northland region was also reported by Ballantine et al (2010). As the majority of these sites are situated in pastoral catchments, improvements such as riparian fencing and reducing point source discharges are the likely reason for these decreases in nitrogen concentrations.

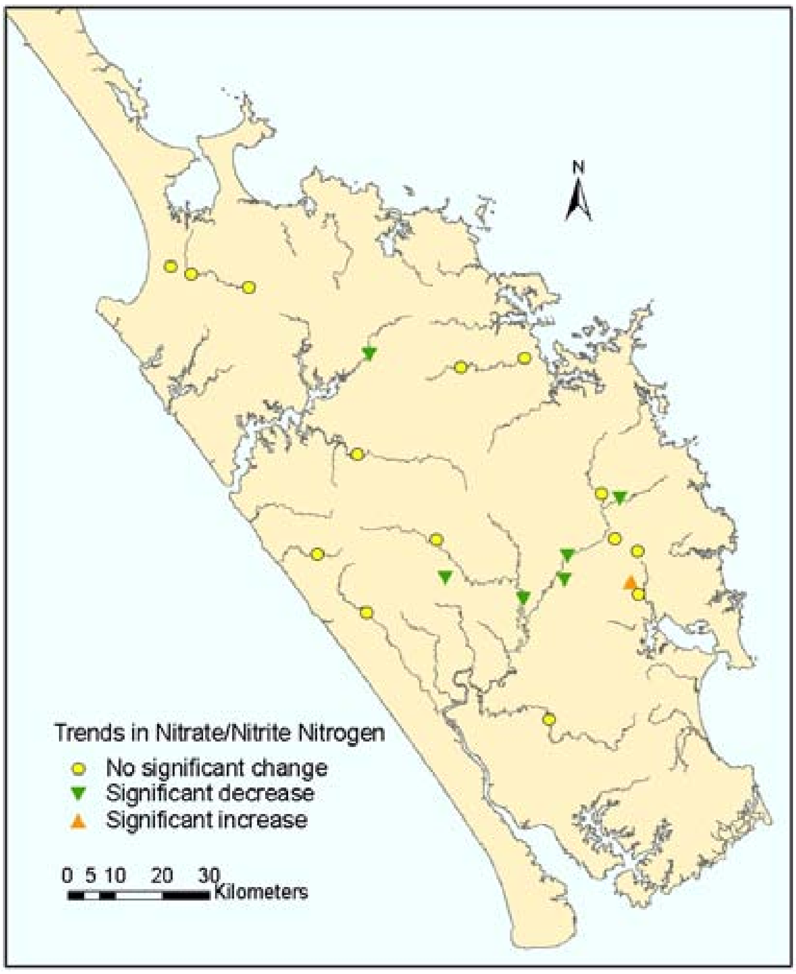


Figure 20: Trends nitrate/nitrite nitrogen (g/m³) at 21 RWQMN sites

4.1.10 Total Kjeldahl nitrogen

Significant decreasing trends in total kjeldahl nitrogen were observed in the Punakitere River, Waiotu River and Waiarohia Stream (both sites). Only one site, Waitangi River at Watea, had an increasing trend. As this is a NRWQN site, total kjeldahl nitrogen has been calculated by subtracting the concentration of nitrate from the concentration of total nitrogen (i.e. TN - NO^3 = TKN).

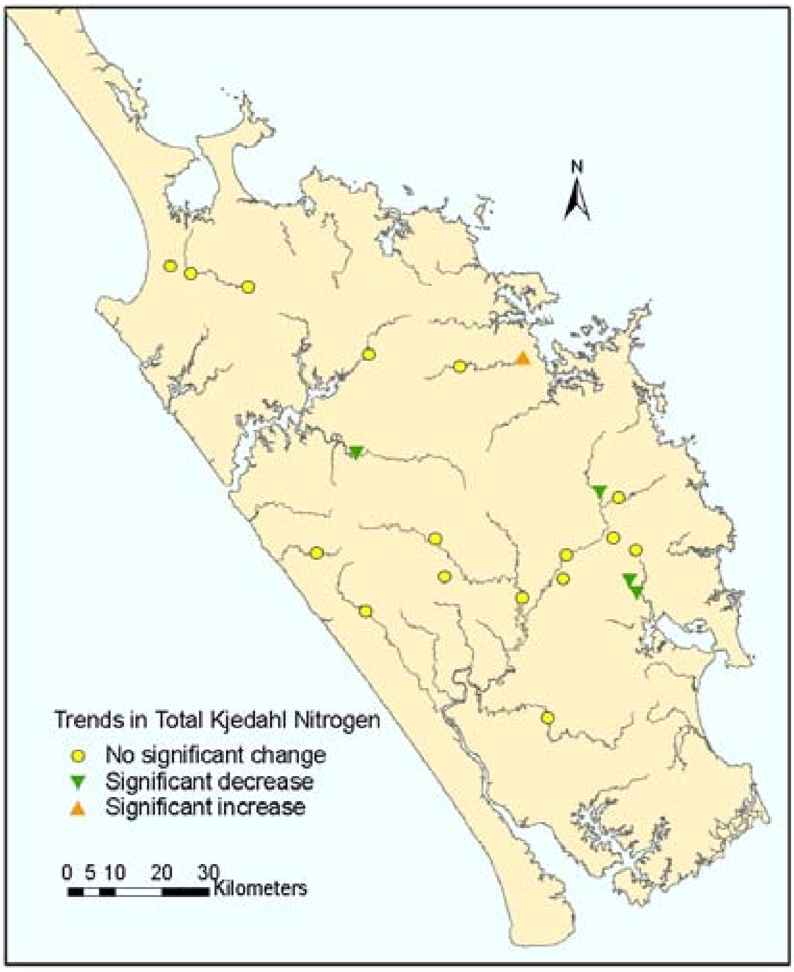


Figure 21: Trends in total kjedahl nitrogen (g/m³) at 21 RWQMN sites

4.1.11 Total nitrogen

Five sites showed significant decreasing trends in total nitrogen. These were Mangakahia (Titoki site), Manganui, Mangere, Punakitere and Waipapa Rivers. All of these sites, except the Manganui River, have corresponding decreasing trends in other nitrogen species. The Northland region has an overall decreasing trend in total nitrogen according to Ballantine et al, 2010, however, at a national scale a significant increasing trend for total nitrogen was found at the NRWQN sites (Ballantine & Davies-Colley, 2009).

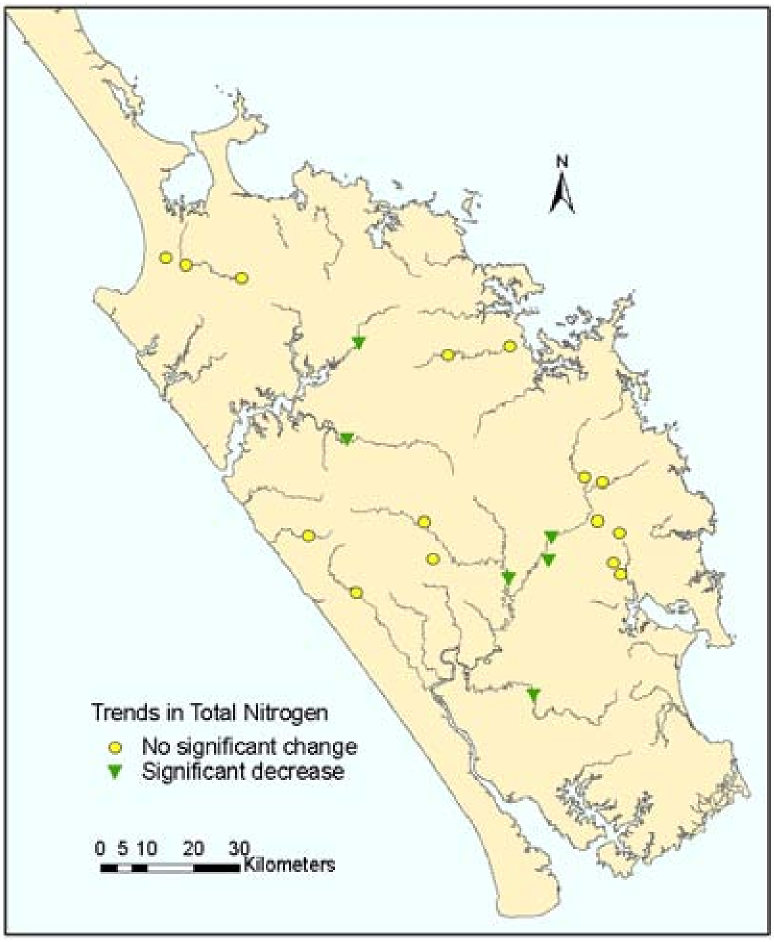


Figure 22: Trends in total nitrogen (g/m³) at 21 RWQMN sites

4.1.12 Dissolved reactive phosphorus

Thirteen of the 21 sites had changes in dissolved reactive phosphorus concentrations. Mangakahia River at Titoki was the only site observed with an increasing trend. The trend result for the Opouteke River is ignored as more than 15% of the samples are below the detection limit.

Ballantine and Davies-Colley (2009) found that there were meaningful increases in dissolved reactive phosphorus at 22 national river water quality sites, three of those sites were Northland sites (Mangakahia River at Titoki, Waitangi River at Watea and Wairua River). Difference in results may be due to the different time periods used when calculating the trends.

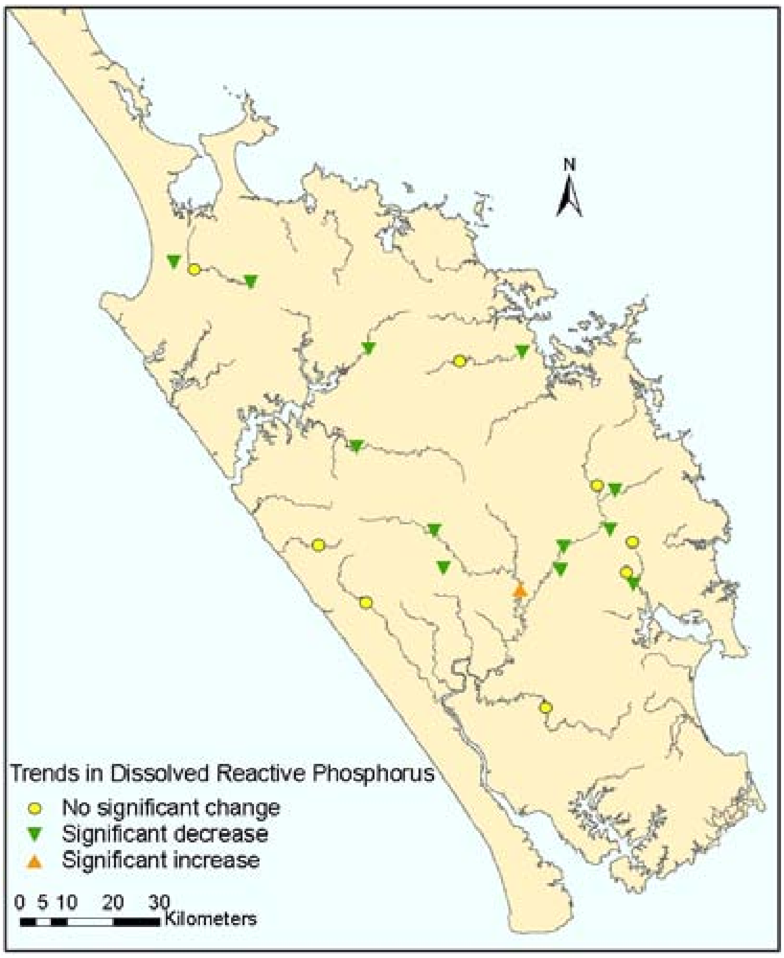


Figure 23: Trends in dissolved reactive phosphorus at 21 RWQMN sites

4.1.13 Total phosphorus

Thirteen river network sites had significant decreases in total phosphorus levels. None of these trends were observed to be meaningful. All but three sites, Manganui, Wairua and Waiarohia at Whau Valley, have corresponding decreases in dissolved reactive phosphorus. Two of ten sites are part of the NRWQN; Waipapa River and Waitangi River at Watea. Ballantine and Davies-Colley (2009) found that there was an increasing trend in total phosphorus at three of the four NRWQN sites in Northland. Differences in results are due to the difference in time period used for the data analysis.

Previous trend results showed an increasing trend in dissolved reactive phosphorus and total phosphorus in the Waipoua River (NRC, 2007). Current results show that there is no significant trend for either parameter indicating that there have been changes in the Waipoua catchment. As this catchment is predominately native; increased concentrations of phosphorus in the past is likely to have come from erosion in the catchment during rainfall events.

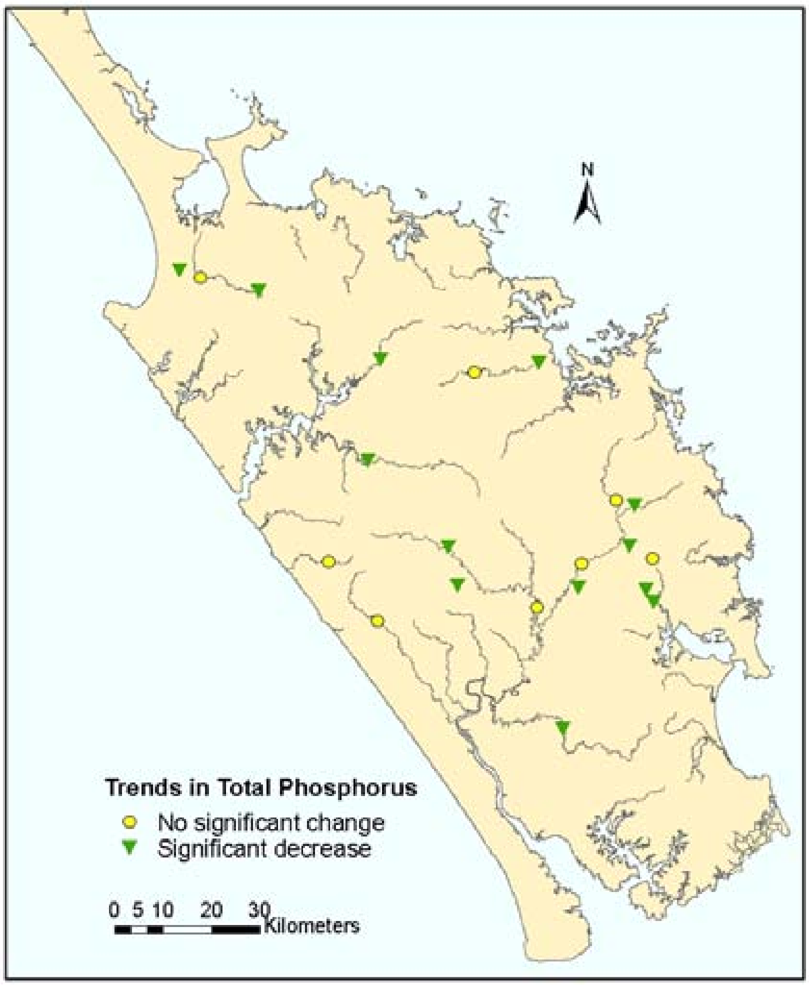


Figure 24: Trends in total phosphorus (g/m³) at 21 RQWMN sites

5. Discussion

5.1 Water quality state

The water quality state in Northland rivers is highly variable. All rivers in the network have poor water quality on occasion and some consistently have poor water quality. Overall compliance with the ANZECC guidelines has improved for dissolved reactive phosphorus, total phosphorus, ammoniacal nitrogen, total nitrogen and turbidity when compared to the previous year's results. Compliance rates have notably improved in a number of catchments, which include the Awanui, Manganui, Mangere, Punakitere and Waipoua catchments. Significant changes were identified in the Waiarohia catchment with compliance rates improving in most parameters at the upper site (Waiarohia at Whau Valley) but dropping in three parameters at the lower site (Waiarohia at Second Ave). Macroinvertebrate trends also show similar results with an improving trend occurring at the upper site and a deteriorating trend at the lower site (Pohe, 2010)

Compliance with the dissolved oxygen ANZECC guideline were particularly poor throughout Northland this year with the majority of sites failing to meet the guideline on more than half of the sampling occasions. The drought likely influenced this year's results as most river flows were below average.

Water quality can be strongly influenced by its surrounding land use. Compliance is generally consistently poor at sites in intensive pastoral farming catchments, which includes the Ruakaka, Paparoa, Utakura and Awanui at Waihue Channel river sites. These sites generally have low water clarity and higher nutrient concentrations. These results are consistent with other national findings (Ballantine et al, 2010; Ballantine & Davies-Colley, 2009; Larned et al, 2004). Compliance rates were higher in native or exotic forest catchments and include the Waipoua, Waipapa, Opouteke and Mangakahia at Twin Bridges river sites. These sites meet the ANZECC clarity, turbidity and nutrient guidelines on the majority of sampling events.

5.2 Water quality trends

The trend analysis indicates that there have been several positive changes in water quality over the past 15 years at most river network sites. There were decreasing trends in both dissolved reactive phosphorus and total phosphorus at 11 and 13 sites, respectively. These trends were recorded across all land use classes; native forest, exotic forest, urban and pastoral. Seven of these sites are predominately pastoral catchments (>50% of the catchment) and include the Mangere, Punakitere, Wairua and Whakapara river sites.

Significant decreasing trends were observed in all nitrogen species across nine sites; three of these sites are in significant dairying catchments (Wairua, Manganui and Mangere rivers). Decreasing ammoniacal nitrogen trends were recorded at five sites that suggest there has been improvements in point source discharges. This is consistent with the national picture of (Scarsbrook, 2006) and research into the impacts of dairy farming (Wilcock et al, 2006)

Improvements in water clarity were detected at seven sites, with the majority of these located in intensive pastoral farming catchments (Mangahahuru, Mangere, Punakitere and Wairua catchments). This could also be related to the reduction of point source discharges in these catchments.

Both increasing and decreasing trends were recorded in dissolved oxygen. Eight out of the ten dissolved oxygen trends were deemed degrading trends as they were falling further away from the ANZECC guideline range. Thirteen of the fourteen pH trends were increasing trends. Scarsbrook (2006) also found mainly increasing trends in pH in the Auckland region, however decreasing trends in pH were recorded in other regions such as Waikato (Vant and Smith, 2004) and Bay of Plenty (Scholes and McIntosh, 2009).

Overall there were fewer negative trends than positive trends detected in water quality this year. Positive trends were observed in water clarity, turbidity and all phosphorus and nitrogen species. The majority of these trends were at sites located in intensive pastoral catchments. Eleven improving trends were recorded in the Mangere catchment, which has a large proportion of dairying in the catchment. NRC has been actively working alongside dairy farmers in the catchment to minimize the impact of discharges.

6. Recommendations

A number of issues in water quality have been identified through the analysis of this year's data. Decreasing trends in dissolved oxygen has been recorded at some sites including the Waipoua, Kaihu and Awanui Rivers. Both the Waipoua and Kaihu rivers generally have good water quality so it is concerning to have poor dissolved oxygen results at these sites. It is therefore recommended that sampling be carried out to investigate low dissolved oxygen in these rivers during the 2011/2012 summer. Data sondes will be used to record dissolved oxygen regularly throughout the day to look at the rivers diurnal pattern.

Bacterial compliance dropped significantly at a number of RWQMN sites this year when compared to the previous year's results. These sites include the Mangamuka, Ngunguru and Waimamaku rivers. Some sites have continuously poor results and include the Kaeo River and Mangahahuru Stream (Apotu Rd). It is recommended that faecal source tracking sampling be undertaken to determine the source of bacterial pollution at these sites.

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Appendix A: RSKSE and P-values

Table 3: Trends slopes for water quality parameters for 21 RWQMN sites with *p*-values from October 1996 to June 2010 or when records began

SITE	Dissolved oxygen		Conductivity		pH		Temperature		*Escherichia coli*		Turbidity		Visual clarity	
	P	RSKSE	P	RSKSE	P	RSKSE	P	RSKSE	P	RSKSE	P	RSKSE	P	RSKSE
Victoria	0.25	-0.21	0.08	0.06	**0.01**	**0.02**	**0.00**	**-0.1**	0.60	-6.5	**0**	**0.01**	**0**	**-0.12**
Awanui (FNDC take)	**0.04**	**-0.98**	**0**	**0.13**	0.95	0	1.00	0	0.89	2.6	0.33	0.08	0.41	0
Awanui (Waihue)	**0**	**-0.73**	**0**	**0.12**	0.05	0.01	**0.01**	**-0.08**	1.00	-1.3	0.25	-0.1	0.12	0
Waitangi (Waimate)	1	0.06	0.11	0.05	0.17	0.01	0.30	0	1.00	3.8	0.27	0	0.96	0
Waitangi (Watea)	**0.01**	**0.08**	0.58	0.02	**0**	**0.01**	0.52	0	0.80	-3.7	0.1	0	0.85	0.01
Waipapa	0.46	-0.02	**0**	**0.05**	**0**	**0.01**	0.77	0.02	0.08	-9.9	**0**	**-0.06**	**0**	**0.1**
Punakitere	0.11	0.3	0.41	0.02	**0**	**0.03**	0.40	0.12	0.70	3.5	0.6	-0.09	**0.02**	**0.05**
Waiotu	0.49	0.41	0.95	-0.02	0.06	0.02	0.17	0.01	0.90	2.2	0.1	0.02	0.88	0.01
Whakapara	**0.01**	**0.59**	0.33	0.01	**0**	**0.03**	0.27	-0.02	0.80	0	0.86	-0.02	0.29	0.02
Mangahahuru (Main Rd)	0.83	-0.17	0.71	0.1	0.52	0	0.05	0.33	0.10	22.5	**0.02**	**0.43**	0.06	-0.13
Mangahahuru (Apotu)	**0**	**0.64**	**0**	**0.12**	**0**	**0.02**	0.29	-0.01	0.87	4.2	0.69	-0.1	**0.02**	**0.03**
Waiarohia (Whau Valley)	0.56	0.4	0.18	0.78	**0**	**0.07**	0.28	0.14	0.10	-58.9	**0.01**	**-0.65**	**0**	**0.23**
Waiarohia (Second Ave)	0.83	-0.07	0.72	**0.05**	**0.02**	**0.03**	0.72	0.14	0.08	-67.6	**0**	**-0.32**	**0**	**0.26**
Wairua	**0.04**	**0.53**	**0.04**	**0.05**	**0**	**0.02**	0.24	0	0.08	-9.7	0.18	-0.15	**0.02**	**0.02**
Mangakahia (Twin)	0.36	0.16	**0.05**	**0.07**	**0**	**0.04**	0.40	-0.02	0.20	-4.2	0.31	-0.03	0.15	0.03
Mangakahia (Titoki)	**0.01**	**-0.12**	0.13	0.05	0.86	0	0.61	0	0.34	16.5	0.81	0	0.83	0
Opouteke	0.34	0.08	**0.01**	**0.07**	**0**	**0.04**	0.44	0.02	**0.00**	**12.5**	0.19	-0.02	0.16	0.02
Mangere	**0**	**0.53**	0.45	0.03	**0**	**0.03**	**0.03**	**-0.06**	0.35	19.9	**0.03**	**-0.12**	**0**	**0.05**
Manganui	1	0.07	1	0.03	**0.01**	**0.04**	0.40	0.1	0.30	-3.5	0.16	0.15	0.67	0.01
Kaihu	**0.01**	**-0.81**	0.88	-0.03	0.3	0.01	0.40	0.07	0.90	1.9	0.31	-0.16	0.15	0.05
Waipoua	**0.04**	**-0.46**	0.16	-0.1	**0.03**	**-0.02**	0.43	0.06	0.42	-0.6	0.4	0.05	0.5	-0.03

Table 3 cont: Trends slopes for water quality parameters for 21 RWQMN sites with *p*-values from October 1996 to June 2010 or when records began

SITE	Dissolved reactive phosphorus		Total Phosphorus		Nitrate/Nitrite nitrogen (or Nitrate)		Total nitrogen		Ammoniacal nitrogen		Total Kjedahl Nitrogen	
	P	RSKSE	P	RSKSE	P	RSKSE	P	RSKSE	P	RSKSE	P	RSKSE
Victoria	**0**	**-0.002**	**0**	**-0.002**	0.25	0	0.44	0	**0**	**-0.001**	0.52	0
Awanui (FNDC take)	0.32	0	0.65	0	0.89	0	0.89	-0.002	0.07	0	0.95	0
Awanui (Waihue)	**0**	**-0.01**	**0**	**-0.016**	0.1	0	0.66	-0.003	**0**	**-0.003**	0.66	0
Waitangi (Waimate)	0.5	0	0.46	-0.011	0.82	0	0.89	0	**0**	**-0.001**	0.68	0
Waitangi (Watea)	0.3	0	**0.01**	**0.0002**	0.53	0	0.22	0	0.95	0	**0**	**0.003**
Waipapa	**0**	**-0.0001**	**0**	**-0.0001**	**0**	**-0.001**	**0.01**	**-0.001**	**0**	**-0.0001**	0.47	0
Punakitere	**0**	**-0.002**	**0.02**	**-0.003**	0.26	-0.01	**0.01**	**-0.02**	**0**	**-0.002**	**0.04**	**-0.01**
Waiotu	0.48	0	0.28	-0.001	0.73	-0.01	0.28	-0.02	0.6	0	0.02	-0.01
Whakapara	**0.01**	**-0.001**	**0**	**-0.003**	0.03	-0.01	0.42	-0.007	0.07	0.22	0.69	0
Mangahahuru (Main Rd)	0.11	0	0.35	0	0.9	0	0.94	0.005	0.9	0	0.72	0
Mangahahuru (Apotu)	0	-0.003	**0**	**-0.006**	**0**	**-0.003**	0.88	-0.005	**0**	**-0.003**	0.76	0
Waiarohia (Whau Valley)	0.23	0	**0**	**-0.012**	**0.02**	**0.06**	0.36	-0.02	0.93	0	**0.02**	**-0.06**
Waiarohia (Second Ave)	**0.02**	**-0.002**	**0**	**-0.009**	0.72	0.002	0.36	-0.025	0.57	0	0.03	-0.016
Wairua	0.01	0	0.51	0	**0.01**	**-0.014**	**0.02**	**-0.016**	**0.04**	**-0.001**	0.53	0
Mangakahia (Twin)	**0**	**-0.004**	**0**	**-0.007**	0.26	0	0.41	-0.002	**0**	**-0.0001**	0.5	0
Mangakahia (Titoki)	**0**	**0.006**	0.59	0	**0**	**-0.003**	**0**	**-0.004**	**0.01**	**-0.0003**	0.87	0
Opouteke	**0**	**-0.005**	**0**	**-0.011**	**0**	**-0.001**	0.57	0	**0**	**-0.00004**	0.11	0
Mangere	**0**	**-0.008**	**0**	**-0.012**	**0**	**-0.027**	**0**	**-0.034**	**0**	**-0.006**	0.31	-0.005
Manganui	0.39	0	**0.03**	**-0.003**	0.36	-0.005	**0.01**	**-0.019**	0.09	0	0.14	-0.01
Kaihu	0.11	0	0.12	0	0.09	-0.01	0.27	-0.011	0	-0.001	0.64	0
Waipoua	0.24	0	0.7	0	0.35	0	0.7	0	**0**	**0**	0.7	0

Appendix B: Compliance of RWQMN sites

Table 4: Compliance for the 2009/2010 data for the 35 RWQMN sites with ANZECC trigger values for DO%, DRP, NH4, pH, water clarity, TP, turbidity and TN (ANZECC, 2000), the recreational bathing guideline for E.coli (MFE, 2002) and the guideline from the RWSP for water clarity of 1.6m (NRC, 2007).

Site	DO (%)	DRP (mg/L)	E. coli (#/100mL)	NH4 (mg/L)	pH	Clarity (m)	TP (mg/L)	Turb (NTU)	TN (mg/L)	Clarity with 1.6m
Awanui (FNDC take)	0	33	92	92	92	100	75	58	100	0
Awanui (Waihue channel)	0	8	67	58	75	78	8	33	83	0
Hakaru	25	0	75	92	58	82	0	25	58	0
Hatea	0	82	75	75	42	83	92	83	75	67
Kaeo	30	83	33	100	33	89	75	58	92	11
Kaihu	58	100	83	92	58	80	83	58	75	60
Kerikeri	50	100	58	83	75	92	83	83	67	67
Mangahahuru (Apotu Rd)	8	9	50	75	17	75	8	33	75	0
Mangahahuru (Main Rd)	17	82	75	100	42	92	92	42	92	33
Mangakahia (Titoki)	17	100	83	100	50	75	90	58	100	33
Mangakahia (Twin bridges)	25	83	83	100	42	78	75	75	75	44
Mangamuka	36	0	50	100	92	100	67	92	92	44
Manganui	17	0	83	92	58	82	25	33	67	9
Mangere	8	0	50	50	67	91	0	50	42	27
Ngunguru	17	82	50	83	25	82	75	58	83	45
Opouteke	42	92	67	100	33	90	92	83	92	60
Oruru	0	0	83	92	92	100	25	50	92	0
Paparoa	33	25	50	58	100	36	0	0	50	0
Punakitere	58	58	50	92	67	90	75	58	42	30
Ruakaka	0	0	50	42	92	55	0	0	33	0
Utakura	0	33	58	92	17	40	0	0	75	0
Victoria	9	17	92	100	58	100	92	92	92	33
Waiarohia (Second Ave)	0	64	67	100	92	90	82	75	58	80
Waiarohia (Whau valley)	36	82	58	100	100	100	73	67	42	50
Waiharakeke	25	73	67	75	67	82	75	50	67	0
Waimamaku	42	100	50	100	75	71	92	83	100	29
Waiotu	33	9	42	75	50	73	33	8	58	0
Waipao	8	0	50	92	75	91	33	92	0	91
Waipapa River	17	100	92	100	83	92	100	92	100	92
Waipapa Stream	17	100	83	100	8	92	100	83	75	58
Waipoua	67	92	92	100	92	90	92	83	100	50
Wairua	0	30	92	90	17	82	20	42	70	36
Waitangi (Watea)	67	100	83	100	67	92	90	83	90	36
Waitangi (Waimate)	67	100	50	92	17	82	83	67	58	58
Whakapara	17	0	75	83	42	73	17	42	75	0

Appendix C: Medians of RWQMN sites

Table 5: Medians for each parameter for the 35 RWQMN sites for 2009/2010

Site	Temp (°C)	Cond (mS/m)	DO (% sat.)	pH	Turb (NTU)	Clarity (m)	NH4 (mg/L)	NNN/NO3 (mg/L)	TKN (mg/L)	TN (mg/L)	DRP (mg/L)	TP (mg/L)	E.coli (n/100 ml)
Awanui (FNDC take)	17.1	20.7	79.8	7.6	4.9	0.80	0.005	0.007	0.165	0.169	0.014	0.029	379
Awanui (Waihue channel)	17.8	22.0	77.5	7.7	9.0	0.60	0.009	0.010	0.295	0.320	0.037	0.067	453
Hakaru	16.2	18.4	107.2	7.7	9.2	0.95	0.008	0.170	0.360	0.550	0.041	0.077	292
Hatea	17.2	73.2	110.2	8.0	3.2	1.84	0.009	0.235	0.185	0.385	0.006	0.017	302
Kaeo	17.5	14.5	97.9	7.1	5.0	1.10	0.005	0.025	0.140	0.178	0.002	0.013	1065
Kaihu	15.3	11.3	101.0	7.3	3.6	1.70	0.005	0.181	0.160	0.375	0.002	0.010	219
Kerikeri	17.0	15.3	100.5	7.3	1.5	1.98	0.005	0.365	0.205	0.525	0.002	0.011	516
Mangahahuru (Apotu Rd)	16.7	14.1	105.2	7.1	6.1	0.99	0.011	0.270	0.240	0.480	0.029	0.061	627
Mangahahuru (Main Rd)	15.6	10.1	96.7	7.1	5.9	1.53	0.005	0.048	0.050	0.164	0.006	0.017	286
Mangakahia (Titoki)	17.3	15.2	96.0	7.6	4.5	1.13	0.008	0.009	0.155	0.170	0.004	0.019	193
Mangakahia (Twin Bridges)	17.5	11.8	115.4	8.1	2.1	1.50	0.005	0.015	0.110	0.133	0.002	0.008	122
Mangamuka	15.9	18.1	95.0	7.5	1.0	1.50	0.005	0.005	0.050	0.055	0.030	0.033	534
Manganui	17.2	21.0	91.8	7.6	10.2	0.86	0.005	0.007	0.340	0.401	0.030	0.060	91
Mangere	15.7	18.3	89.8	7.3	5.5	1.35	0.020	0.345	0.365	0.765	0.041	0.066	553
Ngunguru	17.6	61.2	98.3	7.1	4.9	1.57	0.005	0.035	0.170	0.262	0.005	0.022	539
Opouteke	17.4	13.5	108.6	8.1	2.6	1.88	0.005	0.005	0.100	0.112	0.002	0.008	258
Oruru	17.4	18.3	83.8	7.5	5.6	0.80	0.005	0.010	0.050	0.095	0.024	0.037	314
Paparoa	16.7	111.9	92.2	7.4	23.0	0.45	0.015	0.052	0.495	0.675	0.014	0.085	480
Punakitere	17.1	14.1	103.0	7.7	3.0	1.31	0.005	0.320	0.250	0.640	0.008	0.021	552
Ruakaka	15.4	24.1	78.2	7.3	15.7	0.60	0.025	0.365	0.425	0.700	0.080	0.155	525
Utakura	17.0	9.4	87.5	7.0	13.5	0.56	0.009	0.096	0.340	0.476	0.017	0.064	426
Victoria	15.4	17.3	93.3	7.6	1.0	1.50	0.005	0.005	0.050	0.055	0.015	0.019	104
Waiarohia (Second Ave)	18.6	29.6	116.4	7.6	1.6	2.94	0.005	0.310	0.155	0.460	0.008	0.016	293
Waiarohia (Whau valley)	16.5	35.3	98.8	7.5	4.2	1.66	0.005	0.495	0.190	0.725	0.009	0.025	391
Waiharakeke	16.9	18.1	92.5	7.3	5.1	1.00	0.008	0.125	0.340	0.448	0.006	0.029	447
Waimamaku	16.4	9.7	106.5	7.5	3.4	1.20	0.005	0.002	0.120	0.124	0.002	0.007	569
Waiotu	16.8	9.4	100.7	7.2	8.4	1.00	0.005	0.205	0.245	0.395	0.015	0.039	759
Waipao	16.6	20.0	112.6	7.5	2.3	3.00	0.005	2.550	0.255	2.855	0.031	0.037	535
Waipapa River	16.3	11.9	96.0	7.6	1.1	3.97	0.003	0.005	0.074	0.084	0.004	0.008	59
Waipapa Stream	17.0	7.6	94.5	6.9	2.1	1.79	0.005	0.300	0.200	0.495	0.002	0.009	215
Waipoua	14.3	8.3	101.8	7.4	2.6	1.78	0.005	0.010	0.050	0.070	0.002	0.007	67.5
Wairua	18.1	14.1	95.2	7.2	5.9	0.93	0.008	0.043	0.282	0.307	0.012	0.046	77
Waitangi (Watea)	18.1	12.7	100.1	7.7	3.1	1.68	0.004	0.102	0.195	0.338	0.003	0.016	150
Waitangi (Waimate)	16.6	9.6	102.1	6.9	4.0	1.12	0.005	0.345	0.195	0.535	0.002	0.013	496
Whakapara	16.7	9.4	104.7	7.1	5.9	1.00	0.005	0.158	0.200	0.280	0.019	0.041	200