GROUNDWATER

SUMMARY 2007-08

OVERVIEW

- The main aquifer systems in Northland are found in areas of basalt geology, such as Kaikohe and Whangarei, and in the Aupouri sands.
- Rainfall is the main recharge source for Northland's aquifers.
- Northland Regional Council (NRC) monitors groundwater resources via State of the Environment (SOE) and compliance assessment monitoring, and via specific groundwater investigations.
- NRC also undertakes age testing of groundwater resources and groundwater recharge estimates, in order to understand how each aquifer functions and how much water is available for use.

PERFORMANCE TARGETS

Continue to implement and improve a prioritized State of the Environment (SOE) monitoring programme and monitor compliance with, and the effects of, the exercise of resource consents and Regional Plans by:	**Target Achieved:**
➢ Carrying out investigations into the water resources of 'at risk' aquifers	✓
➢ Operating a region-wide water quality network for the measurement, recording and reporting of river, lake and groundwater quality trends	✓
➢ Collecting water use records and measuring stream flows, groundwater and lake levels associated with significant water abstractions	✓
➢ Reporting to the Council annually on environmental monitoring activities within three months of the end of the financial year	**Ongoing**
➢ Making the results from the annual SOE monitoring programmes available on the Council's website at www.nrc.govt.nz	✓

SUMMARY OF RESULTS 2007-08

- Groundwater level monitoring undertaken at 82 bores in Northland. Groundwater levels found to be above average at most bores.
- Groundwater quality monitoring undertaken at 54 bores in the region. Major determinants in the majority of bores sampled were found to comply with the New Zealand drinking water standards.
- 25% of groundwater bores monitored for compliance found to be non-compliant with bore construction requirements.
- Specific groundwater investigations found areas of saline contamination at Ruawai; elevated nitrate levels at Taipa and bacterial contamination at Russell.

INTRODUCTION

The quantity and quality of groundwater resources in Northland is highly variable and is dependant on the geology of the aquifer system in which it is contained. In Northland, the main aquifer systems exist in the basalts, such as Kaikohe and Whangarei, and in the Aupouri sands. There are also many smaller sand and gravel coastal aquifers, and less productive greywacke aquifers, spread throughout the region. Rainfall is the main recharge source for Northland's aquifers.

Monitoring of groundwater resources in the Northland Region can be divided into three main areas:

- **State of the Environment monitoring** to meet **performance targets** for groundwater monitoring;
- **Compliance monitoring**, which is the monitoring of consented and 'permitted' activities that affect groundwater, such as drilling and groundwater takes; and
- **Specific groundwater investigations**.

State of the Environment monitoring aims to identify environmental issues which may affect our groundwater resources, as well as trends in groundwater quantity and quality over time. This information is used by Northland Regional Council (NRC) and other organisations in environmental decision making. Several different networks are in place to collect this information, including a Regional Groundwater Level Monitoring Network and two groundwater quality monitoring programmes.

Groundwater level monitoring was undertaken in 82 bores in Northland during 2007-2008. Low groundwater levels were recorded at sites from Kaikohe to Mangawhai in 2006-07, as a result of low winter rainfall in 2004-05, however these levels have now recovered and above average levels were recorded for many sites during 2007-08.

Groundwater quality monitoring was carried out at seven sites during 2007-08 as part of the National Groundwater Monitoring Programme (NGWMP), 29 sites as part of the Regional Groundwater Quality State of Environment (SoE), and 18 sites as part of specific groundwater investigations.

Photo: Overflowing artesian bore

Compliance monitoring includes the monitoring of bore construction and groundwater take. During 2007-08, 25% of the bores inspected did not fully comply with bore construction requirements. Action taken to remedy this non-compliance included letters to pump installers and a 'Drillers Seminar', to encourage improved compliance in the future. No formal enforcement action was taken during 2007-08 in relation to resource consents involving groundwater resources.

Specific groundwater investigations continued during 2007-08, including Ruawai, Taipa, Russell, Whatitiri and Maungakaramea aquifers. Areas of saline (saltwater) contamination have been discovered at Ruawai, elevated nitrate levels still occur in a number of bores in Taipa, and monitoring at Russell has indicated bacterial contamination and the increased risk of saline contamination. Specific nitrate investigations also commenced in 2007-2008 in the Maungakaramea and Whatitiri aquifers to determine the extent of elevated nitrate levels in these areas.

In addition to the above monitoring, **age testing** was undertaken at seven monitoring sites during 2007-2008, in order to determine the average age of the groundwater (mean residence time) delivered from bores in the Northland region.

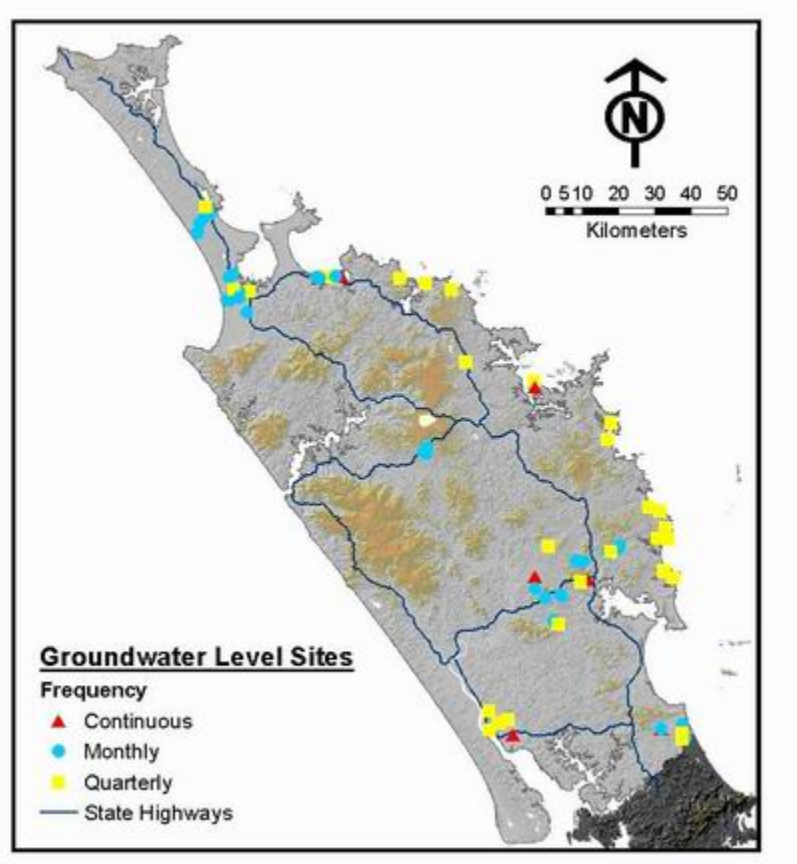
Groundwater recharge estimates were calculated for 11 'at risk' aquifers; Matauri Bay, Te Ngaire, Oakura, Whangaumu Taupo Bay Whananaki North, Bland Bay, Ngunguru, Pataua North, Pataua South and Kerikeri. Groundwater recharge refers to the amount of water (from rain and/or streams) that drains through the ground and meets the water table.

STATE OF THE ENVIRONMENT MONITORING

Groundwater Levels

Groundwater level monitoring provides information on the effects of climate, land use and groundwater abstraction on groundwater resources. Monitoring is undertaken as part of a region-wide hydrometric network and began during the late 1980s, with some records extending back as far as 1975.

Groundwater levels are currently recorded continuously at nine sites, monthly at 43 sites and quarterly at 30 sites around the region. These sites have been chosen to provide adequate regional coverage, as well as targeting areas with specific environmental concerns. The locations of the current groundwater level monitoring sites are shown on the map below.



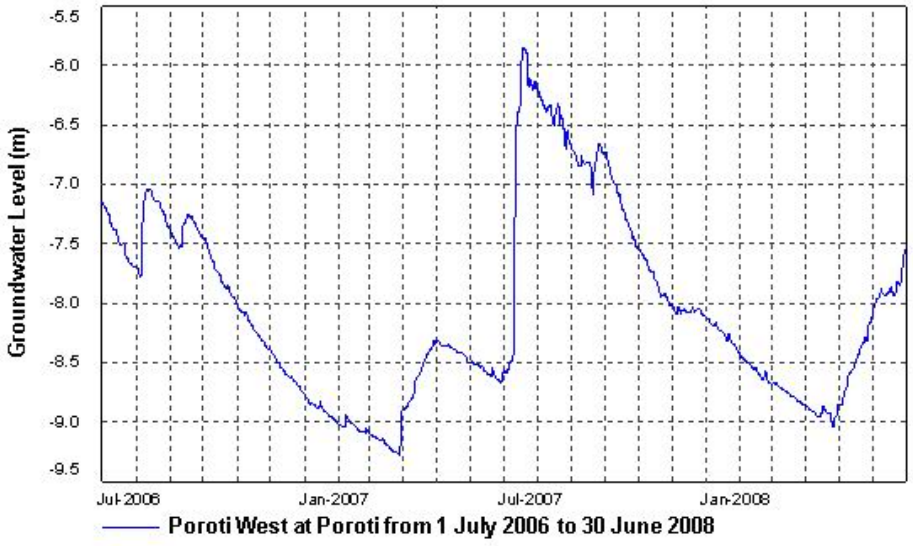
Results of groundwater level monitoring

Results from the 2005-2006 sample period showed that groundwater levels throughout Northland were at or near their lowest since 1990, as a result of low rainfall recharge the preceding winter. Groundwater levels have since recovered and in 2007-08, were generally found to be above average. This can largely be attributed to two significant rainfall events in March and July 2007.

A breakdown of results from 2006-08 for several key aquifers in Northland is given below.

Whangarei basalt aquifer

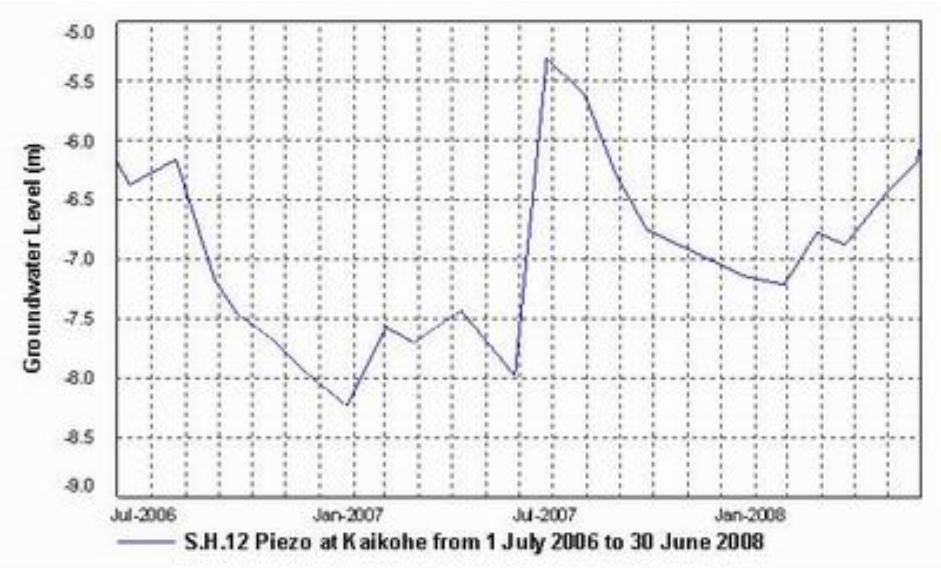
In this aquifer, groundwater levels are typically highest from July to September, dropping to the lowest point in the summer months. This can be seen in the graph below for Poroti West monitoring bore, which is in the Whangarei basalt aquifer. The vertical axis of the graph shows depth below ground level in metres.



The groundwater recharge resulting from the two significant rainfall events in March and July 2007 can clearly be seen, with an increase in groundwater level of approximately 0.8 metres and 2.5 metres respectively. Groundwater levels began to increase within 24 hours of the rainfall events commencing.

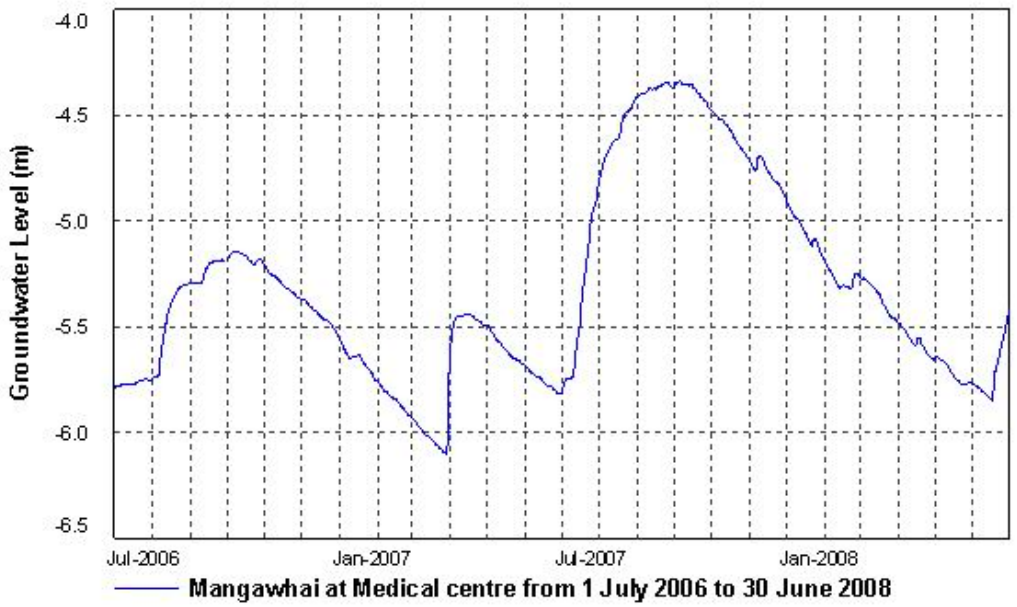
Kaikohe basalt aquifer

The groundwater level in the SH12 monitoring bore shows high seasonal variation and is strongly influenced by rainfall. This influence can be seen during the March and July 2007 rainfall events when groundwater levels increased by 0.8m and 2.7m respectively.



Mangawhai sand aquifer

In the Mangawhai area, groundwater levels generally peak in October as a result of a delay between rainfall events and the actual recharge of the groundwater resource. The March and July 2007 rainfall events resulted in an increase in groundwater levels of approximately 0.7 m and 0.4 m respectively.



Aupouri sand aquifer

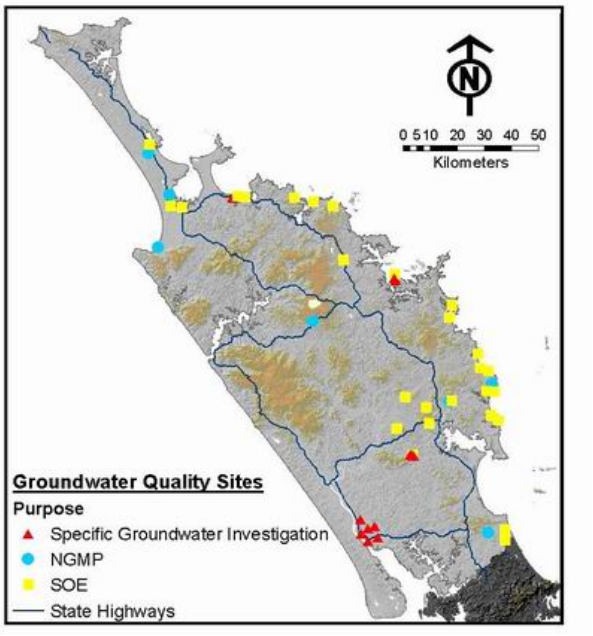
The Aupouri aquifer has a large storage capacity. The large volume of water stored within this aquifer means that it is less influenced by seasonal rainfall trends, as is the case with many other aquifers in the region, and more influenced by long term rainfall trends.

The decline in water levels in the Hukatere Forest monitoring bore from 1987 to 1996 (as seen in the graph below) is likely to be as a result of less than average rainfall in the late 1980's to early 1990's, and the effects of plantation forestry reducing recharge to the system. Felling of the plantation forest and increased rainfall is likely to have resulted in the increase in groundwater levels recorded from 1998 to 2004. Results from 2007-08 show a general increase in water levels due to greater than average rainfall during this period.

Groundwater Quality

NRC participates in the National Groundwater Monitoring Programme (NGWMP), which is a joint project between the Institute of Geological and Nuclear Sciences (IGNS) and all Regional Councils. The focus of this research programme is to determine national groundwater quality trends.

There are seven sites within the programme in Northland. These sites have been sampled every three months since September 1996. The sites are located at Houhora, Paparore, Ahipara, Kaikohe, Tutukaka, Glenbervie and Tara (as shown on the map below). Samples are taken from each site and analysed for major determinants, such as nutrients, metals and bacteria.



NRC also operates a regional groundwater quality 'State of Environment' monitoring programme (SoE), which commenced in November 2002. The data gained from this monitoring helps to improve understanding of the region's groundwater systems and so facilitate the sustainable management of groundwater resources. The aim of the programme is to collect baseline water quality data for each of the different aquifers in Northland, identify any trends in groundwater quality over time, and identify the most likely cause of these trends.

As part of the SoE monitoring, 29 sites are sampled (in addition to the seven sampled for the National Groundwater Monitoring Programme) every three months for a full range of determinants. Twenty-two of these sites are located in coastal aquifers. In addition to analysing the chemical properties of these aquifers, coastal sites are also tested for saltwater intrusion and bacterial indicators on a six monthly basis. Groundwater levels are recorded at each site where possible. All aquifers sampled through the SoE programme are listed below.

Coastal	General
Mangawhai Heads east	
Mangawhai Heads west	
Mangawhai Village	
Sandy Bay	
Taupo Bay	
Tauranga Bay	
Te Ngaire Bay	
Tapeka Point	Maunu Basalt
Pataua Bay	Whatitiri Basalt
Whananaki Bay	Three Mile Bush Basalt
Taiharuru Bay	Matarau Basalt
Ngunguru	Glenbervie Basalt
Whangaumu Beach	Kerikeri Basalt
Matapouri Bay	Maungakaramea Basalt
Oakura Bay (2)	
Bland Bay	
Cable/Mangonui Bay	
Coopers Beach	
Waipapakauri Beach	
Waipapakauri East	
Houhora	

Results of Groundwater Quality Monitoring

Groundwater in Northland is generally of a high enough quality that it can be consumed without treatment. However, three potential sources of contamination that are of concern in Northland are nitrates, bacteria and saltwater (saline intrusion). The results of water quality monitoring for the last five years are reported in detail in the State of Environment Report 2007. For a copy of this report go to http://www.nrc.govt.nz/Resource-Library-Summary/Environmental-Monitoring/State-of-the-Environment-Monitoring/.

The results from groundwater quality monitoring undertaken by NRC in 2007-08 indicate that the majority of determinants analysed for each sample are well below New Zealand drinking water limits, however some results are of concern. Nine of the monitoring sites had median Iron (Fe) concentrations above the aesthetic guideline value of 0.2 mg/L. 12 monitoring sites had median Manganese (Mn) concentrations in excess of the aesthetic guideline value 0.04 mg/L. Out of these 12 sites, two sites had median Manganese concentrations above the Maximum Allowable Value for health reasons of 0.4 mg/L.

The *'Drinking Water Standards for New Zealand* (*Ministry of Health 2005)*', can be found at:
http://www.moh.govt.nz/moh.nsf/by+unid/12F2D7FFADC900A4CC256FAF0007E8A0?Open.

Most of the bores that have median Iron and Manganese concentrations in excess of aesthetic guideline values intersect groundwater in either basalt or fractured greywacke. In Northland, these rock types contain high concentrations of Iron and Manganese and it is therefore likely that elevated levels are the result of natural processes. Elevated levels of Manganese and Iron can cause staining of pipes and laundry.

Photo: NRC staff monitoring a bore site

Results of bacterial analysis undertaken during 2007-08 indicate that sixteen groundwater sites have bacteria present above the guideline value. However, only four of these sixteen sites showed repeated bacterial contamination in three consecutive sampling runs. This may be an indication of onsite wastewater contamination, and/or poor bore construction. It is important to note that the *Escherichia coli* limit set in the *'The Drinking Water Standards for New Zealand 2005'* is less than 1 in 100 ml. Therefore any positive result for bacteria exceeds these drinking water standards.

Nitrate (NO_3^-) is considered a broad indicator of groundwater contamination from a variety of sources, including fertilisers, agricultural, and human wastes. Nitrate is considered toxic in excessive concentrations. Bottle-fed infants are most at risk, as a high concentration of nitrate affects the ability of the blood to transfer oxygen. High nitrate concentrations in water and diet have also been linked to some types of cancer.

The current New Zealand drinking water limit for nitrate is 11.3 mg L^{-1} (as NO_3^-N, taken from the 'New Zealand Drinking Water Standards 2005'). Monitoring has shown that average nitrate concentrations at all groundwater quality sampling sites are well below this level. Nitrate concentrations are generally higher in the basalt bores than they are in the sands and other geology. This may be a result of the horticultural and agricultural land use in the areas surrounding the basalt aquifers. Elevated nitrate concentrations

have been recorded in bores at Taipa, Maungakaramea and Whatitiri. The results of this monitoring are reported in the “specific groundwater investigations’ section below.

Conductivity is an indirect measure of salinity. High levels may indicate salt-water intrusion and may be the result of lowering of groundwater levels. Elevated conductivity values have been recorded at one site in the Ruawai area, which is discussed in the specific groundwater investigation section below. Bores monitored in Pataua North and Cable Bay also registered elevated chloride concentrations during a period of low groundwater levels in the summer of 2007-08. This is likely to be a direct result of the influence of saltwater.

All groundwater quality SoE bores were also analysed for Boron and Lithium. The results of this monitoring indicate Boron and Lithium concentrations are well below '*The Drinking Water Standards for New Zealand*’ (MoH 2005).

COMPLIANCE MONITORING

NRC is responsible for monitoring compliance with resource consents and rules in Regional Plans. Activities monitored in relation to groundwater include groundwater abstraction and bore construction.

Bore Compliance Monitoring

The Council maintains a bore log database that incorporates all bore logs provided by drillers. There are in excess of 4600 bores registered on the database, 131 of which were registered during 2007-08.

All bores installed under a bore permit (resource consent) are visited by NRC monitoring staff to ensure that they comply with the conditions of their consent. During 2007-08, 66 consented bores were inspected by NRC staff and 25% were found to have minor non-compliance. These minor non-compliances included bores lacking a concrete pad, or removable cap and access point where water level readings can be taken.

The photographs below show a poorly constructed and maintained bore (left) and the correct construction of a bore (right) including a concrete pad, 30 cm high casing and removable cap.

Photo: badly constructed bore

Photo: well constructed bore

Formal enforcement action for significant non-compliance was taken on three occasions during 2007-08, with regard to non-compliant bore construction.

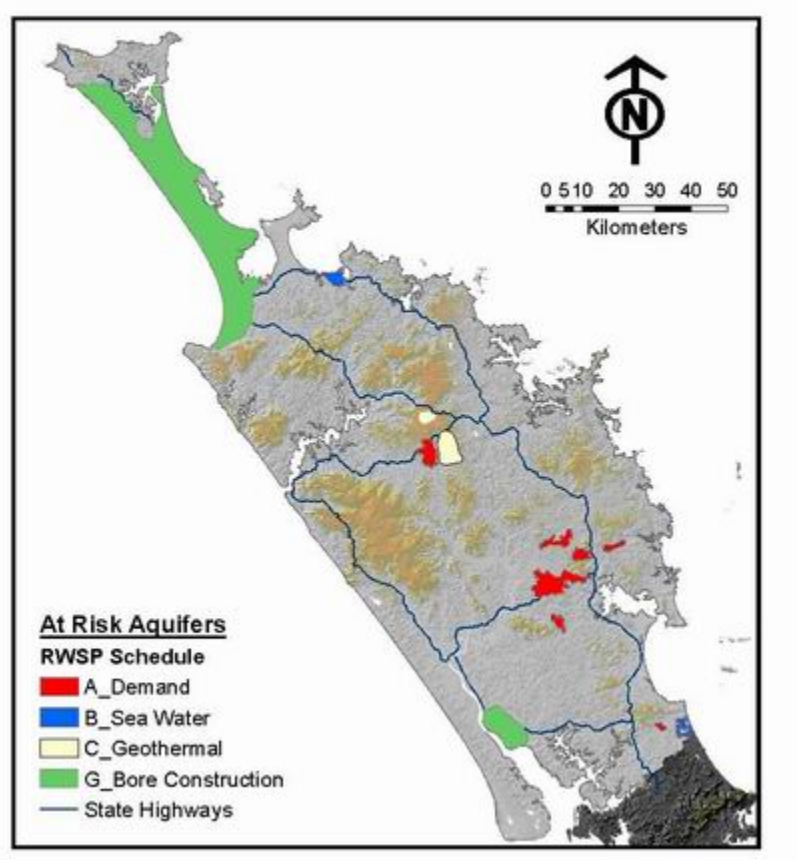
Groundwater Take Compliance Monitoring

Compliance monitoring of resource consents issued for groundwater take continued during 2007-08. There were no cases of significant non-compliance and no formal enforcement action was taken during this financial year.

SPECIFIC GROUNDWATER INVESTIGATIONS

In addition to the above monitoring programs, specific groundwater investigations are currently being undertaken in the Ruawai, Taipa, Russell, Maungakaramea and Whatitiri areas. These projects have been initiated in order to investigate potential issues with groundwater quantity or quality, highlighted during routine monitoring.

The map below shows the location of 'At risk aquifers' in Northland, and the locations of specific groundwater investigations carried out in 2007-2008.



Ruawai Groundwater Monitoring

The Ruawai area, located approximately 15 kilometres south of Dargaville, is predominantly an alluvial flood plain consisting mainly of mud, sands and peat. The Northern Wairoa River bounds the area to the west and south, and limestone hills mark the northern and eastern boundaries. The flood plain is heavily drained. The main land uses in the area are horticulture (particularly kumara growing) and agriculture (such as dairy farming).

Historical bore logs in the area indicate groundwater is present across the flood plain at varying depths and is of varying quality. Groundwater in the Ruawai area is important as a source of water for irrigation, stock drinking and public water supply, as most local surface water has a high salt content.

The main groundwater issues in the area are the potential for intensive horticulture and agriculture to degrade water quality, and for groundwater abstractions to result in saline (saltwater) intrusion. At present, six bores are sampled every three months for a wide range of parameters in order to determine long-term and seasonal variations in groundwater levels and quality.

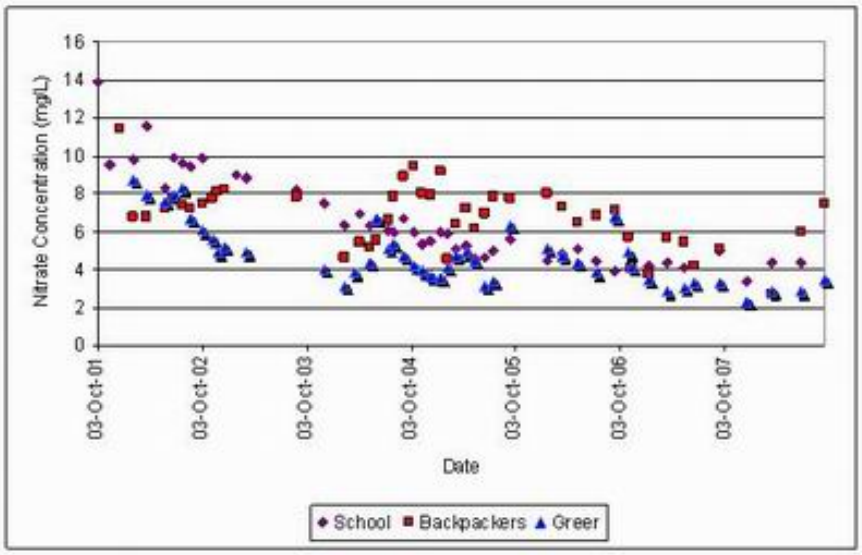
The results of monitoring undertaken during 2007-08 are consistent with previous years' results, which indicate elevated chloride and sodium concentrations in the south-eastern and northern boundaries of the groundwater system. These results suggest that saltwater intrusion is occurring in the south-eastern and northern zones of the Ruawai aquifer however this is not influencing the water quality in the western zone, at the site of the Kaipara District Council public water supply bores.

Over the past four years, there has been no evidence of an increasing trend in nitrate or bacterial levels in this aquifer. Monitoring will continue at reduced determinants and a conductivity survey will be carried out during the summer of 2008-09.

Taipa Groundwater Monitoring

Taipa is a coastal aquifer with a saline boundary on its northern and eastern edge. The main source of recharge for this aquifer is rainfall. The Taipa aquifer has similar groundwater issues to Ruawai, including the potential for land-use activities to degrade water quality and for abstraction to increase saline intrusion. Four bores in this aquifer are sampled monthly and analysed for nitrate and saline indicators, such as chloride.

The results from monitoring over the last six years indicate elevated nitrate levels in a number of bores in the Taipa settlement area, in particular the bore at Taipa school. Nitrate levels here exceeded the drinking water limit of 11.3 mg/L on two occasions in 2001-02. The school does not use groundwater from this bore for drinking. Although nitrate levels have shown an overall decline over the last six years, results indicate a seasonal fluctuation in nitrate levels. Property owners are currently being contacted to obtain fertiliser diaries for the past few months in order to cross reference these records to monitoring results.



Over the monitoring period, there has been no significant variation in chloride levels in bores adjacent to the foreshore. Monitoring of nitrate and chloride levels in groundwater in the Taipa area will continue, and the potential source of the nitrates will be investigated.

Russell Groundwater Monitoring

The groundwater resource at Russell consists of a gravel and fractured greywacke system located close to the coast. The main sources of recharge into the system are rainfall and onsite wastewater discharges. There are many bores in the area that abstract water for domestic use. The main concern for the Russell aquifer is that reduced recharge due to wastewater reticulation, and increased groundwater use, will lead to an increased risk of saline (saltwater) intrusion. Previous groundwater modelling suggests that the reticulation of wastewater will significantly increase the risk of saltwater contamination during prolonged periods of dry weather.

There are currently four monitoring bores in Russell and Matauwhi Bay. These bores are sampled and analysed for saline indicators and bacteria on a quarterly basis. A new bore has been installed at the Russell foreshore to regularly record groundwater level and conductivity. This data is logged and a telemetry system has been installed to enable direct telephone access to these monitoring results. This system provides an early warning of any increase in saltwater contamination in the aquifer. Monitoring in Russell will continue next financial year.

Age Testing

During 2007-2008, seven bore sites were sampled to determine the average age of groundwater in each. Groundwater is generally a combination of water of different ages due to the mixing processes that occur within an aquifer. The age of groundwater is therefore expressed as “mean residence time”, which is not a discrete age but a distribution of ages based on these mixing processes.

Understanding the mean residence time and the age distribution of groundwater has important implications for management of groundwater resources in Northland. For example, if the mean age of groundwater in a particular aquifer is found to be approximately 50 years with limited age distribution, then water quality results would indicate the effects of land use 50 years ago, and will not indicate the influence of any recent land use change.

Samples were collected from groundwater bores at Houhora, Paparoe, Ahipara, Kaikohe, Tutukaka, and Tara and were analysed for tritium, CFC and SF6 isotopes. The initial age estimates are provided in the table below. Further analysis is required to ensure accurate interpretation of these results and to provide an understanding of the distribution of age and mixing processes within each aquifer. The bores will be re-sampled in approximately five years.

Site of bore	Initial mean residence time estimate (years)
Houhora	71
Paparoe	140
Ahipara	35

Site of bore	Initial mean residence time estimate (years)
Kaikohe	35
Glenbervie	110
Tutukaka	28
Tara	35

Groundwater Recharge Estimates

Groundwater 'recharge' refers to the amount of water that drains through the ground and enters the water table. NRC commissioned Sinclair Knight Merz (SKM) to complete groundwater recharge estimates for 10 'At-risk' aquifers in Northland. Using these likely annual recharge estimates (which is calculated as a percentage of average annual rainfall), an interim allocation limit can be set by NRC for groundwater in each aquifer, as is required by the proposed National Environmental Standard (NES) on Ecological Flows and Water Levels (MfE 2008). The results from this study are given in the table below.

In the absence of the data needed to create a Soil Moisture Water Balance Model (SMWBM), groundwater recharge for the aquifers at Matauri Bay, Te Ngaire Bay, Oakura Bay, Whangaumu Bay, Taupo Bay, Whananaki North, Bland Bay, Ngunguru and Pataua (North and South) were estimated using previous studies from similar aquifers in Northland. An SMWBM is essentially a rainfall-runoff model that calculates how much water will flow as surface runoff, and how much will percolate through the soil and into the groundwater.

For the Kerikeri aquifer, an SMWBM was used to estimate the likely annual recharge. Using the SMWBM, the likely range of annual groundwater recharge to the Kerikeri basalt aquifer is 15-20% of average annual rainfall.

Location	Aquifer	Groundwater recharge range (%)	GW recharge volume (m3/yr)	Interim default allocation limits (m3/yr)
Matauri Bay (SKM 2008a)	Greywacke	1-5	56, 405 to 282,025	8,461 to 42,304
Te Ngaire Bay (SKM 2008b)	Alluvium	20-30	147,900 to 221,850	22,185 to 33,278
	Greywacke			
Oakura Bay (SKM 2008c)	Sand	20-30	280,440 to 420,660	42,066 to 63,100
	Greywacke	1-5	60,270 to 301,350	9,040 to 45,202
Whangaumu Bay (SKM 2008d)	Sand	20-30	43,520 to 65,280	6,528 to 9,792
	Greywacke	1-5	91,785 to 458,925	13,768 to 68,839
Taupo Bay (SKM 2008e)	Sand/alluvium	30-40	241,740 to 322,320	36,261 to 48,348
	Greywacke	1-5 (Andesite 10)	340,016 to 530,880	51,002 to 79,632
Whananaki North (SKM 2008f)	Sand	15-25	97,920 to 163,200	14,688 to 24,480
	Greywacke	1-5	14,416 to	2,162 to 10,812

			72,080	
Bland Bay (SKM 2008g)	Sand/gravel	30-40	409,590 to 546,120	61,438 to 81,918
	Greywacke	1-5	30,627 to 153,135	4,595 to 22,970
Ngunguru (SKM 2008h)	Sand	10-20	202,640 to 405,280	30,396 to 60,792
	Greywacke	1-5	44,472 to 222,360	6,670 to 33,354
Pataua North (SKM 2008i)	Sand	30-40	714,420 to 952,560	107,163 to 142,884
	Greywacke	1-5	81,018 to 405,090	12,153 to 60,764
Pataua South (SKM 2008i)	Sand	30-40	185,220 to 246,960	27,783 to 37,044
Kerikeri (SKM 2008j)	Basalt	15-20	46,990,800 to 62,654,400	7,048,620 to 9,398,160

REFERENCES

MfE (2008). Proposed National Environmental Standard on Ecological Flows and Water Levels. Ministry for the Environment, Wellington.

SKM (2008a). NRC Coastal Aquifers Study – Matauri Bay. Sinclair Knight Merz, Auckland.

SKM (2008b). NRC Coastal Aquifers Study – Te Ngaire Bay. Sinclair Knight Merz, Auckland.

SKM (2008c). NRC Coastal Aquifers Study – Oakura Bay. Sinclair Knight Merz, Auckland.

SKM (2008d). NRC Coastal Aquifers Study – Whangaumu Bay. Sinclair Knight Merz, Auckland.

SKM (2008e). NRC Coastal Aquifers Study – Taupo Bay. Sinclair Knight Merz, Auckland.

SKM (2008f). NRC Coastal Aquifers Study – Whananaki North. Sinclair Knight Merz, Auckland.

SKM (2008g). NRC Coastal Aquifers Study – Bland Bay. Sinclair Knight Merz, Auckland.

SKM (2008h). NRC Coastal Aquifers Study – Ngunguru. Sinclair Knight Merz, Auckland.

SKM (2008i). NRC Coastal Aquifers Study – Pataua North and South. Sinclair Knight Merz, Auckland.

SKM (2008j). NRC Coastal Aquifers Study – Kerikeri. Sinclair Knight Merz, Auckland.