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Limited

Future use of groundwater resources in the Bay of Plenty Region

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Prepared for

ENVIRONMENT BAY OF PLENTY

CONFIDENTIAL

Institute of Geological & Nuclear Sciences client report 2005/127
Project Number: 520W2011

September 2005

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EXECUTIVE SUMMARY

Environment Bay of Plenty commissioned the Institute of Geological & Nuclear Sciences to review groundwater resources in the Bay of Plenty region, with the aims of:

- Identifying development and environmental pressures on the resource in the next 20 years;
- Recommending priorities for groundwater investigations in the region over the next five years; and
- Identifying aquifer systems with the greatest needs for investigation.

Population growth in the next 20 years is predicted to cause significant development pressure on groundwater in the Western Bay of Plenty area, including the following aquifers:

- Aongatete Ignimbrite, Waiteariki Ignimbrite, Western Bay Rhyolite and Waihi Beach Rhyolite.

Significant growth in agricultural land use in the next 20 years is predicted for dairy and kiwifruit land uses. This growth is predicted to cause development pressure on the following aquifers:

- Pongakawa Breccia, Rangitaiki Ignimbrite, Te Puke shallow, Rangitaiki Plains, Katikati Gravel and Opotiki Plains.

GNS proposes that EBOP investigate and collate information on groundwater in the Bay of Plenty region. Information can be split into two key elements:

- determine basic information (aquifer names, aquifer boundaries and geological units) for all aquifers in the region, and
- complete geological modelling, groundwater quantity modelling (to steady-state), groundwater quality modelling (including models of nutrient recharge and discharge) and groundwater management information collection (including assembly of data on groundwater use) in the high-priority aquifers.

The high priority aquifers identified in this report for investigation are:

- Aongatete Ignimbrite
- Waiteariki Ignimbrite
- Western Bay Rhyolite
- Mamaku Ignimbrite
- Rangitaiki Ignimbrite
- Opotiki Plain

1.0 INTRODUCTION

Environment Bay of Plenty contracted the Institute of Geological and Nuclear Sciences (Appendix 1) to review the current state of knowledge of groundwater in the Bay of Plenty region and future pressures on the groundwater systems of the region.

An assessment of surface water allocations (Environment Bay of Plenty 1999a) showed that 22 catchments were under usage pressure including approximately 16 Tauranga Harbour catchments and 3 catchments in the Te Puke area. Some streams are over allocated. This led to increasing interest in the groundwater resource as a possible water supply. This also led to Environment Bay of Plenty developing and applying instream minimum flow methods to set effect-based low flows as outlined in Environment Bay of Plenty's Water and Land Plan.

An aim of this project is to identify pressures on the regional groundwater resource over the next 20 years. The region faces significant growth in the next two decades. For example the Statistics NZ medium population growth rate for the Bay of Plenty region is 25% by 2021 (Appendix 2005). These people will need water, and groundwater has significant potential to supply these needs.

Therefore information that is collated as part of this project includes:

- Statistics New Zealand, and district council, population projections;
- district council water use;
- agricultural land and water uses, and predicted trends in these uses;
- industrial water use, and predicted trends;
- geohydrological and hydrological information;
- Environment Bay of Plenty policies and priorities.

This review:

- summarises the current information on the groundwater resource in the Bay of Plenty region including productive use;
- summarises known information on groundwater quality;
- estimates future uses for groundwater for municipal, agricultural and commercial supply;
- identifies the gaps in information.

Recommendations for the priorities for groundwater investigation are included in this report. These recommendations follow from identification of development pressure and environmental pressure on the groundwater resource and from an analysis of current information gaps.

2.0 EXISTING INFORMATION ON GROUNDWATER IN THE REGION

Groundwater use in the Bay of Plenty region (Figure 1) is significant in the vicinity of Tauranga, Te Puke, Maketu, Whakatane, Opotiki, Murupara and Rotorua. Wells take groundwater from aquifers that include coastal sand, ignimbrite and sediments (Figure 2). At least 15 aquifers occur in the region. The naming convention used in this report for them follows that of White (2001).

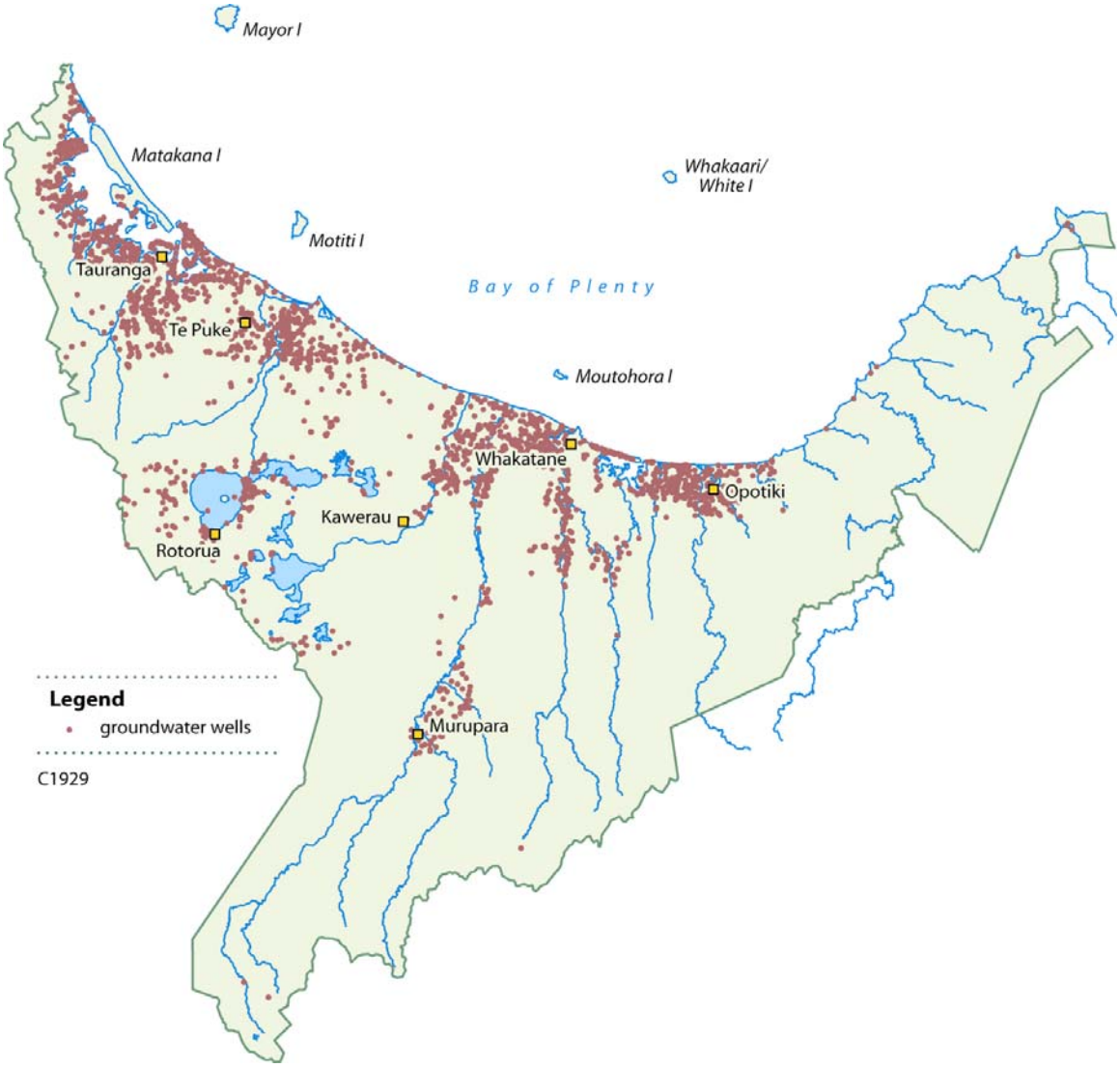

Figure 1: Locations of wells in the Bay of Plenty region (Environment Bay of Plenty, 2004)

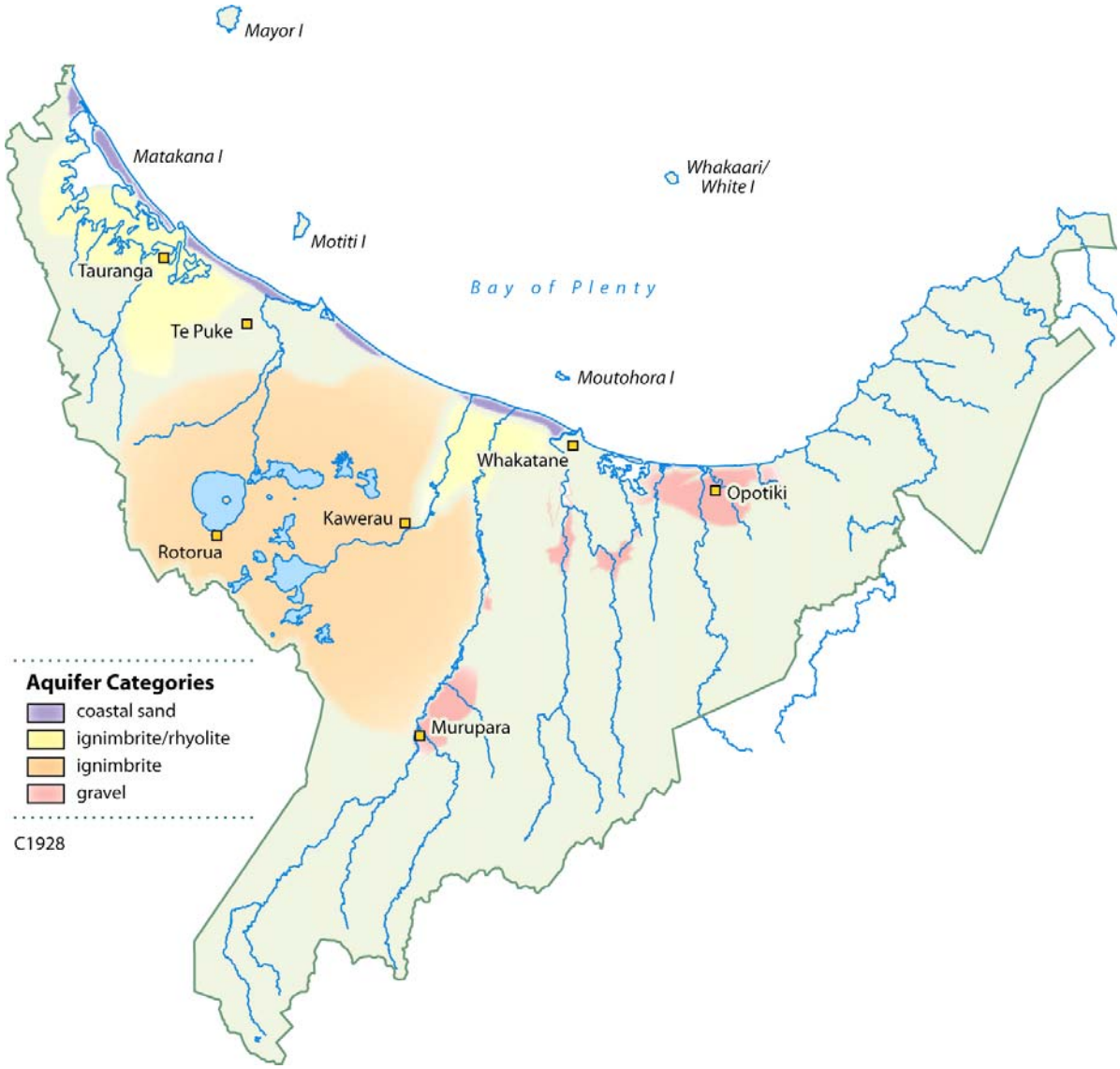

Figure 2. Categories of aquifers in the Bay of Plenty region (Environment Bay of Plenty, 2004)

Environment Bay of Plenty's current groundwater monitoring (NERMN, Environment Bay of Plenty 2001) consists of groundwater level monitoring and groundwater quality monitoring for both cold groundwater and warm groundwater. Groundwater with a temperature in the range 30°C to 70°C is defined as warm.

Groundwater level NERMN monitoring includes 71 sites:

- 63 sites are monitored manually on a quarterly basis; and
- 8 sites with automatic recorders providing a continuous record of water level.

The groundwater quality NERMN consists of 55 sites that are monitored annually. It is suggested that the monitoring of the warm and cold groundwater is separated into two programmes as the RMA defines all water greater than 30°C as geothermal (Gordon pers. comm.); this division would provide for better monitoring management (Environment Bay of Plenty 2001).

The use of groundwater has increased since 1980 (Figure 3) and most groundwater is allocated in the Western Bay of Plenty District (Figure 4). Horticultural irrigation is the largest user of groundwater (Figure 5).

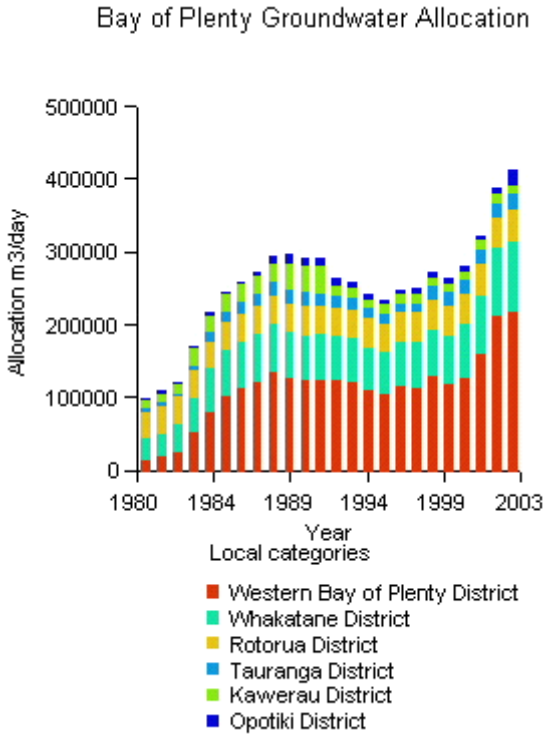

Figure 3: Groundwater allocation in the Bay of Plenty Region 1980- 2003 (Environment Bay of Plenty, 2004)

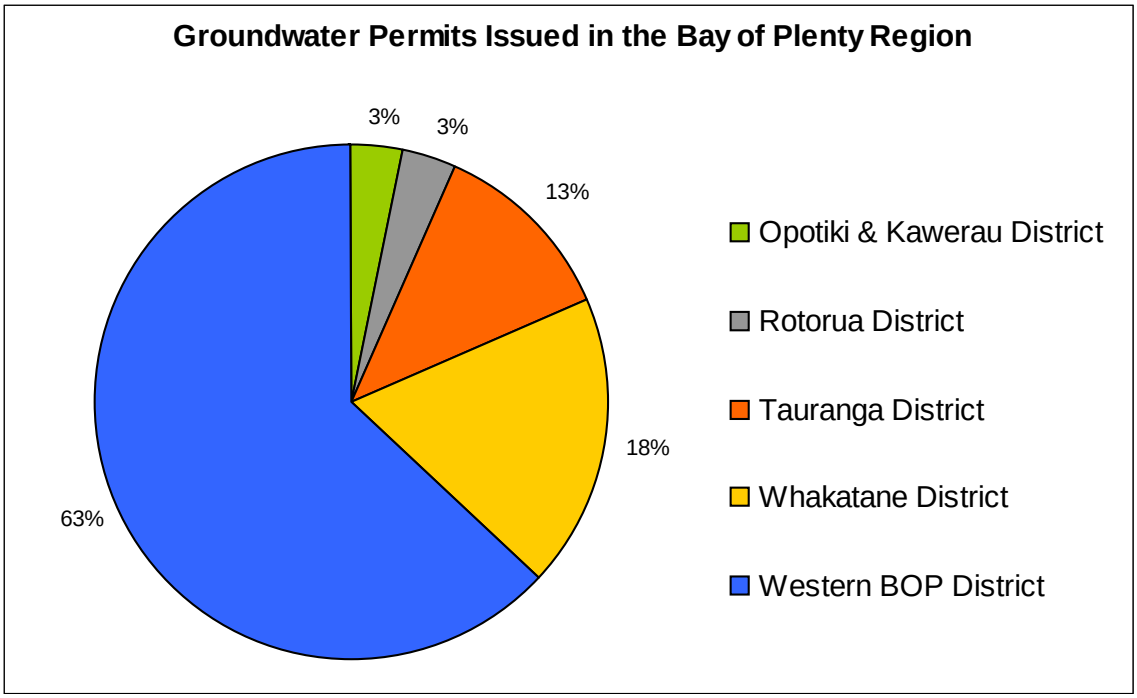

Figure 4. Groundwater allocation in the Bay of Plenty Region by district (Environment Bay of Plenty, 2004)

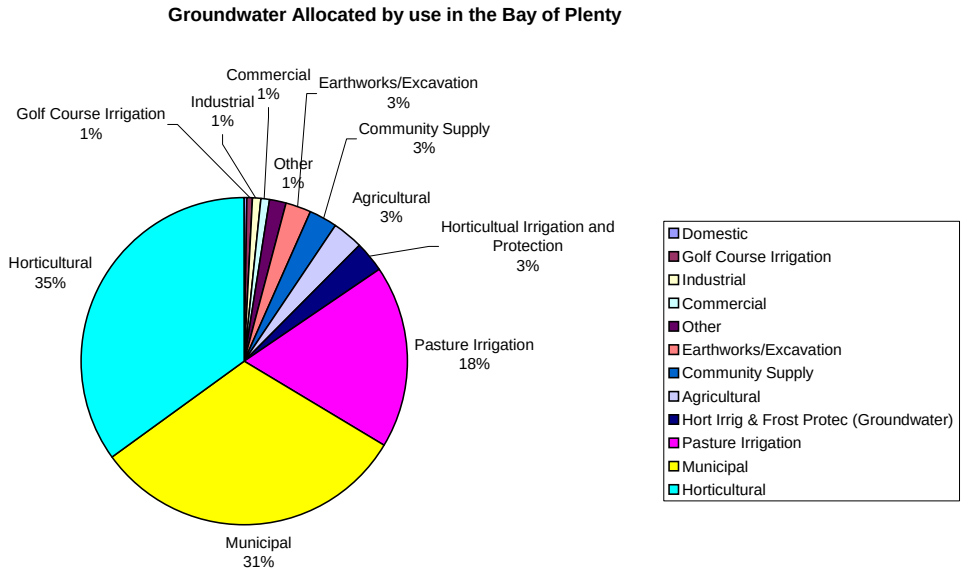

Figure 5. Groundwater allocation in the Bay of Plenty Region by use (Environment Bay of Plenty, 2004)

Groundwater is a very important source of drinking water in the Bay of Plenty Region (Environment Bay of Plenty 1999b); approximately 35 springs and wells in the region are used for municipal water sources.

2.1 Aquifer extents and properties

The groundwater resource of the Bay of Plenty is summarised by Gordon (2001). This information, together with other relevant reports, is summarised in Table 1.

2.2 Groundwater quality

The quality of groundwater in the Bay of Plenty is generally good (Gordon, 2001). However, many of the shallower aquifers have 'high levels of naturally-occurring iron and manganese' (Environment Bay of Plenty, 2004). Published groundwater quality data is reviewed using the aquifer naming convention of White (2001).

Groundwaters of the region are dominated by sodium/bicarbonate ions; this reflects the high silicic nature of the aquifers of the region and volcanic ignimbrites are significant aquifers in the region (Figure 2). Aquifers in sediments are also dominated by carbonate mineralised waters but these aquifers also have higher dissolved cations such aluminium, calcium, magnesium, manganese and iron which are sometimes above aesthetic guidelines for some uses. Low levels of toxic parameters such as arsenic are also present in groundwaters of the region. (Environment Bay of Plenty, 1995).

Groundwater quality is monitored by the National Groundwater Monitoring Programme (NGMP) (Rosen, 2001) in six Bay of Plenty aquifer systems and these analyses are summarised.

2.2.1 Aongatete Ignimbrite

This aquifer is 'generally of a suitable quality for potable supply if drawn from depths no greater than 200 m (to avoid influence of warm mineralised waters)' (Tauranga District Council, 1998, Gordon 2001). Dissolved iron occurs in this aquifer, and concentrations may be above aesthetic drinking water guidelines for (Ministry of Health, 2000).

2.2.2 Waitearikí Ignimbrite

Water in this aquifer is also 'generally suitable for potable supply' (Tauranga District Council, 1998). Western Bay of Plenty District Council (June, 1998) report summarises analysis of water from four wells in this aquifer:

- Total dissolved solids < 270 mg L^{-1}
- Chloride 28-50 mg L^{-1}
- Iron 0.2 - 4 mg L^{-1}
- Manganese <0.05 mg L^{-1}
- Boron <0.2 mg L^{-1}

Some iron concentrations are higher than the drinking water guidelines (Ministry of Health, 2000).

2.2.3 Western Bay Rhyolite

Minden and Haparangi Rhyolite domes have water quality within the guidelines, for example:

- Total dissolved solids 137-140 mg L^{-1}
- Chloride 23-24 mg L^{-1}
- Iron < 0.05 mg L^{-1}

2.2.4 Mamaku Ignimbrite

Groundwater in the Mamaku Ignimbrite is 'oxic or only moderately anoxic' (White et al., 2004). Concentrations of iron and manganese are relatively low. Groundwater that is influenced by geothermal activity has higher conductivities and higher concentrations of Cl relative to HCO_3. Morgenstern et al. (2004) analysed groundwater age measurements and showed that concentrations of nitrate-nitrogen, K and SO_4 are relatively elevated in relatively young groundwater. This is considered to reflect the influence of land use. Older groundwater indicates the effects of water-rock interaction with significantly higher concentrations of PO_4-P, Na, F and SiO_2.

Nitrate-nitrogen concentrations in spring-fed streams are gradually increasing (Rutherford, 2003), presumably reflecting the delayed response of nitrate-nitrogen discharge from land use. Median values of nitrate-nitrogen, in the period of record, at three springs (White et al., 2004) are:

- Taniwha Spring 1.39 mg L^{-1}
- Hamurana Spring 0.78 mg L^{-1} (head spring)
- Utuhina Spring 0.69 mg L^{-1}

Grinsted and Wilson (1978) reported an inverse correlation between nitrate-nitrogen concentration and distance from Lake Rotorua and concluded that agricultural practices around the lake were impacting on groundwater quality.

2.2.5 Matahina Ignimbrite

No published information exists about water quality in the Matahina Ignimbrite. It is presumed that groundwater quality in this aquifer is similar to that in other ignimbrite aquifers. However, it is likely that nitrate-nitrogen concentrations in the Matahina Ignimbrite will be lower than the Mamaku Ignimbrite; land use above the Matahina Ignimbrite is mostly forest and so nitrogen concentrations in rainfall recharge are likely to be lower than with agricultural land use.

2.2.6 Rangitaiki Ignimbrite Aquifer

This aquifer occurs around Lake Rerewhakaaitu (White et al., 2002). Nitrate-nitrogen concentrations up to 7.2 mg L^{-1} are observed in the aquifer. Nitrate-nitrogen concentrations in the Lake Rerewhakaaitu catchment are unusually high for depth, compared to other New Zealand groundwaters resources (Fenwick et al., 2004). For example, a concentration of 7.2 mg L^{-1} is measured at a depth of 57 m (static water level in the well). This presumably reflects the effects of land use, and the relatively low dilution of influent nitrate-nitrogen concentrations in the formation.

2.2.7 Rangitaiki Plains

Groundwater from the deep ignimbrite aquifers on the Rangitaiki Plains is used for public water supplies because of its generally high quality (Gordon, 2001). The deep groundwater can have elevated silica, iron and arsenic levels.

Shallow groundwater in the Rangitaiki Plains generally has higher concentrations of iron than deeper groundwater; shallow groundwaters have concentrations of iron and boron about guideline values for potable water and irrigation water (Gordon, 2001). Iron concentrations are greater than 5 mg L^{-1} over most of the Rangitaiki Plains, and over 20 mg L^{-1} near Edgecumbe. Nitrate-nitrogen concentration are elevated but mostly are below drinking-water guidelines. Groundwater quality is influenced by the Kawerau geothermal field in the southern area of the Rangitaiki Plains.

2.2.8 Katikati Gravel

Some shallow bores on the Matahui Peninsula (Aongatete) have increasing chloride concentrations (Western Bay of Plenty District Council, June 1998), possibly indicating that pumpage exceeds natural recharge. This aquifer is 'unsuitable for human supply' (Western Bay of Plenty District Council, June 1998).

2.2.9 Mt Maunganui Sand

No published information on groundwater quality is known to the author. Saltwater intrusion will be a risk if water is pumped from this aquifer.

2.2.10 Matakana Island Sand

No published information on groundwater quality is known to the author. Saltwater intrusion will be a risk to this aquifer.

2.2.11 Maketu warm water

Maketu has a natural spring producing water at 45^{o}C.

2.2.12 Maketu pumice

Some bores near the coast have elevated chloride 'as a result of sea water trapped in the sediments' (Gordon, 2001).

2.2.13 Te Puke shallow

Close (1993) sampled pesticides in 13 wells around Te Puke in 1990. These wells were in a pumice lithology with an unknown formation name. The pesticide 2,4-D was detected, at low levels, in two wells. Nitrate-nitrogen concentrations in these wells were 4.8 ± 3.3 g m^{-3}. Close (1996) sampled groundwater in eight wells in the Bay of Plenty region and presumably some of these sites were repeated in the 1990 survey; no pesticides were detected. Close and Rosen (2001) detected the pesticide DEA in two (presumed) Te Puke wells (concentrations 0.01 mg m^{-3}).

2.2.14 Opotiki Plain

Environment Bay of Plenty (2002) records nitrate nitrogen concentrations of up to 15.9 g/m3 in the Opotiki Plains. These elevated concentrations are probably due to agricultural land use.

2.2.15 Galatea Plain

Environment Bay of Plenty (2002) records elevated concentrations of ammonium-nitrogen near Galatea, with 84.9 g/m^3 recorded. These concentrations are associated with dairy land use. Environment Bay of Plenty (2002) records nitrate nitrogen concentrations of up to 8.56 g/m^3 in the Galatea Basin.

Table 1. Summary of hydrological properties for Bay of Plenty aquifers

Aquifer name	General locality	Lithology	Typical well yield (Ls^{-1})	Typical aquifer transmissivity ($m^2 day^{-1}$)	Geothermal water	References
Aongatete Ignmbrite	Tauranga	Ignimbrite	unknown	10 to 100	Temperatures of 30^0C to 95^0C in deep bores in the Tauranga area r along coastal strip	Gordon (2001), Western Bay of Plenty District Council (June 1998).
Waiteariki Ignimbrite	Tauranga	Ignimbrite	up to 19	10 to 100	-	Gordon (2001)
Western Bay Rhyolite (includes Minden and Haparangi domes)	Tauranga – Waihi	Rhyolite	up to 75	500 to 1400	Temperatures of 30^0C to 55^0C in deep bores in the Tauranga area	Gordon (2001)
Mamaku Ignimbrite	Rotorua – Te Puke	Ignimbrite		Approx 600 (Cameron pers.comm, 2005)	Rotorua geothermal field in the south with temperatures are up to 350^OC	Gordon (2001)
Matahina Ignimbrite	Matahina	Ignimbrite	unknown	unknown	-	White et al., (2004)
Rangitaiki Ignimbrite	Rerewhakaaitu	Ignimbrite	unknown	unknown	-	
Rangitaiki Plains	Kawerau – Whakatane – Matata	Sediments and ignimbrite	Up to 25	200 to 900 (shallow) 18 to 6000 (deep)	Geothermal influence near Kawerau geothermal field	Gordon (2001) Environment Bay of Plenty (1991)
Katikati Gravel	Katikati	Sediments	5 – 10	unknown	-	Gordon (2001)
Mt Maunganui sand	Mt Maunganui	Sediments	unknown	unknown	Note: hot water for the Mt Maunganui hot springs comes from unit that is deeper than the sand.	-
Matakana Island sand	Matakana Island	Sediments	unknown	unknown	-	-
Maketu warm water	Maketu	Ignimbrite (assumed)	unknown	unknown	A spring produces water at 45^0C. Hot water bores 40 – 45m.	Western Bay of Plenty District Council (June 1998) Gordon (2001)
Maketu pumice	Maketu	Pumice	unknown	unknown	-	
Te Puke shallow	Te Puke	Pumice	1 to 13	350 – 700	-	Tauranga District Council (July 1999)

Aquifer name	**General locality**	**Lithology**	**Typical well yield (Ls^{-1})**	**Typical aquifer transmissivity ($m^2 day^{-1}$)**	**Geothermal water**	**References**
Opotiki Plain	Opotiki	Sediments	2 to 10	unknown	-	Gordon (2001)
Galatea Plain	Galatea	Sediments	0.3 to 2.5	1400	-	Gordon (2001)

3.0 PRODUCTIVE USE OF GROUNDWATER

3.1 Municipal and domestic use

3.1.1 Western Bay of Plenty District Council

Groundwater has been identified by the Western Bay of Plenty District Council as the best water source to supply future growth in water demand, principally because many streams in the area are fully allocated, or close to fully allocated (Environment Bay of Plenty, 1999a). A decentralised supply system is an option for the district because the locations of small communities in the district would make for high distribution costs if a centralised source was used.

Groundwater investigations are ongoing in the district (Western Bay of Plenty District Council: July 1999, October 1999a, October 1999b, October 2000a, October 2000b, November 2000, May 2001, October 2001, January 2002, March 2002a, March 2002b, July 2003).

Three water supply zones are defined in the district: Eastern Supply Zone, Central Supply Zone and Western Supply Zone.

Water supply in the Eastern Supply Zone is from surface water and groundwater with the main supply for Te Puke from Waiari Stream. Surface water from the Eastern Supply Zone may supply Tauranga District in the future.

The water supply systems of the Central Supply Zone and Western Supply Zone are interconnected, allowing transfers of water to meet demand. Water is sourced from surface water and groundwater. The present groundwater drilling programme will allow backup, and therefore increased security of supply, to the surface water supply system. The surface water intake for Omokoroa will be closed and replaced by groundwater.

Western Bay of Plenty District Council's recent activity includes approvals of wells, or well fields, for four groundwater supplies (Western Bay of Plenty District Council: October 2001, January 2002, March 2002a, March 2002b,).

Groundwater quantity

Groundwater yields are generally higher in the hill country. Therefore drilling of investigation and production wells is occurring in the hill country generally south of State Highway 2. Most production is from fractured rock aquifers such as ignimbrites, andesites and rhyolites.

Groundwater quality

Groundwater quality for water supply is generally described as good. Elevated nitrate and

faecal coliform bacteria concentrations from land use effects are observed in some shallow wells. Deeper wells can have elevated water temperatures as a result of natural circumstances. For example, a well on Linderman Road, Katikati, found water at a temperature of 40°C.

Elevated sulphides are observed in some wells. For example, elevated sulphides are indicated at a well at Maketu when the well is pumped at high flow rates.

District population trends

Population in the Western Bay district is predicted to grow by 36% (Table 2) in the period 2001 to 2021.

Table 2. Projected population of Western Bay of Plenty District1.

Population						
Census 2001	**Projected**				**Change 2001-2021**	
	2006	**2011**	**2016**	**2021**	**Number**	**Percent**
39,300	43,100	46,700	50,200	53,600	14,300	36

[1]Figures are Statistics NZ medium-rate projections using the 2001 census as a base (Statistics NZ web site, October 2003).

District water demand trends

The response of water demand to this proposed growth is summarised in the Western Bays Asset Management Plan (Western Bay of Plenty District Council, April 1999). Total district water demand (Table 3) is projected to increase from 16108 m^3/day in 1996 to 23361 m^3/day in 2021 (Western Bay of Plenty District Council, April 1999).

Table 3. Average and peak water demands in the Western Bay of Plenty District (Western Bay of Plenty District Council, April 1999)1.

	1996	**2021**
Average daily (m^3/day)	16,108	23,361
Peak daily (m^3/day)	29,756	43,154

[1] This report projects the population of the district as 62,706 in 2021, which is higher than the more recent Statistics NZ projection (Table 2). Demand is estimated from: residential, agriculture, industrial uses, and leakage.

3.1.1.1 Eastern Supply Zone

Geographic area: Pongakawa to Te Puke, comprising:

- Pongakawa
- Paengaroa
- Maketu
- Te Puke
- Rangiuru
- Upper Papamoa

Table 4. Population trends, Western Bay of Plenty District, Eastern Supply Zone.

Population[1]		Population change 2001-2021	
2001	**2021**	**Number**	**Percent**
10,600	17,140	6,540	62

[1] Western Bay of Plenty District Council (2003). These figures are the population connected to district water supplies. Note that the statistical basis for the figures in this table differ from the Statistics NZ figures in Table 2.

Names of aquifers used for water supply:

- Mamaku Ignimbrite
- Waitearikí Ignimbrite
- Ignimbrite, other
- Minden Rhyolite
- Fractured rock - other
  - Otawa Andesites

Groundwater quantity (Western Bay of Plenty District Council, July 1999):

- an additional 5000 m^3/day is required in the zone in the next 20 years
- ignimbrites are identified as potential sources of groundwater
- groundwater discharges in bores of greater than 15 L/s are observed
- bore depths are typically less than 50 m near the coast
- bore depths are typically less than 200 m near the foothills

Groundwater quality (Western Bay of Plenty District Council, July 1999):

- some well waters have elevated concentrations of: arsenic, boron, iron and manganese above Ministry of Health MAV or aesthetic determinands.

Western Bay of Plenty District Council are currently (Williams et al. 2005) a groundwater supply for Te Puke.

3.1.1.2 Central Supply Zone

Geographic area: Kaimai to Omokoroa, comprising:

- Kaimai
- Ohauiti and Ngapeke
- Minden
- Te Puna
- Omokoroa

Table 5. Population trends, Western Bay of Plenty District, Central Supply Zone.

Population[1]		Population change 2001-2021	
2001	**2021**	**Number**	**Percent**
6,304	16,328	10,024	159

[1] Western Bay of Plenty District Council (2003). These figures are the population connected to district water supplies. Note that the statistical basis for the figures in this table differ from the Statistics NZ figures in Table 2.

Names of aquifers used for water supply:

- Waiteariki Ignimbrite
- Aongatete Ignimbrite
- Minden Rhyolite

Groundwater quantity (Western Bay of Plenty District Council, November 2000):

- drilling has commenced for a new water supply for Omokoroa
- well yields are typically 1 - 7 L/s
- bores are typically 100 m to greater than 300 m deep near the coast and 100 – 200 m deep in the foothills.
- Groundwater quality (Western Bay of Plenty District Council, November 2000):
- boron concentrations are typically less than 0.3 mg/L
- arsenic concentrations are typically less than 0.01 mg/L
- chloride concentrations are typically less than 250 mg/L
- sodium concentrations are typically less than 200 mg/L
- elevated chloride or sodium concentrations occur in coastal bores in the Omokoroa area
- elevated iron concentrations occur in some areas

3.1.1.3 Western Supply Zone

Geographic area: Katikati to Waihi, comprising:

- Aongatete
- Katikati
- Tahawai
- Pios Beach
- Island View
- Athenree
- Waihi Beach

Table 6. Population trends, Western Bay of Plenty District, Western Supply Zone.

Population[1]		Population change 2001-2021	
2001	**2021**	**Number**	**Percent**
9,586	14,035	4,449	46

[1] Western Bay of Plenty District Council (2003). These figures are the population connected to district water supplies. Note that the statistical basis for the figures in this table differ from the Statistics NZ figures in Table 2.

Names of aquifers used for water supply:

- Waitieariki Ignimbrite
- Aongatete Ignimbrite
- Minden Rhyolite

Groundwater quantity (Western Bay of Plenty District Council, October 1999):

- a new water supply for Katikati was planned
- well yields are typically 1 – 7 L/s
- wells are typically 100 – 200 m deep near the coast and greater than 300 m deep in the foothills

Groundwater quality (Western Bay of Plenty District Council, October 1999):

- boron concentrations are typically less than 0.3 mg/L
- arsenic concentrations are typically less than 0.01 mg/L
- chloride concentrations are typically less than 250 mg/L
- sodium concentrations are typically less than 200 mg/L
- elevated iron concentrations occur in some areas
- contaminated sites have been mapped in the area

3.1.2 Tauranga City Council

Tauranga City currently receives its water from surface sources.

City population trends

A 46% population growth is predicted for the district by Statistics NZ (Table 7) in the period 2001 to 2021.

Table 7. Projected population of Tauranga City.

Census 2001	Projected				Change 2001-2021	
	2006	2011	2016	2021	Number	Percent
93,300	107,900	117,400	126,600	135,800	42,600	46

[1]Figures are Statistics NZ medium-rate projections using the 2001 census as a base (Statistics NZ web site, October 2003).

The rate of growth over the 2001-2021 period is the third-largest projected medium-rate growth rate for any territorial authority in New Zealand.

Significant development is likely to continue in the rural hinterland of Tauranga (e.g. Bethlehem, Pyes Pa and Welcome Bay) and also on the coastal strip between Mt Maunganui and Maketu. More in-fill housing is expected as Tauranga City Council has allowed subdivision of smaller lots.

Population growth means increased demands for water. Tauranga City Council installed water meters in a programme that started in 2000 and was completed in 2003. Water meters were installed primarily to manage demand and increase efficiency.

The efficiency of water use has apparently increased since the council started installing water meters. For example water production was 400-450 L/person/day between 1995/96 and 1998/99. By 2002/03 water production had declined to around 325 L/person/day (Spier pers. comm. 2004).

Groundwater sources

Groundwater sources in the area (Gordon 2001; Briggs et al., 1996) include:

- beach sand deposits (Mount Maunganui-Papamoa)
- Papamoa Ignimbrite
- Waitekariki Ignimbrite
- Te Ronga Ignimbrite
- Minden Rhyolite
- Kopukairua Dacite

Groundwater is likely to be found in fractures in the ignimbrite, rhyolite and dacite. Groundwater is used in the area for domestic and agricultural supply. Hot water is taken from groundwater for heating and swimming pools. Most hot water wells are greater than 200 m deep and occur in the Otumoetai-Matua area of the city (Gordon 2001).

The council has investigated groundwater options for supply in a general sense (Tauranga District Council, December 1998) and for the Papamoa-Te Puke area (Tauranga District Council, July 1999). The coastal sand area was ruled out as a water supply because of the potential for saline intrusion. The area of Reid Road, south of Papamoa, was identified as a possible source of groundwater. Surface supplies sourced from the Western Bay of Plenty District are considered likely water sources for Tauranga in the future (Spier pers. comm. 2004). .

Tauranga water supply – future options

Tauranga City Council favours taking water from catchments in the Western Bay of Plenty District to meet future demand (Spier pers. comm. 2004). The headwaters of these catchments are mostly spring-fed streams rising from the Mamaku Ignimbrite.

3.1.3 Rotorua District Council

Groundwater is a significant water source for drinking water in the Rotorua District. Hamurana Springs, Taniwha Springs, Utuhina Springs and Waipa Springs are all supply drinking water to the district.

District population trends

The medium-rate Statistics NZ population projections for Rotorua District show an increase in population, to 72,300, in the period to 2021 (Table 8).

A Rotorua District Council assessment of population growth (Rotorua District Council, March 2001) indicated an annual growth rate of 0.5%. The Statistics NZ projection of an 8% total growth to 2021 (Table 8) is equivalent to a 0.4% compounding annual growth rate which is a little less than the low-growth forecasts of Rotorua District Council in 2001.

Low-growth projections for three water supply zones (Rotorua District Council, March 2001; Table 9) indicate that the Eastern Zone will have the faster population growth rate.

Table 8. Projected population of Rotorua District.

2001(Base) – 2021								
Territorial Authority	**Variant(1)**	**Projected Population at 30 June**					**Change 2001-2021**	
		2001(2)	**2006**	**2011**	**2016**	**2021**	**Number**	**Percent**
Rotorua District	Medium	66,900	68,700	70,100	71,300	72,300	5,500	8

(1) The medium growth projection given fertility, mortality and migration assumptions.
(2) These projections have as a base the estimated resident population at 30 June 2001.

Table 9. Projected rates (low-growth) in Rotorua District (Rotorua District Council, March 2001).

Supply Area	Growth rate (low-growth projections)
Eastern	0.8%
Central	0.3%
Ngongotaha	0.5%

The Council found that water sources were adequate for water supply to 2027, within the resource consents as of 2001, at these low-growth rates. Existing water supplies would be sufficient to 2062 within regional council limits of source availability. Total water demand is estimated as around 55,000 m^3/day in 2020 with low-growth rates.

3.1.3.1 Eastern Water Supply Zone

Estimated water use in this zone is such that the existing supply can supply sufficient water volumes until 2025, with the low-growth forecast (Table 9). It is estimated that the peak day demand will be around 9000 m^3/day in 2020.

3.1.3.2 Central Water Supply Zone

Projected peak day demand is estimated as around 38,000 m^3/day in 2020 with the low-growth forecast (Table 9). Rotorua District Council, March 2001 recommended bringing water from another area because the 2001 consented quantity was being fully used in the central water supply zone. The Ngongotaha water supply connection to the Central Supply is intended to solve this problem.

3.1.3.3 Ngongotaha Water Supply Zone

The Ngongotaha supply (Taniwha Springs) was projected in 2001 (Rotorua District Council, March 2001) to supply sufficient water volumes until 2064 at low population growth rates. Rotorua District Council (March 2001) estimated that peak daily water demand in 2020 would be around 5,000 m^3/day.

3.1.4 Whakatane District Council

Population trends

The medium-rate Statistics NZ population projections for the Whakatane District show a minor decline in population between 2001 and 2021 (Table 10).

Currently the Whakatane and Ohope Beach areas are increasing in population (Selvaratnum pers. comm. 2005) – these areas may increase in population by 10% in the next 20 years.

Modest declines in the rural population are predicted to continue in the next two decades.

Table 10. Projected population of Whakatane District.

2001(Base) – 2021								
Territorial Authority	**Variant(1)**	**Projected Population at 30 June**					**Change 2001-2021**	
		2001(2)	**2006**	**2011**	**2016**	**2021**	**Number**	**Percent**
Whakatane District	Medium	34,000	34,200	34,000	33,800	33,500	-500	-2

(1) The medium growth projection given fertility, mortality and migration assumptions for each area.
(2) These projections have as a base the estimated resident population at 30 June 2001.

Notes: All derived figures have been calculated using data of greater precision than published.
Owing to rounding, individual figures may not sum to give the stated totals.

3.1.4.1 Water supply

Currently 10 water supply schemes are operated by the Whakatane District (Whakatane District Council, 2003a). Ohope is supplied from the Whakatane scheme and Edgecumbe is supplied from the Rangitaiki Plains scheme.

Scheme	**Water source**
Whakatane	River
Ohope	Whakatane scheme
Rangitaiki Plains	Braemar Springs and bores
Edgecumbe	Rangitaiki Plains scheme Braemar Springs and Johnstone Road Bores
Rangitaiki Plains scheme	
Taneatua	Bore

Matata	Spring
Murupara	Bore
Waimana	Bore
Te Mahoe	Bore
Ruatoki	Bore

The annual water use by these schemes in 2002/2003 was approximately 5 million m^3/yr. Annual use by each scheme is as follows:

Scheme	**Water use (000 m^3)**
Whakatane	2,094 (including Ohope)
Ohope	378
Rangitaiki Plains	1,940 (including Edgecumbe)
Edgecumbe	307
Taneatua	211
Matata	113
Murupara	534
Waimana	22
Te Mahoe	n/a
Ruatoki	148

It is expected that the demand for water will increase in the Whakatane/Ohope area; it is estimated that water demand will rise to 10% above current water demand by 2021. Population is expected to decline in other areas of the district so it is likely that the demand for water will also decline. The current water supply system is suitable for meeting future demands. Two improvements to the system were proposed:

- Matata – improving the water supply line
- Rangitaiki Plains – replacing the Te Teko and Te Mahoe and part of the Braemar spring water source with water from the Matahina Dam. Water from the Matahina Dam could supply Edgecumbe, Te Tako, Te Mahoe and Awakeri extension. The current Te Mohoe and Te Teko sources will close should this scheme be built. The Rangitaiki Plains scheme will take approximately 50% of its water from the Matahina source with the remaining 50% coming from Braemar spring.

Groundwater quantity

There are no problems with groundwater availability for the current schemes.

Groundwater quality

Arsenic has been recorded in the Braemar Spring supplying the Rangitaiki Plains water supply (Selvaratnam pers comm. 2004). This is one reason that a supply from the Matahina Dam is being considered.

Coliform bacteria have been reported in water samples from a well at Te Teko and in Braemar springs after heavy rain.

3.1.5 Kawerau District Council

Kawerau District Council takes water for municipal supply from (Environment Bay of Plenty 1999b):

- Tarawera Park bore field;
- Holland Spring; and
- Pumphouse spring.

3.1.6 Opotiki District Council

Opotiki District Council takes groundwater for Opotiki municipal supply (Environment Bay of Plenty 1999b) from:

- Otara Road (two bores); and
- Woodlands Road bore.

Opotiki township obtains approximately 80% of its municipal water from a dam on the Otara River (Opotiki District Council pers.comm.) Groundwater supplies approximately 20% of Opotiki township municipal water.

3.2 Agriculture

Horticulture has the largest number of consents and largest allocation in the Bay of Plenty region. (Table 11). Environment Bay of Plenty sums groundwater allocation by surface catchment.

The five surface catchments with the largest allocation of groundwater for horticulture are:

- Kaituna;
- Rangitaiki;
- Tauranga Harbour;
- Tarawera;
- Waihi.

The five surface catchments with the largest allocation of groundwater for pasture irrigation are:

- Kaituna;
- Waihi Estuary;
- Whakatane;
- Rangitaiki;
- Galatea

Table 11. Groundwater allocation for agriculture by surface water catchment, Bay of Plenty region.

Surface catchment*	Type of use consent		Number of consents	Sum of allocation (m^3/week)
Aongatete	irr	hort	27	28,410
Galatea	irr	hort	1	1,750
	irr	pasture	1	5,362
Kaituna	irr	hort	100	187,785
	irr	pasture	3	72,450
Kopurereua	irr	hort	18	21,235
Mangawai	irr	hort	5	9,072
Matakana Island	irr	hort	6	10,059
Mt Maunganui	irr	hort	4	8,911
Ohiwa	ag	ag	1	319
Otara	irr	hort	2	2,422
Papamoa	irr	hort	2	3,297
	irr	pasture	1	1,050
Pikowai	irr	hort	1	655
Rangitaiki	irr	hort	26	68,568
	irr	pasture	1	12,600
	ag	ag	1	1,400
Rotorua	irr	hort	6	8,036
	irr	pasture	1	2,800
Tarawera	irr	hort	16	53,935
	irr	pasture	2	3,150
Tauranga Harbour	irr	hort	37	56,181
Te Puna	irr	hort	17	16,850
Tuapiro	irr	hort	9	11,445
Uretara	irr	hort	15	24,248
Waiau	irr	hort	10	16,450
Waiaua	irr	hort	1	735
Waihi Estuary	irr	hort	33	46,589
	irr	pasture	2	40,103
Waimapu	irr	hort	40	45840
Wainui	irr	hort	4	5873
Waioeka	irr	hort	7	3616
Waitahi	irr	hort	5	4204
Waipapa	irr	hort	12	16261
Wairoa	irr	hort	31	45814
Waitahanui	irr	hort	7	8127
Welcome Bay	irr	hort	11	16317
Whakatane	irr	hort	14	11869
	irr	pasture	1	14000
	ag	ag	4	4012
Unknown	irr	hort	1	1575

***Note:** Environment Bay of Plenty does not yet have boundaries for aquifer systems in their GIS system. Therefore groundwater allocation for agriculture is summed by surface water catchment.

irr - allocation for irrigation
hort - horticultural land use
pasture - pasture irrigation

3.3 Commerce and industry

Commercial and industrial groundwater use is consented in its own right or takes water from municipal supplies. Nine aquifer systems have groundwater allocated to commercial and industrial users, and groundwater allocated to municipal use (Table 12).

Table 12. Groundwater allocated to industrial and municipal use.

GNS aquifer name	Industrial and part municipal[1] allocation (m^3 / week)
Mamaku Plateau	256774
Matahina Ignimbrite	84000
Galatea Plain	35000
Opotiki Plain	22960
Rangitaiki Plains (assumes shallow system)	16135
Waihi Beach Rhyolite	11158
Rotorua GW	4214
Tauranga Harbour GW	3185
Waitepariki Ignimbrite	3108

[1] this assumes 24% of municipal allocation is used by commerce or industry.
Note that the allocation data of Lincoln Environmental (2000) is used with the aquifer boundary map of White (2001).

Commercial and industrial groundwater use includes:

- food processing;
- milk processing;
- abattoir;
- sale yard;
- quarrying;
- fish farming;
- bottling of drinking water;
- dust abatement;
- cooling;
- ornamental ponds;
- groundwater remediation.

4.0 FUTURE TRENDS IN DEMAND

White et al. (2004) estimate water allocation in the Bay of Plenty, based on the water consents in 1999 (Lincoln Environmental 2000), totalling 5,309,938 m^3 / week, Table 13. Groundwater allocation is an estimated 1,551,571 m^3/week.

Groundwater allocation in 2004 (Environment Bay of Plenty, 2004) was 2,776,926 m^3/week. Differences of Lincoln Environmental (2000) allocation data and allocation data of (Environment Bay of Plenty, 2004) are not assessed in this report. The following analyses use the data of Lincoln Environmental (2000).

Table 13. Consented water allocation in the Bay of Plenty (White et al., 2004), m3/week.

Type	**Source**	
	Surface Water	**Groundwater**
Domestic	1,555,462	621,506
Industrial	964,626	41,537
Irrigation	1,238,279	888,528
Sum	3,758,367	1,551,571
Total, surface water and groundwater	5,309,938	

Future trends in municipal, agricultural and commercial groundwater use to 2021 are discussed in this section of the report.

4.1 Municipal and domestic

Future trends of water demand in districts and cities are based on a summary of projected future population trends (Table 14). Clearly, the largest growth in the Bay of Plenty region is predicted for Western Bay of Plenty and Tauranga City. Population declines are predicted for Whakatane and Kawerau. In spite of the projected population decline, Whakatane District Council is predicting a 10% increase in water use in the next 20 years (Section 3.1.4).

Domestic, non-municipal supply, water use will increase where the population is increasing. Non-municipal supplies include individual water supplies from streams and groundwater. The areas of the Bay of Plenty region where the water use, by individual supplies, will increase will largely be associated with conversion of rural land to lifestyle blocks and intensification of rural land use (Section 4.2).

Table 14. Future population trends for districts and Tauranga City to 2021.

District	Projected population growth 2001-2021	
	Numbers	**%**
Western Bay of Plenty:		
• Eastern Supply Zone	6,540	62
• Central Supply Zone	10,024	159
• Western Supply Zone	4,449	46
Tauranga City	42,600	46
Rotorua	5,500	8
Whakatane	-500	-2
Kawerau	-1,900	-25
Opotiki	900	10

Table 15. Predicted trends in municipal groundwater use to 2021.

	Total weekly allocation (m^3/week)	**Growth in use to 2021[1] (m^3/week)**
Mamaku Plateau	260,624	9,591
Rangitaiki Plains (assumes shallow system)	129,682	0
Matahina Ignimbrite	91,798	0
Waitearikiri Ignimbrite	45,970	9,727
Opotiki Plain	31,962	1,470
Galatea Plain	28,728	0
Upper Tarawera GW	3,675	0
Rotorua GW	2,226	82
Whakatane GW	1,400	64
Waihi Beach Rhyolite	987	209
Tarawera GW	763	0
Waiotahi GW	280	0

[1] The growth is use = allocation*0.46*population growth (Table 14).

The use of groundwater for municipal supply to the year 2021 (Table 15) is predicted with:

- Current allocation, by aquifer (Table 15);
- an assumed 46% of municipal allocation is used;
- population growth estimates to 2021 (Table 14).

This calculation does not consider new groundwater developments. For example a council may want to abstract from groundwater because surface water is declining in quality. In particular this analysis underestimates the effects of an increase in demand of groundwater in the Tauranga City and Western Bays District areas.

4.2 Agriculture

National agricultural statistics, and projections and future predictions are summarised by Ministry of Agriculture and Forestry (2003). Twelve tables of selected statistics listed in Appendix 3 summarise national projections of production, animal numbers, land use etc. in the period 2002 to 2007. Two tables in Appendix 3 (taken from Ministry of Agriculture and Forestry, 2003) summarise land use in the period 1990-2003.

Stock numbers in the Bay of Plenty in the period 1994 to 2003 (Davison, pers. comm.2004) are summarised in Appendix 4.

The trends observed in these data are:

1. Sheep numbers

   Sheep numbers are declining, nationally and in the Bay of Plenty, over time. A linear trend on Bay of Plenty sheep numbers between 1995 and 2003 has numbers declining by an average of 28,000 per year. This rate of decline is unlikely to continue. MAF (2003) predicts a rise in national sheep meat production to 2007.

2. Beef numbers

   National beef numbers have shown a minor decline between 1990 and 2003 (Appendix 3). Beef numbers in the Bay of Plenty region have declined by 40,000 between 1995 and 2003. A linear trend of Bay of Plenty beef numbers has the stock number declining by an average of approximately 5,500 per year between 1995 and 2003. MAF (2003) predicts national beef production to increase by 40,000 tonnes between 2002 and 2007.

3. Dairy

   National dairy cow numbers have increased by about 1.9 million between 1990 and 2003 (Appendix 3). MAF predicts that milk production will increase from 13.9 million tonnes in 2002 to 16.8 million tonnes in 2007 (Appendix 3). Dairy cow numbers in the Bay of Plenty are also increasing (Appendix 4) with an increase of approximately 6,700 cows/year in the period 1995 to 2003. Should dairy cow numbers continue to increase at this rate then the region will have around 550,000 cows by 2020. Conversion of forestry to dairy will be a continuing pressure on land use in the region.

4. Deer

   The national deer numbers have increased by about 700,000 between 1990 and 2003 (Appendix 3) and MAF (2003) predicts that the total deer kill will increase from 456,000 head to 609,000 head between 2002 and 2007. However, stock numbers have been declining in the Bay of Plenty (Appendix 4) by an average of around 2000 head/year in the period 1995 to 2003. Should this trend continue then deer numbers will be an estimated 22,000 by 2020.

5. Poultry

   MAF (2003) predicts an increase in national poultry production from 135,000 tonnes in 2002 to 180,000 tonnes in 2007, a growth of 5% per year.

6. Pigs

   National pig-meat production is predicted to increase from 46,300 tonnes in 2002 to 54,400 tonnes in 2007 (MAF, 2003 and Appendix 3), or around 3% per year compounding.

7. Goats

   National goat numbers have declined from around 1 million in 1990 to 150,000 in 2003 (Appendix 3). Goat numbers in the Bay of Plenty have declined by an average of 1,000/year over the period 1995 to 2003 (Appendix 4). There will be no goat herds in the Bay of Plenty in 15 years should the trend of declining numbers continue at the 1995-2003 rate.

8. Kiwifruit

   National kiwifruit production is predicted by MAF (2003) to increase from 271,000 tonnes in 2002 to 300,000 tonnes in 2007, or about 2% per year compounding.

9. Forestry.

   National forestry production (roundwood and lumber) is predicted to increase from 24.8 million m^3 in 2002 to 30.7 million m^3 in 2007 (MAF, 2003 and Appendix 3). The land given to production forests has increased from around 1.3 million hectares in 1990 to around 1.9 million hectares in 2002 (MAF, 2003 and Appendix 3).

These trends are summarised as estimates of stock numbers and land use in 2021 (Table 16). Trends are taken from the 1994 to 2003 period, or the period of available data.

Table 16. Predicted trends in agriculture to 2021.

	Change in numbers or land area from 2001	**Assumptions**	**Possible trends in water use**
Sheep numbers	- 30%	The 33% decline in sheep numbers 1994-2002 will not continue at the same rate	Lower requirements for stock watering
Beef numbers	- 16%	The percentage decline of 8% 1994-2002 will continue at about the same rate	Lower requirements for stock watering
Dairy	+ 40%	The percentage increase of 20% 1994-2002 will continue at about the same rate	Increased requirements for irrigation
Deer	-16%	The decline in numbers of 8% 1994-2002 will continue at about the same rate	Lower requirements for stock watering
Poultry	+ 250%	Growth in poultry numbers continues at 5% per year compounding	Increased requirements for watering and processing
Pigs	+ 80%	Growth in pig numbers of 3% compounding	Increased requirements for watering and processing
Goats	- 75%	Goat number half about every 10 years	Lower requirements for stock watering
Kiwifruit	+ 50%	Growth in kiwifruit production of 2% per year, compounding	Increased requirements for irrigation, frost protection and processing
Forestry	Nil	Historic increases in the area of forestry land will be balanced by pasture conversions	Nil

Pressures on future land use, predicted from Table 16, will come from dairy, poultry, pigs and kiwifruit. Dairy and kiwifruit are two significant land uses in the region whose importance will probably increase and this will probably increase the demand for water over time.

4.3 Commerce and industry

Future demand for groundwater by industry is predicted (Table 17) assuming:

- 40% of commercial water allocation is used (White et al., 2004)
- commercial water use is 24% of municipal water allocation and 46% of this is used
- growth in groundwater use will be at the population growth rates in Table 13 above current use in Table 11.

A zero population growth is assumed for the Rangitaiki Plains (Matahina Ignimbrite and shallow system) and for the Galatea Basin.

Table 17. Predicted trends in commercial and industrial groundwater use to 2021.

Aquifer name	**Growth to 2021 m^3/week**
Mamaku Plateau	9,449
Matahina Ignimbrite	0
Galatea Plain	0
Opotiki Plain	1,056
Rangitaiki Plains (shallow system)	0
Waihi Beach Rhyolite	2,361
Rotorua GW	155
Tauranga Harbour GW	674
Waiteariki Ignimbrite	658

Modest growth of groundwater use by industry is predicted in six aquifer systems (Table 17). This calculation does not consider new groundwater developments. For example a council may want to abstract from groundwater for a new industry. In particular this analysis underestimates the effects of an increase in demand of groundwater in the Tauranga City and Western Bays District areas.

4.4 Summary

Usage pressures by the productive sector on groundwater in the Bay of Plenty region are summarised in Table 18. The aquifer names follow those of White (2001). An analysis of future groundwater demand for agriculture use from specific aquifers is slightly hampered because groundwater allocation to agricultural is by surface water catchments (Table 11). Surface catchment names are translated into aquifer names in Table 18 (for agricultural use) by assuming that groundwater will come from the most important aquifer in an area. This assumption does not consider that new groundwater sources may be discovered and that use in currently under-utilised groundwater supplies will increase.

Table 18. Summary of usage pressures on groundwater in the Bay of Plenty region to 2021.

Aquifer name	Pressures of increased use to 2021		
	Municipal	**Commercial**	**Agricultural**
Aongatete Ignimbrite	++	+	-
Waitearikiki Ignimbrite	++	+	-
Western Bay Rhyolite	++	+	-
Mamaku Plateau[1]	++	+	+
Matahina Ignimbrite	-	-	+
Pongakawa Breccia	-	-	++
Rangitaiki Ignimbrite	-	+	++
Rangitaiki Plains	-	-	++
Waihi Beach Rhyolite	++	+	++
Katikati Gravel	-	-	++
Maketu Pumice	-	-	-
Te Puke shallow	-	-	++
Opotiki	+	+	++
Galatea Basin	-	-	+

++ significant development pressure
+ mild development pressure
- very low, or nil, development pressure in the author's opinion, or aquifer not suitable for purpose
[1] significant development pressure on the Mamaku Ignimbrite for municipal use arises mainly from population growth in Tauranga; this city intends taking more water from spring-fed streams on the northern side of the Mamaku Plateau

5.0 ENVIRONMENTAL EFFECTS ON GROUNDWATER

Environmental issues associated with the groundwater resource are summarised as they relate to three components of the groundwater system as part of the hydrological cycle: groundwater recharge, the in-situ groundwater resource and groundwater discharge.

5.1 Groundwater recharge

Groundwater recharge to an aquifer may occur from rainfall through the soil, from surface water bodies (e.g. rivers and lakes) or from other aquifers.

5.1.1 Land use effects on groundwater quantity

Land use may impact on the quantity of groundwater recharge. For example Selby (1970) found that infiltration rates near Kaharoa under pasture were lower than under forest on yellow-brown pumice soil. Watson et al. (2004) calculated rainfall recharge under a forest and pasture in Canterbury from 1938 mm of rainfall, finding:

- 148 mm of rainfall recharge under a forest (8% of rainfall)
- 450 mm of rainfall recharge under pasture (23% of rainfall)

White et al.(2003) measured rainfall recharge in 1999 and 2000 in the range of 26% to 37% at four Canterbury locations in pasture soils.

5.1.2 Land use effects on groundwater quality

Groundwater quality may be impacted by land use. For example, Close, et al. (2004) estimated mean nitrate – N fluxes in groundwater recharge under an irrigated Canterbury dairy farm of 38.8 to 60.6 kg N ha^{-1} yr^{-1}. Mean nitrate-N concentrations were measured in the range 8.8 to 15.5 g m^{-3}.

"Pristine" oxidised groundwater is estimated to have an upper limit (95^{th} percentile) nitrate – nitrogen concentration of 3.5 g m^{-3} (Daughney and Reeves 2003). Burden (1980) suggests that nitrate – nitrogen concentrations above 1 g m^{-3} do not occur naturally in New Zealand groundwater.

5.2 Groundwater residence time

The residence time of groundwater is typically many decades or centuries in New Zealand (Stewart and Morgenstern 2001). Therefore groundwater pollution that enters an aquifer may reside in the aquifer for a considerable period. An understanding of the residence times for groundwater resources is important to understand the time lag between policy decisions on land use and effects on groundwater.

5.3 Groundwater discharge

5.3.1 Groundwater use – drinking water supplies

Groundwater is a significant source of drinking water for human (Davies 2001) and animal populations. Groundwater is obtained from bores and springs for public water supply. Many rural households have a well that supplies drinking water. Sinton (2001) describes four categories of pathogens carried by water:

- viruses
- bacteria
- protozoans
- helminths

Elevated concentrations of nitrate-nitrogen are also of concern to human drinking water (Davies, 2001). Arsenic and manganese are also potentially significant to human health; these are naturally occurring.

Proposed drinking water standards require risk assessment of sources waters and better protection of sources waters if raw water is going to be used as a drinking water supply with little treatment.

5.3.2 Groundwater surface water interaction

Groundwater can discharge to lakes, streams, estuaries and springs. Often flow in groundwater provides the pathway for rainfall to enter surface water bodies. For example soils in the Lake Rotorua catchment are quite permeable and in many valleys there are no flowing streams so recharge travels to the lake via the groundwater system. Recharge to groundwater flows vertically, or sub-vertically, downwards through the unsaturated zone and then horizontally, or sub-horizontally to a receiving surface water body. The effects of land use (e.g. nutrients) are carried with this water.

Many of the streams in the Western Bay of Plenty have high baseflow. This baseflow is commonly sourced from groundwater. For example streams in the Lake Rotorua catchment such as Hamurana Stream and Utuhina Stream derive most of their flow from springs.

Nitrate-nitrogen concentrations in streams flowing into Lake Rotorua are steadily increasing over time (Rutherford 2003) and this is ascribed to the delayed effects of land use. Receiving environments can be quite sensitive to nutrient concentrations in inflowing waters. For example, Lake Rotorua has considerable environmental problems with algal blooms. These blooms are probably associated with increasing nutrient inputs to the lake. However, nutrient input to the lake from streams is occurring at relatively low nitrate-nitrogen concentrations (less than a mean of 2 g m^{-3}; Rutherford, 2003).

The interaction between surface water and groundwater is quite dynamic. For example,

streams may recharge groundwater in one reach of a river and then discharge groundwater in another. Excess groundwater pumping may cause springs to dry up and may also induce recharge from surface water bodies. An understanding of the physical hydrology is required to determine the effects of pumpage on surface water bodies, and to determine the effects on groundwater quality of induced recharge from surface water.

Eutrophication of streams, springs and estuaries is consistently associated with increased biomass (e.g. weed) in the receiving waters. Toxic algal growth can occur in more advanced cases of eutrophication; these can kill fish, and are of concern to human health because of contact recreation and drinking water supply.

5.3.3 Salt water intrusion

Groundwater abstraction may cause groundwater levels to be drawn down to below sea level. This may cause salt water to move towards a well in coastal aquifers. Salt water intrusion has been observed at Omaha (Auckland), Motueka and Marlborough. Examples of salt water intrusion in New Zealand generally occur where aquifers are thin (i.e. groundwater storage is low) and aquifers are adjacent to the coast or estuary. Salt water intrusion has not been permanent and reduction in pumpage, moving wells (Motueka) and restricting groundwater abstraction to a sustainable limit (Omaha) have managed these problems.

Salt water intrusion has been addressed for the Kauri Point Aquifer (Bay of Plenty Catchment Board and Regional Water Board, undated) and the warm Tauranga aquifer.

There was a moratorium on consents for the warm Tauranga aquifer in the early 1990s to prevent over-drawing the aquifer (Gordon pers. comm.).

6.0 ENVIRONMENT BAY OF PLENTY CURRENT PRIORITIES

Environment Bay of Plenty has a 'Proposed Regional Water and Land Plan'. This plan makes mention of the groundwater resource in a significant number of issues, policies and objectives (Appendix 5). Current Environment Bay of Plenty priorities, as regards groundwater, are embodied in the key section headings of the plan:

- integrated management of land and water;
- discharges to water and land;
- allocation;
- wetlands;

Groundwater-specific priorities in the plan can be summarised as:

- Groundwater quality;
    - protection of municipal supplies;
    - protection of the recharge areas of lakes, estuaries etc;
    - mitigation of land use effects on groundwater;
    - protection of high quality groundwater;
    - improvement of degraded groundwater;

- Groundwater resources;
    - sustainable yield;
    - investigations;
    - monitoring and groundwater data quality;
    - groundwater-surface water interaction;

- Education.

7.0 GAPS ANALYSIS

Information in four categories is required to understand groundwater sustainability (Appendix 6):

- Geology;
- Groundwater quantity;
- Groundwater quality;
- Groundwater management.

The data and models are required in 51 categories of information (Appendix 6). This list, although it does seem forbidding, forms a useful template for future investigations in the Bay of Plenty region.

The level of information about aquifers in the Bay of Plenty region (Table 19) is qualitatively assessed in the five major categories (above) using a four-rank scale:

0 - no information collected
1 - some information collected but no modelling done
2 - some modelling done, or underway
3 - modelling completed

This ranking is the author's opinion, based on published information obtained as part of this review. These rankings aim to give an overall picture about the current state of knowledge of Bay of Plenty aquifer systems. Some current and historic work on resource consents has modelled specific sections of aquifers. For example, groundwater drawdown in a well about 3 km south of Te Puke is calculated after 20 years of pumping (Western Bay of Plenty District Council, October 2000). This does not assess the sustainability of the pumping because the cumulative effects and ultimate resource sustainability of the aquifer are not addressed.

Current knowledge for groundwater management is assigned a value '1' in Table 19 because Environment Bay of Plenty has a consents database.

Generally, Table 19 shows some progress has been made in deriving geological models for most aquifer systems. Groundwater quantity and groundwater quality are poorly understood in the region. Groundwater management information is poorly developed in the region.

An assessment of general groundwater gaps in the Bay of Plenty region is contained in Lowry et al. (2001).

Table 19. Status of current information and models of Bay of Plenty aquifers.

Aquifer	Geological model	Groundwater quantity	Groundwater quality	Groundwater management	Sum
Aongatete Ignimbrite	2	1	1	1	5
Waitearikiki Ignimbrite	2	1	1	1	5
Western Bay Rhyolite	2	1	1	1	5
Mamaku Ignimbrite	2	1	1	1	5
Matahina Ignimbrite	0	0	0	1	1
Rangitaiki Ignimbrite	1	1	1	1	4
Rangitaiki Plains	2	1	1	1	5
Katikati Gravel	1	1	1	1	4
Mt Maunganui sand	1	1	1	1	4
Matakana Island sand	0	0	0	1	1
Maketu warm water	1	0	0	1	2
Maketu Pumice	1	0	0	1	2
Te Puke shallow	1	1	1	1	4
Opotiki Plains	0	0	0	1	1
Galatea Plains	1	1	1	1	4

8.0 INVESTIGATION PLAN

The current groundwater information (Table 19) is compared with usage pressures on groundwater in the Bay of Plenty region to 2021 (Table 17) to identify and rank the investigation needs and aquifer systems. This ranking is then used to identify priorities (high, medium, low) for investigation and to outline an investigation plan.

8.1 Investigation needs

Future groundwater investigation needs are assessed from future pressure on the resource and the level of current information about aquifer systems. The number of crosses in Table 18 summarises pressure on resource; current information on the resource is taken as the sum in Table 19.

Table 20. Future groundwater investigation needs.

Aquifer	Information Status[1]	Pressure on resource[2]	Investigation needs[3]
Aongatete Ignimbrite	5	3	High
Waitеariki Ignimbrite	5	3	High
Western Bay Rhyolite	5	3	High
Mamaku Ignimbrite	5	3	High
Matahina Ignimbrite	1	1	Low
Rangitaiki Ignimbrite	4	3	High
Rangitaiki Plains	5	2	Medium
Katikati Gravel	4	2	Medium
Mt Maunganui sand	4	0	Low
Matakana Island sand	1	0	Low
Maketu warm water	2	0	Low
Maketu pumice	2	0	Low
Te Puke shallow	4	2	Medium
Opotiki Plain	1	4	High
Galatea Plain	4	1	Medium

[1] Sum of scores in Table 19

[2] Sum of plus signs in Table 18

[3] High = usage pressure 4 or greater
Medium = some usage pressure and some resource in formation
Low = low usage pressure and generally low resource information

8.2 Summary of plan for the next five years

The summary plan aims to provide basic information about all aquifers in the region. This summary plan also aims to bring information in the aquifers with a high priority for investigations (Table 20) to the following information status (Table 19):

- Geological model 3
- Groundwater quantity 2
- Groundwater quality 2
- Groundwater management 2

No timeline is assigned to components of the plan in this report. This detail will be developed in a future project.

8.2.1 Basic information on all aquifers

The aquifer nomenclature of Bay of Plenty aquifers used by White (2001) and Gordon (2001) does not include all actual, or potential, aquifers in the region. Therefore the first priority is to identify these, estimate geographical boundaries, describe the type of aquifer and summarise usage of the resource.

8.2.2 High priority aquifers

The aquifers with a high priority for investigation (Table 20) are:

- Aongatete Ignimbrite;
- Waitеariki Ignimbrite;
- Western Bay Rhyolite;
- Mamaku Ignimbrite;
- Rangitaiki Ignimbrite;
- Opotiki Plain.

Investigations should aim to complete the following in each high priority aquifer:

- geological model, items 1 to 11 in Appendix 6. Geological investigations may include drilling;
- groundwater quantity, items 12 to 30 in Appendix 6;
- groundwater quality, items 31 to 40 in Appendix 6;
- groundwater management, items 43 to 46 in Appendix 6.

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APPENDIX 1 - EBOP GROUNDWATER REVIEW CONTRACT

Scope and nature of the services

This contract agreement and the project brief form the basis of the contract agreement. The Institute of Geological and Nuclear Sciences (IGNS) will conduct a review of the current state of knowledge of groundwater in the Bay of Plenty region in collaboration with regional council staff. This review will summarise current information, will identify gaps in the knowledge about water supply from groundwater and will make recommendations for a medium-term programme of investigation and data collection that is aimed at having sufficient information for sustainable management of the groundwater resources in the region. The programme aims to quantify the groundwater resource in the region. Information needs will be prioritised according to four major criteria:

1. Productive use of groundwater;
   - current use,
   - future growth in:
     a) population and domestic use; b) agricultural use; and c) commercial use.
2. Existing information about aquifer systems including the low temperature non volcanic geothermal resources (e.g. Tauranga geothermal field)
   - geology,
   - hydrology,
   - interactions of cold groundwater with geothermal reservoirs
3. Groundwater quality for; a) domestic use; b) agricultural use and c) commercial use.
4. Environmental values e.g., a) saltwater intrusion; and b) land use effects and receiving environments.
5. Environment Bay of Plenty current priorities as outlined in regional resource management and strategic plans.

Gaps Analysis

The review will identify the gaps in our current information about the resource and gaps in monitoring of the resource. These gaps will be summarised by aquifer and by type, with comment.

Investigation Plan

A simple ranking system will be used to identify the aquifer systems that have the greatest needs for investigation. This ranking of needs will then be compared with the status of current information to recommend an investigation plan for groundwater in the Environment Bay of Plenty region in the next five years.

Reporting

Two reports will be produced: an interim draft report and final report. The final report will outline the methods used, data sources, reference list, and recommendations. Three copies of the report shall be provided and an electronic copy in either MS word (Version 6.0 or greater).

APPENDIX 2 - POPULATION PROJECTIONS, BAY OF PLENTY REGION.

Table A2.1 Projected population of the Bay of Plenty region and New Zealand (Statistics New Zealand web site October 2003).

2001(Base) - 2021								
Regional Council	Variant[1]	Projected Population at 30 June					Change 2001-2021	
		2001[2]	2006	2011	2016	2021	Number	Percent
Bay of Plenty Region	High	246,900	274,200	295,500	316,300	336,900	90,000	36
	Medium		267,200	281,300	294,600	307,700	60,800	25
	Low		260,100	267,400	273,900	279,900	33,000	13
New Zealand	High	3,880,500	4,192,000	4,416,900	4,634,300	4,850,100	969,600	25
	Medium		4,109,300	4,248,300	4,378,600	4,505,900	625,400	16
	Low		4,026,600	4,086,200	4,136,500	4,181,100	300,600	8

(1) There are three alternative projection series incorporating different fertility, mortality and migration assumptions for each area.

(2) These projections have as a base the estimated resident population of each area at 30 June 2001.

Notes: All derived figures have been calculated using data of greater precision than published.
Owing to rounding, individual figures may not sum to give the stated totals.

Table A2.2. Projected population of territorial authorities in the Bay of Plenty region (Statistics New Zealand web site October 2003).

2001(Base) - 2021								
Territorial Authority	Variant[1]	Projected Population at 30 June					Change 2001-2021	
		2001[2]	2006	2011	2016	2021	Number	Percent
Western Bay of Plenty District	High	39,300	44,200	49,000	53,800	58,500	19,200	49
	Medium		43,100	46,700	50,200	53,600	14,300	36
	Low		41,900	44,300	46,700	48,900	9,700	25
Tauranga District	High	3,300	111,400	124,600	137,500	150,600	57,400	62
	Medium		107,900	117,400	126,600	135,800	42,600	46
	Low		104,300	110,400	116,100	121,800	28,500	31
Rotorua District	High	66,900	70,100	72,900	75,400	77,900	11,000	17
	Medium		68,700	70,100	71,300	72,300	5,500	8
	Low		67,400	67,500	67,400	67,100	200	0
Whakatane District	High	34,000	34,800	35,400	35,800	36,200	2,200	6
	Medium		34,200	34,000	33,800	33,500	-500	-2
	Low		33,500	32,800	31,900	30,900	-3,100	-9
Kawerau District	High	7,300	7,000	6,700	6,300	6,000	-1,300	-18
	Medium		6,900	6,400	5,900	5,400	-1,900	-25
	Low		6,700	6,100	5,500	4,900	-2,400	-33
Opotiki District	High	9,500	10,100	10,500	11,000	11,500	2,000	20
	Medium		9,800	10,000	10,300	10,500	900	10
	Low		9,600	9,600	9,500	9,500	0	0

(1) There are three alternative projection series incorporating different fertility, mortality and migration assumptions for each area.

(2) These projections have as a base the estimated resident population of each area at 30 June 2001.

Notes: All derived figures have been calculated using data of greater precision than published.
Owing to rounding, individual figures may not sum to give the stated totals.

Table A2.3. Projected population changes of territorial authorities in the Bay of Plenty region (Statistics New Zealand web site October 2003).

Medium Series
2001(Base) - 2021

Territorial Authority	Year[1)]	Population by Age Group (Years) at 30 June				Population Change by Age Group (Years), Five Years Ended 30 June				Components of Population Change, Five Years Ended 30 June				Median Age[(2)] at 30 June
		Under 15	15-64	65+	All Ages	Under 15	15-64	65+	All Ages	Births	Deaths	Natural Increase	Net Migration	
		(Thousand)												(Years)
Western Bay of Plenty	2001	9.5	24.2	5.6	39.3	…	…	…	…	…	…	…	…	38.9
District	2006	9.4	26.7	7.0	43.1	-0.1	2.5	1.4	3.8	2.4	1.6	0.8	3.0	41.4
	2011	9.2	29.0	8.5	46.7	-0.2	2.3	1.5	3.6	2.4	1.8	0.6	3.0	43.5
	2016	9.3	30.5	10.3	50.2	0.1	1.5	1.9	3.5	2.5	2.1	0.5	3.0	45.3
	2021	9.7	31.6	12.3	53.6	0.4	1.1	1.9	3.4	2.8	2.4	0.4	3.0	46.3
Tauranga	2001	20.3	57.0	15.9	93.3	…	…	…	…	…	…	…	…	37.8
District	2006	22.4	67.2	18.3	107.9	2.1	10.1	2.4	14.6	6.9	4.3	2.6	12.0	38.5
	2011	23.2	73.2	20.9	117.4	0.8	6.0	2.6	9.5	7.2	4.8	2.5	7.0	39.9
	2016	23.9	78.3	24.4	126.6	0.7	5.1	3.5	9.2	7.5	5.2	2.2	7.0	41.1
	2021	24.8	82.8	28.2	135.8	0.9	4.5	3.8	9.2	8.0	5.7	2.2	7.0	41.9
Rotorua	2001	17.3	42.6	7.0	66.9	…	…	…	…	…	…	…	…	32.8
District	2006	16.5	44.5	7.8	68.7	-0.8	1.8	0.8	1.9	5.3	2.5	2.9	-1.0	34.7
	2011	15.3	46.0	8.9	70.1	-1.1	1.5	1.0	1.4	4.9	2.6	2.4	-1.0	36.4
	2016	14.3	46.4	10.6	71.3	-1.0	0.4	1.7	1.2	4.9	2.7	2.2	-1.0	37.9
	2021	14.0	46.0	12.4	72.3	-0.4	-0.4	1.8	1.0	5.0	2.9	2.0	-1.0	39.1
Whakatane	2001	9.3	20.9	3.8	34.0	…	…	…	…	…	…	…	…	33.3
District	2006	8.4	21.5	4.2	34.2	-0.9	0.6	0.4	0.2	2.5	1.3	1.2	-1.0	35.7
	2011	7.5	21.9	4.7	34.0	-1.0	0.4	0.5	-0.1	2.2	1.3	0.9	-1.0	38.0
	2016	6.8	21.4	5.6	33.8	-0.7	-0.5	0.9	-0.2	2.2	1.4	0.8	-1.0	40.2
	2021	6.5	20.4	6.5	33.5	-0.3	-1.0	0.9	-0.3	2.2	1.5	0.7	-1.0	41.8

(1) These projections have as a base the estimated resident population of each area at 30 June 2001 and incorporate medium fertility, medium mortality and medium migration assumptions for each area.

(2) Half of the population is younger, and half older, than this age.

… Not applicable.

Notes: All derived figures have been calculated using data of greater precision than published.
Owing to rounding, individual figures may not sum to give the stated totals.

APPENDIX 3 - MINISTRY OF AGRICULTURE AND FORESTRY (2003): PROJECTIONS OF NATIONAL PRIMARY PRODUCTION, NATIONAL STOCK NUMBERS, AND NATIONAL LAND USE. SUMMARY OF NATIONAL STOCK NUMBERS AND LAND USE 1990-2003.

Note: Table numbers used in this appendix are those from the MAF (2003) report for ease of cross-referencing.

Table 3. Dairy situation and outlook

May Year	Units	2002	2003	2004e	2005f	2006z	2007z
Total milk produced	mil t	13.9	14.4	14.8	15.6	16.3	16.8

Table 4. Beef and veal situation and outlook

September Year	Units	2002	2003e	2004f	2005z	2006z	2007z
Beef production	000 t	554	633	623	618	598	594

Table 5. Sheep meat situation and outlook.

September Year	Units	2002	2003e	2004f	2005z	2006z	2007z
Production*	000 t	414	431	408	428	433	445

* Carcass weight

Table 6. Wool situation and outlook

June Year	Units	2002	2003	2004e	2005f	2006z	2007z
Production	000t clean	173	173	168	167	165	165

Table 7. Deer situation and outlook

June Year	Units	2002	2003e	2004f	2005z	2006z	2007z
Total kill	000 hd	456	528	557	522	555	609

Table 8. Poultry situation and outlook

September Year	Units	2002	2003e	2004f	2005z	2006z	2007z
Production (dressed weight)*	000t	135	144	152	161	170	180

*Production includes broiler chickens, roasting fowls, ducks and turkeys

Table 9. Pigmeat situation and outlook

September Year	Units	2002	2003	2004f	2005z	2006z	2007z
Production* (cw)	000t	46.3	48.3	50.5	51.7	53	54.4

* Includes an estimate for uninspected production

Table 12. Kiwifruit situation and outlook

March Year	Units	2002	2003	2004e	2005f	2006z	2007z
Production	000t	271	248	261	272	296	300

Table 13. Apples situation and outlook

September Year	Units	2002	2003e	2004f	2005z	2006z	2007z
Total production	mil ctn*	29.5	27.8	30.2	30.3	30.4	30.7

* Carton weight = 18 kg

Table 16. Logs and lumber situation and outlook

March Year	Units	2002	2003	2004e	2005f	2006z	2007z
Total roundwood	mil m3	20.9	23.1	21.9	22.5	25.4	25.8
Lumber	mil m3	3.87	4.31	4.43	4.49	4.86	4.94
		24.77	27.41	26.33	26.99	30.26	30.74

Table 25. Main classes of livestock

As at June	2001e	2002	2003e	2004f	2005z	2006z
Numbers (thousands)						
Total sheep	40,000	39,546	39,300	39,000	38,600	38,600
Total beef	4,790	4,495	4,340	4,170	4,060	3,910
Total dairy	4,850	5,162	5,290	5,420	5,520	5,600
Total deer	1,560	1,644	1,710	1,760	1,850	1,930
Stock units (millions)*						
Sheep	36.90	36.20	35.90	35.70	35.30	35.30
Beef	23.00	21.90	21.10	20.30	19.70	19.00
Dairy	31.10	32.70	33.50	34.30	35.00	35.50
Deer	2.94	3.13	3.25	3.38	3.55	3.69
Total^	94.10	94.00	93.90	93.80	93.70	93.60

* A stock unit is a measure used to compare the nutrition requirements of different pastoral livestock. For example, the standard stock unit is based on one breeding ewe of 55 kg liveweight producing one lamb. A dairy cow in calf equals seven stock units.

^ Includes goats

Table 26. Land use (thousand ha)

As at June	2002	2003e	2004f	2005z	2006z	2007z
Sheep	4160	4070	3990	3900	3820	3740
Beef	1924	1900	1870	1840	1820	1800
Dairy	2018	2030	2050	2060	2070	2080
Deer	370	380	390	402	413	423
Pastoral total	8472	8380	8290	8210	8120	8040
Forestry*	1814	1830	1850	1870	1890	1920

*National Exotic Forest Description (NEFD) survey results as at 1 April 2002 with projections for outyears.

The following tables list national stock numbers and national land use from MAF (2003) in the period 1990-2003.

Table 1. Selected indicators of farming activities - stock numbers

June Year	Sheep[1]	Dairy cattle[2]	Beef cattle[2]	Deer[3]	Pigs	Goats
1990	57,852,192	3,440,815	4,593,160	1,031,100	394,701	1,062,900
1991	55,161,643	3,429,427	4,670,569	1,220,400	407,306	792,577
1992	52,568,393	3,467,824	4,676,497	1,335,700	411,148	532,767
1993	50,298,361	3,550,140	4,757,962	1,235,100	395,117	432,720
1994	49,466,054	3,839,184	5,047,848	1,276,000	422,766	283,547
1995	48,816,271	4,089,817	5,182,508	1,222,900	431,004	336,812
1996	47,393,907	4,165,098	4,852,179	1,206,700	424,073	227,942
1997[4,5]	46,834,000	4,256,000	4,806,000	1,327,900	406,900	214,100
1998[4,5]	45,956,000	4,344,000	4,432,000	1,386,300	350,700	200,200
1999	45,679,891	4,316,409	4,643,705	1,413,400	368,887	186,390
2000[4,5]	42,845,000	4,599,000	4,670,000	1,494,200	368,800	173,400
2001[5]	40,010,000	4,846,000	4,791,000	1,553,300	354,500	163,400
2002	39,545,609	5,161,589	4,494,678	1,643,938	386,702	154,500
2003[5]	39,250,000	5,292,000	4,338,000	1,705,000	380,000	150,000

1. Collection date as at 30 June.
2. Collection date as at 31 January until 1970, thereafter as at 30 June.
3. Ministry of Agriculture and Forestry estimates 1988-2001 due to understating in Statistics NZ surveys.
4. Meant and Wool Innovation Economic Service's (MWIES) estimates for sheep and beef.
5. Ministry of Agriculture and Forestry (MAF) estimates.

Table 2. Selected indicators of farming activities - land use (hectares)

Years	Number of Farms	Grazing, arable fodder and fallow land	Land in horticulture[1]	Plantations of planted production forests	Other land[2]	Total land area in occupation
1990	80,904	13,813,547	87,843	1,304,240	2,283,768	17,489,398
1991	80,439	13,715,338	90,614	1,329,202	2,315,127	17,450,281
1992	79,666	13,910,570	89,659	1,335,174	1,965,043	17,300,446
1993	81,196	13,945,176	94,607	1,395,758	1,899,989	17,335,531
1994	69,460	13,535,699	103,789	1,488,083	1,479,399	16,606,969
1995	68,776	13,519,794	124,143	1,598,743	1,335,261	16,577,942
1996	66,045	13,265,431	122,988	1,683,216	1,475,479	16,547,113
1997	..	..	..	1,630,340	..	..
1998	..	..	..	1,678,943	..	..
1999[3]	80,376	13,863,279	..	1,730,765	1,221,103	..
2000[4]	..	..	128,712	1,768,638	..	..
2001	..	..	..	1,798,757	..	..
2002	70,000	11,966,953	109,577	1,878,818	1,684,999	15,640,348

1. For the years 1972 to 1982 inclusive, land in horticulture is included in other land.
2. Prior to 1987, significant tracts of land used for conservation or recreational purposes, and under the control of the New Zealand Forest Service and the Department of Lands and Survey, were included in the agricultural census. The re-organisation of these departments in 1997, enabled 3.5 million hectares of land to come under the control of the Department of Conservation and be excluded from subsequent agricultural surveys.
3. In 1999, the Agriculture Production Survey population was changed to all farm units on Agribase known to hold livestock or engage in gran/arable cropping. For a description of Agribase see www.maf.nz/statistics/Primaryindustries/Livestock/technotes.
4. In 2000, there were 14,175 units surveyed for the 2000 Horticultural Census.

… data not available

APPENDIX 4 - NEW ZEALAND LIVESTOCK CENSUS FOR THE BAY OF PLENTY REGION, 1994-2003 (DAVISON, PERS. COMM.)

Year	Sheep (000s)	Total Beef (000s)	Total Dairy (000s)	Total Deer (000s)	Total Goats (000s)	Sheep Stock Units (000s)	Beef Stock Units (000s)	Sheep & Beef Stock Units (000s)	Dairy Stock Units (000s)	Deer Stock Units (000s)	Goat Stock Units (000s)	Total SU (000s)
1994-95	655	184	368	92	26	597	909	1506	2345	167	17	4035
1995-96	651	183	397	83	22	593	909	1502	2518	150	15	4185
1996-97	560	164	418	68	18	512	816	1328	2649	126	12	4115
1997-98	547	159	428	64	15	501	790	1291	2704	118	10	4123
1998-99	545	160	416	58	13	496	790	1286	2621	108	9	4024
1999-00	516	147	399	55	12	472	729	1201	2502	100	8	3811
2000-01	464	143	433	65	13	429	705	1134	2710	118	8	3970
2001-02	445	143	441	68	15	409	702	1111	2745	124	10	3990
2002-03	439	144	435	73	15	400	686	1086	2697	131	10	3924
2003-04p												

APPENDIX 5 - POLICIES OF ENVIRONMENT BAY OF PLENTY RELEVANT TO THE GROUNDWATER RESOURCE.

A). Notes from Environment Bay of Plenty's 'Proposed Regional Water and Land Plan' (version 8, 4 May 2004, Environment Bay of Plenty web site).

"Environment Bay of Plenty has developed a Regional Water and Land Plan (RWLP) to integrate the management of land and water resources in the Region. Once operative, the RWLP will supersede the current Regional Land Management Plan, which contains provisions to manage land resources in the region. "

"The resources covered by the RWLP are;

- Soil (land) resources
- Rivers, streams, and modified watercourses that are part of land drainage schemes
- Lakes
- Wetlands
- Groundwater
- Geothermal resources (excluding the area covered by the Rotorua Geothermal Regional Plan)

The aims of the RWLP are to:

- Promote the sustainable management of land, water and geothermal resources.
- Achieve the integrated management of land, water and geothermal resources.
- Maintain or improve environmental quality in the Bay of Plenty region.
- Protect existing high quality environments, and sensitive receiving environments.
- Sustain the life-supporting capacity of soil, water and ecosystems.
- Maintain or enhance the ecological, Maori cultural, recreational, natural character and landscape values of land, water and geothermal resources.
- Establish appropriate environmental standards to achieve environmental aims.
- Address the adverse environmental effects of the use and development of land, water and geothermal resources.
- Allow for the use and development of land, water and geothermal resources where it is consistent environmental aims.
- Enable people and communities to provide for their social, economic and cultural wellbeing, while achieving environmental aims.
- Work with communities to promote community participation and interest in the management of natural and physical resources in the Bay of Plenty region."

B) Sections in the RWCP relevant to water supply for drinking water include the following:

Section 3

3.1 Issue 10, para 1	c1 f	-increased nutrient levels in waterways -increased faecal colifom
Issue 10, para 2	1	-land use and land management not suited to site
Issue 11, para 4	1	-degraded water quality in the Rotorua lakes
Issue 11, para 4	2e	-streams or rivers that are a source of municipal water supply
Issue 12, para 1		-adverse effects on groundwater quality
Issue 12, para 2		-causes of adverse effects

Section 3.2 Objectives

Objective 11	-water supply water quality classification for municipal water supply purposes
Objective 13	-high quality groundwater is protected
Objective 14	-degraded groundwater quality is improved
Objective 19A	-recognise beneficial effects of water use

Section 3.3 Policies

Policy 21e	-protect existing groundwater quality
Policy 21e (iv)	-protect groundwater quality in the recharge areas used for municipal water supply
Policy 22	-research and monitor the effects of land use….used for municipal water supply
Policy 23	-develop fair and equitable provisions in relation to existing land use where land use charge or land use restrictions are required to maintain or improve water quality
Policy 29c	-allow resource use and development where there are beneficial effects

Section 3.4 Methods

Method 23	-prioritise the promotion of sustainable land management…
Method 23c	-in the catchment of sensitive receiving environments, especially the Rotorua lakes…
Method 24	a, b, e, f, g, h, i, j

Method 3a	-determine if specific management measures are necessary to control activities in the catchments above municipal water supply surface water intakes in conjunction with district councils
Method 40	-address environmental issues on the property
Method 42	-regulatory measures to control nitrogen and phosphorus
Method 43	-restrict the use and development of land
Method 44	-use of permitted activity rules
Method 47	-require the improvement of groundwater quality
Method 51	-consider reviewing resource consents for point source discharges
Method 55	-assess the combined effects of discharges
Method 56	-investigate and clarify nutrient exports of different land uses
Method 56a	-key monitoring sites
Method 59	-undertake research
Method 60	-identify recharge zones for aquifers that are used for municipal supply and determine if specific management measures are necessary to control activities
Method 61	-identify areas where groundwater quality has been significantly degraded
Method 62	-bacterial levels that pose a risk to human health
Section 3.5	-paragraph 5, Table 2, NERM monitoring modules

C) This proposed plan makes significant mention of the groundwater resource.

Section 3	- regards integrated management of land and water
Section 4	- discharge to water and land
Section 5	- regards provisions to allocate surface water and groundwater
Section 8	- wetlands
Section 9	- regional rules
Section 11	- resource consents
Section 12	- Anticipated environmental results

Section 3.1

3.1 Para 2 (1)	- land use and discharge of nutrients to groundwater is a concern
3.1 Issue 12,	groundwater quality can be adversely affected by some use and development activities
3.1 Issue 12, para 2.	groundwater quality is particular concern where groundwater is used for municipal supply (e.g. Rotorua, Kawerau and Opotiki) and where groundwater feeds sensitive receiving environments (such as the Rotorua lakes, Tauranga and Ohiwa harbours).
3.1 Issue 15	changing land use can affect rainfall infiltration…. Which may affect surface and groundwater hydrology.
Objective 13	high quality groundwater is protected
Objective 14	degraded groundwater quality is improved

Section 3.3 Policies

Policy 21	protect existing groundwater quality including recharge areas of lakes, estuaries and harbours and recharge areas of municipal supplies.
Policy 22	research and monitor the effects of land use on surface and groundwater quality.
Policy 24	avoid, remedy or mitigate the effects of land use on the recharge areas of potable groundwater supplies.
Policy 28	develop and maintain accurate information on soil and water (including groundwater) in the region.
Method 34C	encourage appropriate irrigation rates to prevent transport of nutrients to groundwater.
Method 43	enables restriction of land use to protect groundwater quality.
Method 47	require the improvement of groundwater quality where degradation is due to identifiable human activities.
Method 48	requires drilling and bare records to be collected.
Method 57	NERMN monitoring.
Method 60	identify recharge zones for aquifers that are used for municipal supply.
Method 61	identify areas where groundwater has been significantly degraded.

Method 66C	identify and map aquifers with existing high quality groundwater and their recharge areas.
Section 3.5, para 5	NERMN monitoring for groundwater specified. para 9 provisions for formal plan change or variation to control effects of activities in the recharge areas of potable groundwater supplies.
Section 4, issue 18	discharge of contaminants to land.
Objective 23	avoid contamination of groundwater.
Policy 31	require contingency plans for unauthorised discharges.
Policy 36	require appropriate management of discharges.
Policy 37	require a bond.
Method 79	require monitoring.
Section 4.3	Contaminated land.
Issue 25	discharges from contaminated land can affect groundwater.
Section 5	Take and use of groundwater.
Issue 27	increasing demand.
Issue 29	over-abstraction can degrade groundwater quality.
Objective 36	abstraction of groundwater should be sustainable.
Policy 57	sustainable yield allocation.
Policy 60	investigate linkage between groundwater and surface water.
Policy 61	address adverse effects of groundwater.
Method 112, 118	education re groundwater use.
Method 112A	investigate groundwater resources, water quality, capacity to meet demand, resources under future abstraction pressure.
Method 113	raise awareness of groundwater.
Method 122	monitor groundwater takes.
Method 124	require correct bore construction.
Method 125	list of ‘instruments’ to manage water takes.

Method 126	address the adverse effects of groundwater takes on surface water
Method 133	determine sustainable yield.
Method 134	investigate linkages between groundwater and surface water.
Section 5.1.5	explanation / principal reasons.
	outlines objectives, policies and methods to manager water resources sustainably.
Section 8.1	wetlands
Para 1	groundwater and wetlands.
Policy 119	raise awareness about wetlands.
Section 9.4	discharges of nitrogen or phosphorus
Rule 11	allows control of land use.
Rule 26	discharge of fertiliser.
Rule 28	farm dumps.
Rule 29	offal holes.
Rule 31	silage pits.
Rule 32	composting.
Rule 33	bark and wood.
Section 9.7	take and use of water
	groundwater allowed for firefighting, reasonable domestic needs, animals drinking water.
Rule 38	permitted take and use of groundwater.
Rules 39, 40	installation of bores.
Rule 43	taking and using groundwater.
Section 11.5	water use
Section 11.5.2	groundwater bores.
Section 12	anticipated environmental results.
Section 12.2	groundwater quality is maintained or improved.

Section 12.4 groundwater levels are sustainable.

Schedule 10 water quality classifications.

1. Natural state lake – no net increase of nitrogen or phosphorus as a result of discharge.
3. Managed state lake – no net increase of nitrogen or phosphorus as a result of discharge after mitigation.

Definition of terms

Includes terms relevant to the groundwater resource: aquifer, catchment, contaminated land, groundwater, potentially contaminated land, water, water table.

APPENDIX 6 - GROUNDWATER INFORMATION REQUIRED TO MODEL GROUNDWATER SUSTAINABILITY

A) Geological Model
1) Database of drillers logs
2) Formation identification
3) Conceptual model of aquifer
4) Formation boundary maps
5) Formation thickness maps
6) Formation property maps
7) Formation boundary cross-sections
8) Formation property cross-sections
9) 3D geological model-formations
10) 3D geological model-property
11) Aquifer volume model

B) Groundwater quantity
12) Database of groundwater level information
13) Piezometric maps
14) Identification of recharge sources
15) Rainfall recharge model
16) River/stream recharge model
17) Model of recharge-other
18) Identification of discharge locations
19) Model of discharge to river/streams
20) Model of discharge to springs
21) Model of discharge off-shore
22) Database of usage information
23) Model of usage
24) Model of aquifer water fluxes (simple)
25) Model of water storage (simple)
26) Model of aquifer transmissivity/hydraulic conductivity
27) Model of aquilude conductance
28) 3D model of flow system - steady state
29) 3D model of flow system - transient
30) Estimates of safe yield

C) Groundwater quality
31) Water quality database
32) Land use database
33) Land use map
34) Groundwater age
35) Model of nutrient discharge to groundwater (simple)
36) Model of nutrient discharge from groundwater (simple)

37) Model of microbiological interactions
38) Map of oxidation/reduction boundary
39) Model of water rock interaction
40) 3D model of water chemistry
41) Groundwater biota database
42) 3D model of groundwater biota

E) Groundwater management
43) Groundwater consents database
44) Groundwater use data
45) Groundwater economic database
46) Model of existing usage
47) Model productive economic value of the resource
48) Measure of the in-situ value of the resource

F) Groundwater sustainability
49) Linked models of A,B,C,D, and E
50) Scenario generation
51) Calculations of system response to scenario