JUNE 2005

Groundwater monitoring technical report

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Contents

1. Summary points

1.1 Groundwater quantity

Groundwater level variations in the Wellington Region can be explained by natural variations in recharge in most groundwater zones. Significant pumping induced groundwater level variation appears to be restricted to three Wairarapa groundwater zones: Martinborough, Parkvale and Kahutara.

The volume of groundwater allocated for use over the last nine years has been largely static on the Kapiti Coast and in Lower Hutt. However, the volume has been increasing steadily in the Wairarapa Valley and we believe that a strategic assessment of the potential demand for water in the region is required. Such an assessment would provide guidance on how much more demand we are likely to see, and where that demand might be.

Our current estimates of aquifer safe yield need to be reviewed because the methodology used to derive the estimates is fundamentally flawed as it does not consider natural groundwater discharge. Consequently, the safe yield estimates offer streams, wetlands and springs limited protection from groundwater pumping. The only discharge based safe yield in the region is for the Lower Hutt groundwater zone where discharge to Wellington Harbour has been specifically addressed. Groundwater availability at a regional-scale needs to be reassessed as the proportion of natural discharge that may be taken without resulting in adverse environmental effects.

Such a reassessment will require definition of groundwater discharge areas and rates. Groundwater discharge is poorly constrained throughout the region with only limited information available for wetlands, spring fed streams and submarine discharge. Additional hydrological monitoring sites are required to estimate discharge rates. This additional monitoring needs to be complemented with assessments of the amount of water required to sustain groundwater dependant ecosystems and avoid significant reductions in groundwater level that may affect pump yields. Definition of groundwater discharge will allow minimum groundwater levels to be set that will provide a basis for maximum rates of groundwater use.

Limited metering data indicate the actual use of groundwater for irrigation is about 20% of the allocated volume. A reassessment of aquifer safe yields will permit us to explore more sophisticated allocation methodologies to address the discrepancy between actual and allocated use.

1.2 Groundwater quality

Groundwater quality variation within the Wellington Region can be largely explained by natural geochemical processes and anthropogenic impacts. The redox potential, water composition, and human/agricultural impacts (in the form of nitrate-nitrogen and sulphate) appear to be the main controls on groundwater quality.

To aid a regional assessment of groundwater quality, analysis was undertaken to assign each site in the Groundwater State of the Environment Monitoring Programme into a cluster of sites with similar chemistry.

The analysis shows that groundwater in the region can be grouped into four main clusters, for which we can identify the likely processes that influence the groundwater chemistry:

1. Highly reduced (anoxic), highly evolved groundwater; generally rainfall recharged.

2. Dilute waters; little or no anthropogenic impact; young, oxygenated groundwater; generally river recharged.

3. Low to moderately reduced groundwater, but less reducing than cluster 1; generally rainfall recharged; little evidence of anthropogenic impact.

4. Anthropogenically impacted, oxygenated aquifers; elevated nitrate-nitrogen and/or sulphate; rainfall, or river recharged.

Seventeen sites fall into cluster 4 and show evidence of elevated nitrate-nitrogen or sulphate, which indicates anthropogenic impact. These sites require careful future monitoring to help assess whether this impact is a result of historical or current land use. Cluster 4 sites appear to be limited to a select number of groundwater zones (in particular Hautere, Coastal, Otaki, Te Ore Ore, Upper Plain, Carterton, Parkvale, East Taratahi, Moroa, Matarawa, and South Featherston) however this distribution may reflect the limited spatial coverage of the monitoring programme.

There are thirty-nine unconfined or semi-confined sites in the monitoring network. Of these thirty-nine sites, seventeen (44%) show elevated[1] median concentrations of nitrate-nitrogen. Median nitrate-nitrogen concentrations exceed the New Zealand Drinking Water Standards (2000) at two of these sites. Of the seventeen sites with elevated concentrations, eleven have dairy farming as the major up-gradient land use, and six have sheep or beef farming as the major up-gradient land use.

Despite this apparent relationship between land use and nitrate levels, the current monitoring network is inadequate to accurately assess the impacts of agricultural and on-site sewage discharges to land. Thus the effectiveness of the Regional Plan for Discharges to Land in terms of effects on groundwater quality cannot be determined. An intensive shallow groundwater monitoring network, designed to monitor the effect of discharges is required to test the effectiveness of the Plan.

The use of groundwater for irrigation appears to influence groundwater chemistry variation in several Wairarapa groundwater zones (Lower Valley, Tawaha, Kahutara). A significant seasonal variation in water chemistry, which

[1] While most groundwater in New Zealand rarely has background nitrate levels exceeding 1.0 mg/l (Burden, 1982; Close 2001; Rosen 2001) in this report 3.0 mg/l NO_3-N is used as an indicator of anthropogenic influence in order to increase certainty caused by variability. 3.0 mg/l was also used by Madison and Brunett (1985) and Close (2001) as the threshold value.

coincides with the irrigation season, is apparent at several sites. This variation suggests a high degree of connectivity between aquifer zones, but requires further investigation.

2. Groundwater in the Wellington Region

Groundwater is an important resource in the Wellington Region. Groundwater under the Hutt Valley supplies about a third of Wellington's water supply. Otaki, Waikanae, Martinborough and Carterton also rely on ground water for public supply. In rural areas of the Kapiti Coast and the Wairarapa, groundwater is an important water source for domestic supply, stock water and irrigation. Groundwater is also an important water source for many springs and wetlands and the successful protection of these groundwater dependant ecosystems requires careful management of groundwater use.

In this report we describe the quantity and quality of the Region's groundwater resource by analysing information collected under our hydrological monitoring programme. The objectives of this report are to:

- describe the current state of the Region's groundwater resource at a regional-scale;
- assess reasons for that state; and
- briefly assess Greater Wellington's management of the resource.

This assessment of the Region's groundwater resource will be used to help compile the 2005 State of the Environment report for the Wellington Region. This report will also provide a reference for assessing the effectiveness of the management policies in the Regional Policy Statement and the Regional Freshwater Plan.

2.1 How this report is organised

This report is organised as follows:

- Section 1 outlines our key findings;
- Section 2 introduces the report.
- Section 3 describes where groundwater is found in the Region and provides a summary of the hydrogeology of different areas.
- Section 4 describes the state of groundwater quantity in the Region and the reasons for that state.
- Section 5 describes the state of ground water quality in the Region and discusses natural and anthropogenic influences on the quality. This section makes up a large part of this report as this is the first time a regional assessment of groundwater quality has been made.
- Section 6 discusses Greater Wellington's groundwater management and includes recommendations on work that needs to be done to ensure the sustainable management of the resource.

3. Groundwater in the Wellington Region

There are three principal groundwater areas in the region: the Lower Hutt Valley, the Kapiti Coast and the Wairarapa Valley. Secondary groundwater areas include: Upper Hutt, Mangaroa Valley, Wainuiomata Valley and sections of the eastern Wairarapa coastline.

Aquifers in all of these areas are found in unconsolidated alluvial, aeolian, and beach sediments of varying grain size. Minor aquifers are also found in limestone and fractured greywacke in some areas of the Region.

Groundwater management zones have been defined in all principal and some secondary groundwater areas and are shown in Figure 3.1. We have used these zones as a framework for describing groundwater areas throughout this report.

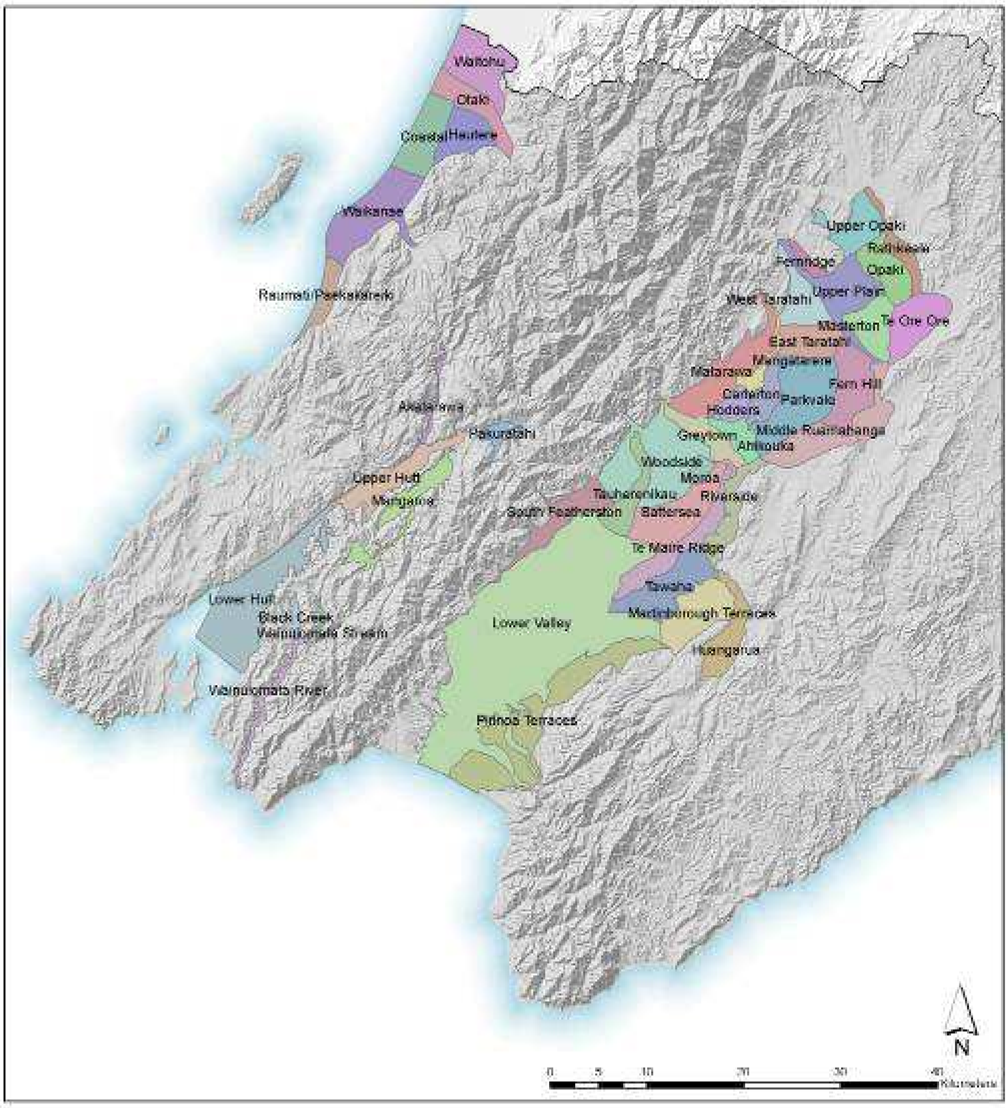


Figure 3.1: Groundwater management zones in the Wellington Region

3.1 Lower Hutt Valley groundwater

There is a long history of groundwater use and investigation in Lower Hutt; the first artesian bore recorded in the valley was drilled in 1883 (Hughes and Morgan, 2001). Consequently, this highly productive aquifer system is heavily used and well understood. Much investigative work was done by the Hutt Valley Underground Water Authority in the 1960s. This work laid a solid foundation for the development of a series of numerical models to simulate the aquifer system and estimate its sustainable yield (Donaldson and Campbell, 1977; Reynolds, 1993; Phreatos, 2003).

3.1.1 Geological setting

The Lower Hutt basin is bounded by the Wellington fault to the west and basement rock to the east. The basin has formed as a result of movement on the fault, and folding to the east of the fault, over the last million years. Up-thrusted basement rock forms Somes/Matiu and Ward Islands in the harbour. As the basin has evolved, it has been in-filled with sediment. The thickness of sediment varies from a few metres at Taita Gorge, to over 600m at Kaiwharawhara (Wood and Davy, 1992).

The sediments that have in-filled the basin are predominantly gravel, sand and silt sourced from the southern Tararua Range and deposited by the Hutt River. This alluvial material is separated by fine-grained marine and marginal marine sediments. The distribution of these marine sediments has been controlled by climatic variations over the last 350,000 years that have caused eustatic sea level change. Four major glacial and interglacial periods are recognised in a deep well (R26/0151) at Petone (Mildenhall, 1995).

3.1.2 Hydrogeology

Aquifers have been formed by the thick accumulations of gravel deposited by the Hutt River. These aquifers are separated by aquitards formed by beds of fine-grained marine sediments, which extend across much of the basin but peter out north of the Kennedy Good Bridge. North of the bridge the aquifers become unconfined. The unconfined aquifer is recharged predominantly by losses through the bed of the Hutt River. River losses at low flow are estimated to be approximately 85,000 m^3/day and 100,000 – 160,000 m^3/day at average flow (Phreatos, 2003). Rainfall recharge is only a minor component of the water balance.

The two recognised confined aquifers are the Waiwhetu Artesian Gravels and the Moera Basal Gravels. The Waiwhetu Gravels form the primary aquifer in the valley. A recent investigation bore confirmed that these gravels contain a laterally continuous, intermediate fine-grained layer that separates an upper and lower aquifer (Brown and Jones, 2000). The Upper Waiwhetu Aquifer is the principal aquifer and is highly productive with transmissivity values as high as 35000 m^2/day. The Lower Waiwhetu Aquifer and the Moera Gravel aquifer are less productive with transmissivity values of less than 2000 m^2/day.

Isotopic analyses of the Upper Waiwhetu Aquifer have been undertaken to determine the mean residence time of the water in the aquifer system. Residence times vary from ~1.5 years at the Waterloo wellfield to ~25 years at Somes/Matiu Island. The variation in residence times indicates there is a preferential pathway for water down the eastern side of the basin.

The Upper Waiwhetu Aquifer is in hydraulic connection with the sea through numerous springs on the harbour floor (Harding, 2000). The deeper aquifers are thought to only have an indirect connection with the sea.

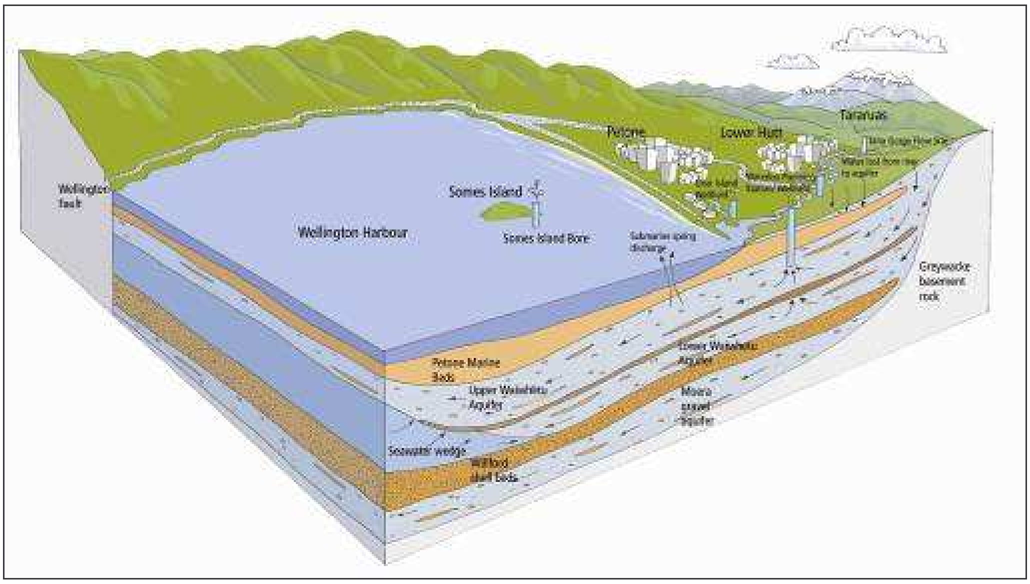


Figure 3.2: Conceptual model of the Lower Hutt groundwater system

3.2 Kapiti Coast groundwater

The Kapiti Coast has a shorter history of groundwater development compared with the Hutt Valley. Some investigative work was undertaken in 1976 (Hutton, 1976), however, it was not until 1982 that a comprehensive groundwater investigation was undertaken. This investigation was done by the Manawatu Catchment Board and was limited to the Otaki area (Kampman and Caldwell, 1985). The report *Hydrology of the Kapiti Coast* (Wellington Regional Council, 1994) provides the first comprehensive assessment of the Kapiti Coast groundwater resource.

3.2.1 Geological setting

The Kapiti Coast is a narrow coastal plain on the western side of the Tararua Range and on the south-eastern margin of the South Wanganui Basin.

As in Lower Hutt, the present day landforms and subsurface depositional sequence are a function of relative sea level change caused by tectonic movement and eustatic sea level change during the Quaternary. Tectonic movement has caused uplift of the Tararua Range and subsidence of the South Wanganui Basin. Global climate change has resulted in cycles of sea level change of many tens of metres.

Cold climate cycles caused increased erosion in the Tararua Range and the subsequent deposition of thick layers of alluvial gravel, sand and silt. During temperate inter-glacial periods vegetation re-established itself to higher altitudes and erosion and deposition was reduced. Also, sea level rose and transgressed over large parts of the coastal plain depositing beach and marine sediments over earlier alluvial material. A prominent geological marker on the coast is a wave-cut cliff that marks the maximum extent of the most recent transgression. This cliff can be traced the length of the coast and is most prominent on the eastern edge of State Highway One just north of the intersection with Peka Peka Road. Rivers responded to the increased sea level by down-cutting and reworking existing sediments.

3.2.2 Hydrogeology

Fleming (1972) defined formal stratigraphic units for the recent Kapiti deposits on the basis of surface mapping and borehole information available at the time. An investigation bore drilled by the Manawatu Catchment Board intercepted many of these units and older sediments; three glacial and inter-glacial phases spanning the last 300,000 years were recognised (Kampman and Caldwell, 1985; Brown, 2003). Recent work commissioned by the Kapiti Coast District Council has provided additional subsurface information and suggests a further refinement of the subsurface classification (URS, 2003 and 2004).

Kapiti Coast aquifers can be broadly classified on the basis of their depositional environment into one of three groups:

- Glacial and inter-glacial deposits
- Post-glacial beach and dune sand deposits
- Recent river gravels

The glacial and inter-glacial deposits form a thick, poorly stratified aquifer system along the length of the coast. This aquifer system is confined, with moderate transmissivity values (500-1000 m^2/day). This system is thought to be predominantly rainfall recharged, although losses from the Waikanae and Otaki Rivers may also be an important component of the water balance.

The post-glacial sand deposits form a wedge shaped aquifer system up to 50 metres thick at the coast and pinching out to nothing at the inland sea-cliff. This aquifer system is largely unconfined although it becomes semi-confined with depth close to the coast. Rainfall is the dominant recharge mechanism. The system encompasses a coastal dune belt. This dune belt has resulted in the formation of a number of inter-dunal wetlands where drainage has been impeded. This aquifer system is generally low yielding and only suitable for domestic supply, however use for garden irrigation is widespread through Raumati, Paraparaumu and Waikanae Beach.

The recent river gravels are gravels that have been reworked by the Waikanae River, Otaki River and the Waitohu Stream. These gravels form high yielding unconfined aquifers that are in direct hydraulic connection with surface water.

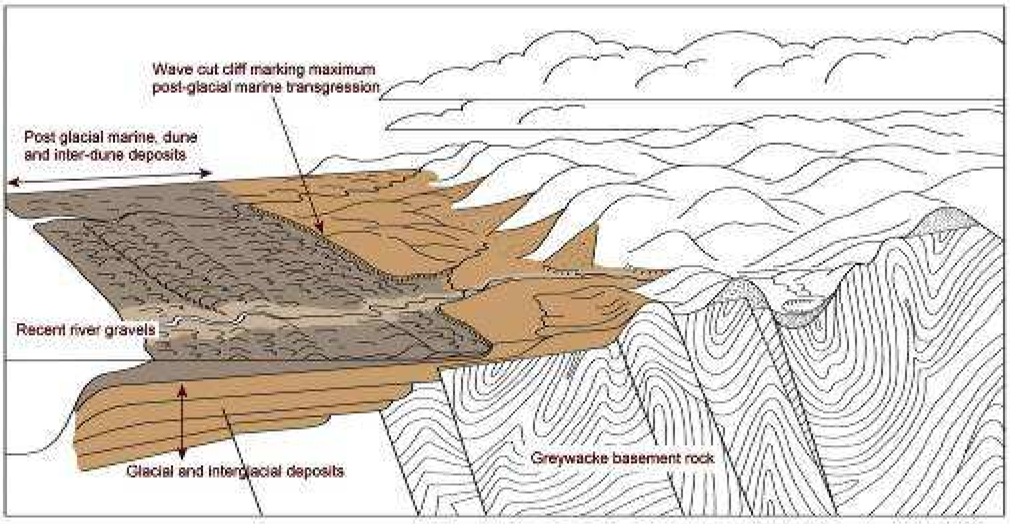


Figure 3.3: Conceptual model of the Kapiti Coast groundwater system

3.3 Wairarapa groundwater

Before the 1970s, groundwater use in the Wairarapa was limited to domestic and stock supply. However, pressure on surface water resources and further agricultural development meant the demand for groundwater began to increase. In response to this demand, the Wairarapa Catchment Board carried out an extensive groundwater study between 1981 and 1986 to assess the extent of the Wairarapa groundwater resource (Annear et al, 1989). Since that study was undertaken, a number of local-scale groundwater assessments have been made for various parts of the valley (Butcher, 1996a, b; 1997; 2000; 2001a, b, c; 2004a, b).

3.3.1 Geological setting

The Wairarapa Valley is a fore-arc basin associated with the convergent plate boundary between the Australian and Pacific tectonic plates. The valley is bound to the west by the Wairarapa Fault and the axial ranges. The valley is bounded to the southeast by Mesozoic rocks of the Aorangi Mountains and bounded to the east by Tertiary rocks of the eastern hill country.

As well as the bounding Wairarapa Fault, a number of other faults and folds are found in the valley. Movement on these structures has resulted in elevated basement and early Quaternary sediments such as Te Maire Ridge, and localised depressions such as the Te Ore Ore area.

The rivers draining the Tararua Range have in-filled the valley with coalescing fans of gravel, sand and silt over the last 800,000 years. Global climate cycles throughout the Quaternary have resulted in successive aggradation surfaces formed during cold periods that have been incised during intervening warm periods causing alluvial terracing. Marine incursions into the lower valley as a result of eustatic sea level change have occurred in a similar fashion to the Hutt Valley and have created a sequence of fine marine sediments and coarse alluvial deposits in the lower 25km of the valley.

3.3.2 Hydrogeology

Aquifers in the Wairarapa may be classified into three broad categories: alluvial fan deposits, reworked river gravels and stratified lower valley deposits.

The alluvial fan deposits are poorly sorted gravel and sand that form low transmissivity aquifers. These aquifers are predominantly recharged by rainfall. In the northern Wairarapa Valley these gravels are transversed by active faults and springs are common at the base of the fault scarps. These springs supply a number of small streams in the valley.

The reworked river gravels are found alongside the large waterways of the Wairarapa Valley and form highly productive unconfined aquifers. These aquifers are in direct connection with surface water and loss from the river is the dominant recharge mechanism.

The stratified lower valley deposits comprise sand and gravel layers separated by fine grained marine sediments. These thin sand and gravel layers form a series of productive confined aquifers. The recharge mechanism for these aquifers is not well understood but is thought to be a combination of rainfall and river losses from both sides of the valley. The discharge mechanism for the Lower Valley aquifers is also poorly understood and the degree of connection with the sea is unknown.

3.4 Upper Hutt, Pakuratahi and Mangaroa groundwater

There is little use of groundwater in these groundwater zones. The Upper Hutt zone is the best understood of the three, as a result of investigation drilling undertaken by the Underground Water Authority in the 1960s. *The Hydrology of the Hutt Catchment* report (WRC, 1995) provides the most up to date summary of these zones.

3.4.1 Geological setting

The three basins have a similar geological setting and history as their Lower Hutt neighbour except that marine sediments are absent. The deepest bore drilled in the Upper Hutt basin (R27/7004) intercepted greywacke basement at 214m below ground. Five sedimentary units have been recognised in this bore and other nearby bores (WRC, 1995).

Begg (1992) describes an investigation well drilled in the Mangaroa Valley that penetrated 48m of Quaternary non-marine sediments without intercepting greywacke basement. The sediments in the well were a combination of swamp, fluvial and floodplain deposits.

3.4.2 Hydrogeology

Despite the thick stack of sediment in the Upper Hutt zone, the strata below 50m are thought to contribute little to groundwater flow. Two aquifers are recognised in the basin: a shallow unconfined aquifer that becomes semi-confined with depth and a deeper confined aquifer capped by a dense silt layer at about 55m below ground level.

The Hydrology of the Hutt Catchment report (WRC, 1995) provides a comparison of groundwater and river hydrographs and the local rainfall record. This comparison shows the Hutt River strongly influences groundwater levels in the west of the basin and that this influence declines toward the eastern hills. Concurrent gaugings of the Hutt River flow show that water is lost into the ground in the upper part of the zone and returned to the river at a similar rate at the base of the zone.

Few data are available to characterise the Pakuratahi and Mangaroa zones, however, the groundwater resource is probably limited to shallow unconfined aquifers formed in alluvial sediments associated with modern and historical stream channels.

3.5 Wainuiomata

There is very little use of groundwater in the Wainuiomata Valley. Consequently, there is little information to characterise the groundwater of this area. The most up to data summary of this area is provided by the *Wainuiomata Water Resource Statement* (WRC, 1993). The groundwater resource is thought to be restricted to shallow unconfined aquifers formed in alluvial gravel and sand associated with the Wainuiomata River and other smaller streams.

3.6 Eastern Wairarapa coastline

There is limited use of shallow groundwater at Riversdale, Castle Point and Flat Point on the Eastern Wairarapa coastline. Aquifers in these areas are found in thin localised sequences of gravel and sand that overlie Tertiary sediments. Groundwater is taken for domestic supply from large diameter wells that are typically less than three metres deep.

Groundwater investigations in these areas have been limited to a survey of groundwater quality at Riversdale Beach (Hurndell and Sevicke-Jones, 2002).

4. Groundwater quantity

In this section we summarise factors that influence the quantity of groundwater and how changes in those influences have affected groundwater levels in the Region. We also describe the variation in groundwater level and how those variations relate to the sustainable use of the groundwater resource.

Throughout this section we have used the existing groundwater management zones and safe yield estimates that are specified in the Regional Freshwater Plan (WRC, 1999a) as a framework for describing the state of the resource. However, it is our view that a number of these zones and safe yield estimates require revision to better reflect the behaviour of the region's aquifers and we discuss our reasons for this view throughout this section.

4.1 Factors influencing groundwater quantity

The amount of groundwater in any aquifer system is a function of the storage capacity of the aquifer and the variation of inflows and outflows to that storage. The amount of groundwater stored in an aquifer can be inferred from the groundwater level or pressure within that aquifer. To monitor groundwater quantity Greater Wellington manages a network of groundwater level recording sites throughout the region. This network has been operating in the Hutt Valley since the late 1960s, the Wairarapa since the early 1980s and on the Kapiti Coast since the early 1990s. Figure 4.1 shows the location and type of all groundwater level monitoring sites in the region. A table of these sites is given in Appendix A.

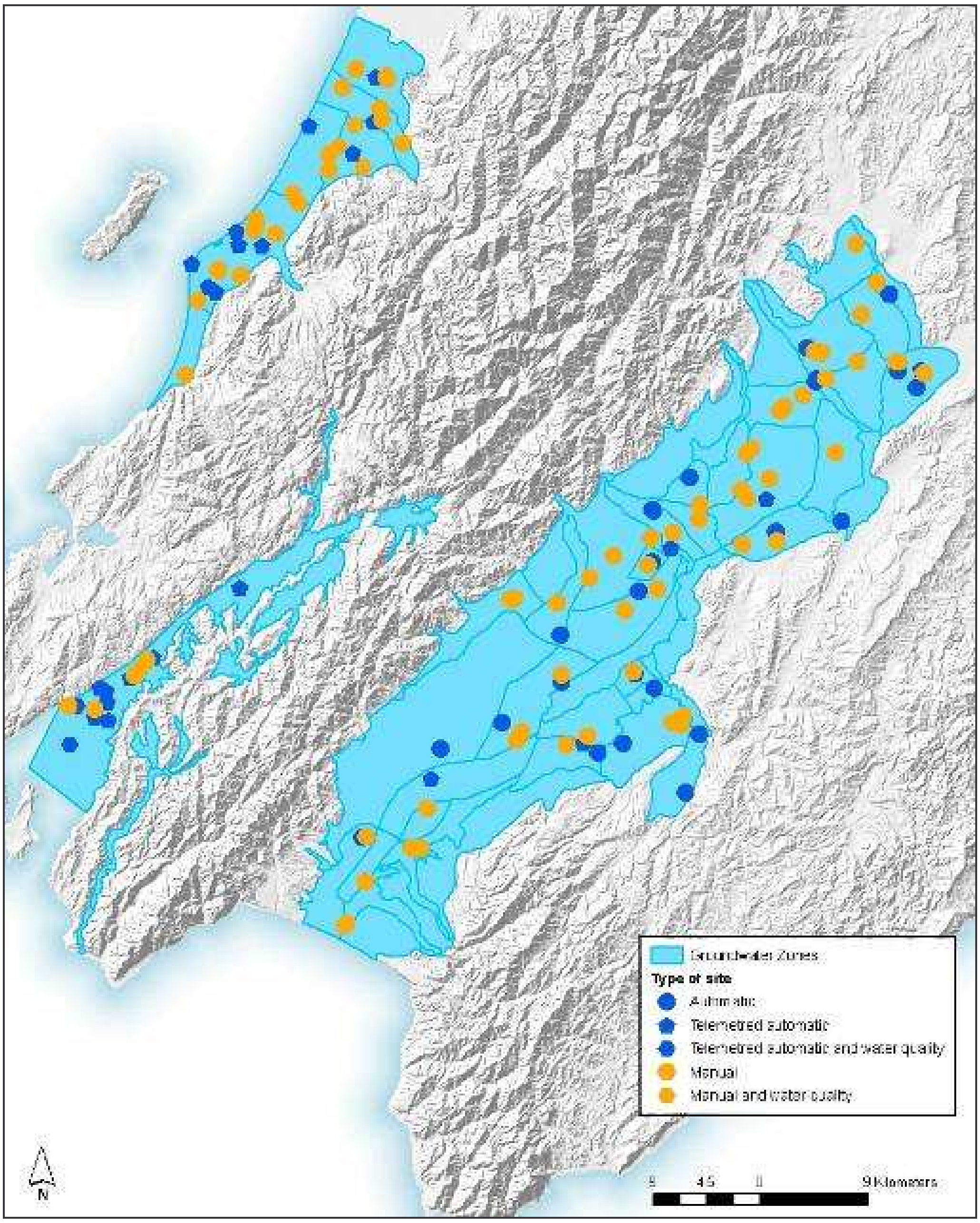


Figure 4.1: Groundwater level monitoring sites in the Wellington Region.

4.1.1 Groundwater recharge

(a) Rainfall recharge

Groundwater is recharged by rain that is able to make its way through the soil profile to the water table. Therefore, recharge typically occurs during the winter months when soil moisture levels are high. Regional estimates of recharge may be made using a soil moisture balance model. Such an approach has been used in the Wellington Region (Butcher, 1993, 2000; Jones and Gyopari, 2005). Calculating these models requires information on soil type and evapotranspiration but where these data are not readily available 40% of rainfall may be taken as a conservative estimate (Lincoln Environmental, 2001). Bekesi and McConchie (1999) modelled recharge in the Manawatu area and found that modelled recharge is essentially linear with respect to annual rainfall, which can therefore be used as an estimator. To simplify matters we have followed this approach and used rainfall data to describe long-term variations in recharge that have influenced groundwater levels throughout the region.

As well as being influenced by variations in rainfall, recharge may be influenced by land use. For example, increasing urbanisation increases surface run-off thereby reducing recharge. Alternatively, recharge to shallow groundwater may be increased by irrigation, both through over-application of water and by raising soil moisture levels, which increases the chance of rain during the irrigation season passing through the soil profile. Some work has already been done on the efficiency of irrigation systems in the Wairarapa Valley (Hawke et al, 2000). In that study, movement of irrigation water through the soil profile was monitored under a number of irrigated areas of varying soil types. The study found that at almost all sites investigated, more water was being applied than could be held in the soil profile and so a proportion of irrigated water was recharging the shallow groundwater.

(b) River recharge

Groundwater is also recharged by water that leaks from rivers, streams and lakes. Ultimately this water originated as rainfall, so recharge from surface water may be considered as indirect rainfall recharge. However, the important distinction is that river recharge can still occur during periods of no rain.

Areas where river recharge occurs may be identified by measuring river flow, piezometric contour mapping, aquifer tests, isotopic analyses and analysing groundwater level changes. At a regional-scale we have a good idea of where significant river recharge is occurring. However, quantifying the amount of recharge is difficult because flow measurements typically have an error of +/-10%, which, for a large river such as the Ruamahanga, represents a significant portion of the estimated loss. Furthermore, as surface water recharges groundwater the opposite is also true and the relationship between the two water bodies changes with time as river and groundwater levels change.

In the Wellington Region, river recharge is best defined in the Waikanae groundwater zone where flow measurements show that the Waikanae River loses about 300L/s at low flow to groundwater, and re-gains about 100L/s from groundwater in its lower reaches. Figures 4.2 and 4.3 show the measured flow loss and gain from and to the river.

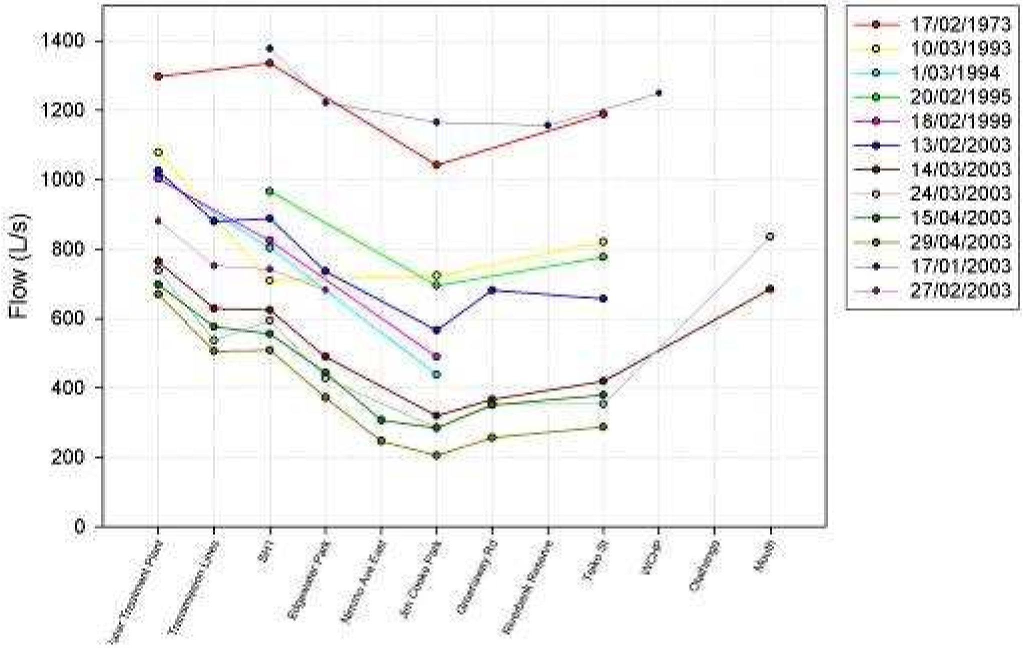


Figure 4.2: Waikanae River concurrent gauging runs

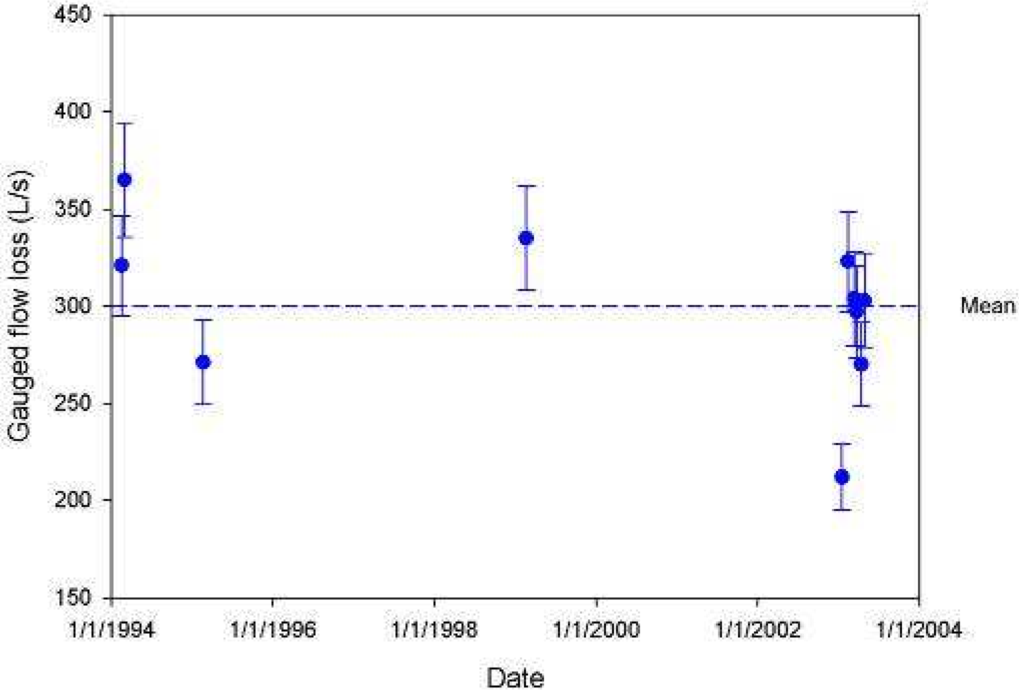


Figure 4.3: Measured flow loss from the Waikanae River between State Highway 1 and Jim Cooke Memorial Park.

4.1.2 Groundwater discharge

Shallow aquifers may discharge to streams, river, wetlands, lakes or the sea. Deep aquifers may discharge to the sea, into shallower aquifers or be blind and not discharge at all. Examples of all these discharge mechanisms are found in the Wellington Region. The diffuse nature of groundwater discharge makes it very difficult to quantify. Consequently, estimates of discharge rely on a water balance approach, which can be improved with the use of a calibrated numerical model.

On the Kapiti Coast and in the Wairarapa, there are a number of groundwater dependant ecosystems. These ecosystems include wetlands, lakes and spring-fed streams that rely on natural groundwater discharge for their water supply. The natural variation in groundwater discharge can be important for the health of these ecosystems. Only a small fraction of the wetland areas that existed in pre-European times still remain and many of these areas are vulnerable to human activity. Management of these wetland systems has gained momentum in recent years and is highlighted by the adoption of a regional wetland action plan (Greater Wellington, 2003). This plan describes how Greater Wellington will address the problem of wetland decline throughout the Region. A key action identified in the strategy is to increase our knowledge of wetlands, in particular wetland hydrology.

In the Hutt Valley the Waiwhetu Artesian Aquifer is known to discharge into the harbour through springs on the harbour floor. This direct connection with the sea poses a limitation on the use of the aquifer as sufficient groundwater pressure must be maintained to prevent the ingress of sea water. The degree of connection between Kapiti and Wairarapa aquifers with the sea is unconfirmed.

4.1.3 Groundwater abstraction

Groundwater abstraction is an important component of the groundwater balance. Greater Wellington regulates groundwater use by issuing water permits that allocate a user a certain volume of water. The amount of water available for allocation is specified in policy 6.2.3 of the Regional Freshwater Plan as safe yield estimates for the various groundwater zones. Although there are limitations associated with these safe yield estimates, which we discuss in section 6.1.1, the total allocated volume provides a useful indicator of the level of use of the resource.

Currently, 539,101m^3/day of groundwater is allocated for use in the Wellington Region. This number represents 195% of the volume allocated in 1996. Figure 4.4 shows the increase in allocated volume in the Wairarapa and Western Wellington Region over the last nine years. The Figure shows that almost all of the growth in groundwater allocation has occurred in the Wairarapa. The only notable exception is an increase on the Kapiti Coast in 2004 with the granting of the District Council's water permit for their new public supply wellfield.

An important question for the management of this groundwater resource is whether the demand in the Wairarapa will continue. It is our view that a strategic assessment of the potential demand for water in the region, especially the Wairarapa, should be undertaken. Such an assessment would facilitate the management of our water resources by identifying areas likely to face increased demand.

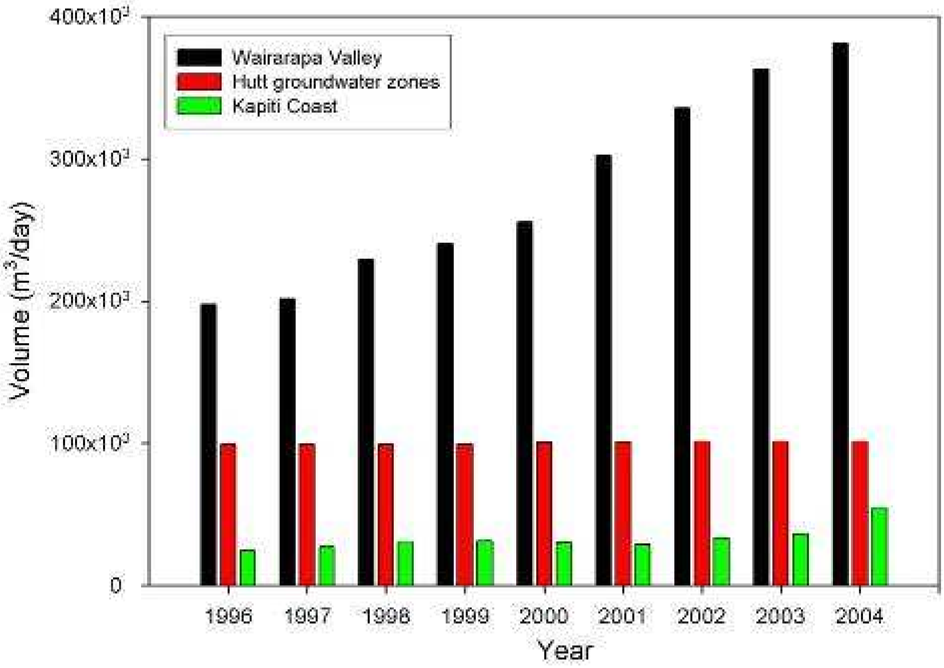


Figure 4.4: Volumes of groundwater allocated for use in the Wellington Region from 1996 to 2004.

There are currently 459 active water permits to take groundwater in the region, the distribution of which is shown in Figure 4.5.

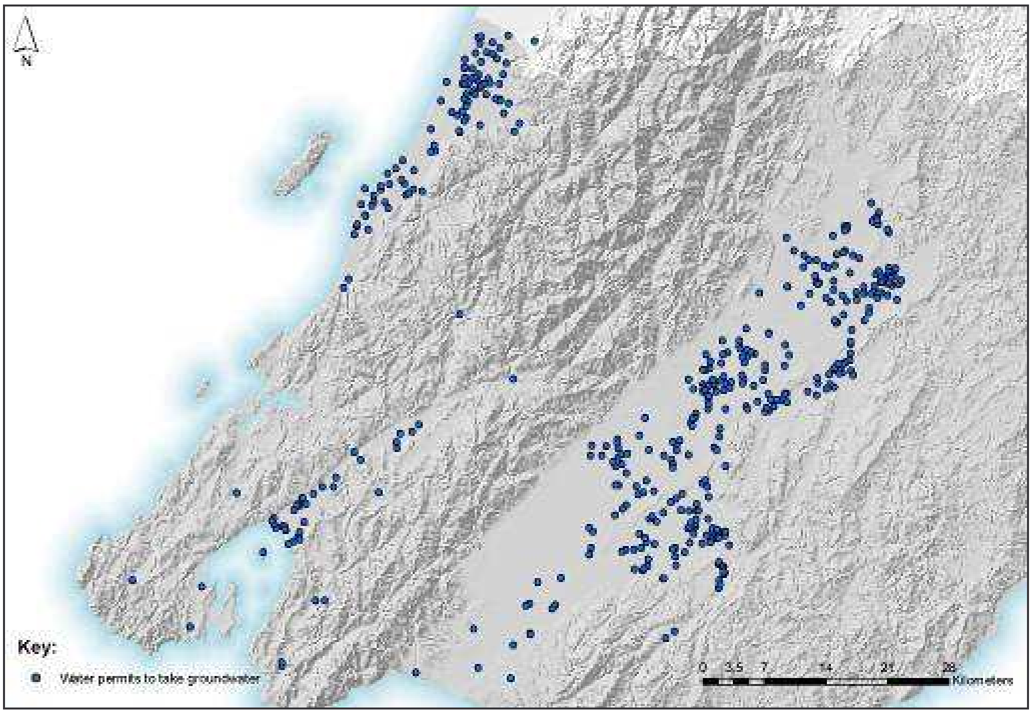


Figure 4.5: Active water permits to take groundwater in the Wellington Region

(a) Different types of water use

The main use of groundwater differs between western and eastern parts of the Region. On the Kapiti Coast and in the Hutt Valley the main use is for public water supply, while in the Wairarapa groundwater is mostly used for irrigation. Figure 4.6 shows the proportion of allocated groundwater used for different purposes in the three principal groundwater areas.

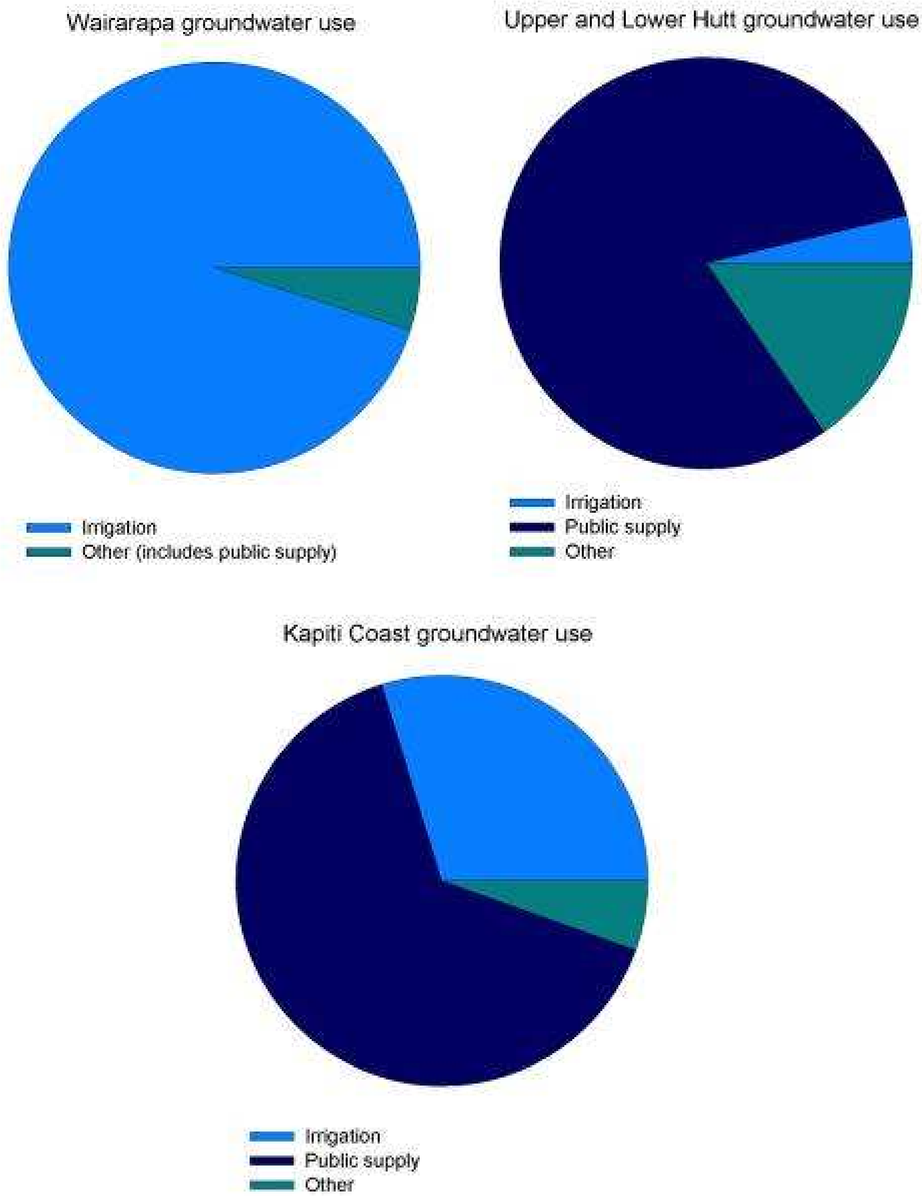


Figure 4.6: The main uses of groundwater in the Wairarapa, Lower Hutt and Kapiti Coast

This difference in main use is reflected in the size distribution of individual water permits where there are few takes between 500-4000m^3/day in the western part of the Region compared with the Wairarapa Valley. This size distribution is shown in Figure 4.7.

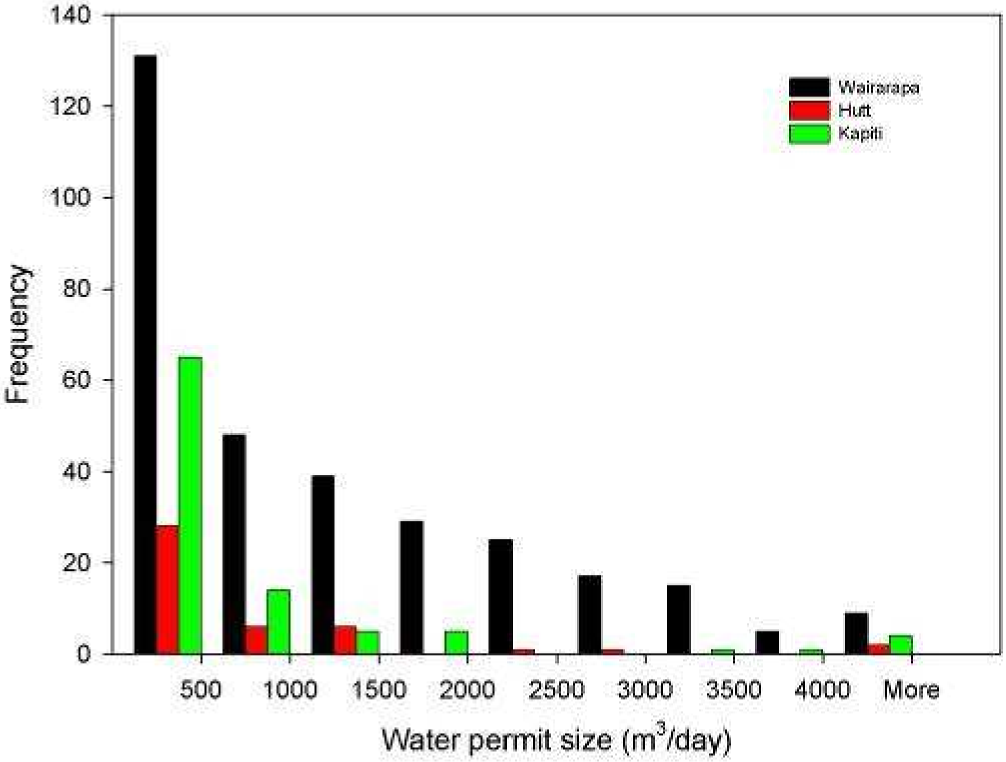


Figure 4.7: Size distribution of active water permits in the Wellington Region

These different uses have different use patterns with the amount of water taken for public supply relatively constant throughout the year compared with irrigation use, which generally occurs only between October and May. Figure 4.8 shows the abstraction record for the Waterloo wellfield in Lower Hutt, which illustrates the continuous daily demand for water. The pattern of abstraction shows seasonal and daily change and larger variations due to changes in the operation of the wellfield, such as in 1999 when the decommissioning of the Buick Street and Gear Island wells saw an increase in the volume taken from Waterloo. The demand for irrigation water is weather dependant and not subject to rigorous metering as is the case with abstraction for public water supply. We discuss the available metering results for Wairarapa irrigation in section 4.4.5.

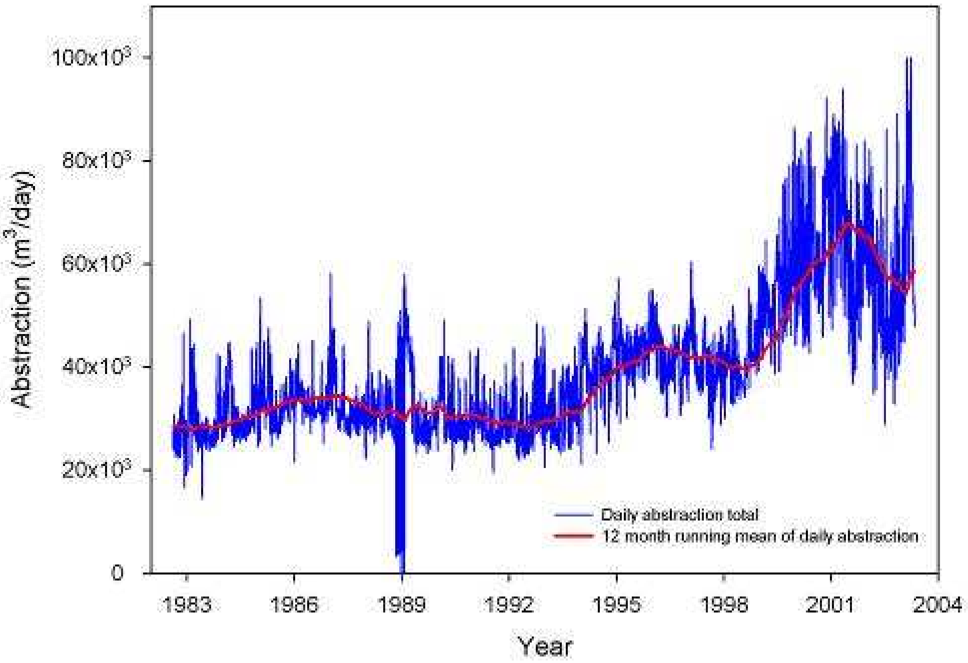


Figure 4.8: Abstraction record for the Waterloo wellfield, Lower Hutt

4.2 The quantity of groundwater on the Kapiti Coast

4.2.1 Kapiti groundwater zones

Figure 4.9 shows the boundaries of groundwater zones that have been defined on the Kapiti Coast and their dominant recharge mechanism based on our current understanding of the groundwater system. This figure also shows the current network of groundwater level monitoring sites.

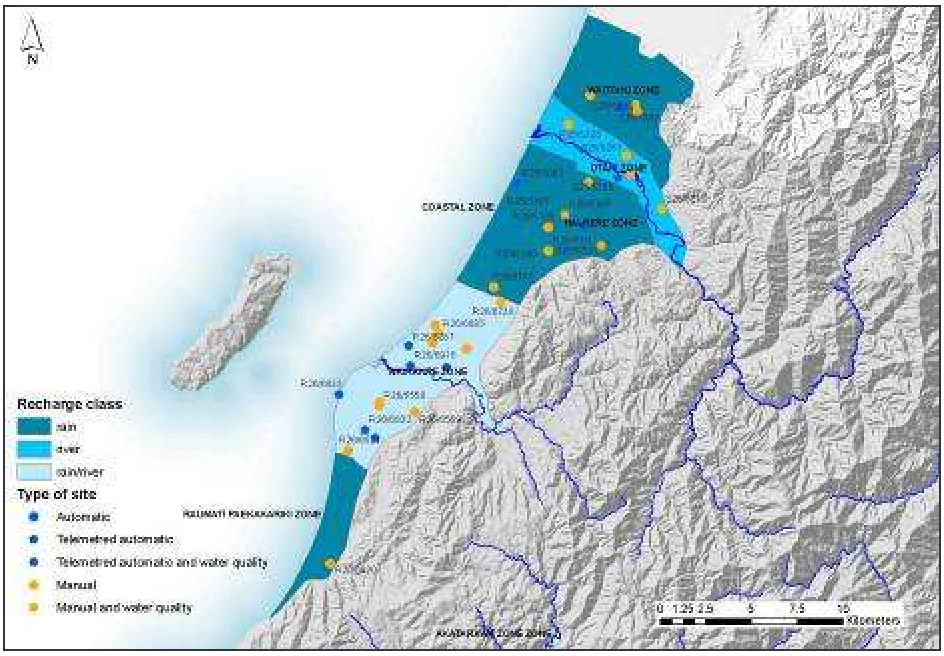


Figure 4.9: Kapiti Coast groundwater zone recharge classification and groundwater level monitoring sites.

Most Kapiti Coast groundwater zones are predominantly recharged by rainfall. The key exception is the Otaki groundwater zone which is in direct connection with the Otaki River. The Waikanae groundwater zone is thought to have a combination of recharge sources, although, losses from the Waikanae River are probably only a significant component of the water balance within less than five kilometres of the river.

4.2.2 Rainfall recharged zones

Figure 4.10 shows the Otaki rainfall record plotted as cumulative deviation from the long-term monthly mean. The Figure also shows the water level record for well S25/5208 on the Hautere Plain, which intercepts a rainfall recharged aquifer at 160 metres below ground. The cumulative deviation plot charts the cumulative variation from the long-term monthly mean of subsequent monthly totals. Upward slopes indicate periods of above average rainfall and downward slopes mark periods of below average rainfall. These changes in slope explain the long-term variation in groundwater level, for example the general increase in groundwater level from 1994 to 1997. The hydrograph also shows a strong short-term seasonal pattern as groundwater levels respond to reduced recharge in late summer and autumn and increased recharge in late winter and spring.

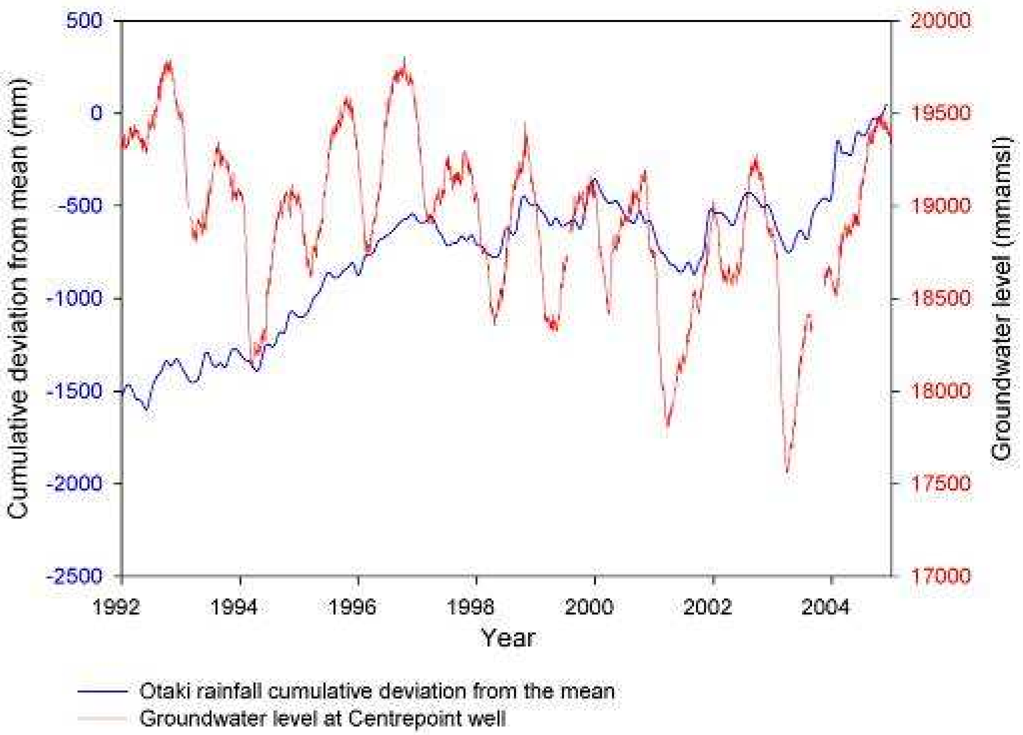


Figure 4.10: Groundwater level under the Hautere Plain at the Centrepoint well (S25/5208) compared with the Otaki rainfall record

A similar pattern can also be seen for the shallow groundwater site R26/6831 in Paraparaumu. At this site a soil moisture model has been calculated and the variation in modelled recharge correlates well with the variation in groundwater level (Figure 4.11).

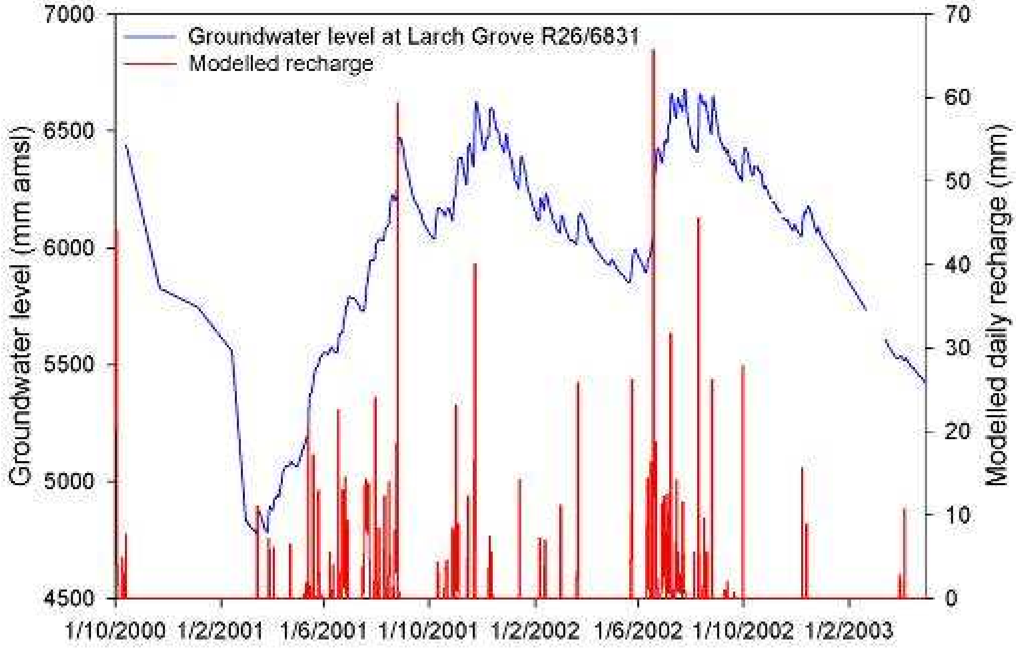


Figure 4.11: Paraparaumu shallow groundwater level compared with modelled rainfall recharge

4.2.3 River recharged zones

Figure 4.12 shows the hydrograph for well S25/5258 on the true left bank of the Otaki River above State Highway One. The hydrograph shows a high frequency of small variations that reflect changes in river flow. The hydrograph also shows pronounced peaks during the October 1998 and September 2000 flood events as a result of increased recharge but no extraordinary response to the 2000/2001 and 2002/2003 droughts as the river still recharged groundwater despite the lack of rain. Figure 4.12 also shows the hydrograph for well R26/6916 on the true right bank of the Waikanae River at the Waikanae Christian Holiday Park. This hydrograph has a similar pattern to the Otaki example and also shows a marked response to the floods in 1998 and 2000. In addition to the high frequency variations caused by changes in river flow this site is also tidally influenced.

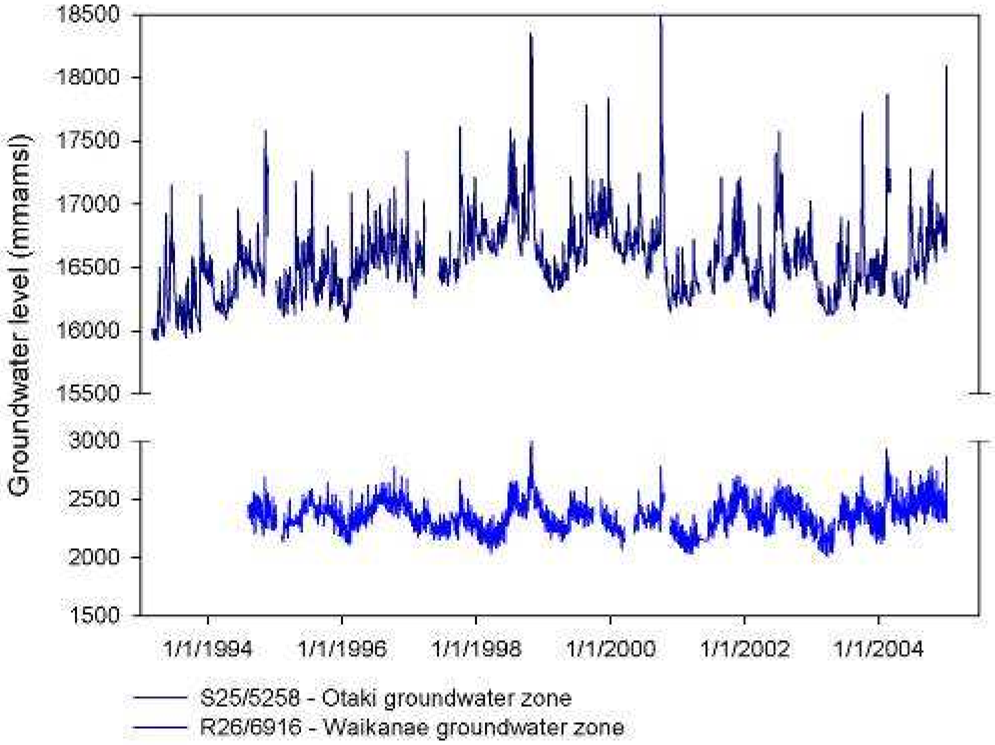


Figure 4.12 Hydrographs for river recharged aquifers in the Otaki and Waikanae groundwater zones.

4.2.4 Abstraction

Figure 4.13 shows the location of all water permits that allow the abstraction of groundwater and the allocation status of the various groundwater zones as a percentage of their safe yield.

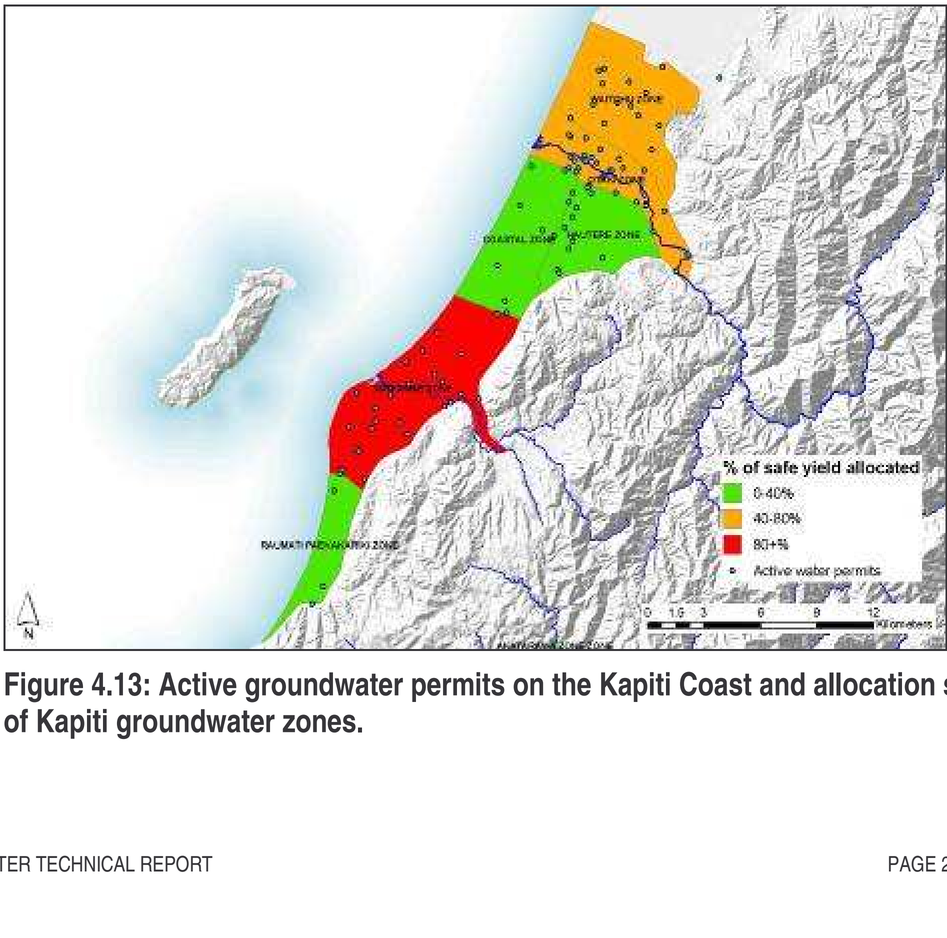


Figure 4.13: Active groundwater permits on the Kapiti Coast and allocation status of Kapiti groundwater zones.

A full table of these permits is given in Appendix B. The Waikanae, Waitohu and Otaki groundwater zones owe their elevated allocation status largely to permits for the abstraction of water for public supply.

In the Otaki groundwater zone the District Council take water from a production well on Rangiuru Road. Close to this well is monitoring well R25/5228, the hydrograph for which is shown in Figure 4.14. This hydrograph shows a consistent series of seasonal lows that reflect the river-recharged nature of the groundwater zone and show that the current level of pumping is not exacerbating normal seasonal declines. However, because the aquifer is so transmissive, it is likely that recharge is being induced from the river. Additional minor groundwater abstraction should not adversely affect river flow because the 7-day annual low flow for the Otaki River is $5.4m^3/s$. However, abstraction of 100s of L/s may cause concern. This concern was born out in 2001 when an application by the Kapiti Coast District Council to take up to 400L/s of groundwater from a near-river wellfield was declined, partly because of the uncertainty about the potential effect pumping may have had on river flow (WRC, 2001a). Further development of this groundwater zone will require refinement of our understanding of the connection between groundwater and the river.

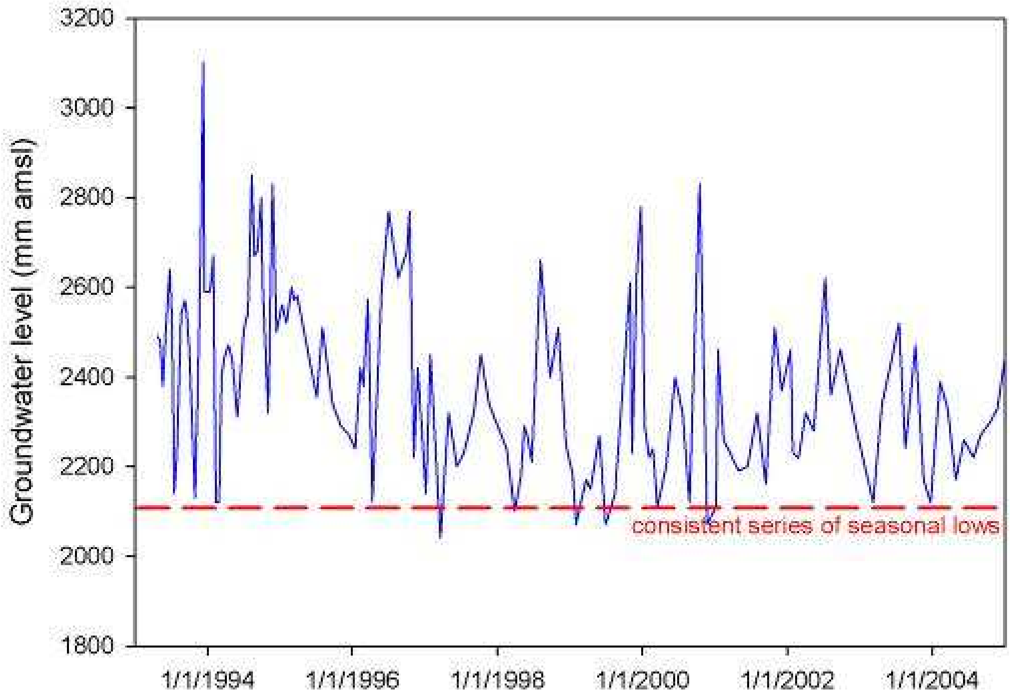


Figure 4.14: Hydrograph for well R25/5228 in the Otaki groundwater zone.

The Waikanae groundwater zone is the most heavily allocated zone on the coast because of the recent issue of a permit to the Kapiti Coast District Council to operate a new public supply wellfield. The short and long-term impact of this wellfield on groundwater levels has been modelled but will not be measured until the wellfield is operational.

4.2.5 Use of shallow groundwater for garden irrigation.

Extensive use of the shallow groundwater is made for garden irrigation in Raumati, Paraparaumu and Waikanae. This use has grown in recent years as gardeners have sought an alternative water supply as the District Council has restricted the use of the public system for garden use. The restriction became necessary as the public supply was unable to meet peak demand. These users operate under the permitted activity rule of the Regional Freshwater Plan and therefore do not feature in terms of water permits. However, Figure 4.15 shows the large number of well records on the coast, most of which are likely to be used for garden irrigation. The location of many of these wells is only known because of a change to the Regional Freshwater Plan in 2002 that required a resource consent for well construction. The earlier permitted activity approach was ineffective in providing information on the location of shallow groundwater users.

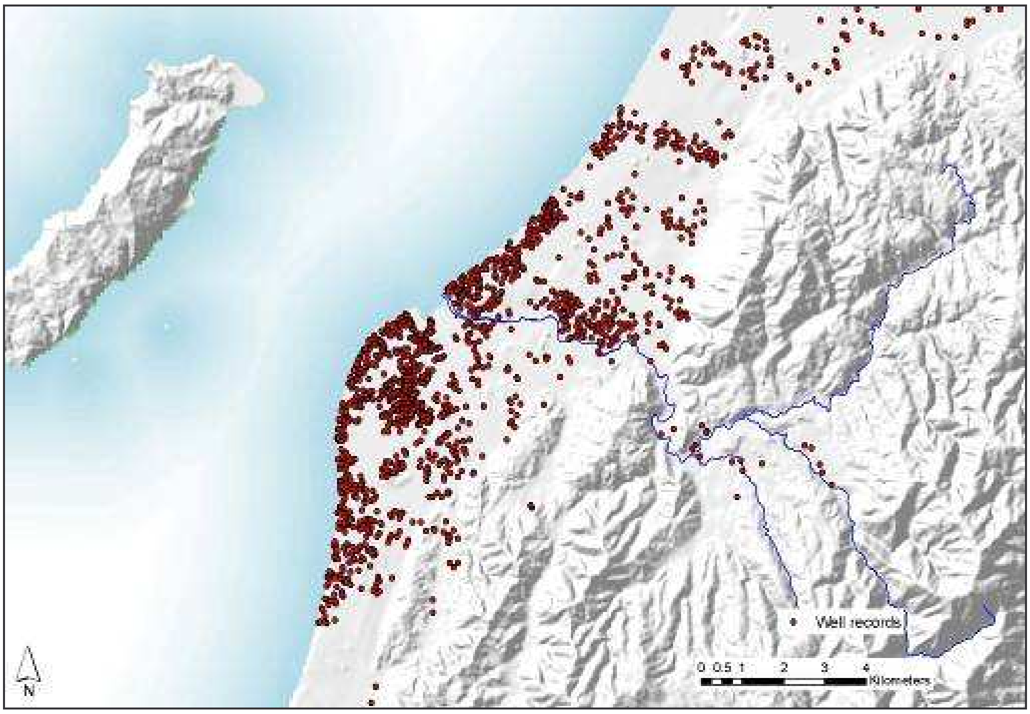


Figure 4.15: Well locations in Raumati, Paraparaumu, Waikanae and Peka Peka

The large number of wells in the Raumati-Paraparaumu-Waikanae area is clear to see. These wells are almost all shallow (<6m) narrow diameter (25mm) wells. The proliferation of these wells prompted an investigation into the sustainable use of the shallow groundwater that culminated in the development of a numerical model of the shallow groundwater system (Jones and Gyopari, 2005). The modelling exercise has shown that stream flow and wetland levels should be unaffected by large numbers of groundwater users pumping at the low rate typical of the narrow diameter wells. However, pumping at rates greater than 100m^3/day close to wetlands and spring-fed streams may adversely affect these features. Accordingly, the modelling work recommended 150m buffer zones around wetlands and springs in which water use would be regulated to avoid excessive drawdown effects. Figure 4.16 illustrates the modelling results for water levels in the Te Harakeke wetland at Waikanae

Beach. The figure shows little difference in wetland water level for three different groundwater pumping scenarios: no pumping, the current level of pumping plus additional potential pumping for a new subdivision west of the wetland, and twice the current level of pumping.

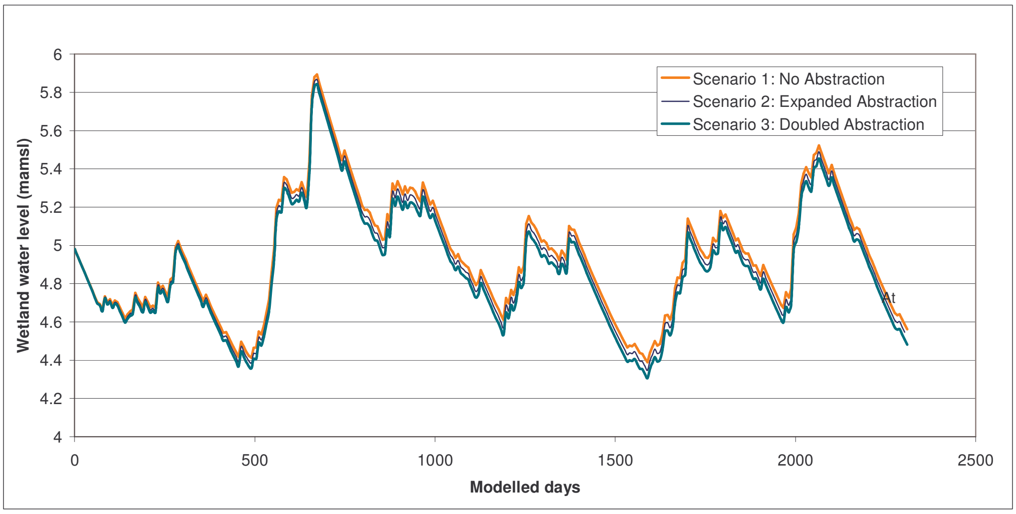


Figure 4.16: Modelled water levels in the Te Harakeke wetland under different abstraction scenarios.

4.2.6 Groundwater discharge

(a) Wetlands and springs

Although the modelling work has indicated that use of the shallow groundwater system is unlikely to affect coastal wetland water levels, the relationship between wetlands, springs and the shallow groundwater system is poorly constrained.

Monitoring of wetland water levels has begun in a number of locations and preliminary investigations of wetland dynamics have been undertaken at Queen Elizabeth Park and Waikanae Beach (Phreatos, 2001b; 2002).

(b) Submarine discharge

The degree of connection between Kapiti aquifers and the sea is unknown. A multi-level monitoring well close to the mouth of the Waikanae River estuary (R26/6566 and R26/6956) exhibits a marked increase in electrical conductivity between its shallow (52m) and deep (76m) screened interval, which suggests some seawater influence. However, a 30 day aquifer test of wells R26/6559 and R26/6664, approximately 1400m from the coast, resulted in a slight decline in conductivity values at the estuary monitoring site (Pattle Delamore Partners, 2003). The combined pumping rate from the wells was 45L/s and the change in conductivity values indicates that the aquifer is not vulnerable to seawater intrusion at that rate of pumping.

The issue of potential seawater intrusion from pumping of the Kapiti Coast District Council's new Waikanae wellfield was addressed by consent conditions requiring the establishment of sentinel wells close to the coast. Trigger levels based on conductivity values in the sentinel wells are specified on the water permit for the wellfield. These trigger levels will regulate the rate of abstraction from the wellfield to ensure seawater intrusion does not occur.

Minor seawater intrusion is known to have occurred in the Coastal groundwater zone at Te Horo Beach. A recent investigation (Wilson, 2003) concluded that pumping from the shallow aquifer has caused the freshwater-seawater interface to migrate 10m further landward than would be expected under natural conditions. This intrusion has adversely affected the quality of the shallow groundwater beneath beachfront properties. The study recommends that groundwater use of the shallow aquifer should be limited to avoid exacerbating the extent of the seawater contamination.

4.2.7 Summary

Groundwater level variations in Kapiti aquifers are the result of natural fluctuations in recharge; abstraction appears to be having no significant effect. The new Waikanae wellfield has the greatest potential to influence groundwater levels, however the extent to which levels will be affected will not be known until the wellfield becomes operational. Conditions attached to the wellfield permit should be adequate to manage its effect. The permit conditions also allow for data collection that will allow groundwater level and quality management objectives to be set for the prevention of seawater intrusion.

Recent modelling work on the shallow aquifer under Raumati, Paraparaumu and Waikanae indicates that the widespread pumping for garden irrigation should not have a significant effect on groundwater and wetland water levels. However, specific management objectives for groundwater dependant ecosystems are required; in particular, confirmation of how much pumping induced drawdown can be safely supported by these ecosystems. Furthermore, additional use of the Otaki groundwater zone will require confirmation of the degree of connection between the groundwater and the river to assess the potential effect of groundwater pumping on river flow.

4.3 The quantity of groundwater in Lower Hutt

4.3.1 Lower Hutt groundwater zone

Figure 4.17 shows the Lower Hutt groundwater zone which encompasses all of Lower Hutt and extends offshore to a nominal boundary south of Somes/Matiu Island. The Figure shows the zone as being predominantly recharged by losses from the Hutt River. Rainfall recharge is a minor component of the water balance because the zone is highly urbanised causing high runoff rates.

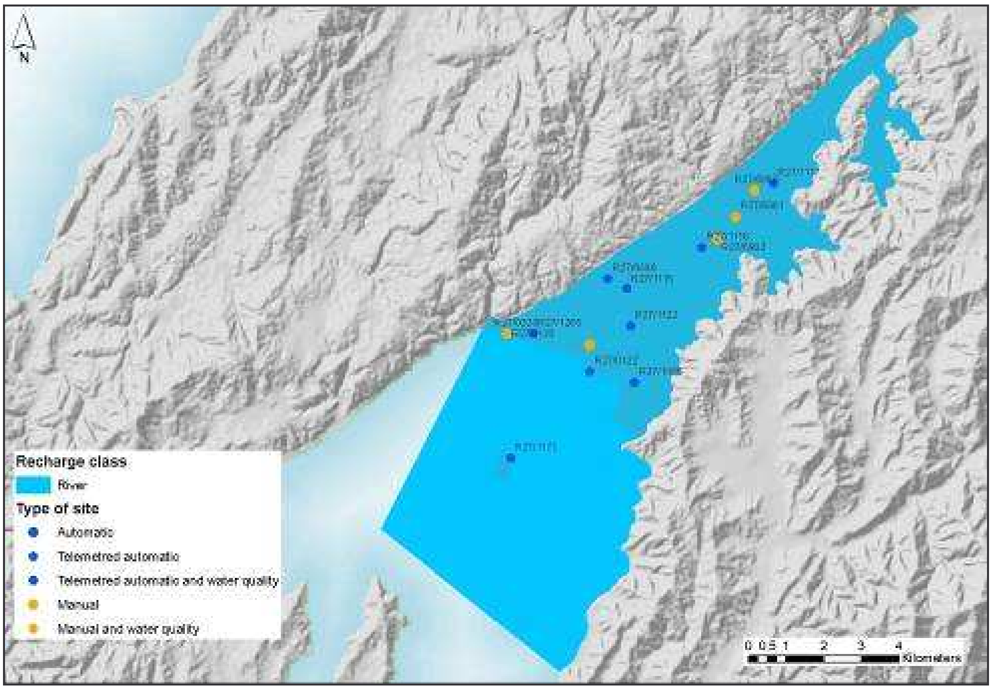


Figure 4.17: The Lower Hutt groundwater zone recharge classification and groundwater level monitoring sites.

4.3.2 River recharge

At low to normal flow the Hutt River loses 900-1800 L/s to groundwater. The variation in groundwater level in the unconfined recharge area correlates well with variations in river flow as shown in Figure 4.18. This correlation applies throughout the whole aquifer system although the effects of pumping and tidal variation introduce additional variation downstream of the recharge area.

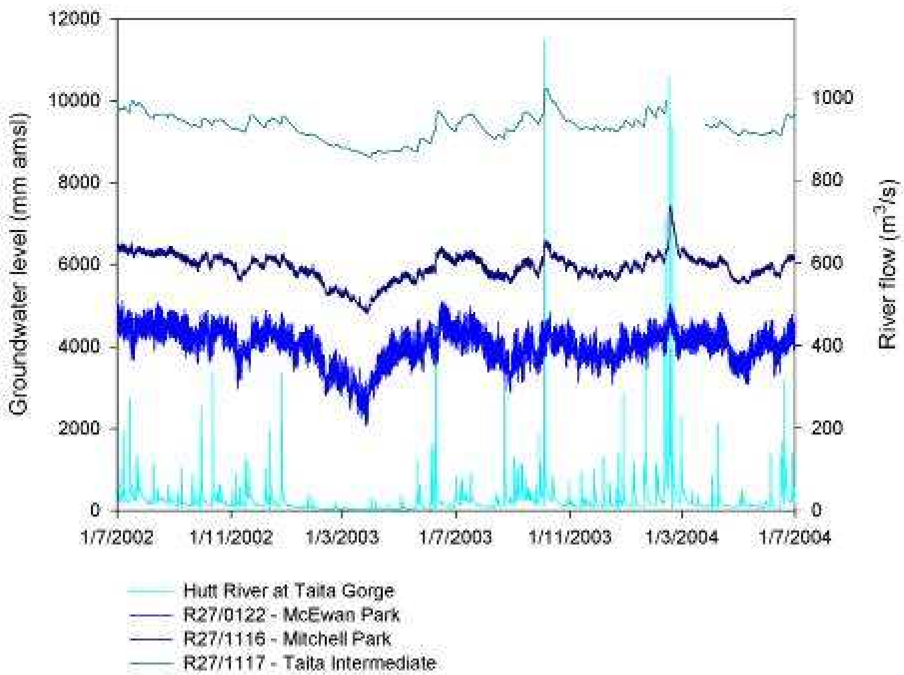


Figure 4.18: Variation in groundwater level throughout the Lower Hutt groundwater zone in response to changes in Hutt River flow.

An extended period of low flow in the Hutt River from January to April 2003 is reflected in marked declines in groundwater level throughout the aquifer system. Modest increases in river flow from April 2003 resulted in rapid recovery of groundwater levels. Likewise, peaks in river flow are simultaneously represented by sharp increases in groundwater level.

4.3.3 Abstraction

The Lower Hutt groundwater zone is fully allocated and Figure 4.19 shows the location of all active groundwater permits in the zone. A full table of permits is listed in Appendix B. Although there are a number of permits, 87% of the allocated volume is held by Greater Wellington for public water supply from the Waterloo and Gear Island wellfields.

The large volume of water taken from these wellfields is the dominant abstraction pressure on the resource. Abstraction from the Waterloo wellfield is shown in Figure 4.8 (section 4.1.3).

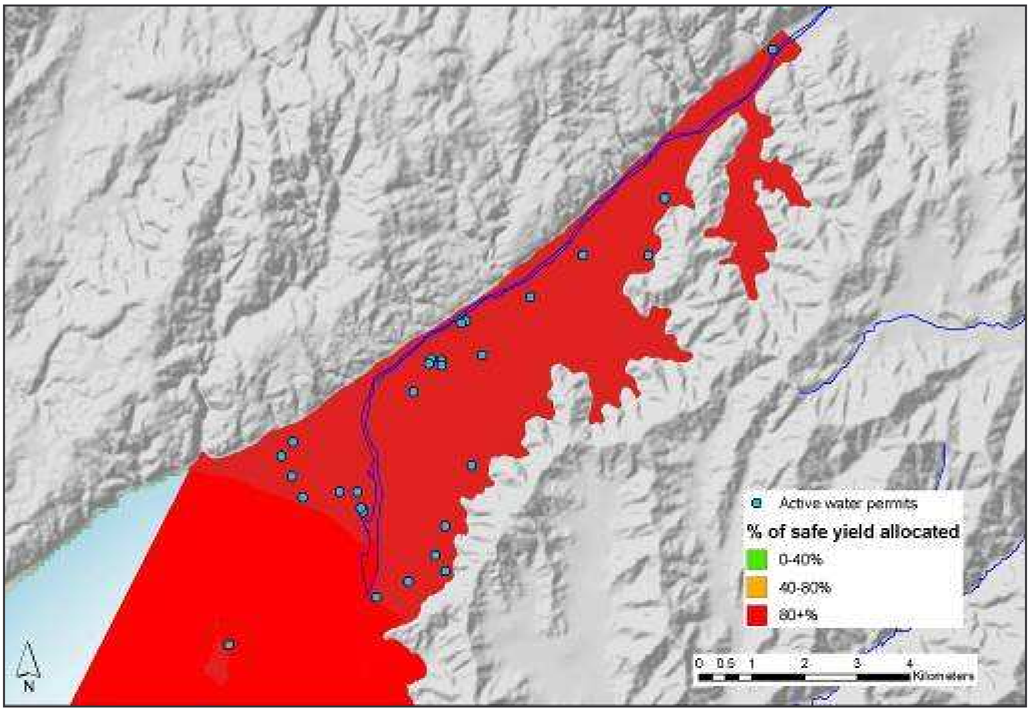


Figure 4.19: Active groundwater permits in the Lower Hutt groundwater zone.

4.3.4 Submarine discharge into Wellington Harbour

The Upper Waiwhetu Artesian Aquifer discharges directly in Wellington Harbour through a number of discrete springs (Harding, 2000). Discharge is also thought to occur on a diffuse basis through the Petone Marine Beds, particularly where this confining layer is thin. Because the aquifer is directly connected to the sea, seawater intrusion is a real risk to the aquifer system.

Donaldson and Campbell (1977) compared the groundwater pressure between the Petone foreshore and Somes/Matiu Island and concluded that if the groundwater pressure at the McEwan Park monitoring well was maintained above 1.4 mamsl[2] then seawater intrusion would not occur. This water level was reviewed in 2001 (Phreatos, 2001a) and a series of threshold levels were defined for the McEwan Park well:

Warning level: 2.5m amsl. Below this level modelled groundwater through-flow ceases and the natural southward offshore hydraulic gradient may reverse.

Critical level: 2.3m amsl. Measurement of the discharge rate from submarine springs on the harbour floor suggests that discharge from the springs will stop when the water level drops below this level. With no freshwater discharge occurring, seawater may enter the aquifer through the springs.

Minimum level: 2.0m amsl. At this level the Ghyben-Herzberg approximation indicates that seawater will reach the foreshore in the Lower Waiwhetu Artesian Aquifer.

These new levels are higher than the original 1.4m because in the 1970s pumping was concentrated in Petone causing pumping induced drawdown on foreshore groundwater levels. Since the 1970s large industrial users of groundwater have closed and the principal public supply abstraction point moved northward from Hutt Park to the Waterloo wellfield. This shift in abstraction regime is reflected in the hydrograph for the McEwan Park monitoring well (Figure 4.20) with a general increase in groundwater pressure from 1972 to 1982.

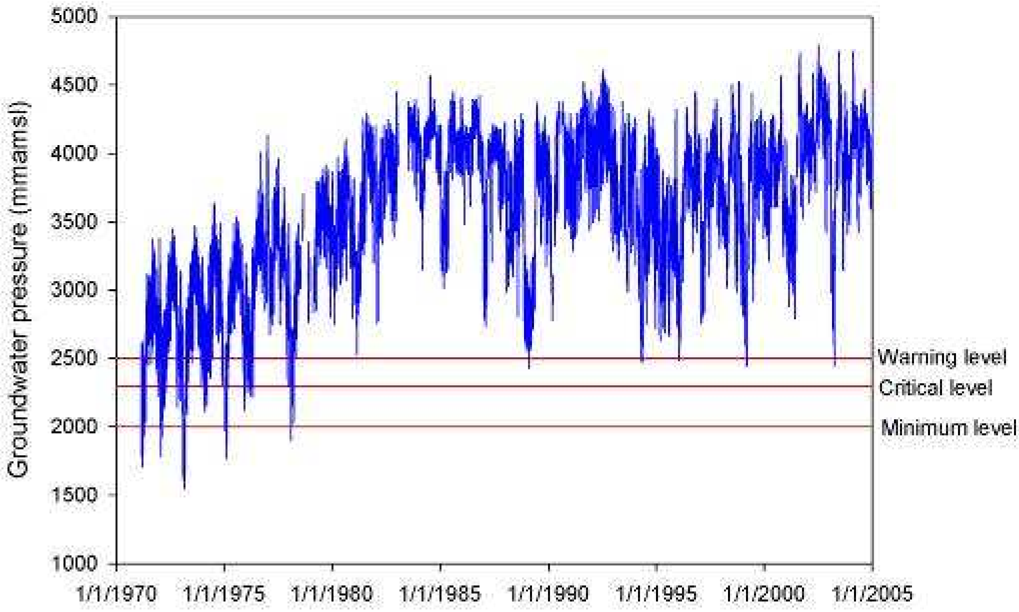


Figure 4.20: Hydrograph for the Upper Waiwhetu Artesian Aquifer at the McEwan Park monitoring well (R27/0122).

[2] Metres above mean sea level

4.3.5 Summary

The Lower Hutt groundwater zone is fully allocated with 87% of the allocated volume assigned for public water supply. The zone is well understood and has a well defined safe yield designed to prevent seawater intrusion. Nevertheless, to improve the protection of the system from the sea, at least one additional fully penetrating sentinel well should be constructed on the Petone foreshore. Such an investment would be in keeping with the value of the system as a source of high quality water for public supply.

4.4 The quantity of groundwater in the Wairarapa Valley

4.4.1 Wairarapa Valley groundwater zones

Figure 4.21 shows the groundwater zones of the Wairarapa Valley and the monitoring wells currently operating. The Figure also shows the dominant recharge mechanism for each zone based on our current understanding of the groundwater system. Most zones are predominantly rainfall recharged. The Lower Valley zones are shown as rainfall recharged, however, the recharge mechanism is unclear and river losses from further up the valley may be an important component of the water balance for the aquifers of these zones.

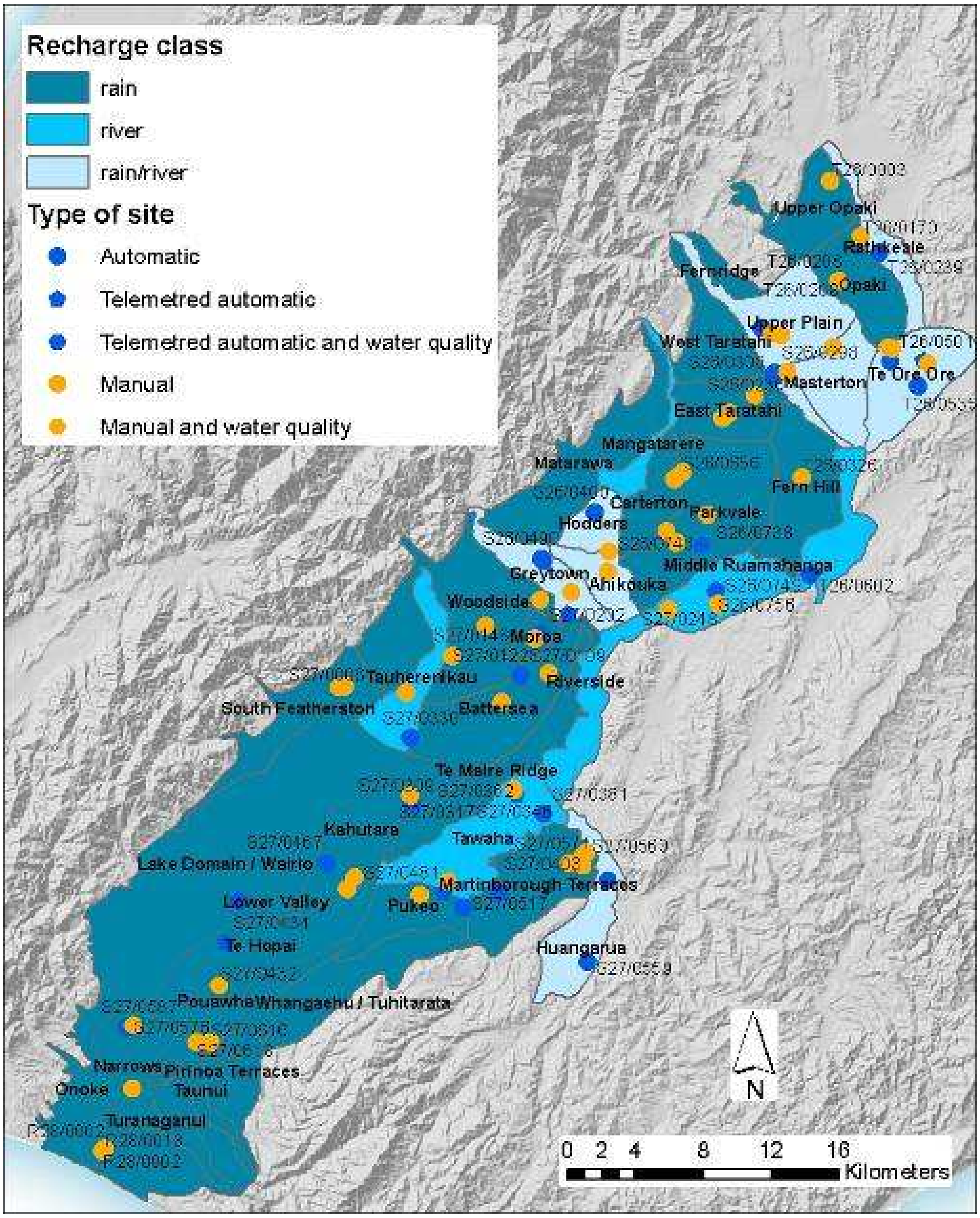


Figure 4.21: Wairarapa Valley groundwater zones recharge classification and groundwater level monitoring sites

4.4.2 Rainfall recharged groundwater zones

Because the majority of Wairarapa groundwater zones are thought to be predominantly recharged by rainfall the variation in rainfall is an important consideration when assessing the quantity of groundwater in these zones.

Figure 4.22 shows the hydrograph for well S27/0571 at Martinborough Golf Club. Superimposed on this graph is a plot of the cumulative deviation from the long-term mean for the nearby rainfall record at Mahaki.

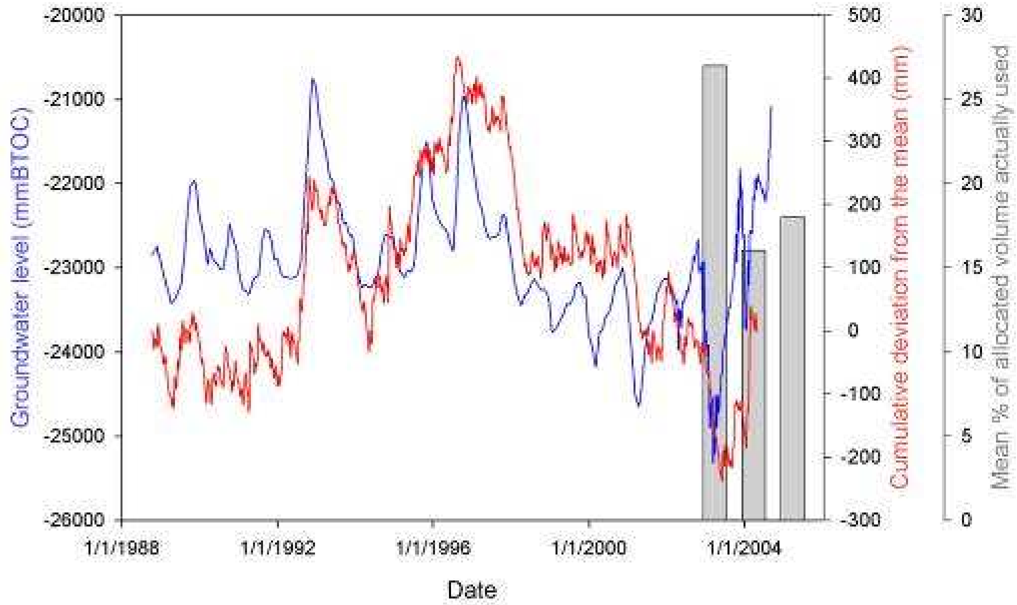


Figure 4.22: Hydrograph for the Martinborough Eastern Terraces groundwater zone at Martinborough Golf Club (S27/0571) shown with rainfall at Mahaki and metered groundwater use.

The variation in groundwater level is strongly correlated with variation in rainfall as periods of above average rainfall are matched by pronounced increases in groundwater level. Similarly, the decline in groundwater level from about 1998 to 2003 may be attributed to average to below average rainfall over the same period. We do not think that abstraction has played a large part in the decline over this period because the amount of water actually taken by groundwater users is low compared to the estimated recharge to the aquifer system. This pattern of use is shown in Figure 4.22 as the mean percentage of allocated volume actually used by nine groundwater users in the Martinborough area. Butcher (2001a) assessed the recharge to the Martinborough aquifer system and recommended an allocation limit of 0.31 million m^3/year, which represents 20% of the total estimated rainfall recharge. The aquifer system is currently 135% over-allocated so the metered abstraction represents about 5% of the total estimated recharge to the system. This low proportion leads us to conclude that groundwater level variation in the Martinborough area reflects variation in rainfall recharge.

4.4.3 River recharged groundwater zones

The amount of river recharge is poorly defined, particularly from larger rivers where flow losses are similar to the margin of error on the flow measurements.

However, in many places there is a clear link between shallow unconfined aquifers and adjacent surface water bodies. An example is the Burt well (S27/0330) on the eastern bank of the Tauherenikau River. Figure 4.23 shows a portion of the hydrograph for this site and the river flow site at the Tauherenikau Gorge where the river leaves the Tararua range. A clear correlation can be seen between river flow and groundwater level.

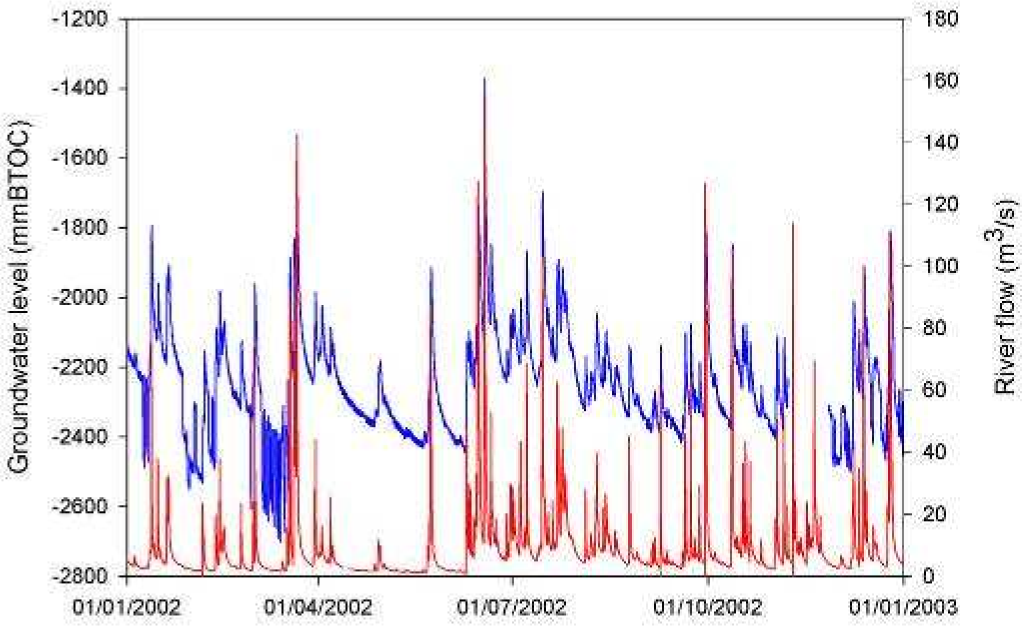


Figure 4.23: Hydrograph for the Burt well (S27/0330) shown with the flow in the Tauherenikau River at the Gorge.

As is the case on the Kapiti Coast, shallow river recharged aquifer systems tend to be highly transmissive and the groundwater levels correlate strongly with changes in river stage. This highly transmissive nature masks any abstraction effects on groundwater levels by allowing additional recharge from the adjacent surface water body.

Section 4.4.5 shows that the shallow aquifer adjacent to the Ruamahanga River is fully allocated. However, it is important to recognise that the safe yield is based purely on rainfall recharge estimates (Butcher, 1996c) and consequently will underestimate the amount of water available. However, concurrent gauging data to assess the degree of connection with the river have not been collected, and will be problematic to collect because of the high flows in the river. A reassessment of the safe yield is required in conjunction with an instream flow values assessment.

4.4.4 Abstraction

Groundwater is widely used in the Wairarapa and the volume of water allocated for use has been increasing over the last nine years. Groundwater is used for public supply but the predominant use is for irrigation. Actual groundwater use is poorly known because very few takes are metered. Those takes that are metered are typically read before and after an irrigation season giving a bulk value for that season. We discuss metering further in the next section.

Figure 4.24 shows the allocation status of groundwater zones in the Wairarapa Valley and the location of active water permits. A full table of permits is found in Appendix B. The high allocation levels in Parkvale, Martinborough and Kahutara prompted moratoria on new permits until the yield of the aquifer system can be confirmed (WRC, 2001b and 2002).

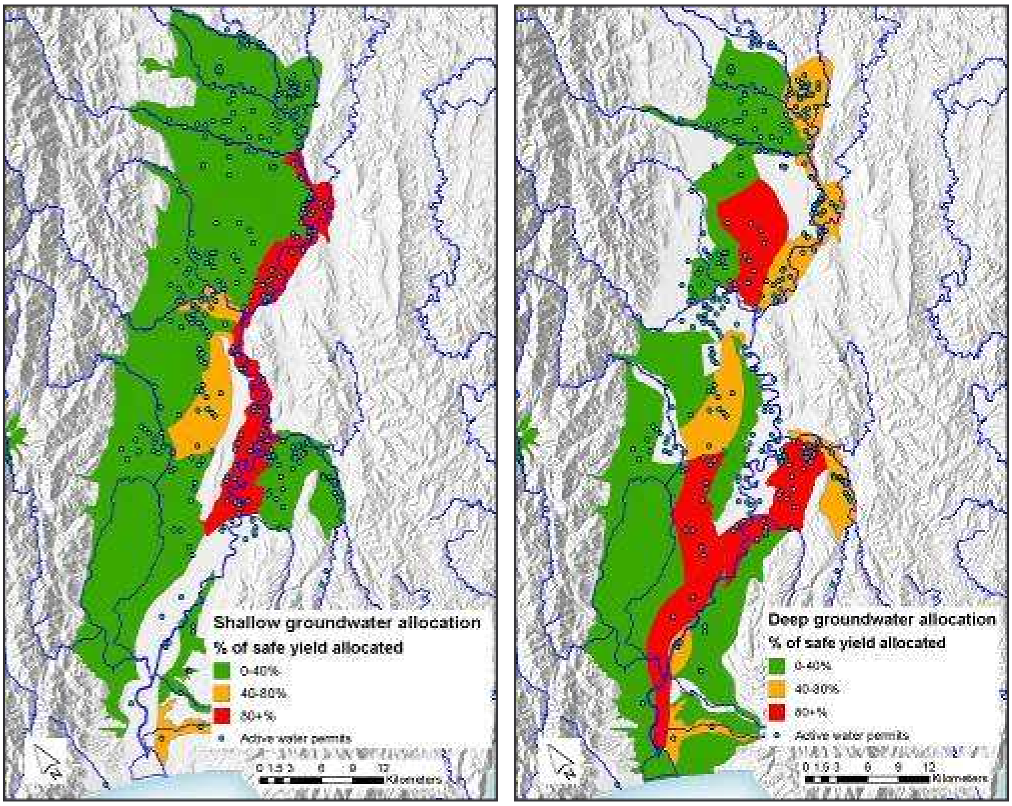


Figure 4.24: Allocation status of Wairarapa groundwater zones. Shallow groundwater is considered to be that taken from wells less than 15m deep while deep groundwater represents all groundwater below 15m.

(a) Metering groundwater use

There are a limited number of metered abstractions in the Wairarapa. Figure 4.25 illustrates the available results. The first half of the Figure shows the actual use compared with allocated use in terms of volume, while the second half of the Figure presents the same data as percentages of the allocated volume. The limited results that we have indicate that about 20% of the allocated volume is actually being used.

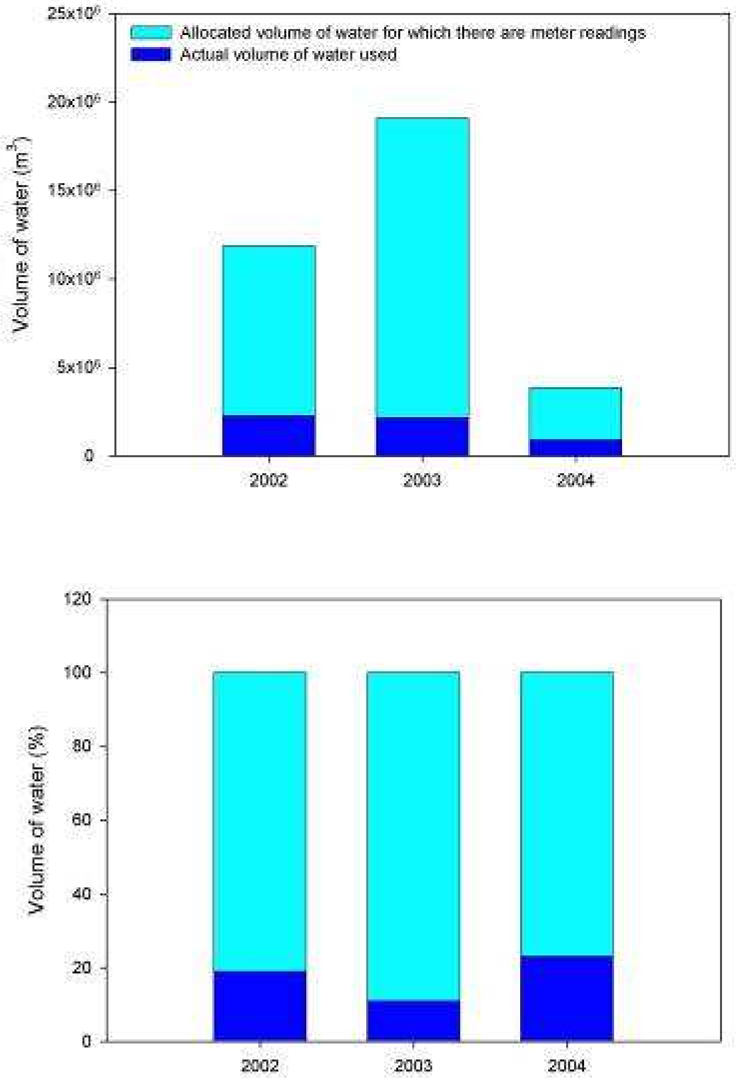


Figure 4.25: Actual use compared with allocated use for Wairarapa groundwater users.

(b) Groundwater level declines caused by pumping

Groundwater level declines have been observed in some areas despite the low percentage of allocated water volume actually used. Figure 4.26 shows annual maximum and minimum daily values for the Woodside, Battersea and Kahutara groundwater zones. We interpret the variation between these plots as the increasing influence of groundwater pumping with increasing distance down-gradient through the aquifer system. There is very little pumping in the Woodside zone, which is reflected in the stable annual maximum and minimum groundwater levels. The Battersea zone has some pumping that appears to be having an increasing influence on seasonal low groundwater levels but is insufficient to deplete groundwater storage to such an extent that seasonal maximum groundwater levels are affected. The Kahutara zone has the highest level of groundwater pumping, which has caused a long-term decline in groundwater storage as shown by decreasing annual minimum and maximum groundwater levels.

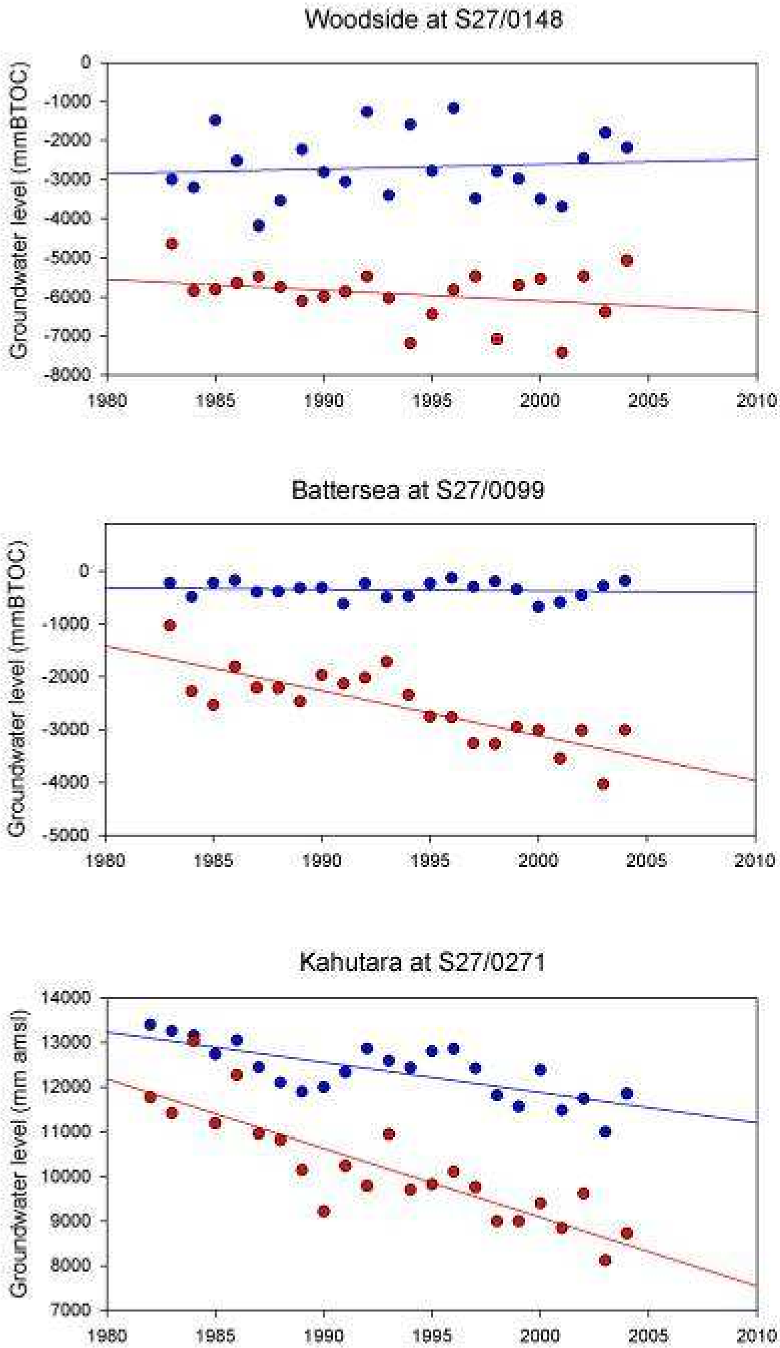


Figure 4.26: Annual maxima and minima for groundwater levels in select wells from the Woodside, Battersea and Kahutara groundwater zones.

A similar pattern is observed in the Parkvale groundwater zone when the little used shallow unconfined aquifer is compared to the deeper aquifer, which is used for irrigation. Figure 4.27 shows the shallow Towgood well (S26/0738) and the deeper Baring well (S26/0743). The deeper aquifer shows a decline both in seasonal maxima and minima while the shallow aquifer shows little long-term variation in either time series. We interpret this difference to be the result of pumping.

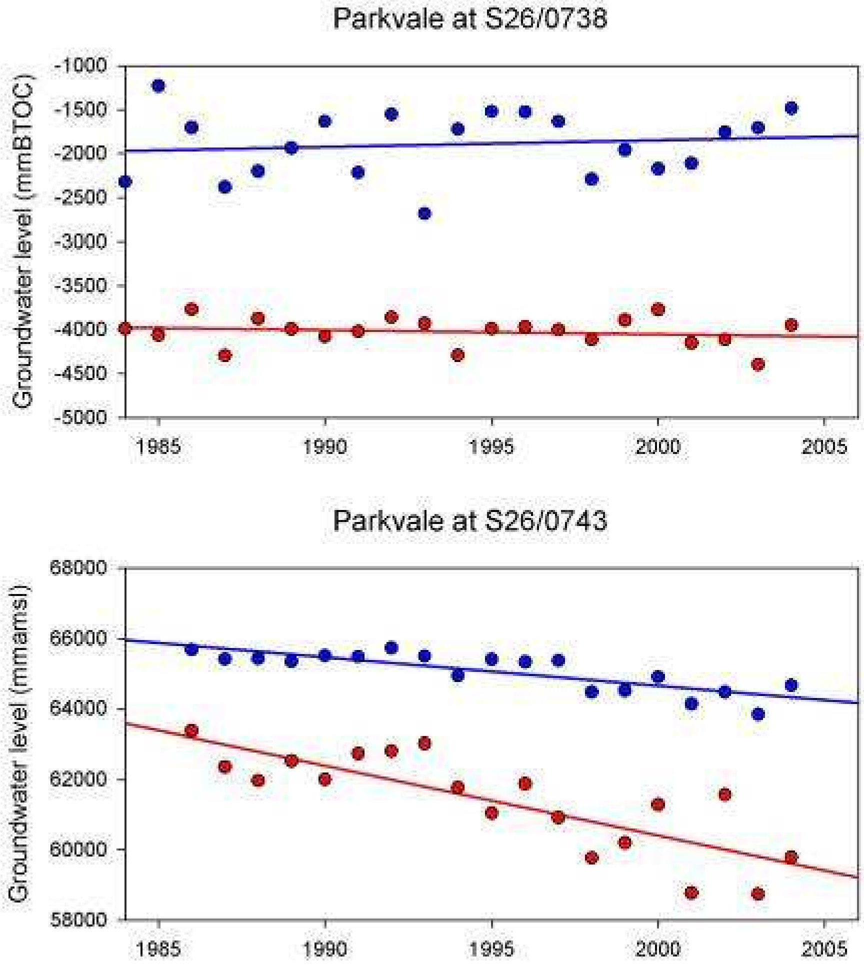


Figure 4.27: Annual maxima and minima of groundwater levels in the shallow (well (S26/0738) and deeper (well S26/0743) aquifers of the Parkvale groundwater zone.

The Kahutara and Parkvale zones are currently covered by moratoria on the issue of additional groundwater allocation until such time as the sustainable yield of these zones can be confirmed. The decline in groundwater level indicates that the current safe yield estimate for these zones is incorrectly set to avoid long-term depletion of groundwater storage. Refinement of the safe yield estimates will require a detailed examination of groundwater discharge from these zones to determine what degree of groundwater level decline may be tolerated.

4.4.5 Groundwater discharge

(a) Springs, streams and wetlands

Groundwater discharge mechanisms and rates are poorly constrained in the Wairarapa Valley. There are a number of known springs and recharge-discharge relationships with streams, however the spatial extent and temporal variation in discharge is undefined.

In the Parkvale groundwater zone Butcher (2004b) states that the springflow discharge from the shallow unconfined aquifer may represent 55% of the estimated rainfall recharge. This percentage is a large proportion of the water balance for this groundwater zone and highlights the importance of considering groundwater discharge. This type of assessment is required throughout the Wairarapa Valley and will involve the establishment of additional groundwater level and streamflow monitoring sites.

Definition of discharge areas and measurement of discharge rates will need to be complemented with habitat assessments. These assessments are required to determine the degree to which groundwater discharge may be reduced by pumping without causing adverse ecological effects.

(b) Connection with the sea

The relationship between the aquifers in the Lower Valley and the sea is unknown. However, geological evidence suggests that the southern margin of the valley is being uplifted while the area around Lake Wairarapa is subsiding (Begg et al, in prep). The uplift across the southern margin of the valley has uplifted Miocene-Pliocene groundwater basement above sea level on the Lake Ferry side of the valley. And at the western edge of the valley, Early to Middle Quaternary mud and silt-bound gravel are exposed in cliffs. These relatively impermeable sediments form a plug at the bottom end of the Wairarapa Valley groundwater system. This plug, coupled with subsidence around Lake Wairarapa means it is likely that the Wairarapa groundwater system is largely isolated from the sea. If this inference is true, then groundwater pumping in the Lower Valley is unlikely to result in seawater intrusion.

4.4.6 Summary

Groundwater level variation in most Wairarapa groundwater zones can be explained by natural variation in recharge. However, long-term pumping induced water level reductions have been observed in the Kahutara and Parkvale zones.

The allocated volume from these zones is close to their specified safe yield values, so doubt has arisen over the validity of the safe yield estimates, which were designed to prevent long-term depletion of groundwater storage. Exacerbating this issue are limited metering data that indicate actual groundwater usage is only about 20% of the allocated volume.

The discharge mechanism of Wairarapa aquifers is poorly constrained and so the potential for pumping to affect groundwater dependant ecosystems is unknown. There is a need to confirm groundwater discharge areas and rates and the ecological importance and sensitivity of those areas.

A programme to revise our conceptual model of the Wairarapa groundwater system is underway. This work will underpin a revision of the safe yield estimates for different aquifers.

5. Groundwater quality

This section of the report reviews the results of groundwater quality monitoring conducted over the Wellington Region by Greater Wellington. Data utilised in this review has been collected since the early 1990s through the Groundwater State of the Environment Monitoring Programmes (GWSOE), pesticide monitoring programmes, and several targeted groundwater quality studies. The data is reviewed to:

- provide information on the ambient quality of the region's groundwater;
- identify both spatial and temporal trends in groundwater quality; and
- assess compliance with Greater Wellington's groundwater quality objectives.

5.1 Rationale

Water 'quality' is a difficult concept to define, even though it is a commonly used term. The quality of the groundwater can be described through the analysis of physical, chemical, and microbiological analysis.

Groundwater in the Wellington Region is used by a large range of domestic, industrial and agricultural users. Groundwater is the main source of drinking water for a number of individual households, small communities and larger towns in the region including 35% of the greater Wellington urban area, Carterton, Martinborough, Otaki and Waikanae. Groundwater is also used extensively throughout the region for irrigation, stock watering and dairy shed washdown. In areas where groundwater provides the baseflow to streams and rivers, flows into wetlands, or rises to the surface in springs or seeps, the quality of the groundwater can also have an impact on the surrounding ecosystems. Monitoring, managing and protecting the quality of groundwater in the region is therefore an important task for which Greater Wellington holds responsibility.

The groundwater quality objective (Policy 5.2.7) in Greater Wellington Regional Council's Regional Freshwater Plan (1999a) is:

> *To manage all groundwater in the Wellington Region so that there are no net adverse effects on its quality as a result of discharges to surface water or groundwater.*

5.1.1 How do we assess groundwater quality?

As previously mentioned the concept of 'water quality' is subjective. In New Zealand there are several sets of guidelines, standards and maximum acceptable values for use in water quality assessments.

In this report groundwater quality data is assessed primarily using the New Zealand Drinking Water Standards (Ministry of Health, 2000). These standards provide maximum allowable values and guideline values for a wide range of chemical and microbiological contaminants. The applicable drinking water standards are outlined in Appendix G. There are however, a number of parameters for which no maximum or guideline values have been set. For these analytes, results are compared to other studies, and previous data, in order to assess trends and variability.

5.2 What influences groundwater quality?

Groundwater quality is naturally variable. The source of the water (rainfall or river), aquifer geology, residence time of water in the aquifer, land use, and other anthropogenic impacts, can all influence the quality of an aquifer system.

5.2.1 Natural processes

As groundwater flows through an aquifer system its chemical composition changes according to various chemical, solubility, and electrochemical equilibria within the aquifer system (Freeze & Cherry, 1979). The geochemical composition of groundwater is influenced by a number of factors including:

- the confinement and depth of the aquifer system;
- the mode of aquifer recharge;
- distance from recharge source;
- nature of aquifer materials;
- hydraulic characteristics of the aquifer system.

As groundwater flows through the saturated zone, increases of total dissolved solids and most of the major ions (calcium, magnesium sodium, potassium, bicarbonate, sulphate, chloride) normally occur. This is known as rock–water interaction. It has been observed through numerous investigations that shallow groundwater in recharge areas is lower in dissolved solids than the water deeper in the same system, and lower in dissolved solids than water in shallow zones in the discharge areas (Freeze & Cherry, 1979).

Chebotarev (1955) concluded that groundwater tends to evolve chemically toward the composition of seawater. He observed that this evolution is normally accompanied by the following regional changes in dominant anion species:

Travel along the flowpath $\longrightarrow$

$$HCO_3^- \rightarrow HCO_3^- + SO_4^{2-} \rightarrow SO_4^{2-} + HCO_3^- \rightarrow SO_4^{2-} + Cl^- \rightarrow Cl^- + SO_4^{2-} \rightarrow Cl^-$$

Increasing age $\longrightarrow$

These changes generally occur as the water moves from shallow zones of active flushing (recharge areas), through intermediate zones, and into zones where the flow is sluggish and the water is old. This sequence however, must be viewed in the context of aquifer scale and geology and is often incomplete or interrupted.

Large variations in major cations commonly occur in groundwater systems. However, since cation exchange commonly causes alterations or reversals in the cation sequences, generalisation of the cation sequence is more difficult (Freeze & Cherry, 1979). Cation exchange results in the removal of calcium and/or magnesium from the groundwater and replaces them with sodium.

Aquifers recharged by rainfall infiltration generally contain groundwater with higher levels of nutrients than groundwater derived from river recharge (Hughes, 1994). The higher nutrient loading in rainfall recharged aquifers reflects the leaching of nutrients e.g. nitrate, by soil moisture infiltration. Confined aquifers are protected from direct leaching, however nutrients contained in aquifer recharge can travel into confined systems. Thus, the use of groundwater chemistry data can help in the determination of aquifer recharge and discharge mechanisms.

5.2.2 Anthropogenic impacts

In addition to natural changes in water chemistry, there are a number of anthropogenically derived effects on groundwater quality. The main anthropogenic factor influencing groundwater quality is land use. Land use is an important consideration in groundwater quality studies as it influences the shallow, unconfined aquifer systems which are the most vulnerable to contamination. These shallow, unconfined systems are also the most likely to be used for domestic water supplies, and also have a high likelihood of connection with surface water systems.

Potential contamination is not restricted to the shallow unconfined systems however. Semi-confined, and even confined systems are also at risk given the right flow, and chemical conditions.

Pressures from agricultural and horticultural land uses are mainly through additional inputs of nutrients into the groundwater system. Effluent, fertilisers and soil cultivation often lead to increases in nitrate, ammonium, phosphorus and potassium in the groundwater system. Increases in chloride are also often associated with effluent disposal, and the use of pesticides and herbicides is another potential source of contamination.

Other potential impacts on groundwater quality include on-site sewage disposal through septic tanks, leaching from contaminated sites, landfills and irrigation.

The abstraction of large amounts of water for irrigation use also has the potential to influence the quality of an aquifer system. By drawing large amounts of water, especially from a confined groundwater system, recharge into the system may be induced. There is potential for this induced water to be chemically and bacterialogically different from the existing water and thus change the chemistry of the aquifer.

(a) Land use and land cover

Land use information for this section of the report has been calculated based on only that land beneath which there has been a groundwater zone defined in the Regional Freshwater Plan (WRC, 1999). The groundwater zones described in the Regional Freshwater Plan are shown in Figure 3.1 and cover 140,000ha, or 17% of the total region (811,000ha) - essentially the central Wairarapa valley, the Hutt Valley and the coastal plains of the Kapiti area. The eastern (Wairarapa) groundwater zones cover 108,000ha while the western (Wellington) zones cover 32,000ha.

Land cover was determined through the use of the Land Cover Database 1v2 (MfE, 1998). The dominant land cover in the Wellington Region is pasture (76%). Pastoral land uses are generally sheep, beef or dairy farms. When the eastern and western sides of the region are compared there are significant differences between the two sides (Fig 5.1). The western (Wellington) side has a lower percentage of pastoral land (52%), and higher urban land cover (21%). The eastern (Wairarapa) is dominated by pastoral land cover (85%) and has only 2% of urban land cover.

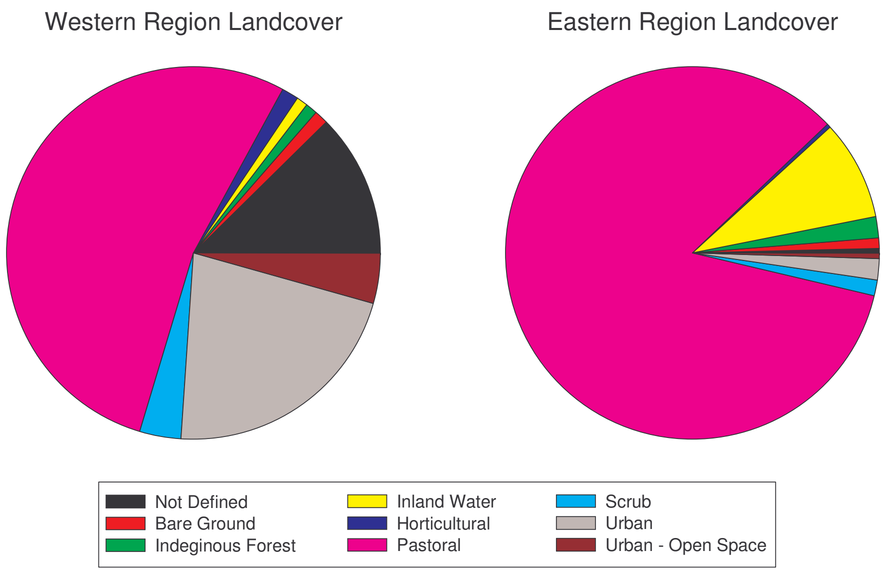


Figure 5.1: Land cover of the western Wellington Region (left) and the eastern Wellington Region (right). Source: MfE, 1998.

Using the AgriBase dataset (AgriQuality New Zealand, 2000) the farm types of the land classified as horticultural and pastoral in the LCDB can be determined (Figure 5.2). The dominant farm type in the groundwater zones in the Wellington Region is dairy (32%), followed closely by sheep and beef, and mixed sheep and beef farms. The Wairarapa has a higher percentage of sheep and beef farms than the eastern part of the region, and a greater proportion of total farms due to the larger land area.

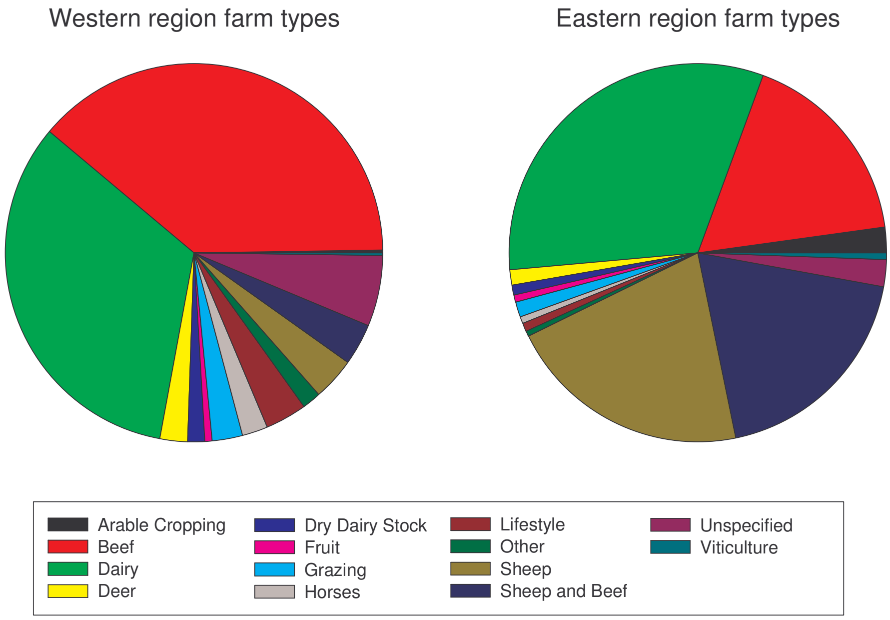


Figure 5.2: Agricultural land use in the Wellington Region. Source: AgriQuality, 2000.

Given that 85% of the land designated as groundwater zones in the Regional Freshwater Plan is used for dairying, sheep, or beef farming, it is clear that the greatest anthropogenic pressures on shallow groundwater quality in the Wellington Region come from agriculture and horticulture. Of all of the agricultural and horticultural land uses, it is acknowledged that dairying, with increasing stocking rates, milksolids production and urea fertiliser use (162% increase nationally 1996-2002; Parliamentary Commissioner for the Environment, 2004) has the greatest potential to effect shallow groundwater quality.

(b) Discharges to land (agricultural effluent and on-site sewage)

Dairy farms and piggeries throughout the region produce large volumes of effluent and contaminated wash-down water from milking sheds and yards that needs to be disposed of. Prior to 1994 it was a commonly accepted practice to discharge this effluent into rivers, streams or lakes. However, these types of discharges are now either discretionary or non-complying under the Regional Freshwater Plan (WRC, 1999a). Applying agricultural waste to land is now the preferred method and is a controlled activity under the Regional Plan for Discharges to Land (WRC, 1999b).

Over the last ten years Greater Wellington has moved towards removing all discharges of agricultural effluent to rivers/lakes (Table 5.1). At the end of 2004 there were only three farms still discharging to rivers/lakes in the Wellington Region.

	Kapiti/Hutt Valley	Wairarapa
1994	14 **(16)**	60 **(215)**
2004	3 **(26)**	0 **(186)**

Table 5.1: Change in the number of farms discharging to river or lake in the Wellington Region 1994 – 2004.

The change in discharging agricultural waste from water to land has removed most discharges from waterways across the region. However, the application of effluent onto land needs to be carefully managed to ensure minimal leaching of nutrients into the shallow groundwater system. Figure 5.3 shows the distribution of discharge to land consents across the region and highlights the density of these consents around Carterton, Featherston, the Lower Wairarapa Valley and Otaki. Section 5.4 provides the results of groundwater quality monitoring in these areas.

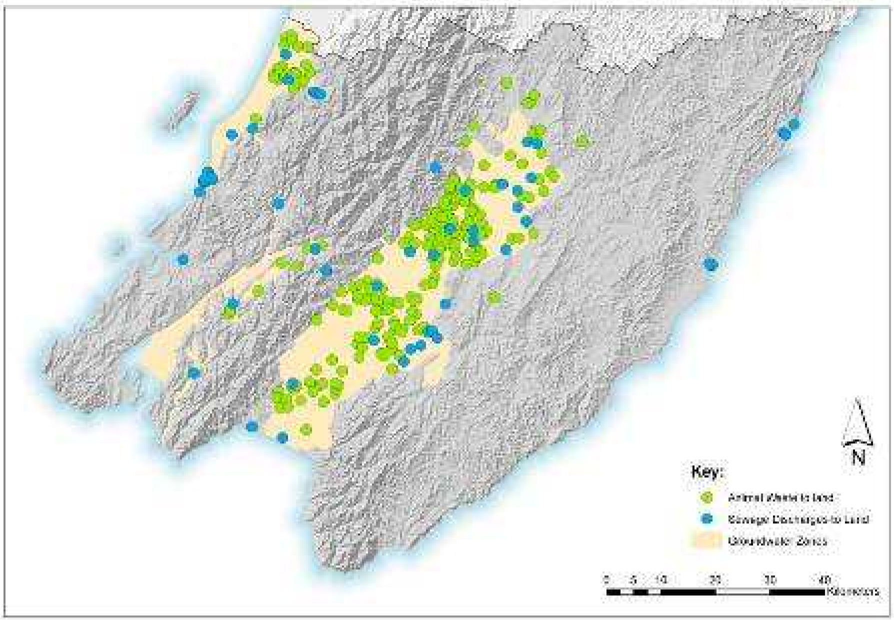


Figure 5.3: Discharge consents for Animal waste and sewage to land - December 2004

Contamination of groundwater from septic tanks has been reported at a number of locations in the Wellington Region including Riversdale Beach (Hurnell & Sevicke-Jones, 2002), Te Horo (Hughes, 1998) and Blue Mountains in the Hutt Valley (WRC, 1998). Contamination is a particular problem in areas where there are high densities of septic tanks and shallow groundwater levels.

Discharges from on-site sewage treatment systems are a permitted activity under the Regional Plan for Discharges to Land (WRC, 1999b) provided they are discharging less than 1300 litres per day and meet a number of performance conditions. On-site sewage systems discharging over this amount require a resource consent. The locations of consented discharges from sewage systems are shown in figure 5.3.

Because they are a permitted activity, managing the effects of on-site sewage systems on groundwater quality is difficult. High densities of septic tanks occur in small communities outside of the bigger cities reticulated sewer systems, however the specific locations of these systems are unknown, and not required by Territorial Authorities of the Regional Council to be recorded.

(c) Fertiliser use

Fertiliser is another agricultural pressure. Over the past decade, in response to a strengthening agricultural sector and pasture management strategies, the use of fertilisers, in particular nitrogen based fertilisers, has increased substantially. Figure 5.4 shows the dramatic increase between 1992 and 2004 of urea based fertiliser in the Wellington Region of approximately 900%.

Studies have shown the leaching of nitrogen from the urine patch to be far greater than nitrogen leaching from fertiliser application (i.e. Ledgard et al, 2000; Monaghan et al., 2000; Silva et al., 1999). However, the dramatic increase in the use of urea has increased the risk of nitrogen leaching to groundwater. Groundwater quality in these areas of intensive fertiliser therefore requires careful monitoring.

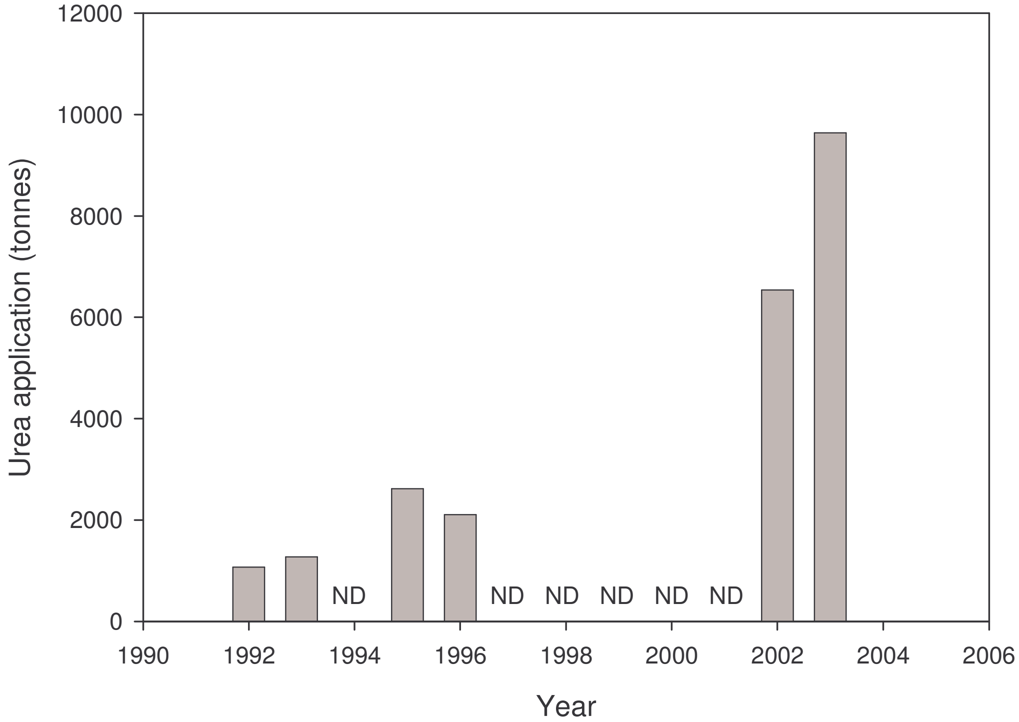


Figure 5.4: Total Quantity of Urea fertiliser spread in the Wellington Region 1992 – 2003 (ND = no data). Source: Statistics New Zealand, 2004.

5.3 Overview of groundwater quality monitoring in the Wellington Region

Greater Wellington monitors groundwater quality through a state of the environment programme, participation in the Institute of Geological and Nuclear Sciences run National Groundwater Quality Monitoring Programme (NGMP), pesticide monitoring and some smaller targeted studies.

5.3.1 Greater Wellington programme aims

State of the Environment groundwater quality monitoring at Greater Wellington was managed separately from the Wellington and Wairarapa offices until 2003. These programmes were merged in 2003 to provide more consistency in sampling, analysis and reporting, however, the aims of the programme did not change. The objectives of the programme (as identified by Butcher, 1996 & Cussins, 1997) are to:

- provide information on the baseline quality of groundwater in the Wellington Region;
- identify spatial and temporal trends in the quality of groundwater in the Wellington Region;
- assess compliance with Greater Wellington's groundwater quality objectives and identify areas where maintenance or enhancement of groundwater quality is necessary;
- to provide chemical analysis of groundwater to support conceptualisation of groundwater flow models and resource definition;
- quantify potentially important groundwater quality issues;
- evaluate the effectiveness of the policies and strategies relevant to groundwater quality; and
- provide data which can be used for appropriate effects-based decisions on discharge and water permit applications.

5.3.2 Programme structure

The current groundwater state of the environment (GWSOE) programme consists of 80 sites monitored on a quarterly basis. The parameters analysed in this programme are summarised in table 5.2. Most of the sites in the western part of the region have been sampled since 1994, and in the eastern part of the region approximately half have been monitored since 1997. A number of sites were added in the eastern part of the region in 2003. Refer to Appendix C for a list of the GWSOE bores.

The fifteen bores monitored as part of the NGMP are also monitored as part of the GWSOE programme. The parameters analysed in this programme are summarised in Table 5.2. Refer to Appendix C for a list of the NGMP bores.

Pesticides have been monitored at select sites throughout the region as part of the Institute of Environmental Science and Research's (ESR) national pesticide survey. The ESR programme is conducted every four years subject to available funding.

	Bacteria		Major ions							Nutrients					Metals				Trace Elements			Other						Calculations						
Programme	faecal coliforms	Escherichia coli	Dissolved Sodium	Dissolved Potassium	Dissolved Calcium	Dissolved Magnesium	Chloride	Sulphate	Total Alkalinity	Total Ammoniacal-N	Nitrate-N + Nitrite-N (TON)	Nitrate-N	Nitrite-N	Dissolved Reactive Phosphorus	Dissolved Iron	Dissolved Manganese	Dissolved Lead	Dissolved Zinc	Bromide	Fluoride	Dissolved Boron	pH	Electrical Conductivity	Dissolved Oxygen	Reactive Silica	Total Organic Carbon (TOC)	Pesticide Screen	Total Dissolved Solids	Free carbon dioxide	Bicarbonate	Total Hardness	Total Anions	Total Cations	% Difference in Ion Balance
GWSOE	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
NGMP			x	x	x	x	x	x	x	x		x	x	x	x	x			x	x		x	x	x	x							x	x	x
Pesticides																						x	x	x			x							

Table 5.2: Parameters analysed as part of Greater Wellington's groundwater quality monitoring programmes.

5.3.3 Site selection and sample collection

The wells and bores selected for the GWSOE programme have been selected on the basis of objectives of the programme and their location, depth and suitability for sampling. All of the groundwater zones (Figure 3.1), and the majority of the aquifers in these zones, are sampled as part of this programme. Figure 5.5 shows the location of these sites over the region (detailed location maps of monitoring sites are given in Appendix D).

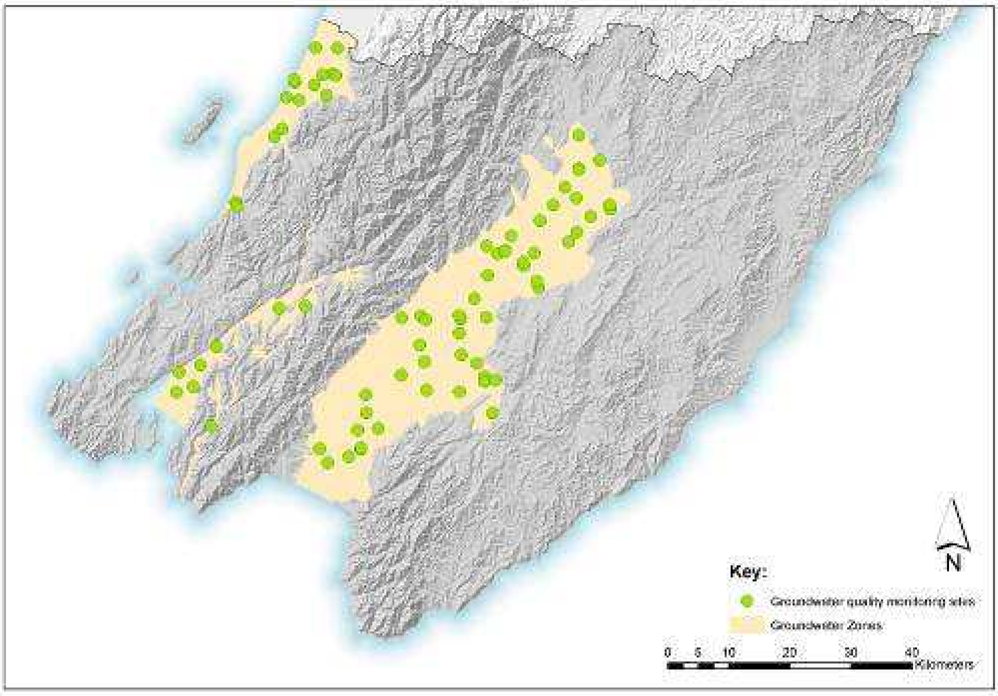


Figure 5.5: Groundwater quality monitoring sites in the Wellington Region

Samples for both the GWSOE programme and the NGMP are collected by Greater Wellington staff according to the protocols outlined in the New Zealand Guidelines for the Collection of Groundwater Samples for Chemical and Isotopic Analyses (Rosen et al., 1999).

Since October 2003 analysis of the major ions, nutrients, metals, trace elements and total organic carbon have been performed at Hill Laboratories in Hamilton. Bacteriological samples have been analysed at Biostandards Laboratory in Wellington. All NGMP samples are analysed at the IGNS laboratory in Wairakei, Taupo. The methods of analysis used by both of these laboratories are outlined in Appendix E.

Prior to October 2003 samples for the GWSOE were analysed at several laboratories. All samples collected in the Wairarapa were analysed by Wairarapa Laboratory Services for analysis. Samples from sites in the Western Region were analysed by Greater Wellington's Utility Services Division laboratory in Lower Hutt. The sites in the Western Region sampled as part of the NGMP had 'top up' analyses performed at the Utility Services laboratory to fulfil the requirements of the GWSOE programme.

5.3.4 Quality control of data

A range of quality control measures are used to ensure the integrity of monitoring data.

Field meters are calibrated on a daily basis for dissolved oxygen and pH in accordance with the manufactures specifications. Electrical conductivity and pH are measured by Hill Laboratories which allows a quality check against the field measurements, and may also provide an indication on whether the samples have undergone chemical changes between collection and laboratory analysis.

Both Hill Laboratories and the IGNS Wairakei laboratory are accredited by the International Accreditation New Zealand (IANZ) for all tests performed for Greater Wellington.

Ion balance for the GWSOE samples is calculated by Hill Laboratories. If electrical neutrality of the groundwater is assumed across the major cation and anions, the charge balance errors should ideally be less than 5%. However, in water with a low ionic load, charge balance error of less than 10% can be acceptable. At the request of Greater Wellington, Hill Laboratories re-analyses all samples with charge balance errors of greater than 5%.

5.3.5 Total vs. dissolved concentrations and field vs. lab measurements

There are a number of ways a sample can be presented for testing. Two common ways are the sample as collected and the sample after filtration. The results of testing are described as total concentrations or dissolved concentrations. The total concentration of a particular analyte in groundwater includes the analysis of any sediments or suspended solids in the sample. Dissolved concentrations are preferred for groundwater as these reflect the analytes moving in the groundwater, as opposed to an analysis including constituents associated with sediments or other solids collected during sampling. Where dissolved concentrations are referred to in this report this generally refers to filtration through a 0.45 μm filter in the field immediately upon sampling.

Prior to October 2003 results for calcium (Ca), sodium (Na), potassium (K), magnesium(Mg), manganese (Mn), boron (B), lead (Pb), zinc (Zn), and iron (Fe), were analysed and reported as total concentrations. At the same time as the change of laboratories, the analysis of these parameters was changed from total concentration to dissolved concentrations.

Regression analysis performed by Daughney (2004) for GWRC analysed the differences between dissolved and total concentrations of the above parameters at the 10 Kapiti and Hutt Valley NGMP sites. The results showed no differences between calcium, iron, zinc and lead and small but significant differences between boron, potassium, magnesium, manganese and sodium. These results are not unexpected given the change in sample technique but as they were based on a small dataset they must be treated with caution.

Regression analyses were also performed on conductivity and pH measurements made in the field and laboratory. The results showed small but significant differences between laboratory and field measurements of pH and conductivity. This result was also only based on a small dataset and must be treated with caution.

For the calculation of medians, deviation and trends, total and dissolved analyses of the above parameters were merged to form full data sets. It is therefore important, especially in the interpretation of trend results, that there may be bias caused by the different analytical methods.

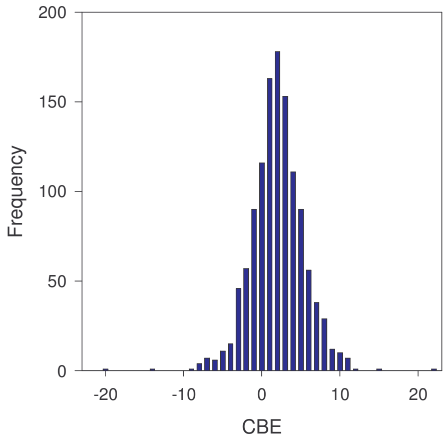
5.3.6 Charge balance error

All waters are electrically neutral, meaning that the sum of concentrations (measured in equivalents per litre) of all positive ions (cations) must be equal to the sum of concentrations of all negative ions (anions). Therefore, calculation of the charge balance error, or the difference between the sum of equivalents of cations and the sum of equivalents of anions, can be used as a measure of the analytical accuracy of water quality data. Ideally, the value for the charge balance error is 0%.

Appendix F (Daughney, 2005) details the calculation of charge balance error, and the calculation of the acceptable limits for charge balance error. The acceptable limits are approximately 5% of each sample but may range as low as 4.35% and a high as 6.35% for samples with very high or very low concentrations of total dissolved solids, respectively.

The majority of samples from the GWSOE programme have charge balance error within acceptable values (refer Appendix F for detailed methodologies), indicating that laboratory analytical results are reliable for most samples and most sites. Charge balance error was able to be calculated for 1207 of the 1386 samples collected (Appendix H and Appendix I - summary tables of GWSOE and NGMP data). Of the 1207 samples for which CBE could be calculated, 1077 (77.7%) were within acceptable limits, 26 (1.8%) were 'low' (anion excess), and 104 (7.5%) were 'high' (cation excess).

Histograms of charge balance error distribution show that for all samples collected as part of the GWSOE programme, regardless of laboratory, there is a slight positive skew in the data (Figure 5.6). However, on further investigation, this skew appears to have been biased by data from the Utility Services Laboratory. Data from the Utility Services Laboratory has historically had a skew towards positive charge balance errors (excess cations; Figure 5.8). This indicates an analytical bias in the laboratory and is not investigated further in this report. Since the change to Hill Laboratories in October 2003, the distribution of samples has not been skewed as shown in Figure 5.6.



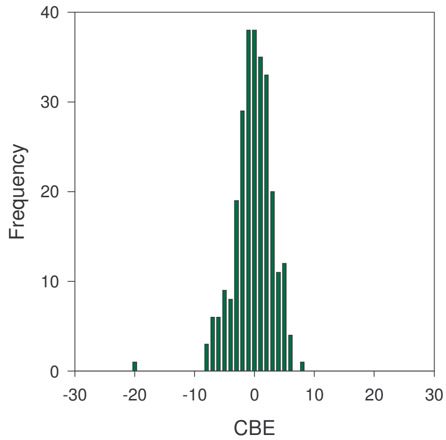


Figure 5.6: Histogram of charge balance error (%) for all GWSOE samples (left) and only Hill Laboratories samples (right).

A scatterplot shows the variation in CBE over time for all results (Figure 5.7), and between laboratories (Figure 5.8). A clear shift in the median and range of CBE is apparent from October 2003 onwards. This shift can be explained by two factors. Firstly there was the change in laboratories (see section 5.3.2 for more details), and secondly the change to field filtering all samples, as opposed to total concentrations being measured. Figure 5.8, which shows the charge balance errors from the NGMP samples, shows a much more consistent spread of results. All NGMP samples are field filtered. Overall the change in laboratories and change to field filtering has increased the quality of the results obtained.

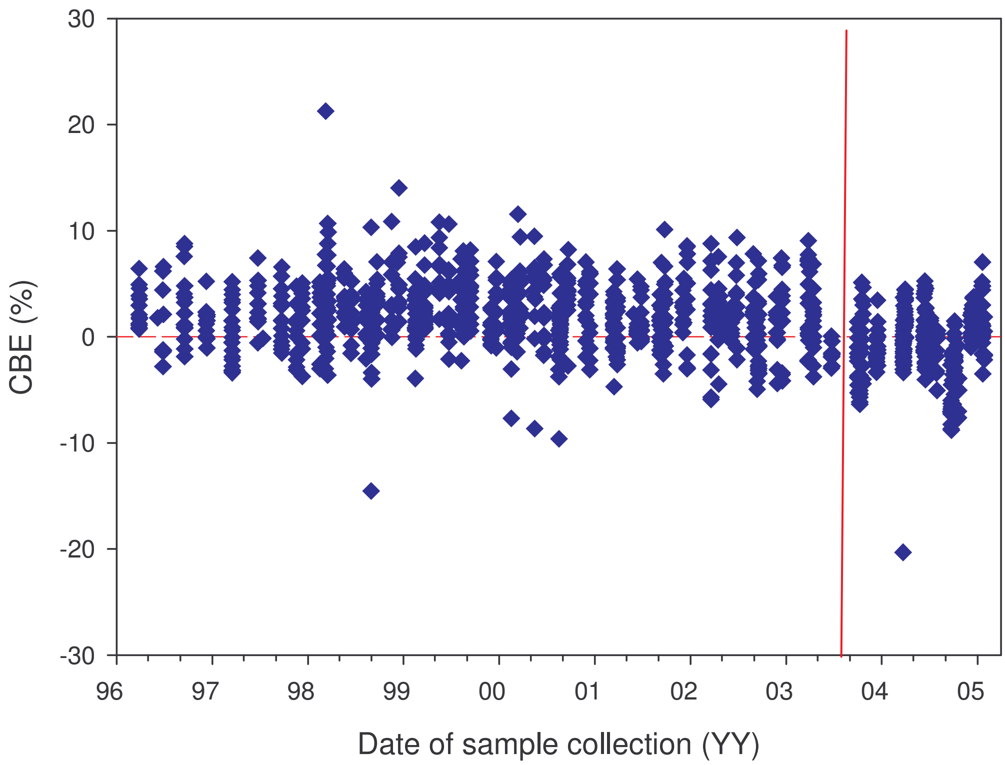


Figure 5.7: Charge balance error for all GWSOE and NGMP samples. The vertical red line denotes the change in laboratories and change to field filtering of samples.

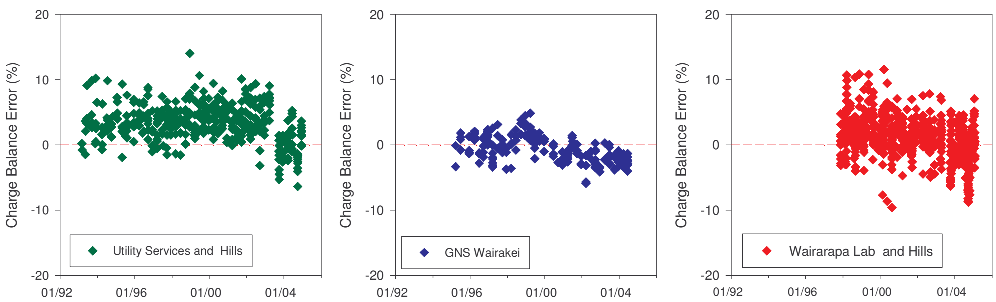


Figure 5.8: Scatterplots of charge balance errors for sites previously analysed at the Utility Services lab then analysed at Hill labs (left), NGMP sites always analysed at IGNS Wairakei lab (centre) and sites previously analysed at Wairarapa laboratory services then analysed at Hill laboratories (right).

5.4 Review of GWSOE monitoring data

This section of the report analyses the median values of all measured parameters and where applicable makes reference to the New Zealand Drinking Water Standards (NZDWS; MoH, 2000; Appendix G). Summary tables of all median concentrations are given in Appendix H and Appendix I. Median values in excess of the relevant maximum allowable value (MAV) or guideline values (GV) in the NZDWS are shown in red. If fewer than eight samples from a site had been analysed for the parameter in question, or if more than 70% of the results were below detection limit, the values in Appendix H and Appendix I are given in italics to indicate lower confidence in the result.

5.4.1 Summary points

The shift from measuring total concentrations of analytes to measuring dissolved concentrations has biased our dataset for boron, potassium, magnesium, manganese and sodium, although this is not unexpected given the different methodologies. However, the change in laboratories that analyse the monitoring programmes samples has resulted in an increase in data quality, as seen through the analysis of charge balance error results. A noticeable decrease in the range of errors, and a change in distribution to normal about zero percent error is apparent.

The most geochemically evolved groundwaters in the region (and when compared to NGMP data some of the most evolved in New Zealand), are found in the Lower Wairarapa Valley, and in the deep aquifers of the Kapiti Coast. These aquifers are highly reduced and generally show high concentrations of bromide, calcium, chloride, iron, bicarbonate, potassium, magnesium, manganese, sodium, ammoniacal-nitrogen, phosphorus and silica. These aquifers are dominated by natural oxidation and reduction (Redox) processes; although analysis of the variability in analytes suggests that during the irrigation season, pumping induced recharge may affect the chemistry of some aquifers.

Elevated concentrations of nitrate-nitrogen are evident in 30% of all monitoring sites (23 of 78), and 44% of all unconfined or semi-confined sites (17 of 39). Of those sites with elevated nitrate concentrations, 56% are in predominantly dairying areas and 34% are in sheep/beef farming areas. While it appears that areas of elevated nitrate concentrations are spatially limited, this may be a reflection of the limited number of shallow sites in the monitoring network.

Elevated phosphorus concentrations are evident in 33% of all sites, however these are generally all deep confined sites and are unlikely to discharge to surface water bodies. The elevated phosphorus concentrations are a result of rock-water interaction, and not anthropogenic influences in all but one site, which shows evidence of contamination from an on-site sewage system.

Evidence of saline intrusion is limited to one bore in the groundwater state of the environment monitoring programme, R25/5164. This is a shallow domestic bore located close to the coast in Te Horo. However, significant decreasing trends in boron and zinc, and probable decreasing trends in sodium and chloride indicate the effects of saline intrusion may be diminishing.

The highest variability occurs in shallow, unconfined aquifers in nitrate-nitrogen, phosphorus, fluoride and carbon dioxide. The high degree of variability indicates a low level of security.

Repeated bacterial contamination is limited to eleven sites in the groundwater state of the environment monitoring programme. Analysis suggests that poor wellhead protection is generally the cause, and that large diameter wells are prone to coliform contamination.

Hierarchical Cluster Analysis was used to group sites of similar water chemistries. 4 major clusters were identified:

1. Highly reduced (anoxic), highly evolved groundwater. Generally rainfall recharged.

2. Least impacted, dilute waters. Little or no human influence, young, and oxic groundwater. Generally river recharged.

3. Low to moderately reducing groundwaters, but less reducing than cluster 1. Generally rainfall recharged systems.

4. Anthropogenically impacted, oxic aquifers. These sites are not in reducing systems, and show elevated nutrients and sulphate

The current monitoring network is inadequate to determine the effects of agricultural discharges to land in the Wellington Region. Monitoring discharge to land requires a more intensive coverage of shallow groundwater, and does not require the full analysis of chemistry that the GWSOE programme requires.

The current knowledge of on-site sewage system locations, and the effects of on-site sewage systems in the Wellington Region, is limited. The GWSOE programme does not target areas with high densities of on-site sewage systems therefore quantifying the effects of these systems on groundwater quality is impossible.

5.4.2 Median values of GWSOE parameters

(a) Sodium and chloride

Median sodium (Na) and chloride (Cl) are analysed together as their concentrations generally fall on or close to the seawater concentration-dilution line (SCDL). The SCDL represents water with the same proportional concentrations of sodium and chloride as seawater (the ratio of Na:Cl is 0.556). As water is rained out over the land sodium and chloride will contribute to the recharge waters. Therefore water collected closer to the ocean will tend to have Na:Cl ratios similar to the SCDL (Rosen, 2001). Marine derived gravels, saltwater intrusion and the presence of connate (relic seawater, as opposed to present day seawater influence) can also influence the concentrations of sodium and chloride in groundwater. Sodium enrichment relative to chloride concentrations can occur either due to water-rock interaction, mostly with sodium feldspars, and ionic exchange with clays, or input from various land uses (Rosen, 2001).

The majority of sites in the Wellington Region have Na:Cl ratios that fall on or close to the SCDL (Figure 5.9). The sites with the highest concentrations of sodium and chloride are generally in deep, confined rainfall recharged aquifer systems (Lower Wairarapa Valley and

Hautere deep groundwater zones). However, two sites (R25/5164 & S27/0552) with elevated sodium and chloride concentrations are shallow unconfined sites. R25/5164 (Card) is located approximately 200m from the coast. Hughes (1998) and Wilson (2003) have shown that saltwater intrusion is likely to be occurring in the area. S27/0552 (Duggan) is located in the Martinborough western terraces groundwater zone in an unconfined, rainfall recharged aquifer (Butcher, 2001) with predominantly lifestyle and pastoral farming up-gradient. Transmissivities in the zone are generally low (Butcher, 2001) and it is likely that the high sodium and chloride concentrations are due to rock-water interaction.

Two sites, S27/0585 (McCreary, 43m deep) and S27/0268 (Barton, 52m deep), show elevated sodium concentrations in respect to chloride. Both are located in the Lower Wairarapa Valley in aquifers 2 and 3 respectively. Both bore logs show considerable amounts of clay and silt in the profile, and silt in the screened gravels indicating the possibility of ionic exchange. Bore S27/0607 (Findlayson, 38m deep) shows a significantly higher concentration of sodium and chloride than all other GWSOE bores, and is also very gaseous water, generally accepted to be methane (Annear pers. comm., 2005). Butcher (1996) suggested these higher sodium and chloride concentrations are likely to indicate the presence of connate seawater rather than rock-water interaction in the presence of clays.

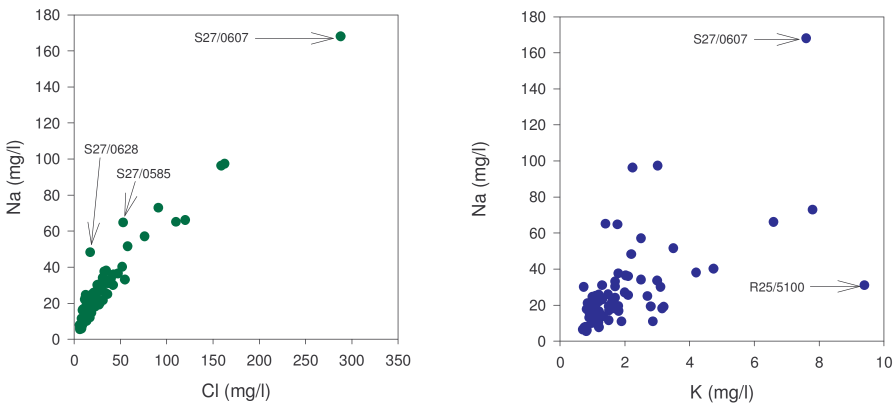


Figure 5.9: Median sodium plotted against median chloride (left) and median sodium plotted against median potassium (right).

(b) Potassium

Potassium (K) concentrations in New Zealand groundwater are generally low (<10 mg/l) as there are many sinks for potassium both in the soil zone and within aquifers. These sinks include plant uptake of potassium, ion exchange reactions, and the formation of clays (Rosen, 2001). Natural levels of potassium are generally controlled by aquifer geology, especially Greywacke of which potassium feldspars are a major component (Begg and Mazengarb, 1996). Common anthropogenic sources of potassium include fertilisers and human and animal waste.

Potassium in the GWSOE correlates well with sodium concentrations (Figure 5.9) indicating most median potassium concentrations are due to natural geochemical evolution. S27/0607 (Findlayson) again stands out as being more evolved groundwater. R25/5100 (O'Malley, 48m deep) is a semi-confined bore located in the Coastal groundwater zone close to the coastline, and shows significantly enriched potassium levels in respect to sodium levels.

(c) Calcium and magnesium

Total Hardness is calculated as 2.5(Ca) + 4.1(Mg) in milligrams per litre and is defined as the content of metallic ions in water that can react with sodium soaps to produce solid soaps or scummy residue (Freeze and Cherry, 1979). Water with a hardness value of greater than 150 mg/l is designated as being very hard (Freeze and Cherry, 1979) however the GV for aesthetic reasons in the DWSNZ (2000) is 200 mg/l. Freeze and Cheery (1979) defined soft water as that with a hardness value less than 60 mg/l.

Hardness exceeds the GV at 3 sites (S27/0607, S27/0268 & S27/0433; Figure 5.10) all in the Lower Wairarapa Valley at sites located in deep confined aquifers which display high concentrations of other major ions. Three sites in the GWSOE programme also show a higher proportion of calcium relative to magnesium than found at all other sites (S27/0547, S27/0681 & S27/0396). All three of these sites are located in groundwater zones recharged from the Huangarua catchment which drains several tertiary limestone formations (Begg & Johnston, 2000).

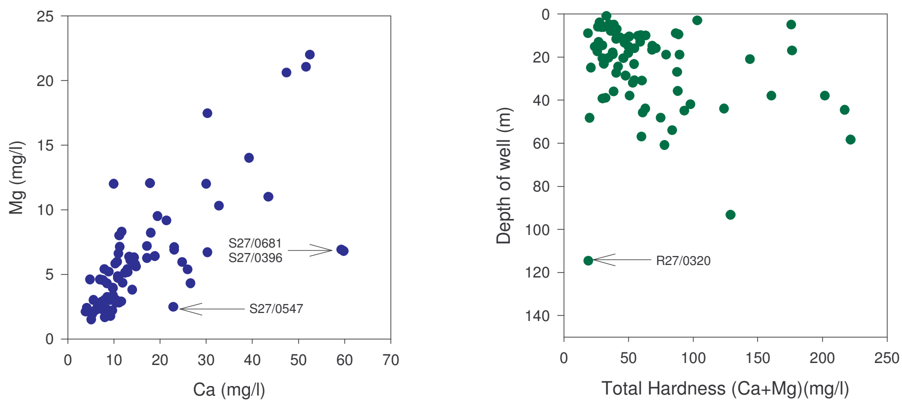


Figure 5.10: Median calcium plotted against median magnesium for all GWSOE sites (left) and median total hardness plotted against total depth of well/bore for all GWSOE sites.

Total hardness generally increases with depth, and can be correlated with more reduced/evolved waters. However, one site R27/0320

(IBM1), differs from most sites. R27/0320 is located near the foreshore in Petone in the Moera basal gravels, the deepest identified sequence in the Hutt Valley. Downes (1980) attributed the low levels of calcium (also magnesium, potassium, silica, iron, sodium, and chloride) to low levels of geochemical reactions in the clean gravel sequences between the recharge area and the bore.

(d) Alkalinity ($CaCO_3$)

Alkalinity is a measure of those chemicals in the water that buffer the pH. The lower the alkalinity, the less capacity the water has to absorb acids without becoming more acidic. The main components that buffer pH and contribute to alkalinity are carbonate (CO_3^{2-}), bicarbonate (HCO_3^-) and carbonic acid (H_2CO_3). For water with a pH between 4.5 and 8.3, bicarbonate is the main contributor to alkalinity (Rosen, 2001) and for the GWSOE programme is reported as calcium carbonate ($CaCO_3$).

The alkalinity of groundwater in the GWSOE ranges considerably (Figure 5.11). Alkalinity correlates very well with aquifer confinement – the highest alkalinities all occur in confined aquifers, the lowest alkalinities are all in unconfined systems. This can be explained through the main sources of bicarbonate being from the reduction in sulphate (see sulphate below), and from the dissolution of carbonate rocks, both processes which occur under reducing conditions often found in slow moving, confined aquifer systems.

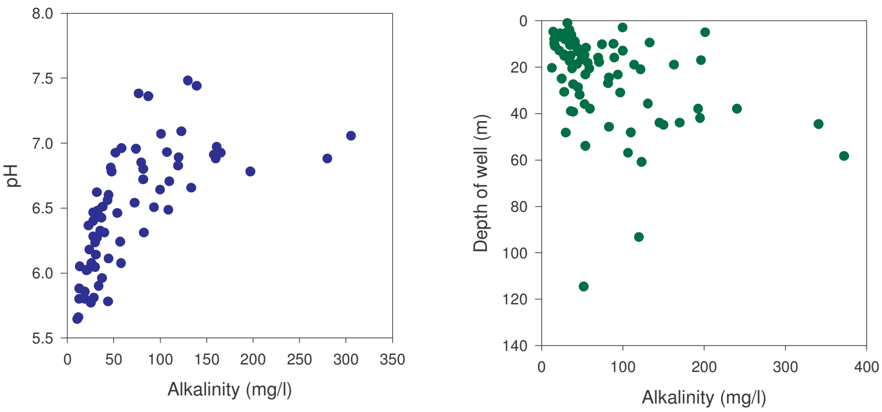


Figure 5.11: Median pH (field) plotted against median alkalinity (left) and depth of well/bore plotted against median alkalinity (mg/l) (right).

(e) Sulphate

Sulphate mainly comes from the oxidation of pyrite and the dissolution of sulphate minerals. Pyrite is relatively abundant in silicate rocks (i.e. Greywacke) and can be important in some carbonate sequences (Rosen, 2001). Sulphate can also come from fertilisers such as super phosphate and gypsum. In the Wellington Region median sulphate concentrations correlate very well with confinement showing the lowest sulphate concentrations are all found in confined aquifers. This pattern suggests that sulphate reduction is occurring. Reduction of sulphate produces bicarbonate and hydrogen sulphide as the product. Sulphate concentrations also decrease with depth (Figure 5.12).

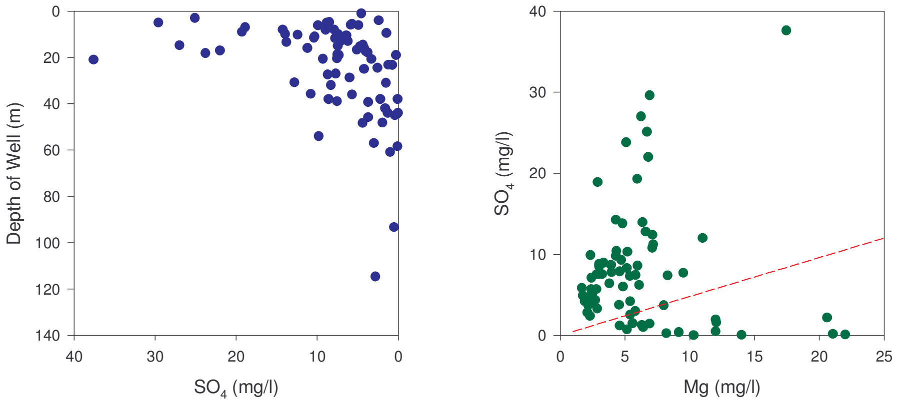


Figure 5.12: Median sulphate concentrations plotted against well/bore depth (left) and median magnesium concentrations plotted against median sulphate concentrations (right). The dashed red line is the SCDL for SO_4 and Mg.

Rekker (1998) in a study of groundwater in Southland, found that sulphate concentrations near the head of recharge zones plotted very closely to the seawater concentration-dilution line (SCDL) for magnesium and sulphate. Figure 5.12 shows sulphate and magnesium in the Wellington Region. Two clear patterns emerge, firstly there are a number of bores with little to no sulphate and high magnesium, and these are all bores with strong reducing environments suggesting the sulphate has been reduced out. There are also a large number of bores with elevated sulphate concentrations which appear to be controlled mainly by geology and not land use (four of the eight highest sulphate concentrations at sites in the Martinborough area).

(f) Silica

Median silica (SiO_2) concentrations are high at many sites in the GWSOE. Silica is a component in quartzite rocks, including greywacke so it is therefore not surprising to find it in high concentrations throughout the region. Silica correlates well with sodium, especially at low levels (<30 mg/l Na and <30 mg/l SiO_2) but doesn't hold so well at higher concentrations (Figure 5.13). While seawater has high sodium concentrations it does not have high silica indicating that it is unlikely the elevated sodium concentrations are from connate seawater. However one site, S27/0607 (Findlayson) may display evidence of connate seawater with the highest median sodium concentrations in the GWSOE but not excessively high silica.

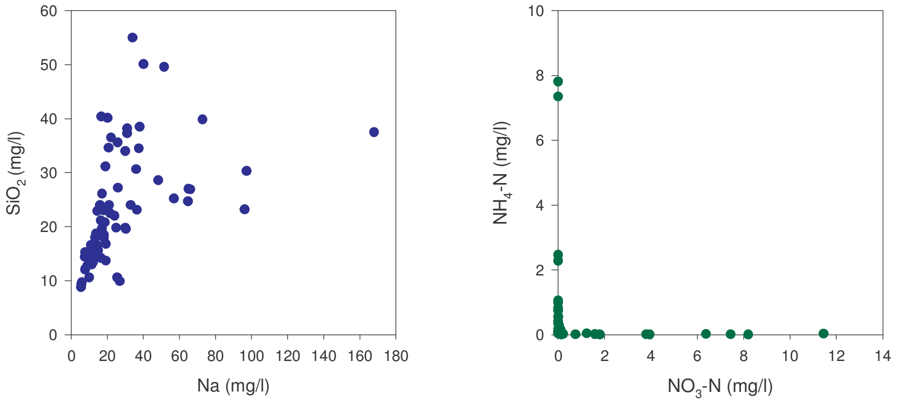


Figure 5.13: Median Silica concentrations plotted against median Sodium concentrations (left) and median NH_4-N plotted against median NO_3-N (right).

(g) Nitrate

Elevated (>3.0 mg/l NO_3-N)[3] nitrate-nitrogen levels occur at 23 of 78 (30%) of GWSOE monitoring sites (Figure 5.13). 12 of these sites have a median concentration of greater than 0.5 of the MAV (5.65 mg/l) and 2 sites S26/0223 (Nicholson) and S25/5322 (Edhouse) have median concentrations exceeding the MAV of 11.3 mg/l. Of the 23 sites with elevated nitrate-nitrogen concentrations, 17 are in unconfined or semi-confined aquifers, 6 in confined. Regionally, 44% of all unconfined or semi-confined monitoring sites have elevated nitrate-nitrogen concentrations. Nitrate-nitrogen concentrations are discussed in further in section 5.4.10.

(h) Ammoniacal-nitrogen

Figure 5.13 shows a plot of median nitrate-nitrogen and median ammoniacal-nitrogen (NH_4-N) for all GWSOE sites. This shows that relatively high ammoniacal-nitrogen concentrations are associated with low nitrate-nitrogen concentrations and vice versa. This is expected because nitrate-nitrogen is the oxidised form of nitrogen, while ammoniacal-nitrogen occurs essentially under anaerobic conditions. The high ammoniacal-nitrogen concentrations all occur in confined aquifers, and the highest nitrate-nitrogen concentrations all occur in unconfined or semi-confined systems.

Nitrate-nitrogen concentrations have been observed to decrease with depth in many studies (i.e. Burden 2004; Hanson, 2002). However figure 5.14 shows this observation does not hold in the Wellington Region; and that in unconfined aquifer systems, median nitrate-nitrogen appear to increase slightly with depth.

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[3] While most groundwater in New Zealand rarely has background nitrate levels exceeding 1.0 mg/l (Burden, 1982; Close 2001; Rosen 2001) in this report 3.0 mg/l NO_3-N is used as an indicator of anthropogenic influence in order to increase certainty caused by variability. 3.0 mg/l was also used by Madison and Brunett (1985) and Close (2001) as the threshold value.

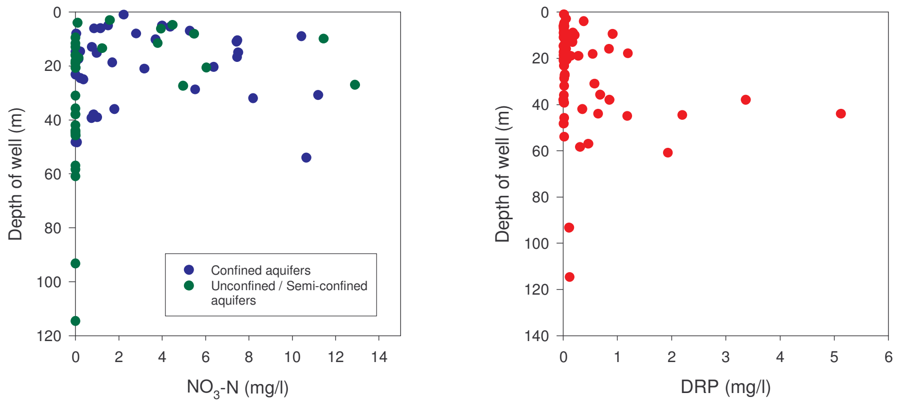

Figure 5.14: Median NO3-N concentration plotted against depth of well/bore and median DRP concentrations plotted against depth of well/bore.

(i) Dissolved Reactive Phosphorus

The mineral apatite, $Ca_5(PO_4)_3(OH, F, Cl)$, is commonly found in metamorphic rocks and is a major natural source of phosphorus to groundwater (Seafriends, 2004). The most common anthropogenic source of phosphorus in groundwater in New Zealand is from fertiliser use (Rosen, 2001), although it can also be from waste water treatment plant discharges. Phosphorus is measured in the GWSOE programme in the form know as dissolved reactive phosphorus (DRP) which is a measure of phosphorus available for uptake by aquatic plants.

High median levels of dissolved reactive phosphorus (DRP) (>0.1 mg/l) occur in 26 of 78 sites (33%) and are extremely high (>1 mg/l) in six sites (S26/0568, S27/0389, S27/0602, S27/0433, S27/0607, S27/0435). The extrememely high values are all located in the Wairarapa. Five of the six sites are in the deep confined Lower Valley aquifers and also display high conductivity and silica concentrations. This is a strong indication that the dissolved reactive phosphorus is derived from rock-water interaction and not anthropogenic sources. S27/0389 (Dimittina) however, is an unconfined bore on the Martinborough Western Terraces and appears to be affected by a nearby septic tank.

(j) Total organic carbon

Total organic carbon in groundwaters is commonly found in concentrations in the range of 0.1 mg/l to 10 mg/l (Freeze and Cherry, 1979). Organic carbon is generally derived from organic matter deposited in the strata, swamp or peat deposits, or from wastewater contamination (Chapman and Kimstach, 1996).

Total organic carbon has only been measured as part of the GWSOE since October 2003. Median values of total organic carbon in the GWSOE range from 0.2 mg/l to 10.6 mg/l. Organic carbon is highest (greater than 5 mg/l) in R25/5164 (Card) and R25/5165 (Salter), both in Te Horo; and the deep confined Lower Wairarapa Valley bores S27/0607 (Findlayson), S27/0435 (Wairio) and S27/0433 (Mapuna Atea). Bore logs in the Lower Wairarapa Valley often show signs of organic matter such as peat and tree roots (Annear pers. comm., 2005). Peat material is also common in the post-glacial sediments of the Kapiti Coast. This material may explain the elevated carbon concentrations. Furthermore, the Te Horo community is reliant on septic tanks which also are a potential source of carbon to the groundwater.

(k) Iron and manganese

Both iron (Fe) and manganese (Mn) are not dissolved in water in large quantities if oxygen is abundant in solution (Rosen, 2001). Moderately reducing and anoxic conditions are normally required before significant levels of dissolved iron and manganese are found. Iron and manganese are derived from water-rock interaction and there are few land uses that would contribute soluble iron and manganese to groundwater (Rosen, 2001). While both iron and manganese are often found together in high concentrations, there is generally no statistical correlation between the two analytes. This is likely to be due to manganese being dissolved before iron in the redox sequence and because iron is the dominant metal in rocks (Rosen, 2001).

A high proportion of sites in the GWSOE programme have iron and manganese at concentrations above the GV as set in the New Zealand Drinking Water Standards (2000, Figure 5.15). Iron exceeds the GV at 40 of 78 sites (49%) and manganese exceeds the GV at 34 of 78 sites (43%). The majority of these sites also have ammoniacal-nitrogen above detection limit and low or no nitrate-nitrogen indicating the presence of reducing conditions at these sites. It must be noted however that prior to October 2003 both iron and manganese were measured as total, not dissolved concentrations.

Daughney (2004) performed regression analysis between dissolved and total iron and manganese concentrations at a selection of sites in the GWSOE programme and found small but significant differences between the two concentrations. For the purpose of long term trend analysis, both dissolved and total concentrations were joined to gain full time series data. Prior to calculation of the mean, samples which did not meet select criteria for charge balance error were removed (refer to Appendix F for detailed methodologies) thus reducing bias caused by the filtering for dissolved totals. In addition when looking at median concentrations as opposed to trends, the bias caused by combining dissolved and median concentrations is reduced.

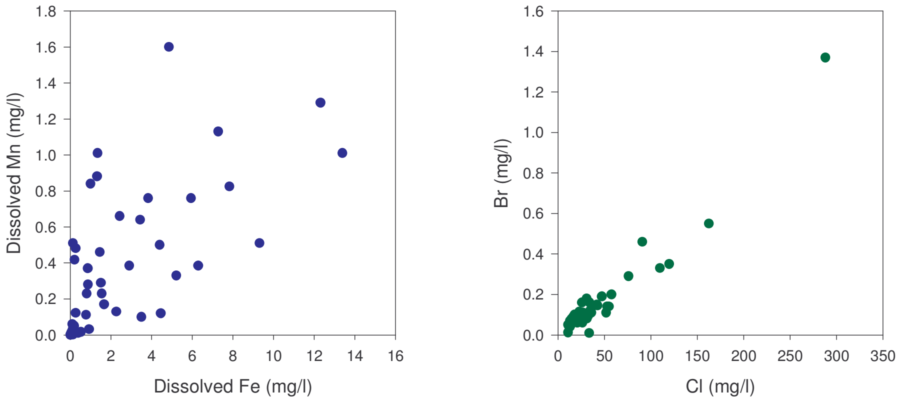

Figure 5.15: Median dissolved Fe plotted against median dissolved Mn (left) and Median Cl plotted against median Br (right).

(l) Bromide and fluoride

The major natural sources of bromide in groundwater are salt water intrusion and bromide dissolution from sedimentary rocks. Anthropogenic sources include sewage and industrial effluent as well as road and agricultural runoff (USGS, 2005). There are no MAVs or GVs set for bromide concentrations in New Zealand.

Bromide appears to be well correlated with chloride indicating the bromide may be from rock-water interaction (Figure 5.15). Bromide concentrations are highest in the Kapiti sites, all of the Hutt sites, and nearly all of the sites in the Lower Wairarapa Valley. In these areas it is not expected that the bromide is from an anthropogenic source.

Fluoride naturally originates from the weathering of fluoride containing minerals but can also be found in some fertilisers and in the wastewater of communities who get their water from a fluoridated supply. For example, the reticulated water supply in the Hutt Valley and Wellington has fluoride added to bring the concentration into the range of 0.7 mg/l to 1.0 mg/l.

Median fluoride is below detection limit in 22 of 78 sites and ranges from 0.03 mg/l to 0.5 mg/l in the remaining sites. Fluoride appears to be highest in more evolved groundwater and lowest, or non existent in the river recharged sites.

(m) Boron

Boron (B) enters the environment mainly from the weathering of boron-containing rocks, from seawater and from volcanic and other geothermal activity such as geothermal steam (Mandel & Shiftan, 1981). Boron is found in the borosilicate mineral tourmaline, a common mineral in New Zealand greywacke, and concentrations of boron in greywacke appear to range from 13ppm to 30 ppm (IGNS, 2005).

Boron only exceeds the MAV (1.4 mg/l) at R25/5135 (Windsor Pk, 2.51 mg/l) and is elevated (>0.1 mg/l) at the Lower Wairarapa Valley confined bores S27/0607, S27/0433, S27/0435 and the coastal Te Horo bore R25/5164 (Card). Boron is also elevated at 4 other bores in the GWSOE however these sites were only sampled on one occasion prior to this analysis. Hughes (1998) identified that salt water intrusion is likely to be occurring below R25/5164 which may explain the elevated boron levels at that site. Boron at sites in the Lower Wairarapa Valley may be derived from connate seawater or rock-water interaction, and is not likely to be from geothermal influence.

(n) Lead

Lead was below detection limits at all 78 sites in the GWSOE except for bore R25/5165 (Salter) at Te Horo beach (Figure 5.16). Median lead concentration was equal to the MAV of 0.01 mg/l. Prior to October 2002 the median value was 0.05 mg/l, since October 2003 all results have been below the detection limit (0.005 mg/l). It must be noted that prior to October 2003 lead at this site was measured as total lead, it then changed to dissolved lead and the detection limit dropped from 0.05 mg/l to 0.005 mg/l. The maximum lead (total) concentration recorded at this site was 0.46 mg/l in March 2002. Bore R25/5165 (8m deep) is located on a raised, unconfined sand dune system. The reason for the apparent increases in lead concentration is unknown and requires further investigation. As no lead has been found in the dissolved form, it is possible that lead may be in particulate form.

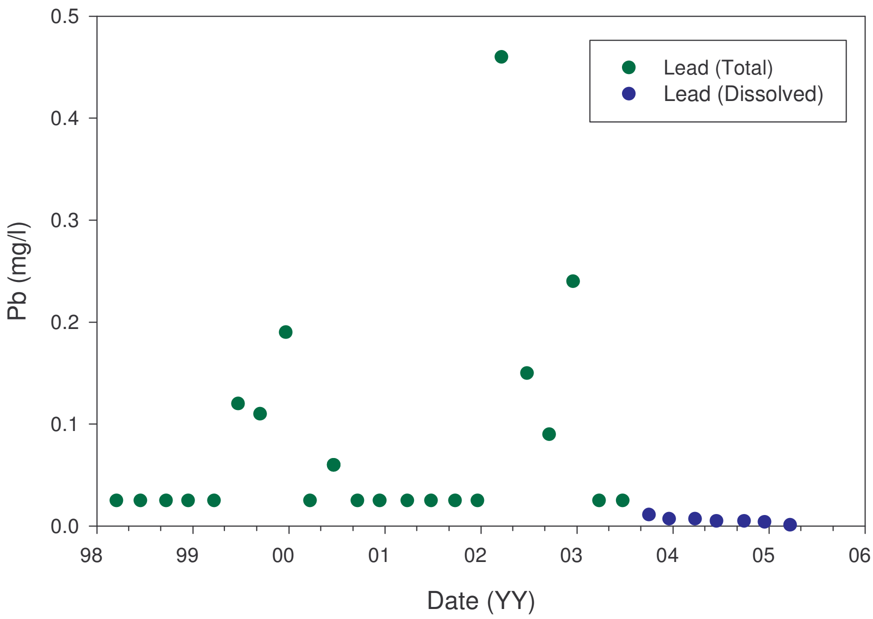

Figure 5.16: Lead concentrations at bore R25/5154 (Salter) March 1998 – March 2005.

(o) Zinc

Zinc (Zn) can be derived from one of three sources. Most commonly zinc is derived naturally from geochemical interaction in confined aquifer systems (Rosen, 2001). Zinc may also be found in groundwater from interaction with galvanised or brass plumbing fittings, and is also commonly used in agriculture to control facial eczema and bloat in livestock. Zinc, along with other metals, becomes more soluble in water with decreases in pH and increases in temperature (Rosen, 2001).

Zinc is found in moderate (>0.01 mg/l) levels in 23 bores in the GWSOE programme. There is a fairly even split between confined and unconfined sites. The majority of the unconfined sites are located in pastoral farming areas except for R25/5164 at Te Horo beach, and S26/0457 in a Greytown orchard. In the deeper confined sites the zinc is likely to be from natural geochemical evolution and all of the sites display significant concentration of other metals (manganese, iron).

5.4.3 Variability of GWSOE parameters

The median absolute deviation (MAD) was calculated for each parameter at each site as a means of assessing variability. The median absolute deviation is a measure of the spread of analytical results and is analogous to standard deviation (Daughney, 2005). However, the median absolute deviation is less likely to be biased by extreme values (Helsel and Hirsch, 1992). By comparing the median absolute deviation to the median an impression of groundwater security can be obtained, with secure groundwater displaying low or no variability in chemistry. For example, Close et al. (2000) suggested that if the standard deviation is more than 5% of the average for certain analytes (this is analogous to the median absolute deviation as a percentage of the median), then the site is likely non-secure and affected by significant seasonal variation, groundwater abstraction, land use change, or some similar process (Daughney, 2005).

At most GWSOE programme sites most analytes have low variability (MAD is less than 10% of the median) (Appendix F). In Appendix H & I median absolute deviations above 10% of the median are highlighted in orange text, if fewer than eight samples have from a site had been analysed, or more than 70% of the results were below detection limit, the values are given in italics to highlight lower confidence (Daughney, 2005).

At most shallow unconfined sites, relatively high variabilities in the concentrations of nitrate-nitrogen, dissolved reactive phosphorus, sulphate, fluoride and carbon dioxide are apparent. The greatest variability occurs at sites with river recharge influence, such as T26/0289, S25/5125 and R26/6587 and to a lesser degree at unconfined rainfall recharged sites (Percy). Figure 5.17 shows the variability in nitrate-nitrogen at these four sites. It is clear there are large seasonal shifts in nitrate concentrations, with concentrations highest during late winter and spring and lowest during late summer. Peaks occur later in those unconfined systems dominated by rainfall as opposed to the river recharged aquifers which react more quickly.

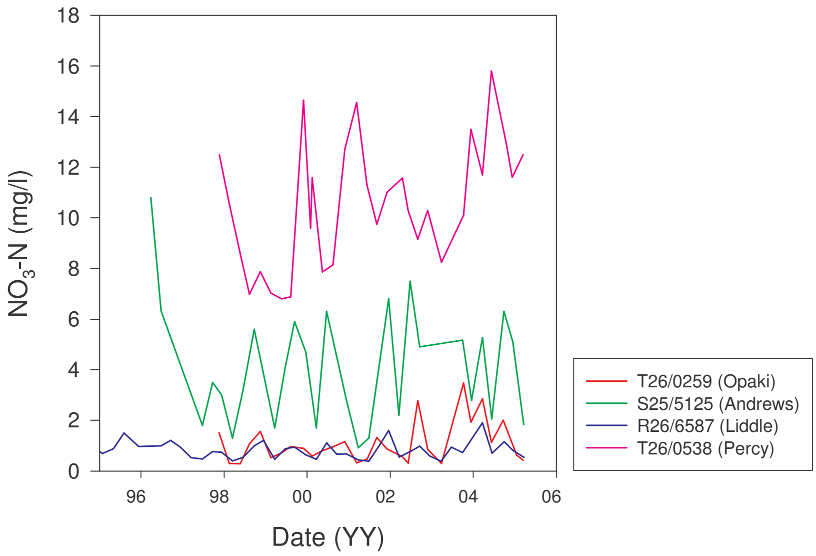

Figure 5.17: Nitrate-nitrogen values in shallow, unconfined aquifer systems

The confined aquifer systems in the GWSOE programme show much lower variability than the unconfined systems. Of all the parameters, manganese, iron, bromide, boron and zinc show the most variability in the confined systems. All of these analytes are controlled by geochemical process and are often found in significant concentrations in confined, reducing systems.

Bores S27/0607 (Findlayson) and to a lesser extent S27/0615 (Sorenson Northern) show significant seasonal variation in almost all parameters (Figure 5.18). We interpret the dramatic shifts in chemistry to be a seasonal pattern that is related to pumping for irrigation. S27/0607 (Findlayson) is located in the Pouawha aquifer (Appendix D) at a depth of 38m. It is used solely for irrigation during the period from October - March dependent on climatic conditions. The vast differences in water chemistry between the summer and winter months suggest that during periods of heavy pumping, high drawdown in the aquifer is pulling in a more dilute water source. WRC (1984) identified that after 10 minutes of pumping a boundary was encountered. This result highlights the possibility of rapid drawdown, and potential to draw water from another source. White (1982) during resistivity work in the area identified a marked boundary between potable and non-potable water close to the bore.

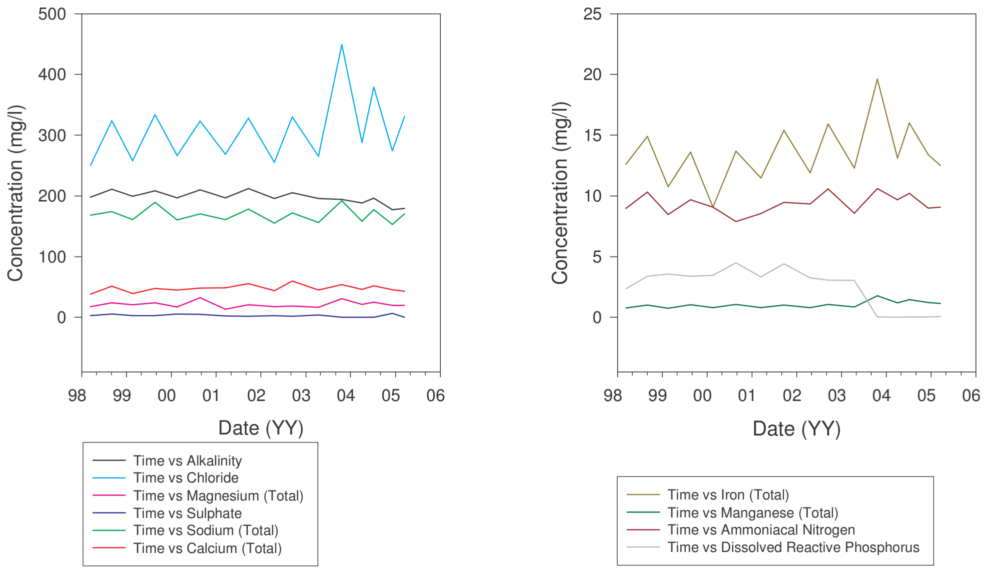

Figure 5.18: Variability over time in major ions at bore S27/0607 (Findlayson).

5.4.4 Trends in GWSOE parameters

At the majority of the GWSOE sites most analytes do not have significant trends at the 95% confidence level (Appendix H & I; for detailed methodology refer to Appendix F). It should be noted that the detection of a trend is made more difficult if the corresponding MAD is high (Daughney, 2005). It should also be noted that because both total and dissolved concentrations of calcium, sodium, potassium, magnesium, manganese, boron, lead and iron were combined for analysis, the lower concentrations of dissolved analytes may bias the determination of a trend. In Appendix H & I, if the calculated trend is significant at the 95% confidence level, and if it is more than 10% of the median, then it is highlighted in red. If fewer than eight samples from a site had been analysed, or more than 70% of the results are below detection limit, the trend is given in italics.

Decreasing trends of sulphate and dissolved reactive phosphorus were observed in S26/0762, S27/0283, S27/0268, S27/0495, S26/0568, S27/0585, S27/0433, S27/0615 and S27/0435. All of these sites are deep confined bores located in the Wairarapa. On closer inspection of the data record it is apparent that at all of these sites, there has been a decrease in concentrations of sulphate and dissolved reactive phosphorus with the change in laboratory. Prior to October 2003, concentrations above the detection limit were reported. However, since the change all results have been reported as being less than the detection limit.

Increasing trends of dissolved reactive phosphorus (0.03 mg/l/year) and decreasing trends of boron (-0.02 mg/l/year) and zinc (-0.01 mg/l/year) are apparent at R25/5163 (Card). While not statistically significant, sodium and chloride levels also appear to be decreasing at this site. Hughes (1998) had shown evidence of saline intrusion at this site. Based on these trends is it likely that the impacts of the saline intrusion are diminishing.

Decreasing carbon dioxide (CO_2) concentrations (-2.97 mg/l/year) have been observed at S27/0615 (Sorenson Northern). This is the shallower (18m) of the two bores located on this property. While not statistically significant, apparent decreases in alkalinity, pH and large variability in chloride, sodium, magnesium, potassium and bicarbonate suggest that during summer irrigation a younger source of water is being drawn into the aquifer.

Increasing trends of sulphate are evident at three bores in the Wairarapa. These bores are S27/0396 (SWDC Martinborough,) 2.36 mg/l/year, T26/0538 (Percy) 4.31 mg/l/year and T26/0259 (Opaki Water Supply) 0.63 mg/l/year (Figure 5.19). T26/0259 (Opaki) is a shallow unconfined well dominated by river recharge (Butcher, 2004). Increases in sulphate at this site are not as large as the other two bores but should be monitored carefully because it is used for public water supply. T26/0538 (Percy) is a shallow bore in the unconfined Te Ore Ore aquifer surrounded by dairy farms. It is unlikely any change in water source has occurred, so increases are possibly land use related. The Te Ore Ore groundwater zone has a history of groundwater contamination from various land uses (Van der Raaij, 2000).

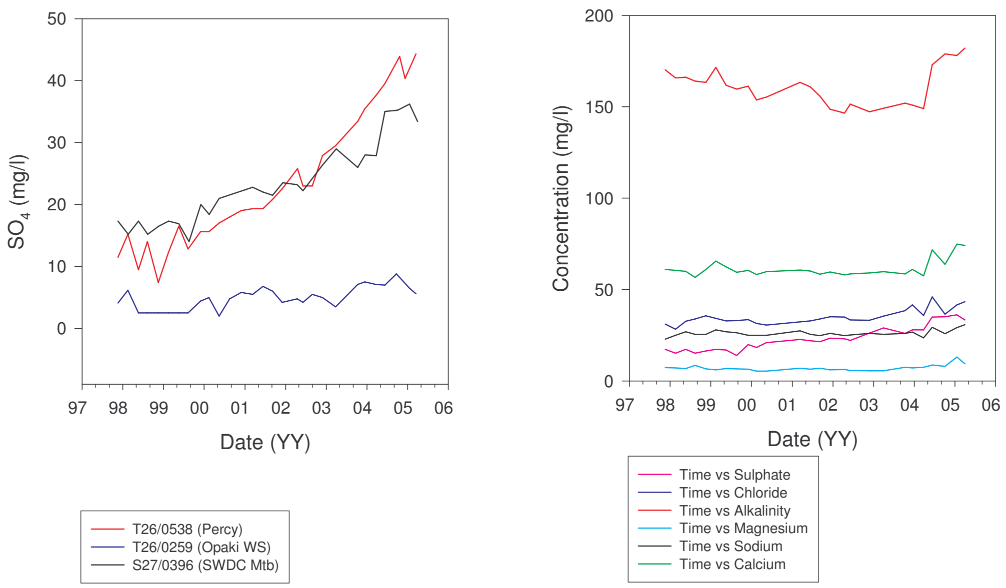

Figure 5.19: Line plot of bores showing significant increasing trends in SO_4 concentrations (left) and apparent increasing trends in major ions at T26/0259 (SWDC Martinborough).

S27/0396 (SWDC Martinborough) shows significant increases in sulphate and less significant increasing trends in the major ions of calcium, chloride, alkalinity, magnesium, and sodium. These trends appear to be most significant in the last 3-4 years. South Wairarapa District Council has three bores in this area; two of them are used for the public water supply, including T26/0259. In addition to calcium, chloride, alkalinity, magnesium, sodium and nitrate-nitrogen are also increasing. These increases suggest a change in aquifer chemistry. This change may be related to a change in recharge source driven through pumping, but it is also possible that repeated flooding over the site since 2003 may be affecting the recharge chemistry too.

Boron shows a decreasing trend at sites S27/0607, T26/0538, S26/0762, R25/5165, R27/1265, R27/1182 and R27/1171. At all sites there is a notable drop in boron concentrations when the analysis was changed from measuring total concentrations to measuring dissolved concentrations. However, in the long-term all these sites still show decreasing concentrations. R27/1265 (IBM2), R27/1182 (Seaview Wools) and R27/1171 (Somes Island) are all located in the lower part of the Lower Hutt groundwater zone. S27/0607 (Findlayson), as previously discussed, has high variability in most major ions and is possibly screened in an area of connate seawater. T26/0538 (Percy) is unconfined and S26/0762 (Schaef) is semi-confined, both are rainfall recharged and predominantly used for stock water.

5.4.5 Multivariate analysis[4]

Several complementary methods are used in this section with the overall aim of being able to assign each site, into a group, or cluster, of similar sites. By clustering sites we are able to determine what makes the clusters different and what processes control the differences in aquifer chemistry.

(a) Water type

A sites water type (or hydrochemical facies) is a description of the major composition of the water (generally using calcium, magnesium, sodium, potassium, chloride, sulphate and bicarbonate to classify the water). This is determined by plotting the major ions on a Piper diagram and determining which domain they fall into (Appendix J). Water types are determined in this report using AquaChem™.

An assessment of the water types shows that 58 of the 78 sites are characterised by groundwaters with sodium as the dominant cation and 20 with calcium as the dominant cation. 22 sites have chloride as the dominant anion and all other (56) sites have bicarbonate as the dominant anion (Appendix J). Figure 5.20 is a piper diagram of median concentrations on which the GWSOE sites are divided into 4 groups based on hierarchical cluster analysis (see below).

[4] For methods of water type determination, principal component analysis and hierarchical cluster analysis refer to Appendix F, for detailed PCA methodology refer to Helsel & Hirsch (2002) pp 58-59.

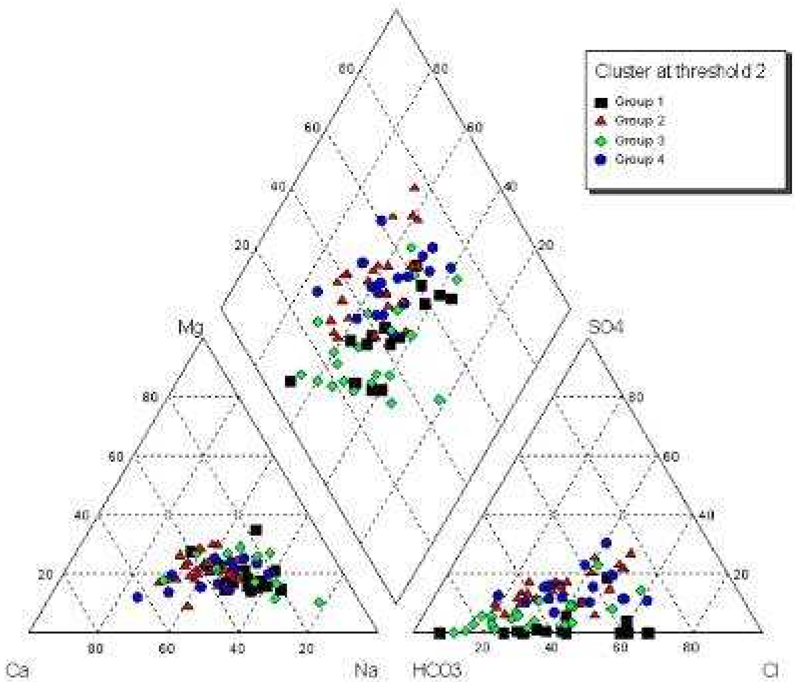

Figure 5.20: Piper diagram of median concentrations grouped by cluster identification at threshold 2 (see below for results of Hierarchical Cluster Analysis).

(b) Principal component analysis

Principal component analysis (PCA) was performed by Daughney (2005b) on data from all GWSOE sites. Principal component analysis was conducted with log-transformed combined dissolved and total concentrations of the following determinands: bromide, calcium, iron, potassium, magnesium, manganese, sodium and total concentrations of ammoniacal-nitrogen, nitrate-nitrogen, sulphate, chloride, iron, silica and dissolved reactive phosphorus. Figure 5.21 shows a plot of the weightings of the two main components and is similar to results obtained by Daughney and Reeves (2003) and Daughney (2005a).

Principal component analysis of the GWSOE results suggests that natural rock-water interaction and possible human/agricultural impacts are opposing drivers that control groundwater chemistry in the Wellington Region (Daughney, 2005b). The redox potential, water composition and human/agricultural impact (in the form of nitrate-nitrogen and sulphate) appear to be the main controls on groundwater chemistry.

Component 1 in Figure 5.21 shows a strong negative loading of nitrate-nitrogen and strong positive loading of ammoniacal-nitrogen, iron and manganese. This demonstrates the importance of redox potential as an assessment tool because nitrate is only dominant in oxidised groundwaters; whereas ammoniacal-nitrogen, iron, and manganese are generally only present in reduced or anoxic groundwater (Daughney, 2005a). Component 1 also shows positive weighting of all analytes except for nitrate-nitrogen and sulphate. Daughney (2003) suggests this indicates the distinction between dilute waters with low total dissolved solids and more concentrated waters with higher total dissolved solids. The fact that nitrate-nitrogen and sulphate are inversely related to total dissolved solids (i.e. the concentrations of all other analytes) suggests that sulphate and nitrate are added to groundwater by anthropogenic activities.

Component 2 has strong negative weightings of bromide, calcium, chloride, potassium, magnesium and sodium, indicating these analytes behave similarly and tend to occur together. Component 2 also has strong positive correlations of manganese, iron, ammoniacal-nitrogen and phosphorus, again indicating they are likely to occur together. Silica, bicarbonate and fluoride have weightings close to zero, suggesting they are not dominant analytes in controlling the differences in groundwater chemistry. The fact that all of the major cations have a strong negative weighting suggests they are likely to occur together, which is in accordance with analysis of median chemistries in section 5.4.4 which showed a lot of sites dominated by both sodium and calcium.

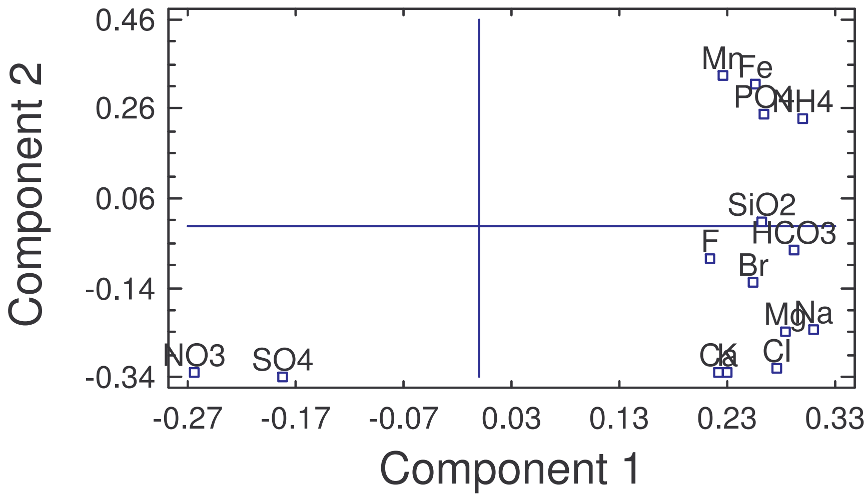

Figure 5.21: Component bi-plot based on principal component analysis using scaled log-transformed medians of the selected parameters. This plot shows the weights for the two dominant components. A weight close to zero indicates little contribution of the variable to that component (Daughney, 2005a).

(c) Hierarchical cluster analysis

Hierarchical Cluster Analysis (HCA) was performed by Daughney (2005b) with log-transformed median concentrations of 15 analytes (Br, Ca, Cl, F, Fe, HCO_3, K, Mg, Mn, Na, NH_4, NO_3, PO_4, SiO_2, SO_4). For sites where the median boron, fluoride and silica concentrations could not be determined (i.e. all results were below the detection limit), medians were estimated using linear regression (bromide) or multiple regression (fluoride, silica). The calculated and estimated median concentrations are given in Appendix J.

The first step in the cluster analysis was to use the nearest neighbour algorithm. The nearest neighbour algorithm is used to determine the most geochemically unique sites that should be treated as residuals (Daughney, 2003). After this analysis, SWDC Martinborough was the most unique, and was excluded from further clustering (Figure 5.22).

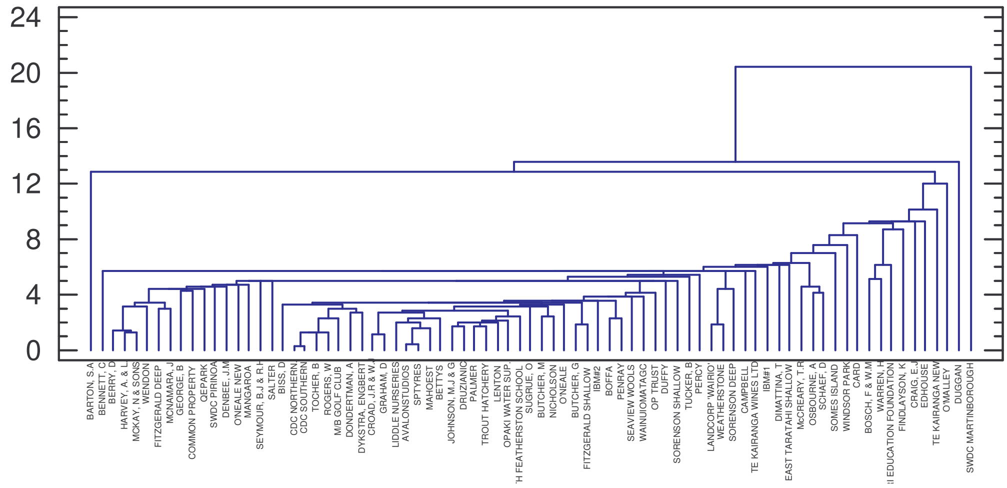

Figure 5.22: Dendrogram of all GWSOE sites using Br, Ca, Cl, F, Fe, HCO_3^-, K, Mg, Mn, Na, NH_4, NO_3, PO_4, SiO_2, SO_4 and the nearest neighbour clustering rule.

The next step, using the Ward's linkage rule[5], is to perform cluster analysis on all sites not identified as residuals. The Ward's linkage rule is based on the analysis of variance, and produces smaller, more distinct clusters than other linkage rules (Daughney, 2003). The results of this clustering are shown in Figure 5.23. Figure 5.23 clearly shows 2 major clusters that are very different from each other (Threshold 1). These two clusters contain 15 and 63 sites respectively. If the threshold for the separation measure is decreased, the number of clusters increases to 4. Threshold 2 separates cluster 2 into 3 subclasses (2, 3 & 4) containing 25, 21 and 17 sites respectively. A further decrease in separation measure to threshold 3 results in 9 sub-clusters. The clusters to which the GWSOE sites are assigned are listed in Appendix J.

[5] For detailed methodology refer to Daughney (2003), analysis performed using StatGraphics™

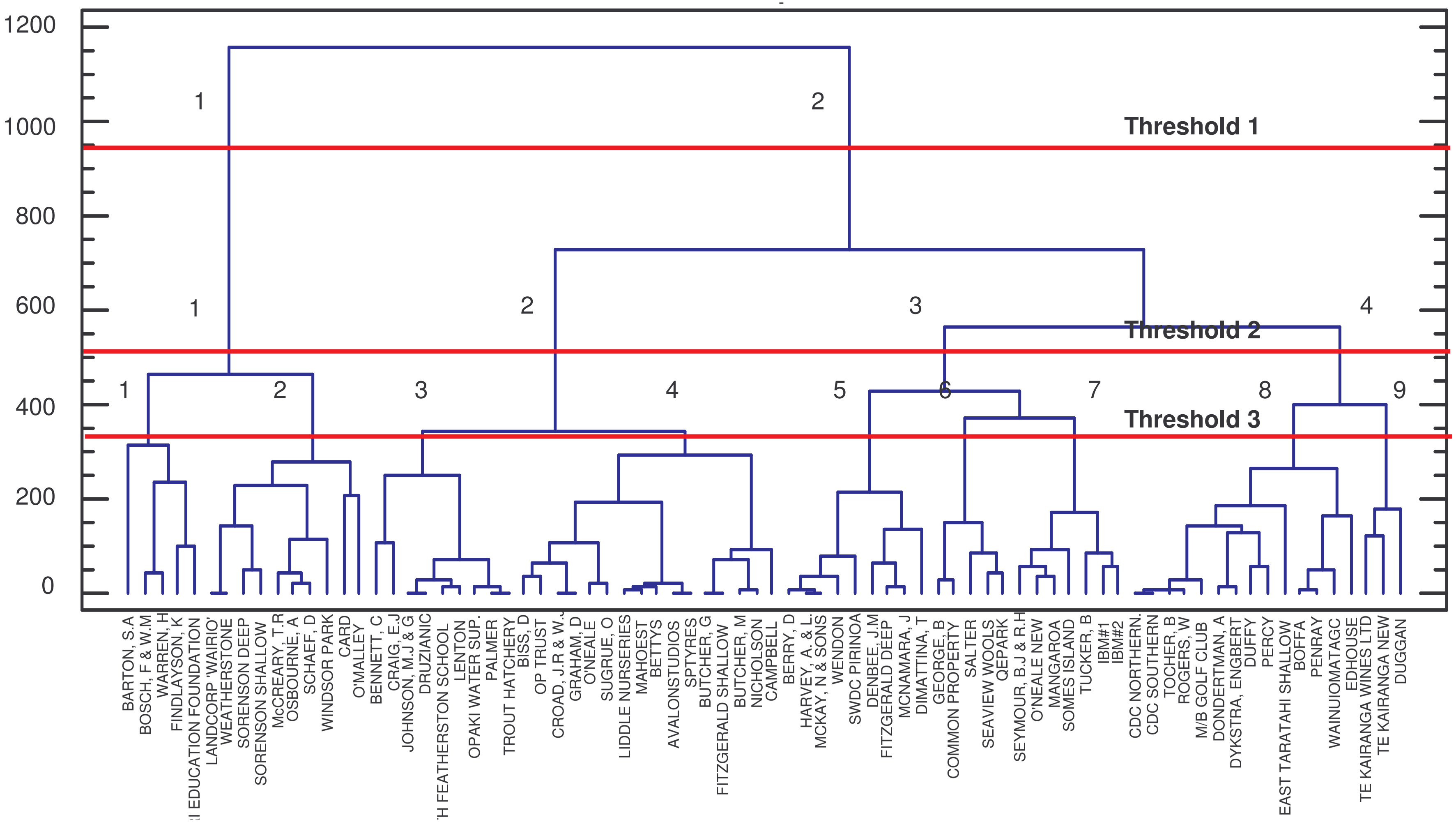

Figure 5.23: Dendogram based on Hierarchical cluster analysis conducted using log transformed and scaled medians of selected parameters. The Y-axis is a measure of similarity (small values) or dissimilarity (large values) between two sites or clusters of sites (Daughney, 2003). The site names are displayed on the X-axis. The red lines denote the threshold levels, and the number represents the cluster numbers.

HCA creates homogenous groups of samples, but it does not return any information on what actually makes the groups different, or how significant any differences are (Daughney, 2003). Taking into account the above Principal Component Analysis however, a more accurate determination of what makes the clusters different can be undertaken.

For this report, the results of the cluster analysis at threshold 2 will be discussed further. The usefulness of interpreting threshold 3 is questionable as the differences between clusters become very small, and interpretation of threshold 1 is too broad to give a true representation of the groundwater in the Wellington Region. The mean analyte concentrations for each cluster are given in Appendix J. The mean analyte concentrations define centroids, which essentially represent the 'average member' of the cluster (Daughney, 2003) and can summarised as follows:

- Cluster 1: These are highly reduced (anoxic), highly evolved groundwaters. These sites are in the Lower Wairarapa Valley, but also include Windsor Pk, Card and O'Malley (Figure 5.23). They display high concentrations of Br, Ca, Cl, Fe, HCO_3^-, K, Mg, Mn, Na, NH_4-N, DRP and SiO_2; accordingly the highest total dissolved solids, highest conductivity and lowest pH. These sites display no nitrate-nitrogen and the lowest concentrations of sulphur. These are likely to be confined aquifer systems, close to equilibrium with the surrounding geology, slow moving or possibly blind systems. Generally Na-Ca-HCO3-Cl waters. Some display more dominance of Mg. Likely to be near the bottom of aquifer systems.

- Cluster 2: These sites display no or low levels of human impact. They are the most dilute groundwaters in the GWSOE, and display the lowest concentrations of Br, Ca, Cl, F, Fe, HCO_3^-, K, Mg, Mn, Na, NH_4-N, DRP and SiO_2. Nitrate and sulphate are low, but not zero, indicating these sites are not reduced and may show some signs of anthropogenic influence. They are generally shallow, unconfined aquifers, often river recharged but possible rainfall recharged. Likely to be near the recharge zones of aquifer systems and young water.

- Cluster 3: These sites show evidence of reducing conditions, but are not as reduced (anoxic) or evolved as cluster 1. Concentrations of Br, Ca, Cl, Fe, HCO_3^-, K, Mg, Mn, Na, NH_4-N, DRP and SiO_2 are lower than in cluster 1 but higher than clusters 2 and 4. Nitrate-nitrogen is zero, ammoniacal nitrogen is elevated and sulphate is low. Sites may be confined or unconfined, and recharged predominantly by rainfall. They display moderate total dissolved solids and conductivity. Likely to be in the middle of aquifer systems.

- Cluster 4: These are the most impacted sites in the GWSOE. They display high concentrations of nitrate nitrogen and sulphate. Their major ion chemistry is different from all other clusters, showing higher Ca, Cl, K, Mg, Na than clusters 2 and 3, but less Br, F, Fe, Mn, HCO_3^-, SiO_2. Ammoniacal nitrogen is zero, and nitrate nitrogen and sulphate are high. These groundwaters are not reduced, but are likely to be older than cluster 2 thus more evolved. These appear to be unconfined or semi-confined sites, likely to be rainfall recharged.

The different chemical constituents of each of the four clusters described above are also shown on the Piper diagrams (Figure 5.24) and their spatial spread shown on the map (Figure 5.25). The similarity between clusters 1 and 3 and clusters 2 and 4 is clearly evident.

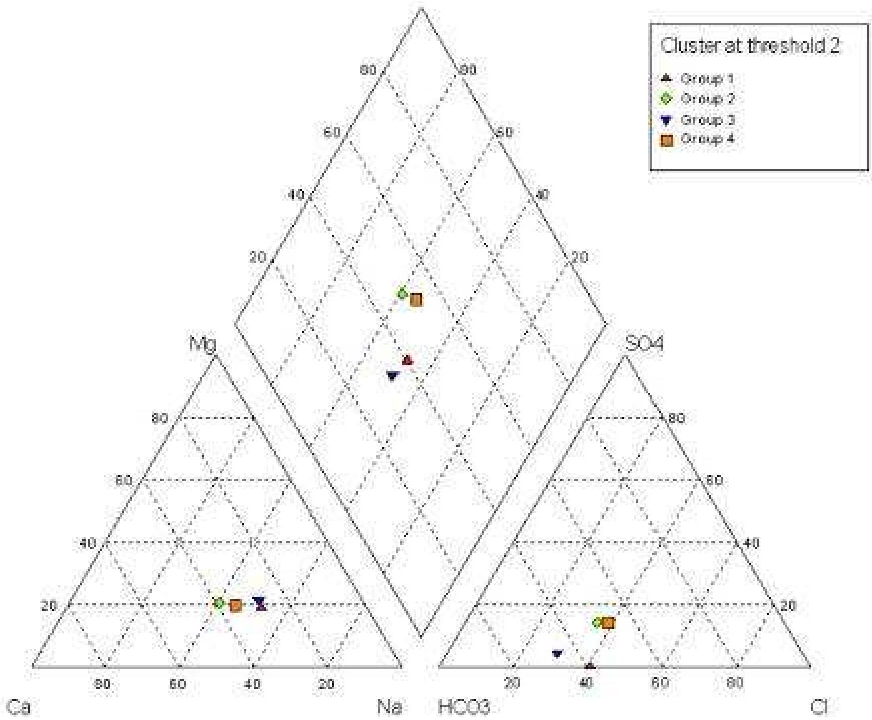

Figure 5.24: Piper plot of centroid chemistries for clusters at threshold 2.

The spatial spread of clusters described above shows some clear regional patterns, as seen in Figure 5.25.

In the Hutt Valley, increased reducing conditions are clearly evident as you move from the head to the bottom on the valley. The sites toward the head of the valley, in Upper Hutt, and Lower Hutt, are dominated by river recharge and fall into cluster 2. As water progresses through the aquifer system, it becomes more reduced, and the sites towards Petone and Seaview fall into cluster 3. This is agreement with the findings of Downes (1980) in his study of redox reaction in the Hutt Valley aquifers.

On the Kapiti Coast, sites fall into all 4 clusters. Three sites in shallow river gravels, near the Otaki and Waikanae rivers, fall into cluster 2. In the rainfall recharge zones along the base of the foothills, the dominant cluster is 3, the moderately reduced groundwater. Highly reduced groundwater is found at three sites, two are in the deep gravels of the Hautere and Coastal groundwater zones, and one is a shallow bore at Te Horo. The impacted sites appear to be rainfall recharged sites, and all occur in dairying areas.

In the Wairarapa the pattern of more reducing conditions toward the bottom of the Valley is clearly evident. The most reduced waters, cluster 1, generally occur in the deep confined aquifers at the bottom of the valley. Cluster 2 sites are generally associated with river recharge and this is clearly evident in Figure 5.25. Sites in clusters 3 and 4 are generally found in the rainfall recharge zones towards the sides of the Valley.

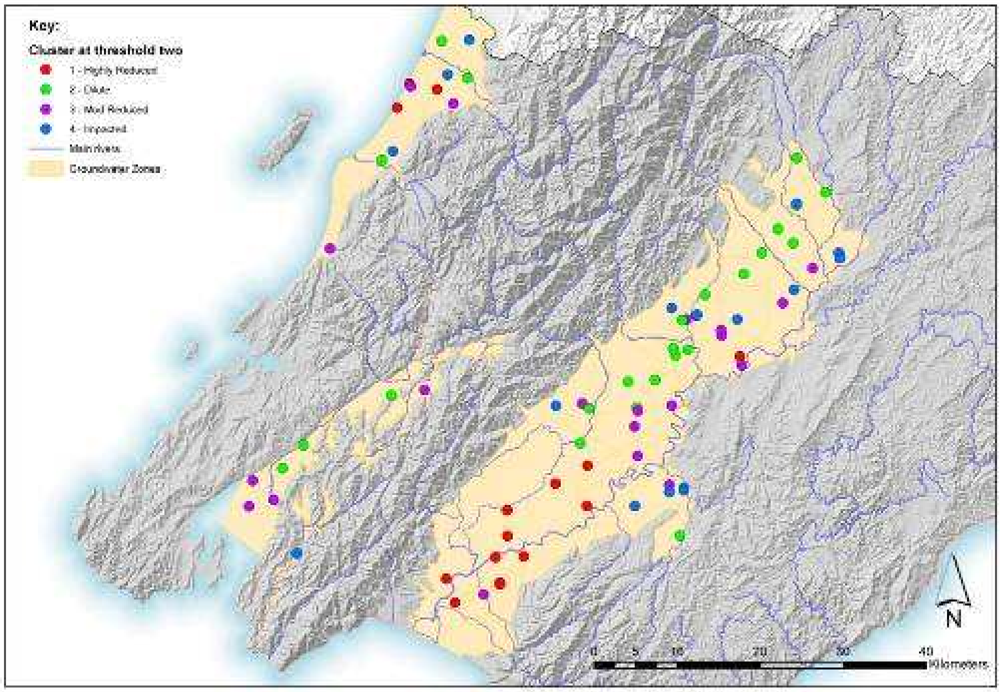

Figure 5.25: Map of monitoring sites keyed by their cluster number based on threshold 2.

5.4.6 Bacteriological results

Faecal contamination of water leads to the occurrence of harmful pathogens in the water body (Sinton, 2001). A wide range of bacterial pathogens are found in faeces and wastewater however their measurement and is often expensive and misleading. Instead of directly measuring the presence of pathogens, indicator organisms are used to indicate the possible presence of these harmful pathogens. Coliform bacteria, including the subset group of 'faecal' coliforms are the most commonly used indicator faecal contamination of water. One faecal coliform species – *Escherichia coli* – is almost certainly from faeces (Sinton, 2001).

Bacteriological contamination (either faecal coliforms or *E.coli*) has been recorded at 19 of the 78 sites at some time during the length of the GWSOE programme (Appendix K). Of the 19 sites, 11 have had coliforms present on more than one occasion (S25/5322, S25/5256, S25/5200, S25/5125, R27/6833, R27/6418, R26/6587, T26/0430, S27/0389, S27/0202, S27/0681). S27/0202 (Croad), R27/6418 (Wainuiomata Golf course) and S27/0681 (Te Kairanga new) are all large diameter concrete lined wells and have had faecal counts on numerous occasions. T26/0430 is a shallow spring and therefore coliform counts are not unexpected. R26/6587 (Liddle Nurseries) is an unconfined bore in Waikanae with poor bore head protection and very dirty headworks. The site was upgraded in early 2004 and has had no coliform counts since then. S27/0389 (Dimittina) had positive *E.coli* results during 2004. These counts coincided with the installation of a septic tank 50m from the bore, and increased concentrations of ammoniacal-nitrogen, dissolved reactive phosphorus, chloride and bromide all indicate sewage contamination.

5.4.7 Pesticide monitoring

Pesticide monitoring in the Wellington Region has taken place in 1990, 1994, 1998/99 and 2002 as part of the National Survey of Pesticides in Groundwater. This programme has been run most recently by the Institute of Environmental Science and Research (ESR) and prior to that by the Institute of Geological and Nuclear Sciences (IGNS). A one-off investigation of 14 bores in the western Wellington Region was also carried out in 1996 by Hughes (1996).

The study by Hughes (1996) found detectable concentrations of pesticides at 3 of the 14 sites - R25/5166, S25/5125 and R26/6503. All concentrations were less than 2% of the maximum allowable values as set by the Ministry of Health (2000). Contamination at S25/5125 and R26/6503 was attributed to spaying of Bromacil for weed control along the main trunk railway line and at site R25/5166 contamination was attributed to weed control sprays used in the Orchard.

In 1998 pesticides were detected at three sites - S25/5125, S25/5322 and R27/1137. All of the pesticides detected were well below the maximum allowable values as set by the Ministry of Health (2000).

The 2002 pesticide study sampled 12 bores across the Wellington Region. No pesticides were detected at any of the sites.

5.4.8 Regional assessment of discharges to land

Under Greater Wellington’s Regional Plan for Discharges to Land (1999) discharges of less than 1300 litres per day of on-site sewage are a permitted activity and discharges of agricultural effluent to land are controlled activities. There are currently no dedicated programmes to monitor the effects of either of these activities, although previous programmes and one-off studies have taken place. However, through the Groundwater State of the Environment programme, a broad regional assessment of shallow groundwater can be made to help understand effects of these discharges to land.

Thirty-nine of the seventy-eight sites assessed in this report are in shallow unconfined or semi-confined aquifers (Figure 5.26). These are the sites most likely show effects of land use and on-site sewage disposal. As discussed previously, the most commonly measured analyte used to indicate contamination from land use is nitrate-nitrogen. However, increased concentrations of phosphorous, sulphate, ammoniacal nitrogen and coliform bacteria are also possible indicators of land use effects.

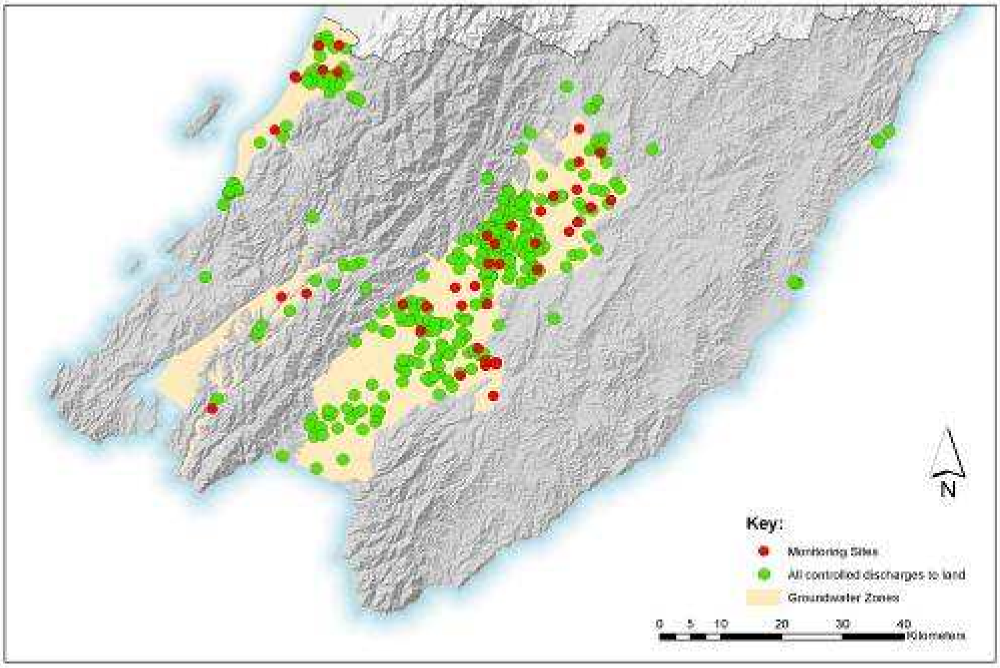

Figure 5.26: Location of unconfined and semi-confined monitoring sites relative to controlled discharges to land of agricultural effluent and controlled on-site sewage discharges.

Of the thirty-nine unconfined and semi-confined sites in the GWSOE programme, seventeen (44%) show elevated nitrate concentrations. None of these sites show increasing trends of nitrate over the length of record. Of these seventeen sites, eleven have dairying as the major up-gradient land use, and six have sheep/beef farming as the major up-gradient land use.

Several targeted studies, and one monitoring programme, focussed on agricultural discharges to land have been undertaken by Greater Wellington. In the Wairarapa, the Wairarapa Annual Ag-Effluent survey was run from 1990 – 1997. This programme was conducted by Consents and Compliance staff alongside the annual dairy inspection programme. The survey monitored nitrate levels in groundwater at all dairy farms in the Wairarapa (approximately 215) up until 1995. In 1996 and 1997 this programme was limited to those dairy farms discharging waste to land (at that time approximately 70 farms). The monitoring programme was reviewed in 1997 (Butcher, 1998) and has not been undertaken since then.

In the western part of the region, two targeted nitrate studies have been completed (Hughes, 1996 & Hughes, 1998) to investigate nitrate levels on the Kapiti Coast. Median nitrate concentrations from these studies have been incorporated with results from the GWSOE into Figure 5.27. Results from all of these studies and monitoring programmes show elevated nitrate levels in the Hautere, Coastal, Otaki, Te Ore Ore, Upper Plain, Carterton, Parkvale, East Taratahi, Moroa, Matarawa, and South Featherston groundwater zones (Figure 5.27).

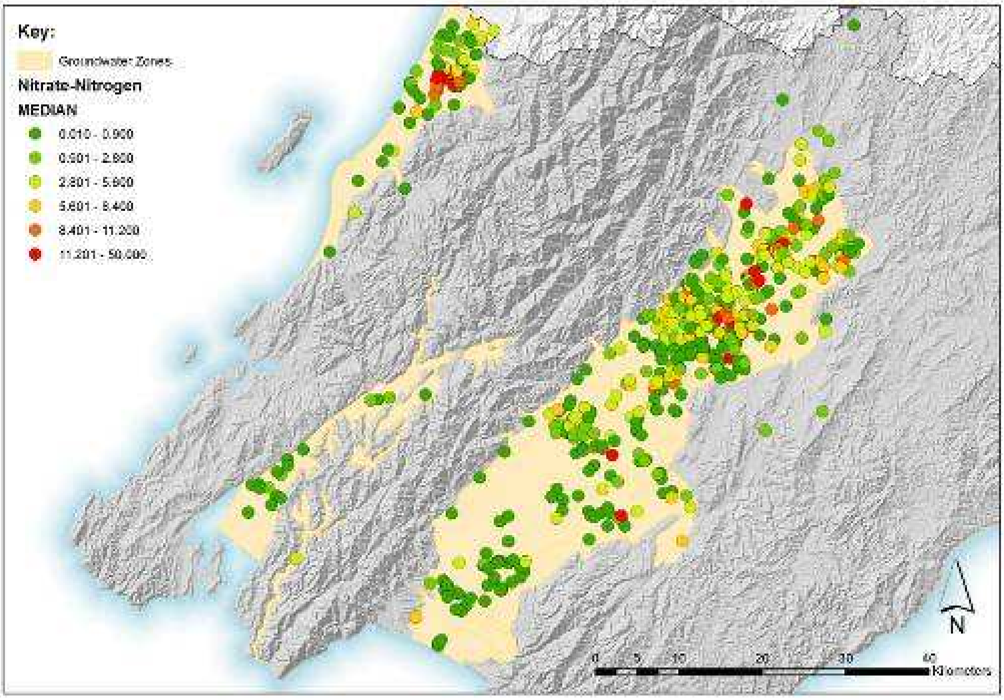

Figure 5.27[6]: All historical median nitrate-nitrogen results 1983 - 2004. It is important to note that data quality for some sites not in the GWSOE is of a lesser standard due to samples being collected under different sampling protocol and that the date range for the samples is large. Median data is from the GWRC Hilltop database and Van der Raaij (2000).

Site selection for the GWSOE programme has generally been conducted to monitor aquifer conditions at a broad scale. The sites have not been chosen to monitor point-source discharges to groundwater such as on-site sewage systems. There are however, three sites which are located within 50m of septic tanks in the Wairarapa. All of these sites display possible evidence of contamination. S27/0389 (Dimittina) shows elevated concentrations of phosphorus, ammoniacal nitrogen, chloride and has had *E.coli* detected during several sampling rounds. S27/0571 (Martinborough Golf Cub) is only used for irrigation, and in a semi-confined system and displays elevated (median >8.0 mg/l) nitrate concentrations. T26/0259 (Opaki Water Supply) is located down gradient of several septic systems; the closest is approximately 50m distant. This large diameter well has never had any bacteria measured in the water but does show evidence of increasing nitrate-nitrogen, chloride and sulphate.

Care must be taken however in drawing too much from any results from these three bores located close to on-site wastewater systems. Wastewater from on-

[6] Note that figure 5.27 has been created using median values, regardless of the time of sampling. As a result, the map does not account for any seasonal or long term trends. Therefore, differences in concentration between some of the bores on the map may be an artefact of time of sampling rather than true spatial variation.

site systems needs both time and distance in the soil and groundwater zone to attenuate; therefore, the possible indication of contamination is not surprising given the bores locations, and does not necessarily indicate a problem. Further monitoring is required to determine the source of the contamination.

5.5 Discussion/summary points

At a regional scale groundwater quality in the Wellington Region is highly variable. Analysis of the data shows that the dominant controls on groundwater chemistry in the region are natural processes, although there is evidence that in some areas agricultural land use is adversely affecting groundwater quality.

5.5.1 The quality of our data

The change from measuring total concentrations of analytes to measuring dissolved concentrations, and the change in laboratories, has increased the quality of our data, as seen through the analysis of charge balance error results. A noticeable decrease in the range of errors, and a change in distribution to normal about zero percent error are apparent.

5.5.2 Assistance of resource definition

The most geochemically evolved groundwater in the region is found in the Lower Wairarapa Valley groundwater zones, and in the deep aquifers of the Kapiti groundwater zones. These aquifers are highly reduced and generally show high concentrations of bromide, calcium, chloride, iron, bicarbonate, potassium, magnesium, manganese, sodium, ammoniacal-nitrogen, phosphorus and silica. These aquifers are dominated by natural oxidation and reduction (redox) processes. Compared to data from the National Groundwater Monitoring Programme (NGMP; Rosen, 2001), groundwater in the Lower Wairarapa Valley is some of the most reduced in New Zealand.

Significant variation in aquifer chemistry in several Wairarapa groundwater zones (Lower Valley, Tawaha, Kahutara) is evident during the irrigation season. This suggests there may be a high degree of connectivity between aquifers, with different water sources being drawn into the aquifers under high drawdown. Further study is needed to better understand recharge dynamics and the degree of connectivity between these aquifers.

The fact that these aquifers are so reduced also raises the question about whether or not the deep Lower Valley aquifers are discharging or are in-fact blind. Morgenstern (pers. comm., 2005) suggested that given the highly reduced chemistries, and the occurrence of methane gas, that natural movement of water in the aquifer must be extremely slow, or stagnant. However, the high clay content of these aquifers may also be a factor in speeding up the reduction of the groundwater.

While this groundwater is not suitable for use as untreated drinking water, it is widely used for irrigation water. The effects of this highly mineralised water on soils are largely unknown and should be investigated.

5.5.3 Significant temporal trends

The majority of sites in the GWSOE network show no significant trends (at the 95% confidence interval). Significant decreasing trends are found at two sites: one at Te Horo, which may display diminishing effects of saline intrusion; and one in the Lower Wairarapa Valley that shows decreasing trends in carbon dioxide, which is likely to be from a change in recharge source. Several sites in the Wairarapa show increasing trends in sulphate concentrations; two are shallow unconfined bores, and one is in a semi-confined aquifer. While it is possible that these changes are land use derived, further investigation needs to be undertaken to accurately determine the cause.

5.5.4 Land use management

Hierarchical cluster analysis showed a group of seventeen sites (21% of total sites) in the GWSOE programme that show evidence of anthropogenic impact. These sites are mainly characterised by their elevated nitrate-nitrogen and/or sulphate concentrations. Monitoring of these sites should continue, and careful attention given to future results.

The lack of monitoring of both discharges to land of agricultural waste and discharge to land of waste from on-site sewage systems is concerning. Both of these activities have the potential, if not managed properly, to have detrimental effects on groundwater quality, however the coverage of shallow, unconfined sites in the GWSOE network is insufficient to assess these impacts. In addition, the aims, and structure of the GWSOE programme are not compatible with the intensive programme needed to monitor discharges to land.

Historical data, and data from the limited number of shallow unconfined bores in the GWSOE programme, indicate that there are a number of groundwater zones in the region (in particular Hautere, Coastal, Otaki, Te Ore Ore, Upper Plain, Carterton, Parkvale, East Taratahi, Moroa, Matarawa, and South Featherston) where elevated nitrate-nitrogen concentrations suggest agricultural land is affecting groundwater quality. Nitrate-nitrogen monitoring in these areas needs to be spatially more intense, but could be temporally less intense than the GWSOE programme.

While there are a large number of sites showing elevated nitrate-nitrogen levels, no sites show any significant increases in nitrate-nitrogen. This suggests that at these sites, nitrate in groundwater is in a state of equilibrium with land use, or that due to the time for water to move through the vadose zone into groundwater, the effects of land use intensity have yet to be picked up in the groundwater. For example, in the Te Ore Ore groundwater zone, CFC dating (Van der Raaij, 2000) suggests that the nitrate concentrations in the shallow aquifer measured today are a result of land use practices 20 years ago.

Alongside the issue of agricultural effluent discharge to land, is the application of nitrogen based fertilisers to land. While the quantity of nitrogen applied to land has increased substantially in the past decade, our monitoring shows no increasing nitrate concentrations. This may however, be a reflection of the limited site coverage.

A spatially intensive sampling programme, similar to the old Wairarapa Ag-Effluent monitoring programme is needed region-wide to address the impacts of agricultural discharge to land and monitor the potential impacts of increased fertiliser use. Without this programme, the effectiveness of the Regional Plan for Discharges to Land cannot be accurately assessed. This programme should monitor sites once a year, during late winter, or spring.

Possible contamination from areas with high densities of on-site wastewater systems is impossible to quantify with the available data. Unintentional site positioning in the GWSOE programme has picked up contamination of the groundwater from septic tanks from at least one site, showing that on-site systems do have the potential to adversely affect groundwater. There have been many incidences of individual system failures reported to Greater Wellington; however there have been few detailed assessments of significant contamination issues. A much more site specific, intensive monitoring programme is needed to fully assess this issue.

5.5.5 Groundwater-surface water interaction

As groundwater-surface water quantity interaction is poorly constrained in the Wellington Region, it is hard to make an assessment on the effects of groundwater discharge on surface water quality. Evidence of elevated nutrient levels in shallow groundwater raises the possibility that groundwater discharge will affect surface water quality, however measuring this requires knowledge on hydraulic interaction first.

6. Management of the Region's groundwater resource

6.1.1 Defining sustainable groundwater use

The concept of safe yield employed by the Regional Freshwater Plan is the avoidance of long-term reduction of aquifer storage by allowing users to take no more than the estimated volume of recharge to the aquifer system. Thus the safe yield limits groundwater abstraction to the amount of water that is replenished.

Unfortunately such an approach is fundamentally flawed as it makes no allowance for natural discharge from a groundwater system. By allowing abstraction equal to the rate of recharge, natural discharge rates will be reduced and may eventually cease, resulting in adverse effects to groundwater dependant ecosystems such as springs and wetlands. Furthermore, underestimating the recharge to a deep groundwater system with little natural discharge can result in the depletion of aquifer storage and adverse effects on well yields. This situation appears to have occurred in the Parkvale and Kahutara groundwater zones.

An alternative, and in our view preferable, concept of safe yield is the volume of natural discharge that may be abstracted without causing adverse effects on groundwater dependant ecosystems. Bredehoeft (1977 and 2002) refers to this volume of water as capture. Capture is independent of recharge and depends on the dynamic response of the aquifer system to development. The determination of discharge from an aquifer system requires a robust conceptual hydrogeological model and monitoring of the surface water environment. Such a model exists for Lower Hutt and also for the shallow groundwater resource in the Paraparaumu/Waikanae area. Although the Lower Hutt safe yield is designed to prevent seawater intrusion and is not based on the requirements of a groundwater dependant ecosystem, it does illustrate that the discharge from an aquifer system is typically the limiting factor on the sustainable development of a groundwater system. A work programme is currently underway to revise our understanding of the Wairarapa groundwater system. Determining the proportion of discharge that may be taken as capture will require case by case assessments of the reduction in discharge that may be tolerated without causing adverse ecological effects.

6.1.2 Allocation of groundwater

The limited metering information that we have shows there is a clear discrepancy between allocated volumes and actual usage. This situation has arisen from the practice of allocating water on a "first come, first served' basis. Under this practice, irrigators typically apply for the maximum rate of use they may require under extended dry conditions which in reality occurs infrequently. Consequently, groundwater allocation is effectively locked up when the maximum rate of use is not required and in fully allocated areas there is no room for new groundwater users.

Fortunately the discrepancy provides a useful safety margin given the uncertainty with the existing estimates of aquifer safe yield. Upon revision of our safe yield estimates we recommend that we explore improvements to our allocation methodology to make better use of the available water.

6.1.3 Land use management

The Groundwater State of the Environment Monitoring Programme has shown that 44% of unconfined and semi-confined sites in the network display evidence of anthropogenic impacts. Elevated nitrate-nitrogen and/or sulphate concentrations suggests that agricultural land use is having an impact on groundwater quality, however, the limited spatial coverage of shallow monitoring sites means that a proper assessment of the effects of agricultural discharges to land cannot be undertaken. To address this issue we recommend the development of a region-wide programme to monitor nitrate-nitrogen concentrations in shallow groundwater.

At least one site in the GWSOE programme show signs of contamination from on-site sewage disposal. This result highlights the potential for on-site sewage disposal to affect shallow groundwater, but does not help to determine the extent of contamination because the distribution of monitoring sites is too sparse. An assessment of the effect of on-site sewage systems requires a dedicated network of sites targeted at areas with a high density of systems such as Te Horo Beach, Rathkeale and Riversdale. Such a programme would assess the extent of contamination from individual and multiple disposal systems.

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Appendix A: Groundwater Level Monitoring Sites in the Wellington Region

Well number	Site name	Easting	Northing	Site type*	Groundwater zone	Depth (m)
S26/0545	Craig /Deep	2719490	6013103	M	Ahikouka	18
S26/0547	Craig /Shallow	2719471	6011895	M	Ahikouka	4
S27/0109	Ewington	2714327	6005856	A	Battersea	8
S27/0099	Simmonds /John	2713190	6004230	A	Battersea	17
S27/0183	Morrisons Bush Hall	2715948	6005982	M	Battersea	37
S27/0099	Simmonds /John	2713190	6004230	M	Battersea	17
R25/0003	Sims Road South	2686600	6044900	AT	Coastal	57.5
S26/0229	East Coast Fert./Deep	2726562	6021309	M	East Taratahi	24
S26/0242	East Coast Fert./Shall	2726569	6021323	M	East Taratahi	8
S26/0223	Nicholson	2726219	6021005	M	East Taratahi	10
S26/0236	Oldfield	2728135	6022294	M	East Taratahi	41
T26/0326	McKay	2730876	6017526	M	Fern Hill	10
S27/0225	Hammond	2717090	6009439	AT	Greytown	5
S26/0537	Harding	2715622	6012552	A	Greytown	6
S26/0490	Perry	2715511	6012696	A	Greytown	5
S26/0395	Papawai Spring	2717574	6010702	S	Greytown	
S26/0500	Roganns	2717266	6010716	M	Greytown	3
S25/5208	Centrepoint	2690300	6042600	AT	Hautere	160
S25/5256	Penray	2690500	6045000	MQ	Hautere	32
R25/5135	Windsor Park	2689200	6043200	MQ	Hautere	95
S25/5200	Common Property	2691200	6041500	MQ	Hautere	59.9
R25/5123	Faith	2688300	6042500	M	Hautere	13
R25/5111	Jamieson	2688300	6041200	M	Hautere	50
S26/0400	Fitzgerald	2718695	6015416	A	Hodders	16
S27/0559	Craggy Range	2718263	5988924	A	Huangarua	24
S27/0572	List	2719462	5993769	A	Huangarua	3
S27/0467	Green	2702846	5994763	A	Kahutara	30
S27/0309	Simmonds - 6E/44/30/I	2707899	5998181	A	Kahutara	30
S27/0317	Simmonds - 6E/51/18/I	2707821	5998803	AT	Kahutara	18
S27/0446	Awaroa /Deep	2704505	5993955	M	Kahutara	60
S27/0465	Awaroa /Shallow	2704079	5993248	M	Kahutara	61
S27/0271	Simmonds /Jim	2707818	5998780	M	Kahutara	30
R27/1117	Taita Intermediate	2673500	6000200	AT	Lower Hutt	14.4
R27/1122	Randwick	2669700	5996400	AT	Lower Hutt	24.4
R27/1171	Somes Island	2666500	5992900	ATQ	Lower Hutt	23.2
R27/0122	McEwan Park	2668600	5995200	AT	Lower Hutt	28.4
R27/0320	IBM1	2667100	5996200	ATQ	Lower Hutt	114.6
R27/1265	IBM2	2667100	5996200	ATQ	Lower Hutt	48.3
R27/1115	Hutt Recreation Ground	2669600	5997400	AT	Lower Hutt	23.5
R27/1116	Mitchell Park	2671600	5998500	AT	Lower Hutt	51.8
R27/1086	UWA3	2669800	5994900	AT	Lower Hutt	65
R27/6386	Marsden Street	2669089	5997663	AT	Lower Hutt	106.2
R27/1223	Nevis Street	2666400	5996200	M	Lower Hutt	46.9
R27/6980	Earlston Well	2673000	6000000	M	Lower Hutt	8.4
R27/6982	Thornycroft Avenue	2672000	5998700	M	Lower Hutt	9.3
R27/6981	Fairway Drive	2672500	5999300	M	Lower Hutt	10.1

S26/0658	Wither	2725320	6015300	M	Mangatarere	8
S27/0571	Martinborough Golf Club	2717180	5994736	AT	Martinborough Eastern Terraces	32
S27/0560	Collins/McCullum	2717992	5994608	M	Martinborough Eastern Terraces	39
S27/0571	Martinborough Golf Club	2717180	5994736	M	Martinborough Eastern Terraces	32
S27/0640	Te Kairanga/Deep	2718144	5995373	M	Martinborough Eastern Terraces	69
S27/0403	Wall	2717954	5995177	M	Martinborough Eastern Terraces	42
S27/0522	Duggan	2713054	5993045	A	Martinborough Terraces	21
S27/0517	Stuart	2710888	5992174	A	MartinboroughTerraces	19
T26/0430	Trout Hatchery	2732149	6024746	S	Masterton	
T26/0209	Cameron	2732725	6025154	M	Masterton	5
S26/0749	Blundell	2725860	6010810	A	Middle Ruamahanga	10
T26/0602	Gladstone WSS	2731345	6011735	A	Middle Ruamahanga	12
S27/0248	Morrison	2723081	6009730	M	Middle Ruamahanga	8
S26/0756	Wenden	2725937	6010018	M	Middle Ruamahanga	22
S27/0202	Croad	2715480	6008240	A	Moroa	4.8
S27/0171	Field	2715117	6008003	M	Moroa	7
S27/0594	Warren	2691376	5981438	M	Narrows	44
S27/0587	Luttrell	2691066	5985096	A	Onoke	34
R28/0002	Annear	2689633	5977762	M	Onoke	17
S27/0576	Luttrell /Deep	2691443	5985224	M	Onoke	56
T26/0208	Tocher/Lawrence	2733062	6029067	A	Opaki	17
T26/0003	Lenton	2732572	6034955	M	Opaki	5.5
S25/5258	Bettys	2692100	6045200	AT	Otaki	4.9
R25/5228	Rangiuru Road	2689400	6048100	M	Otaki	32
S25/5212	Lutz	2694500	6043500	M	Otaki	8
S25/5287	Horowhenua Racing Club	2692600	6046400	M	Otaki	8
S25/5228	Andrews	2692800	6045400	M	Otaki	10
S26/0743	Baring	2725045	6013506	AT	Parkvale	33
S26/0738	Towgood	2725320	6015300	A	Parkvale	5
S26/0656	Tulloch /Investigation	2723379	6017372	A	Parkvale	92
S26/0568	Denbee	2723504	6013642	M	Parkvale	45
S26/0675	McNamara	2722941	6014309	M	Parkvale	32
S26/0155	Tulloch /Shallow	2723845	6017830	M	Parkvale	13
S27/0432	Diversion	2696549	5987564	M	Pouawha	38
S27/0481	Dry River Beef	2709741	5993037	AT	Pukeo	23
S27/0484	Ness /Deep	2708328	5992892	M	Pukeo	43
S27/0485	Ness/Shallow	2708329	5992892	M	Pukeo	20
T26/0239	Zyzalo	2735451	6030720	A	Rathkeale	6
T26/0170	Hodgins	2734392	6031719	M	Rathkeale	16
R26/6520	QE Park No2	2676300	6024000	M	Raumati/Paekakariki	6
R26/5102	QE Park No3	2676300	6024000	M	Raumati/Paekakariki	2.6
R26/6919	QE Park No4	2676300	6024000	M	Raumati/Paekakariki	5.5
R26/6920	QE Park No5	2676300	6024000	M	Raumati/Paekakariki	5.5
S27/0012	Windy Farm /Deep	2703799	6005119	M	South Featherston	66
S27/0009	Windy Farm /House	2703916	6005200	M	South Featherston	10.5
S27/0006	Windy Farm /Shallow	2703562	6005165	M	South Featherston	12
S27/0330	Burt & Co	2707788	6002140	A	Tauherenikau	20

S27/0122	Alecock	2710270	6006990	M	Tauherenikau	9
S27/0035	Sth Featherston School	2707527	6004826	M	Tauherenikau	6
S27/0381	Herrick	2715672	5997662	A	Tawaha	21
S27/0346	Smith	2714080	5998823	AT	Tawaha	9.5
S27/0542	Butcher	2710011	5993660	M	Tawaha	19
S27/0362	Osborne	2713933	5999049	M	Tawaha	9
S27/0434	Wairoria	2696876	5990055	AT	Te Hopai	45
T26/0494	Oliver - deep	2738052	6024402	AT	Te Ore Ore	23
T26/0501	Oliver - shallow	2736112	6024333	A	Te Ore Ore	5
T26/0535	Percy	2737743	6022898	A	Te Ore Ore	5.9
T26/0486	Chittick/Deep	2738280	6024180	M	Te Ore Ore	28
T26/0243	Masterton District Council	2736240	6025100	M	Te Ore Ore	47
T26/0232	Waicon	2735953	6025169	M	Te Ore Ore	30
R28/0018	Daniell	2689746	5977924	M	Turanaganui	2
S26/0031	Dick/House	2729620	6025870	M	Upper	5
R27/7004	Trentham Memorial Park	2680800	6006100	AT	Upper Hutt	32.3
S26/0030	Dick /Investigation	2729680	6025909	A	Upper Plain	38
S26/0033	Downing	2728508	6026282	A	Upper Plain	12
S26/0308	Oldfield Ltd /Domestic	2729228	6023435	A	Upper Plain	5.5
S26/0298	Oldfield Ltd /Industrial	2729240	6023650	A	Upper Plain	7
S26/0032	Candy	2729110	6025990	M	Upper Plain	7
T26/0429	Transport Wairarapa	2730037	6023706	M	Upper Plain	13
R26/6594	WCHP Deep	2680700	6034900	AT	Waikanae	73
R26/6916	WCHP Shallow	2680700	6034900	AT	Waikanae	20
R26/6831	Larch Grove	2678775	6030888	AT	Waikanae	3.5
R26/6832	WRC Golftech	2678228	6031345	AT	Waikanae	4
R26/6833	McLean Park	2676800	6033300	AT	Waikanae	4
R26/6287	Rangihiroa Street	2680600	6036000	AT	Waikanae	3
R26/6284	Waikanae Park	2682700	6034800	AT	Waikanae	87.1
R26/6569	NZ Staff College	2680943	6032331	M	Waikanae	44.6
R26/6521	Weka Park	2677300	6030200	M	Waikanae	41
R26/6557	Mazengarb	2679034	6032855	M	Waikanae	25.9
R26/6558	Mazengarb Deep	2678997	6032667	M	Waikanae	91.3
R26/6884	Te Harakeke Wetland 1	2682107	6037107	M	Waikanae	5.5
R26/6885	Te Harakeke Wetland 2	2682244	6036608	M	Waikanae	5.5
R26/6886	Te Harakeke Wetland 3	2681953	6036142	M	Waikanae	5.5
R26/6626	McLauchlan	2683800	6035800	M	Waikanae	16
R26/6738	McCardle	2685700	6038400	M	Waikanae	5
R26/6747	Quinn	2685300	6039200	M	Waikanae	69.5
S27/0428	Wairio	2697641	5992527	A	Wairio	44
S25/5332	Taylors	2692200	6049000	AT	Waitohu	6
S25/5322	Edhouse	2693100	6049200	MQ	Waitohu	27
S25/5329	Laurenson	2690600	6049700	M	Waitohu	25
S25/5320	Hunt	2693200	6048800	M	Waitohu	60
S27/0618	Atkinson	2695193	5984189	M	Whangaehu/ Tuhitarata	47
S27/0616	Tuhirangi Marae	2695989	5984192	M	Whangaehu/ Tuhitarata	11.6
S27/0148	Carlisle	2712249	6008765	M	Woodside	9
S26/0352	Stella Bull Park	2715428	6010284	M	Woodside	92

Site type classification:

AT -	automatic telemetred
A -	automatic
ATQ -	automatic telemetred and water quality
M -	manual
MQ -	manual and water quality
S -	spring

Appendix B: Groundwater permits in the Wellington Region

Kapiti Coast water permits

Consent no	Consent holder	Inst. take (l/s)	Vol/day (m^3)	Days/ week	Weeks/ year	Volume per year (m^3)	Bore Number
Waitohu Zone							
WGN98019501	Donald Edhouse	1.26	54.6	7	52	19874	S25/5322
WGN96007801	Taylors Road Water Company 2004 Lt	3.3	180.0	7	52	65520	S25/5328
WGN010188	J H & K M Simcox	0.9	29.2	7	52	10614	
WGN020114	J H & K M Simcox	1.25	108.0	7	12	9072	
WGN040075	Otaki Golf Club Inc	15	432.0	5	22	47520	S25/5115
WGN97015601	J H & K M Simcox	1.25	37.0	7	52	13468	S25/5372
WGN010208	Pritchard Group Limited	0.7	30.2	7	52	11007	
WGN020198	Otaki Golf Club Inc	7	604.8	7	2	8467	S25/5330
WGN000016	Cabrach Holdings Ltd	2	43.2	7	52	15725	S25/5310
WGN98009902	William Hunt	4.9	423.4	7	52	154103	S25/5320
WGN97026201	Kapiti Coast District Council	83	7172.0	7	52	2610608	
WGN96003001	Laurenson Partnership	12.6	365.0	7	15	38325	S25/5329
WGN010216	Waitawa Farm Limited	2.5	108	7	52	39312	
WGN040079	Pritchard Group Limited	1.736	75.0	7	52	27298	S25/5399
Otaki Zone							
WGN97004301	M P Tracy	5.55	490.0	7	20	68600	S25/5239
WGN98013201	Riverlea Farm Water Supply Co-owner	0.35	30.0	7	52	10920	S25/5246 or S25/5209
WGN96012101	Te Awamara Partnership	4	346.0	7	24	58128	
WGN040193	G E Jewell	8.33	719.7	7	52	261971	S25/5314
WGN97017201	R G & C D Lindsay	5	125.0		52	0	S25/5295
WGN98001701	Wellington Anglican Diocesan	1.4	60.0	7	52	21840	
WGN96004601	B & C Coe	2.2	142.6	7	52	51892	R25/5245
WGN96004501	Amos Water Scheme	5	432.0	7	20	60480	
WGN97002601	Willow Park Community	27	1555.2	7	24	261274	R25/5220
WGN96012001	Murray Cameron	4	288.0	7	15	30240	
WGN050148	David Walshaw	22.77	655.8	7	52	238702	

WGN99024001	Otaki Olives Ltd.	13.5	54.0	3	12	1944	S25/5285
WGN000052	E & M Lutz	15.2	1092.0	7	22	168168	S25/5212 or 5213
WGN000143	Winstone Aggregates	21.1	760.0	6	52	237120	S25/5345?
WGN950226	Winstone Aggregates	22.2	800.0			0	
WGN000079	A & K C Tam	8	230.4	7	26	41933	
WGN010125	Kapiti Coast District Council	16	1382.4	7	52	503194	S25/5379
WGN000087	Braeview Properties	6.3	68.0	7	12	5715	S25/5227
WGN96011901	Jones Partnership	4	288.0	7	15	30240	R25/5246
WGN96005301	Aileen Ramsbottom	15	432.0	5	20	43200	
WGN96006101	Stresscrete Otaki	0.5				0	S25/5345
WGN96008201	Young Guy	0.42	24.0			0	R25/5258
WGN010187	Watsons Garden	9	129.6	7	52	47174	S25/5309
WGN000051	Carl Lutz	15.2	1094.4	7	20	153216	S25/5213
WGN97026202	Kapiti Coast District Council	47	4061.0	7	52	1478204	
WGN000154	Arcus Road Water Scheme Ltd	35	3024.0	7	52	1100736	
WGN020144	Riverbank Orchards Ltd	5.83	125.9	7	20	17630	
Coastal Zone							
WGN96007901	Awatea Water Company Ltd	0.64	34.6	7	52	12594	
WGN960054	Adrian and Robyn Mourie	25	197.0	7	22	30338	
WGN020003	John Wong	6	172.8	6	52	53914	S25/5116
WGN000079	A & K C Tam	8	230.4	7	26	41933	
WGN98014501	Timberlea Gardens	4.2	90.7	4	26	9435	R25/5129
WGN010172	Adrian and Robyn Mourie	13	1029.6	7	22	158558	
WGN96009201	Niggle and Te Horo Trust	15.14	654.0	5	52	170052	R25/5131
WGN99000301	Sir Ron & Lady Margaret Trotter	10	288.0	2	24	13824	
WGN050161	KRL Developments	2.5	108.0	7	52	39312	R25/5262
Hautere Zone							
WGN96011101	Douglas Walker Family Trust	7.8	309.0	7	20	43260	I
WGN000090	B Bertelsen	5	1800.0	7	25	315000	S25/5359
WGN020005	PA & EA Reid	12	604.8	5	52	157248	S25/5114
WGN010047	P Pretty	28.8	207.4	7	52	75479	R25/5121
WGN96007201	Te Waka Water Company Limited	6.94	400.0	7	52	145600	R25/5208
WGN97015701	G E Jewell	4.5	194.0	7	52	70616	R25/5156
WGN96003801	A D Pain	4.16	180.0	7	52	65520	R25/5148
WGN000105	G R Sharp	8.00	691.2	7	22	106445	
WGN97023101	Windsor Park	15.1	756.0	7	26	137592	R25/5135
WGN98007401	Common	4	345.6	7	52	125798	S25/5200

	Property Limited						
WGN96003901	Te Horo Water Company Ltd	6.25	216.0	7	52	78624	R25/5109
WGN97000801	Bobbie and Jon McPhee	2.8	3600.0	7	20	504000	R25/5118
WGN98017501	R J and J K Hollis	1.9	41.0	7	20	5746	R25/5153
WGN97001201	Penray Gardens	7	302.4	7	26	55037	
Waikanae Zone							
WGN99025602	Kapiti District Trust Board	2.5	135.0	7	52	49140	R26/6565
WGN99019901	J & D Feast	2	43.2	7	52	15725	
WGN98020601	D K Yee	4	43.2	3	20	2592	
WGN99000802	Summerset Village Ltd	2.5	135.0	7	52	49140	R26/6563
WGN96009001	Harrison Garden Centre	1.8	52.0	7	52	18928	
WGN020188	Nga Manu Nature Reserve	0.5	12.6	7	52	4586	R26/6895
WGN040268	Kapiti Coast District Council	23	2000.0	7	52		R26/6293
WGN98027101	Martin J	15	648.0	7	16	72576	
WGN010087	Paraparaumu Beach Golf Club	15	648.0	7	16	72576	
WGN040151	Waikanae Christian Holiday	8.33	188.9	3	52	29468	R26/6585?
WGN010138	Robert and Christine McGechan	1.6	40.3	7	52	14676	R26/0009
WGN99000102	Paraparaumu College Board Of Truste	4.2	60.0	3	16	2880	R26/6248
WGN050025	Kapiti Coast District Council		7000.0	7	52	0	R26/6559?
WGN98017603	Kapiti Coast District Council	6	130.0	3	15	5850	R26/6521
WGN020021	Kapiti Coast District Council	1.15	33.1	3	15	1490	
WGN020076	Warren Austad	2.8	100.8	7	20	14112	R26/6674
WGN010136	Kooroora Holdings Limited	15	1296.0	7	24	217728	R26/6799
WGN010129	Waikanae Golf Club	15	432.0	5	16	34560	
WGN94007601	Kapiti District Trust Board	4	135.0	7	52	49140	R26/6550
WGN040356	Kooroora Holdings Limited	13	936.0	6	30	168480	
WGN020203	Golf Tech Limited	6.5	175.5	7	26	31941	R26/6561
WGN020102	Jeffery McNamara	2	57.6	7	50	20160	R26/5057
WGN98017601	Kapiti Coast District Council	7	150.0	3	15	6750	R26/6557
WGN020099	Paraparaumu Retirement Village	5	90.0	5	20	9000	R26/6516
WGN98017604	Kapiti Coast District Council	3	130.0	3	15	5850	R26/5108
WGN050025	Kapiti Coast		23000.0	7	52	8372000	

	District Council						
Raumati/Paekakariki Zone							
WGN97027101	Wellington Regional Council	22	872.0	7	52	317408	R26/6403
WGN98017602	Kapiti Coast District Council	6	130.0	3	15	5850	R26/6512

Lower Hutt, Upper Hutt, Wainuiomata, Mangaroa, Pakuratahi and Akatarawa water permits

Consent no	Consent holder	Inst. take (l/s)	Vol/day (m^3)	Days/week	Weeks/year	Volume per year (m^3)	Bore Number
Wainuiomata River Zone							
WGN010040	Oil Change Partnership	4	172.8	7	20	24192	
WGN010213	Wainuiomata Golf Club		413.1	7	52	150368	R27/6418
WGN010030	Godfrey and Clara Fernandez	0.5					R27/6931
Upper Hutt Zone							
WGN98023101	Trentham Camp Golf Club Inc	?	400.0	7	52	22500	
WGN020153	Upper Hutt Bowling Club	3.4	25.0	7	52	9100	R27/7023
WGN020027	Wellington Golf Club		1000.0	5	13	65000	
WGN030277	Wellington Golf Club	Av=	219.0	7	52	79950	
WGN020038	Te Marua Golf Club Incorporated	0.3	13.0	6	50	3888	R26/6713?
WGN040019	Piccadily Investments Ltd	5.9	340.0	5	52	88400	
WGN020011	South Pacific Tyres	69	6000.0	7	52	2184000	
WGN020016	Wellington Racing Club (Inc)	20	47.0	7	52	17338	
Mangaroa Zone							
WGN95012201	Schering-Plough Animal Health	0.35	30.2	7	52	11007	R27/4010
WGN010173	P R Kidd	4	172.8	7	12	14515	
WGN97012101	Salvation Army Property Trust	?	40.0	7	52	14560	
WGN98014301	Maudi & David Porta	?	56.0	7	52	20384	R26/6715
Pakuratahi Zone							
WGN020126	Kaitoke H20 Ltd	0.66	33.0	7	52	12012	
Lower Hutt Zone							
WGN98018501	Boulcott Golf Club		400.0	7	52	145600	
WGN98005501	Imperial Tobacco New Zealand		65.0	7	52	23660	R27/1234

WGN99023401	Veldhoven Properties Limited		400.0	7	52	145600	R27/1136
WGN040360	Petone Pure Water Company Ltd	2	50.0	7	52	18200	R27/6441
WGN020042	Exide New Zealand Limited	8	100.0	7	52	36400	R27/6908
WGN000020	Hutt Valley Health	25	1200.0	7	52	436800	
WGN99000601	Woolyarns Ltd	5	128.6	7	52	46810	
WGN99014202	The Hutt City Council		30.0	7	52	10920	R27/1238?
WGN040332	Dux Industries Limited	3.5	75.6	5	48	18144	R27/6943
WGN000020	Hutt Valley Health	5.23	450.0			0	
WGN98005401	Feltex Carpets Ltd		542.9	7	52	197616	
WGN970036	Wellington Regional Council		81865.0	7	52	29798860	
WGN99005601	NZ Fish Products	3.8	168.0	7	52	61152	R27/5200
WGN98005301	Wellington Regional Council	23	1250.0	7	52	455000	
WGN030126	Teri Puketapu	0.5	43.2	7	52	15725	R27/6390
WGN98005601	Unilever Australasia		2700.0	7	52	982800	
WGN010194	Avalon Studios	28	2450.0	7	52	0	
WGN970146	Shandon Golf Club	32	560.0	7	52	203840	R27/1235
WGN98018601	Hutt Golf Club	11.5	995.0	7	52	362180	
WGN980221	Hutt City Council	17.7	46.8	7	52	17075	
WGN99013701	Department of Conservation	2.3	24.0	7	52	8736	
WGN020104	Shell New Zealand Limited	3.2	276.5	7	52	100639	R27/1156
WGN98018701	Manor Park Golf Club		680.0	7	52	247520	
WGN98005201	NZTS Services Limited		143.0	7	52	52052	R27/4003

Wairarapa water permits

Consent no	Consent Holder	Inst. take (l/s)	Vol/day (m^3)	Days/week	Weeks/year	Volume per year (m^3)	Wairarapa Bore Number
Ahikouka Zone							
WAR 010232	Palmer C J & S J	6.94	250.0	7	38	66500	4G/31/-/-
WAR 010199	Pinehaven Orchards Ltd	2.5	108.0	7	26	19656	4G/34/3/-
WAR 010234	Slater B & J	18	583.2	2.5	18	26244	4G/210/6/I
WAR 010172	Slater C J	20.83	1425.0	4.5	26	166725	4G/142/10/I
WAR 020018	Platform Farm Ltd	40	3456.0	7	30	725760	4G/191/12/I
WAR 010277	Warburton E & J	2	57.6	7	30	12096	4G/146/7.5(10.5)/DI

WAR 010091	Wong Donald	16.7	480.0	7	30	100800	4G/137/7/I and 4G/215/8/I and 4G/216/6.5/I and 4G/217/6.5/I
WAR 010258	Van Der Put M	12	518.4	6	35	108864	4G/133/9/I and 4G/211/10.25/I and 4G/212/9.1/I
WAR 010071	Wong Les	25.3	364.3	7	38	96904	4G/93/9/-
WAR 010262	Whitley, D	1.94	84.0	7	22	12936	4G/160/9/DI
WAR 010198	Wright A N	23.33	336.0	7	30	70560	4G/141/9.5/I
WAR 030120	Druzianic W T	40	3456.0	7	30	725760	4G/227/39/IDS
Battersea Zone							
WAR 000291	Dell & Page Partnership	1.5	64.8	7	30	13608	6F/36/15/I
WAR 020108	Harvey A & L	15.2	981.7	7	26	178673	5F/23/11(92)/I
WAR 020146	Thompson D J	5	360.0	7	30	75600	5F/69/5.5/I, 5F/70/5.5/I, and 5G/88/5.5/I
WAR 010126	O'Neale B R	10	864.0	7	30	181440	5F/22/18(27.5)/I
WAR 010354	O'Neale B R & L R	5	432.0	7	30	90720	5F/63/20/I
WAR 980213	Harvey A & L	18	1296.0	7	30	272160	5F/53/18/I
WAR 990241	Harvey A & L	22	1900.8	7	30	399168	5F/56/18/I
WAR 970017	Thompson D J	10	864.0	7	30	181440	5F/47/18/I
WAR 020064	O'Neale B R & L R	5	432.0	7	30	90720	5F/67/21/I
Carterton Zone							
WAR 010311	Blank J	3.5	25.2	7	30	5292	4H/99/10/I
WAR 950004	Reid G & D	5	146.4	7	30	30744	4H/75/6/I
WAR 950050	Carterton District Council	40	3456.0	7	22	532224	4H/66/21/P & 4H/90/27/P
WAR 960178	Premiere Bacon Co Ltd	1.94	168.0	7	52	61152	4H/31/18/In
WAR 960179	Premiere Bacon Co Ltd	0.38	32.4	7	52	11794	4H/54/22/In
WAR 970300	Saywell J	8	662.4	7	30	139104	4H/137/23.5/I
WAR 000374	Terry N R	11.4	944.0	7	30	198240	4H/122/27/I
WAR 000343	Wilmshurst R W	10	828.0	7	30	173880	4H/83/22/SI
WAR 020049	Wilmshurst L E	15	1296.0	7	30	272160	4H/151/18/I
East Taratahi Zone							
WAR 000321	Carterton Golf Club	6	160.0	4.5	26	18720	3H/70/3.6/I
WAR 980170	Busby Family Trust	11	905.4	7	30	190134	3I/106/41(61)/I
WAR 950082	Wilson I J & S	2.3	99.6	7	30	20916	3I/70/4.3/I

Fern Hill Zone							
WAR 980183	McNab Family Trust	3.5	151.2	3	14	6350	4I/62/23/I
WAR 040107	Tulloch G H	10	864.0	7	26	155520	3J/176/19/I
WAR 010333	Tulloch G H	18	1555.2	7	30	326592	3J/164/38/I & 3J/165/50/I
Greytown Zone							
WAR 990249	Bicknell J A	13	1123.2	7	30	235872	5G/43/4.5/SI
WAR 010109	Borland R	1.5	59.4	1.75	16	1663	4G/162/6/SI
WAR 010197	Coley D K	4.03	115.2	4	20	9216	4G/180/11/I
WAR 030132	Hammond And Co	80	6912.0	7	30	1451520	5G/68/8/I
WAR 010215	Greytown Villas Ltd	10	360.0	7	30	75600	4G/168/12/SI
WAR 010237	Murphy A G	4	115.2	5	22	12672	4G/52/6/I
WAR 010163	Pinehaven Orchards Ltd	11.00	633.6	7	34	150797	4G/205/11/I
WAR 950037	Rita Mary Kemp Trust	3.8	123.3	7	22	18988	4G/149/13/I
WAR 010233	Slater B & J	18	583.2	2.5	22	32076	4G/198/9/I & 4G/200/8.5/I
WAR 970012	Smith Dave	5	108.0	7	26	19656	4G/186/6/I
WAR 040067	South Wairarapa District Council	60	5184.0			155520	4G/230/11/P
WAR 040067	South Wairarapa District Council	40	1728.0	7	26	314496	4G/230/11/P
WAR 010231	Van Vliet J R	2.78	240.2	7	30	50442	4F/18/4.6/I
Hodders Zone							
WAR 020184	Brazendale L	10	864.0	7	20	120960	4G/214/6.2/I
WAR 010111	Price T J & I N	15.3	1265.0	7	30	265650	4G/148/4.7/I
WAR 020126	Jamieson B	5	162.0	7	30	34020	4G/107/4/DS
WAR 960250	Fitzgerald D P & P L	15	1242.0	7	30	260820	4G/143/16/IR
WAR 010145	Fitzgerald D P & P L	20	1152.0	7	30	241920	4G/208/18.5/ I
WAR 010169	McLennan H L & L M	20	1656.0	7	30	347760	4G/204/13/I
Huangarua Zone							
WAR 990260	Dyfed Enterprises	5.6	60.0	5	30	8400	7G/6/3/I
WAR 010322	Te Kairanga Wines Ltd	9	777.6	5.8333	30	136079	7G/8/3/I
WAR 020197	Te Kairanga Wines Ltd	6.8	241.0	7	39	65793	
WAR 000311	Douglas J & Gouldstone K	1.3	112.3	7	30	23587	7G/25/27/I
WAR 020026	Redbank Estate	7	403.2	7	30	60682	7G/32/42/I
WAR 990093	Barber J	6	388.8	7	30	58514	7G/17/24/I
WAR 000232	Craggy Range Vineyards Ltd	8	691.2	7	30	145152	7G/23/24(42) /I
WAR 990227	Craggy Range Vineyards Ltd	18	1555.2	7	30	326592	7G/19/47/I
WAR 990071	Julicher Family Trust	3	108.0	7	30	22680	7G/13/30/DI
WAR 030032	Campbell I A	8	691.2	7	30	145152	7G/33/27/I
WAR 990089	McKenna L	10	864.0	7	30	127008	7G/16/27/I

Lower Valley Zone							
WAR 030017	Raho Ruru Trust	17.3	1370.0	7	32	306902	Water is extracted via tile drains
WAR 950100	South Wairarapa District Council	1	28.8	7	52	10483	8B/20/12/P
WAR 980192	Coveney J	36	3110.4	7	30	653184	9B/4/16/I
WAR 000368	Lakeview Trust Partnership	10	864.0	7	30	181440	8C/25/18/I
WAR 010364	Bidwill A J C	30	2592.0	7	30	544320	6E/67/29(32)/I
WAR 020158	Osborne A L	15.2	1253.5	7	26	228137	6E/20/19/I
WAR 010249	Roto Farm Trust (RF & VL Green)	60	2592.0	7	30	544320	6D/10/30.5/I
WAR 020111	Caldwell Trust	25	2160.0	7	30	453600	7D/24/26/I
WAR 020093	Thurston A W	20	1728.0	7	30	362880	6E/21/14/I
WAR 020095	McCreary, TR & HM	22.2	1600.0	7	26	291200	8B/18/42/I
WAR 020145	Finlayson K & S	18.7	1552.5	7	22	239085	8C/18/38/I
WAR 020115	Finlayson K & S	23	1660.0	7	30	348600	8C/19/50/I
WAR 010072	Bosch AA & HM	59	2973.6	6	30	535248	7E/32/30/SI
WAR 010073	Bosch BF & J	48	3801.6	7	30	798336	7E/36/38/I
WAR 000386	Cirrus Estate Ltd	4	250.0	7	30	52500	7F/35/17(25)/I
WAR 030134	Hudson P & J	5	180.0	7	30	37800	7F/42/27/I
WAR 960165	Loch Ness Farm	40	3312.0	7	26	602784	7E/35/29/I
WAR 030170	Thomson I	15	1296.0	7	30	272160	7F/43/36.4/I
WAR 990222	Maori Education Foundation	80	6912.0	7	30	1451520	7C/15/45/I
WAR 010300	Te Pare Farm Partnership	68	5875.2	7	34	1398298	7D/20/34/I & 7D/18/34/SI
WAR 950174	Star Delta Trust Partnership	2	57.6	7	22	8870	7E/33/15/D
WAR 980192	Coveney J	20	1728.0	7	30	362880	9B/5/42/I
WAR 010350	Warren R	45	3888.0	7	30	816480	9B/6/32/I
WAR 020105	Lakeview Trust Partnership	18	1555.2	7	30	326592	8C/24/37/I
WAR 020054	Oporua Dairy Farm	50	4320.0	7	30	907200	7D/23/38/I
WAR 020156	Windy Farm Ltd	35	3024.0	7	30	635040	5D/16/24/I
WAR 020100	Rotopai Trust	25.2	2093.0	7	26	380926	8C/13/61/I
WAR 020101	Rotopai Trust	20	1656.0	7	26	301392	8C/21/55/I
WAR 020155	Barton S	33	2732.4	7	30	573804	6D/7/58/SI
WAR 020110	Caldwell Trust	g	2185.9	7	34	520244	7D/14/59/I
WAR 020143	Simmonds J	6	518.4	7	30	108864	Multiple Bores
WAR 020092	Thurston A W	22	1900.0	7	30	399000	6E/31/25/I
WAR 000231	Fuge D F & E A	20	1440.0	7	30	302400	6F/33/81/I
WAR 040126	D B Osborne Trust	30	2592.0	7	30	544320	6E/69/30/I
Mangatarere Zone							
WAR 970113	Little S D & S M	4	168.0	7	38	44688	3H/63/6/I
WAR 010371	Reid N & E E	12.6	1092.0	7	52	397488	3H/62/7/S
WAR 930007	Thompson A M	19	1564.0	7	22	240856	2H/1/4/DSI
WAR 010136	Craig R B & L J	28	2419.2	7	30	508032	4H/148/18/I
WAR 040058	Fisher Family Trust	25	2160.0	7	30	453600	4H/170/24/I

WAR 010098	McFadzean	18.89	1564.0	7	20	218960	2H1/4/DSI
WAR 010370	Reid N & E E	17.22	1364.0	7	30	286440	3H/77/11/I
WAR 000298	Smith D G & A B	26.5	2194.2	7	32	491501	3H/81/4.3/I
Martinborough Western Terraces Zone							
WAR 010243	Margrain Vineyard	2.8	121.0	7	30	25410	7F/37/4.2/I
WAR 040034	Atarangi Vineyard	2	170.1	4	30	20412	6G/24/46/I
WAR 010281	Burnt Spur Martinborough Ltd	3	120.0	7	30	25200	6G/43/24.5/I
WAR 000270	Personal Property Ltd	4	230.4	7	30	48384	7F/34/33/I
WAR 010246	Leslie IR	3.5	151.2	7	30	31752	6F/39/28/DI
WAR 990309	Burnt Spur Martinborough Ltd	10	864.0	7	30	181440	7F/30/39/I
WAR 000265	Nga Waka Vineyards Ltd	3	97.2	7	30	20412	6G/38/27/I
WAR 020182	Palliser Estate Wines	9	588.0	7	34	139944	6G/19/25/I
WAR 020005	Palliser Estate Wines	3.5	185.7	7	30	38997	6G/45/24/I
WAR 980173	Telfer Properties Ltd	2	80.0	7	52	22190	7F/33/30/DI
WAR 010375	Fraser I	2.5	108.0	7	30	22680	6F/37/24/I
WAR 020040	Martinborough Cottage Grove Resort Ltd	1.5	43.2	7	30	9072	6G/39/32/I
WAR 030086	Seriously Nuts Ltd	3	70.0	7	30	14700	7F/40/30/I
WAR 030148	Sutherland RA	3	259.2	7	30	54432	
Martinborough Eastern Terraces Zone							
WAR 980071	Alexander & Finucane Vineyards Ltd	2	129.6	7	34	30845	7G/15/34/DI
WAR 980073	Crook P E & A M	0.5	43.2	7	34	10282	7G/14/32/DS
WAR 980094	Martinborough Estate Ltd	2	108.0	7	30	22680	7G/18/32/I
WAR 020138	Martinborough Golf Club	1.2	51.8	7	30	10878	7G/5/32/I
WAR 020086	Palliser Estate Wines	6	518.4	7	30	108864	6G/32/35/I
WAR 000307	Paul Collins Family Trust	3	205.2	7	30	43092	7G/24/39/I
WAR 020139	White Steven L	4	288.0	7	30	60480	7G/9/39/I
WAR 000419	Amapur Securities Ltd.	1.5	97.2	7	30	20412	6G/40/26/I
WAR 040098	Burnt Spur Martinborough Ltd	1	86.4	7	30	5250	6G/44/44/I
WAR 020072	Riverside Trust	4.5	388.8	7	30	81648	6G/47/69/I
WAR 040001	The Terrace Martinborough	3	129.6	7	30	27216	6G/55/80/I
Masterton Zone							
WAR 960172	Air Services 1979 Ltd	0.56	48.0	7	52	17472	3J/75/-/D
WAR 960231	Amatiatia Mission Board	1.39	120.0	7	30	25200	2J/139/7(14)/I
WAR 010317	Auchincloss, JA & ML	4	345.6	7	30	72576	3J/162/14/I
WAR 960236	Masterton District	2.78	240.0	7	34	57120	3J/67/8/DS

	Council						
WAR 960182	Hatchard L T B	1	43.2	7	34	10282	3J/120/24/I
WAR 960177	Ryan P	1.8	77.8	7	30	16330	3J/142/9/DI
WAR 040129	Wairarapa College	6.6	237.6	3	28	19958	???
WAR 960099	Wood R J & S J	1	83.0	7	26	15106	3J/117/16/DI
WAR 030176	Paku R C	5.8	62.6	7	26	11393	3J/86/4/I
WAR 980060	Paul V S	3	172.8	7	30	36288	3J/148/27/I
Matarawa Zone							
WAR 010235	Brazendale W E & E M	15	648.0	7	40	181440	4G/127/6/I
WAR 040102	Knowles R J	16	1382.4	7		165888	4G/230/6/I
WAR 010275	Percy R	6.1	506.0	7	26	92092	4G/147/37/I
WAR 030167	Smith P I	12	950.4	7	30	199584	4G/196/4.5/I
Middle Ruamahanga Zone							
WAR 990132	Booth J B	33.3	2158.2	7	30	453222	4J/15/9/I
WAR 970057	Borthwick R	7	936.0	7	30	196560	4J/25/8.2/I
WAR 960245	Broadmore D R & R C	5	216.0	7	16	24192	4I/41/10/DSI
WAR 990077	Budd & Watters Partnership	16	1276.0	7	30	267960	5H/8/9.5/I
WAR 010312	Budd & Watters Partnership	27.5	1584.0	7	30	332640	5H/13/13/I
WAR 960239	Westbourne Partnership	12	950.0	7	22	146300	4I/46/13/I
WAR 960240	Merlot Meats Ltd	2	100.0	7	52	36400	4J/24/9/InD
WAR 000430	Cliffs Trust	25	1700.0	7	30	357000	4J/44/6(10)/I
WAR 000391	CMK Associated Ltd	5.6	262.1	7	30	55041	4J/41/9.4/I
WAR 010369	Cottier Family Trust	4.6	397.4	7	30	83462	4J/51/10/I
WAR 020085	Cunningham K J & E M	10	828.0	7	30	173880	4I/34/10/I
WAR 000416	East Taratahi Estate Limited	1.75	119.7	7	30	25137	4J/42/7/DI
WAR 000238	George M	9	324.0	7	30	72014	4J/37/9/I
WAR 000316	Gladstone Water Supply Assn Inc.	6	260.0	7	52	94640	4J/39/12/P
WAR 010217	Hayes AP & JB	2.8	241.9	7	30	50799	4J/47/8/I
WAR 010279	Herrick M B & H F	28	2419.2	7	30	508032	5H/11/14.3/I
WAR 990012	Johner & Schubert	20	1728.0	7	30	362880	4J/27/8/I
WAR 000306	Lynfer Estate Ltd / Leafyridge Olives Ltd	6	432.0	7	30	90720	4J/38/9/I
WAR 030153	McLaren Family Investment Trust	4.2	302.4	7	30	63504	
WAR 980190	MacPhail D W	8	691.2	7	30	145152	4I/61/8/I
WAR 000361	Mebus Estate	13	748.8	7	15	78624	4J/19/6.3/I
WAR 990018	Patrick B B & C M	15	1296.0	7	30	272160	4J/28/6/I
WAR 020194	Patrick B B & C M	11	950.4	7	30	199584	4J/53/8/I
WAR 990018	Patrick B B & C M	25	2160.0	7	30	453600	4J/29/20/I
WAR 010125	Patrick B	32	2764.8	7	30	580608	4J/48/23.5/I
WAR 960137	Saywell J	16	1267.2	7	26	230630	4I/51/12/I
WAR 030177	Southey CT	20	1728.0	7	35	207360	3J/171/4.8/I
WAR 990159	Stevenson R J & C A	25	2070.0	7	30	434700	4I/37/11/I

WAR 990160	Stevenson R J & C A	24	1987.2	7	30	417312	4H/132/13/I
WAR 990129	Taylor S M & J D	16.9	1403.0	7	30	294630	5H/5/13/I
WAR 970240	Taylor S M & J D	4	345.6	7	30	72576	4H/134/6.6/I
WAR 030093	Thomson A	15	1296.0	7	34	308448	4J/56/10/I
WAR 990275	Westbourne Partnership	13	842.4	7	30	176904	4H/136/6(9)/I
WAR 040037	Wylie O	3.2	276.4	7	30	30000	4J/33/5.4/DS
WAR 010230	Booth BJ	17	864.0	7	30	181440	4J/49/24/I
WAR 960151	Budd & Watters Partnership	18.3	1518.0	7	30	318780	5H/7/24/I
WAR 010280	Herrick M B & H F	20	1728.0	7	30	362880	5H/12/22/I
WAR 970258	Te Mara No. 2 Trust	15	1242.0	7	26	226044	4J/26/32/I
WAR 960191	R J & C A Stevenson	13	1081.0	7	26	196742	4I/47/22/I
WAR 000296	Westbourne Partnership	25	2070.0	7	30	434700	4H/117/29/I
Moroa Zone							
WAR 010257	Algie K D	7	100.8	7	30	21168	5G/59/4/SI
WAR 010302	Cox Allan	7.14	257.0	2.5	16	10280	5G/52/6.8/I
WAR 010294	Schofield R & McGillivray M	3.5	100.8	7	30	21168	5G/48/5/IR
WAR 020176	Toms S	1.4	40.3	7	30	8467	5G/48/5/IR
WAR 010301	Field Brothers	22.73	984.0	7	26	179088	5G/46/6/I
Opaki Zone							
WAR 970041	Limpopo Estate Ltd	6.4	276.5	7	20	38710	2J/82/29/I
WAR 030142	Norwood Vineyard Ltd	2.5	108.0	7	38	28728	2J/174/24/I & 2J/175/17/I
WAR 960118	Wilton S A R	3.17	273.6	7	30	57456	2J/133/24/I
Parkvale Zone							
WAR 920192	Somerville Family Trust	17.2	1426.0	7	26	259532	3H/64/5/I
WAR 010362	Rose J A & J B	10	864.0	7	30	181440	4I/66/6.5/I
WAR 000262	Tulloch G H	15	1296.0	7	30	272160	3H/60/12/I
WAR 950151	Barker S & Harrold J	27	1166.0	7	26	212212	4H/64/13/I
WAR 000308	Engel C G & J R	15	1296.0	7	30	272160	4H/142/36/I
WAR 000375	Parkvale Dairy Ltd	23	1490.4	7	30	312984	4H/106/31/I
WAR 010283	Westbourne Partnership (Renall)	25	2160.0	7	30	453600	4H/149/20/I
WAR 000352	Kilmory Farms Ltd	25	2160.0	7	30	453600	4H/1/45/I
WAR 010041	Engel C G & J R	13	1029.6	7	30	216216	4H/103/48/I
WAR 000293	Sage K & A	33	2732.4	7	28	535550	4I/59/47/I
WAR 950005	Tulloch G H	15	1296.0	7	25	226800	3H/89/41/I
WAR 000348	Wither I R & M A	40	3456.0	7	30	725760	4I/36/33/SI
Rathkeale Zone							
WAR 990116	Hellebrekers R L	10	360.0	7	22	55440	2K/21/4.1/DS
WAR 000423	McLachlan S J & J E	36	3110.4	7	30	566093	2K/65/5/I & 2K/66/5/I
WAR 020116	Opaki Water Supply Association	4.22	364.8	7	52	132787	2K/40/6/P

WAR 000273	Ordish Aqua Ltd	1.44	100.8	7	52	36691	2K/63/2.7/P
WAR 960017	Sinclair P & S	1	57.6	3.5	30	6048	2K/53/2.5/I
WAR 940079	Stuart D R	35	2898.0	7	32	649152	2K/48/4/I
WAR 990021	Stuart G J	30	2592.0	7	30	544320	1K/6/5.7/I
WAR 990124	Rathkeale College	12.6	364.0	5	26	47320	2K/58
WAR 990124	Rathkeale College	5.08	92.4	7	52	33634	2K/39/2.6/D, 2K/57/3/-, & 2K/37/4/D
Riverside Zone							
WAR 990140	Calvert R & D	21.5	1238.4	7	30	260064	5G/42/11/I
WAR 990117	Kershaw Partnership	12.5	1080.0	7	26	196560	6G/29/11.3/I
WAR 020102	Station Bush Partnership	4	72.0	7	26	13104	5G/63/4/I
WAR 010127	Tucker B T	30.2	2180.0	7	22	335720	5G/31/10/I
WAR 020083	Guscott P	64	5529.6	7	30	1161216	5G/84/15/I & 5G/85/17/I
WAR 020099	Kershaw R	30	2592.0	n/a	n/a	155520	6G/48/17/I
WAR 020117	Tucker B T	52	4492.8	7	30	943488	5G/86/12/I & 5G/87/14/I
WAR 030096	A S Phelps Family Trust	24.5	740.0	n/a	n/a	156000	6G/51/13/I
WAR 030128	Morison N	28	2419.2	7	30	508032	6G/54/14/I
WAR 040056	Cresswell C	40	1728.0	7	100 days	170000	6G/59/12/I
South Featherston Zone							
WAR 010003	Geange R & E	20	1728.0	7	30	362880	Not allocated yet
WAR 960217	Totara Grove Farm	10	828.0	7	28	162288	5E/32/5.5/I
WAR 020022	Totara Grove Farm	25	2160.0	7	30	453600	5D/13/24/I
WAR 030014	Dondertman A J	18	1490.4	7	30	312984	5D/3/66/S
Tauherenikau Zone							
WAR 000390	Rylib Dairies Ltd	32	2764.8	7	30	580608	6E/64/16/I
WAR 990002	Diversion Partnership	25	2160.0	7	30	453600	6E/59/14/I
WAR 990010	Johnson M S & G	44	3326.4	7	30	698544	6E/35/17/I
WAR 010265	Cates M E	36	2980.8	7	30	625968	5E/55/12/I
WAR 010286	Clarke C A Estate	23	1821.6	7	30	382536	5E/35/19/I
WAR 010285	Clarke C A Estate	15	1242.0	7	30	260820	5E/39/24/I
WAR 010284	Elliott P J	1	72.0	5	35	12600	5E/50/17/DI
WAR 010304	Farrier P G	30	2484.0	7	24	417312	5E/52/21(27)/I
WAR 010084	Feast J K	20	1728.0	7	30	362880	5E/75/5/I
WAR 990238	Wairarapa Aggregates Ltd	15	540.0	5.5	52	99000	5E/64/4.2/In
WAR 010360	Wairarapa Racing Club	8.9	256.0	7	30	53760	5E/34/11(15)/I
WAR 020094	Presbyterian Chuch of NZ	44	3168.0	7	28	620928	5E/78/18/I
Tawaha Zone							
WAR 980229	Barton A J	40	3312.0	7	30	695520	6F/25/18/I
WAR 020142	Butcher O L & P J	39	3229.2	7	30	500526	7E/21/27/I
WAR 020154	Osborne R	45	3888.0	7	30	816480	6F/23/14.5/I
WAR 020037	Vollebregt C L J &	32	2764.8	7	28	541901	7E/20/23/I

	R M						
WAR 030117	George B L	37.7	2720.0	7	30	571200	6F/13/16.5/I
WAR 020109	Caldwell Trust	50	4320.0	7	30	799200	6F/2/15/I
WAR 020160	Melton Farms	27.2	2254.0	7	22	347116	6G/10/12(15)/I
WAR 020159	Melton Farms	26.5	2196.5	7	22	338261	6F/22/10/SI
WAR 990019	Osborne A L	35	3024.0	7	30	635040	6F/28/20/I
WAR 030095	A S Phelps Family Trust	25	740.0			156000	6G/51/14/I
WAR 030131	Barton A J	43	3715.2	7	27	702173	6F/40/15/I
WAR 020104	Scadden RL & RE	32.2	2666.0	7	30	559860	6F/20/22.5/I
WAR 020112	Simmonds S A R	18.9	1564.9	7	26	284815	6E/70/17/I
WAR 020128	Smithfield Farm	37.7	3128.0	6	30	563040	6F/14/14/I
WAR 990001	South Wairarapa District Council	90	7776.0	7	52	2231712	6G/27/17/P, 6G/34/14/P, & 6G/53/17/P
WAR 010352	Sutherland T	30	2592.0	7	30	544320	7F/39/21/I
WAR 020153	Vollebregt C L J & R M	45	3801.6	7	30	703296	7E/16/21/I
Te Ore Ore Zone							
WAR 990262	Apple Source Partnership	2.6	222.6	7	30	46754	3K/84/9/I
WAR 040055	Blakemore S D & M S	2	172.8	7	35	42336	3K/94/5/D
WAR 990092	Eglinton R K	3	108.0	7	20	15120	3K/88/8(12)/I
WAR 990092	Eglinton R K	3	172.8	7	30	36288	3K/26/10/I
WAR 990306	Homebush Dairy Co Ltd	25	2160.0	7	30	453600	3K/113/8.5/I
WAR 030141	Little Avondale Stud	26	2246.4	7	35	550368	3K/2/6/I
WAR 960135	Master Roads & Services Ltd	2	86.4	6	52	26957	3K/50/14/In
WAR 960187	Pannett G R	2	161.0	7	30	33810	3J/77/3/DSI
WAR 990289	Percy J F & C A	30	2592.0	7	30	544320	3K/112/11.5/I
WAR 000383	Baily-Gibson T J	13	468.0	7	27	88452	2K/50/31/I
WAR 990088	Bosch A & J	12.5	900.0	6	26	140400	3K/23/36/I
WAR 990272	Longworth M L & B A	8.33	720.0	7	30	151200	3K/24/54(74)/I
WAR 990218	Fitzgerald D M & A W	8.33	149.9	7	30	31487	3K/24/54(74)/I
WAR 990217	Fitzgerald D M & A W	1.5	129.6	7	30	27216	3K/39/19/I
WAR 970145	Pearce A R A & Costello N M	4.63	400.0	7	30	84000	3K/42/18/I
WAR 990134	The Terrace Orchard Ltd	6.38	309.0	7	34	73542	3K/31/21/I
WAR 010261	Hurrell C J & D C	10.69	307.9	5	26	40027	3K/65/24/I
WAR 990009	Landkroon A & Dekker F	5	180.0	2	30	10800	3K/105/23/I
WAR 990214	Lyndor Partnership	4.7	204.0	4	30	24480	3K/64/46/I
WAR 950007	Masterton District Council	8.3	717.1	7	52	261032	3K/28/28/DS
WAR 990172	B L & A T Anderson Family Trust	3.3	285.1	7	30	59875	3K/63/15/I
WAR 990231	McKenzie J B	17	1220.0	7	34	290360	3K/72/25/I

WAR 000314	McKinstry J F	15	1296.0	7	30	272160	3K/115/30/I
WAR 990269	Milne J D G & M E	6.67	384.0	5	30	57600	3K/25/26/I
WAR 010355	Percy J F & C A	11	950.4	7	30	199584	3K/116/33/I
WAR 990060	Tulloch DJ & FB	11	633.6	7	30	133056	3K/98/18/DI
WAR 030143	Percy JF & CA	17	1468.8	7	35	176256	3K/122/27/I
WAR 030147	Percy JF & CA	40	3456.0	7	35	414720	3K/121/32/I
WAR 040066	Deans MR & AB	8	691.2	7	38	82944	3K/119/29/I
Upper Plain Zone							
WAR 030136	Bryant LRV & SA	8	288.0	7	1.7143	3456	2J/187/12/Fr
WAR 960114	Cameron P N & M L	2.5	72.0	7	30	15120	2J/31/4/DS
WAR 980051	Chamberlain R T	7	604.8	7	30	127008	2J/162/12/I
WAR 000350	Daniell M E	25	1584.0	7	28	310464	2J/148/4/I
WAR 990258	Dean R E	15	432.0	7	30	90720	3J/133/3/I
WAR 960195	Fernridge Water Supply Associati	6	388.0	7	52	141232	2I/55/5/P
WAR 010297	G H & L E Tulloch Family Trusts	25	2160.0	7	30	453600	3J/163/3.3/I
WAR 960219	Kaz Holdings	6	216.0	7	28	42336	2J/109/5/I
WAR 970031	Liggins K E & L P	1.4	50.0	7	22	7700	2J/27/12/DSI
WAR 000300	Oldfield Aggregates Ltd	2.8	80.0	5	52	20800	3I/85/5/In
WAR 960126	Oldfield Aggregates Ltd	10	360.0	6	52	112320	3I/77/7/In
WAR 960127	Oldfield Aggregates Ltd	3.11	89.6	5	52	23296	3I/102/4/DIn
WAR 970029	Operations Department, WRC	2	57.6	7	52	16531	2J/121/12/DI
WAR 970289	Real B	0.75	65.0	7	26	11830	2I/51/7/I
WAR 960136	Tarrant G W & E H	1.4	120.0	7	28	23520	2I/10/12/DS
WAR 030135	Tulloch GH	28	2419.2	7	30	508032	3J/173/4.2/I
WAR 000327	Van Der Put M	5	216.0	6	30	38880	2I/31/14/I
WAR 970141	Van Der Tol A	6	259.2	7	26	47174	2I/67/4/I
WAR 000380	Wadham N H & B A	22.7	1471.0	7	30	308910	2I/42/5/I
WAR 000259	Wairarapa Aggregates Ltd	6.31	227.0	5.5	52	64922	3I/88/7/In
WAR 960194	Peebas Trust	2.5	216.0	7	30	45360	2J/77/47.4/I
West Taratahi Zone							
WAR 010351	Stolte Dairy Ltd	25	2160.0	7	30	453600	3I/114/4.2/I & 3I/116/4.5/I
WAR 040123	Stolte Dairy Ltd	15	1296.0	7	30	272160	3I/122/4.5/I
Woodside Zone							
WAR 020010	O'Neale BR & LR	20	1728.0	7	30	362880	5F/64/10(18)/I
WAR 960206	Berry D D Ltd	20	1152.0	7	30	241920	5E/47/53/I
WAR 040090	Oriwa Grove Ltd	0.7	45.4	7	52	16511	?
WAR 030175	Plimmer A & K	6	518.4	7	30	108864	5F/73/44/I
No groundwater zone							
WAR 020004	Te Kairanga Wines Ltd	20	1296.0	7	18	163296	8F/4/104/I
WAR 020169	Te Kairanga Wines Ltd	7	604.8	7	34	143942	8F/3/117/I

WAR 990014	Wharekauhau Holdings Ltd	1.56	135.0	7	52	14560

Appendix C: Site Location and bore details

Table 1: List of groundwater quality monitoring sites analysed as part of this report

Well Number	Site	Depth	Confinement	Easting	Northing
R27/1183	AVALONSTUDIOS	25	Confined	2673100	6000400
S27/0268	BARTON, S.A	58.4	Confined	2703470	5995770
S27/0059	BERRY, D	57	Confined	2706720	6005410
S25/5125	BETTYS	<10	Unconfined	2692900	6044600
T26/0087	BISS, D	36	Confined	2730310	6026470
R26/6624	BOFFA	10.2	Confined	2683900	6035800
S27/0495	BOSCH, F & W.M	38	Confined	2707250	5993050
S26/0117	BUTCHER, G	5	Unconfined	2721500	6018500
T26/0099	BUTCHER, M	15	Unconfined	2732532	6029339
S27/0547	CAMPBELL	16.7	Unconfined	2718480	5989550
R25/5164	CARD	<10	Unconfined	2685900	6043900
S26/0824	CDC NORTHERN.	20.6	Confined	2720470	6016030
S26/0705	CDC SOUTHERN	27.4	Confined	2720550	6016120
S25/5200	COMMON PROPERTY	45.8	Confined	2691200	6041500
S26/0547	CRAIG, E.J	4	Unconfined	2719450	6011900
S27/0202	CROAD, J.R & W.J	4.8	Unconfined	2715480	6008240
S26/0568	DENBEE, J.M	45	Confined	2723504	6013642
S27/0389	DIMATTINA, T	17.85	Unconfined	2717220	5995590
S27/0009	DONDERTMAN, A	10.5	Unconfined	2703550	6005120
S26/0846	DRUZIANIC	39.3	Confined	2717921	6011212
T26/0489	DUFFY	54	Confined	2737640	6023590
S27/0522	DUGGAN	21	Unconfined	2713054	5993045
S26/0734	DYKSTRA, ENGBERT	7	Unconfined	2725411	6015545
T26/0332	EAST TARATAHI SHALLOW	13.4	Unconfined	2732246	6019123
S25/5322	EDHOUSE	27	Semi-confined	2693100	6049200
S27/0607	FINDLAYSON, K	38	Confined	2696300	5986920
S26/0400	FITZGERALD DEEP	16	Confined	2719290	6015570
S26/0467	FITZGERALD SHALLOW	6.2	Unconfined	2718740	6015430
S27/0344	GEORGE, B	16	Confined	2713380	5999070
S26/0299	GRAHAM, D	8.1	Unconfined	2728370	6023590
S27/0141	HARVEY, A. & L.	13	Confined	2713020	6002620
R27/0320	IBM#1	114.6	Confined	2667000	5996100
R27/1265	IBM#2	48.3	Confined	2667000	5996100
S27/0299	JOHNSON, M.J & G	17.4	Unconfined	2706500	6000630
S27/0435	LANDCORP 'WAIRIO'	44	Confined	2697631	5992523
T26/0003	LENTON	5.5	Unconfined	2732572	6034955
R26/6587	LIDDLE NURSERIES	12.96	Unconfined	2682600	6034700
S27/0571	M/B GOLF CLUB	32	Confined	2717190	5994720
R27/1180	MAHOEST	39	Confined	2670600	5997580
R27/6833	MANGAROA	24.5	Unconfined	2670600	5997580
S27/0433	MAORI EDUCATION FOUNDATION	44.6	Confined	2697680	5989480
S27/0585	McCREARY, T.R	42	Confined	2690345	5984315
T26/0326	MCKAY, N & SONS	10	Unconfined	2730900	6017530
S26/0576	MCNAMARA, J	31	Confined	2723479	6014255
S26/0223	NICHOLSON	9.9	Unconfined	2726219	6021005
R25/5100	O'MALLEY	48.2	Confined	2684400	6041000
S27/0106	O'NEALE	11	Unconfined	2713274	6004926
S27/0156	O'NEALE NEW	20.7	Confined	2713423	6004496
S27/0156	OP TRUST	18.7	Unconfined	2689800	6049100
T26/0259	OPAKI WATER SUP.	6.1	Unconfined	2736030	6030880
S27/0283	OSBOURNE, A	19	Confined	2707320	5997920
S26/0457	PALMER	6	Unconfined	2717680	6012060
S25/5256	PENRAY	30.78	Semi-confined	2690500	6045000
T26/0538	PERCY	9	Unconfined	2737770	6022900
R26/6503	QEPARK	14.8	Confined	2676300	6024100
S26/0439	ROGERS, W	11.5	Unconfined	2717510	6016900

Table 2: List of groundwater quality monitoring sites analysed as part of this report (cntd.)

Well Number	Site	Depth	Confinement	Easting	Northing
R25/5165	SALTER	8	Unconfined	2686030	6043600
S26/0762	SCHAEF, D	9.5	Confined	2725720	6011070
R27/1182	SEAVIEW WOOLS	38	Confined	2669500	5993800
T26/0413	SEYMOUR, B.J & R.H	23.3	Unconfined	2734500	6021700
R27/1171	SOMES ISLAND	23.2	Confined	2666500	5993000
S27/0615	SORENSON DEEP	35.8	Confined	2696800	5983800
S27/0614	SORENSON SHALLOW	18.2	Confined	2696800	5983670
S27/0070	SOUTH FEATHERSTON SCHOOL	14.6	Unconfined	2707500	6004800
R27/1137	SPTYRES	15.2	Unconifned	2683700	6006400
S27/0136	SUGRUE, O	20.4	Unconfined	2712260	6008030
S27/0396	SWDC MARTINBOROUGH	17	Confined	2694860	5982440
S27/0588	SWDC PIRINOA	11.7	Unconfined	2715980	5997640
S27/0681	TE KAIRANGA NEW	5	Unconfined	2718974	5995264
S27/0574	TE KAIRANGA WINES LTD	3	Unconfined	2718950	5994920
T26/0206	TOCHER, B	28.7	Confined	2732580	6029520
T26/0430	TROUT HATCHERY	1	Unconfined	2732160	6024730
S27/0198	TUCKER, B	9	Unconfined	2717480	6005180
R27/6418	WAINUIOMATAGC	8	Unconfined	2672300	5987400
S27/0594	WARREN, H	44	Confined	2691400	5981450
S27/0602	WEATHERSTONE	60.9	Confined	2699650	5987020
S26/0756	WENDON	19	Confined	2725937	6010018
R25/5135	WINDSOR PARK	93.27	Confined	2689200	6043200

Appendix D: Locations of sites used in this report

Figure 1: Hutt Valley groundwater quality monitoring sites

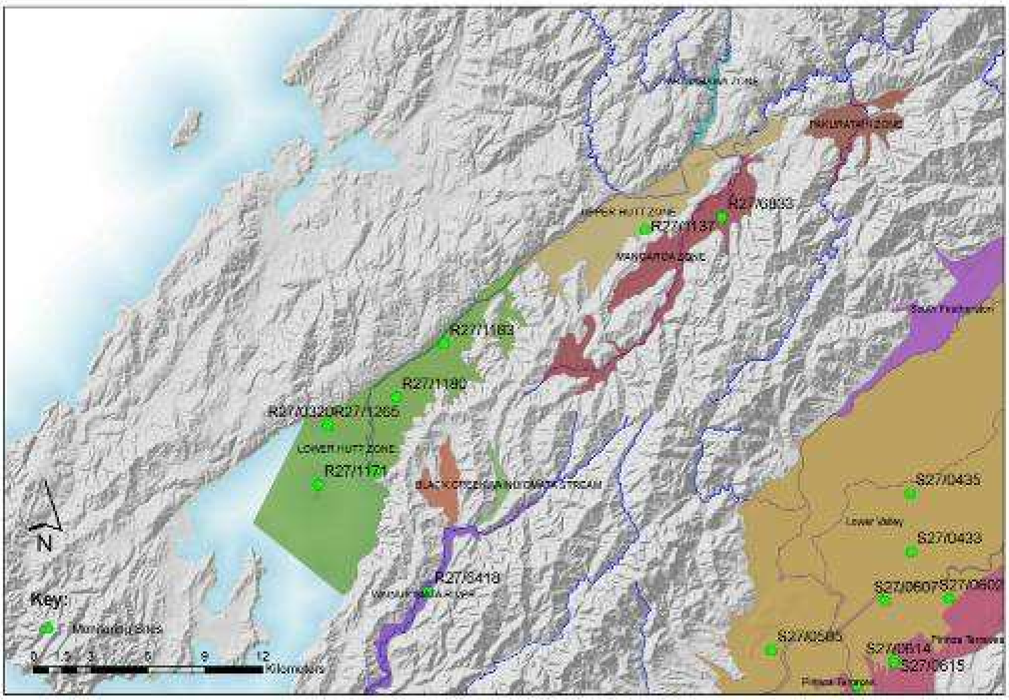


Figure 2: Kapiti groundwater quality monitoring sites

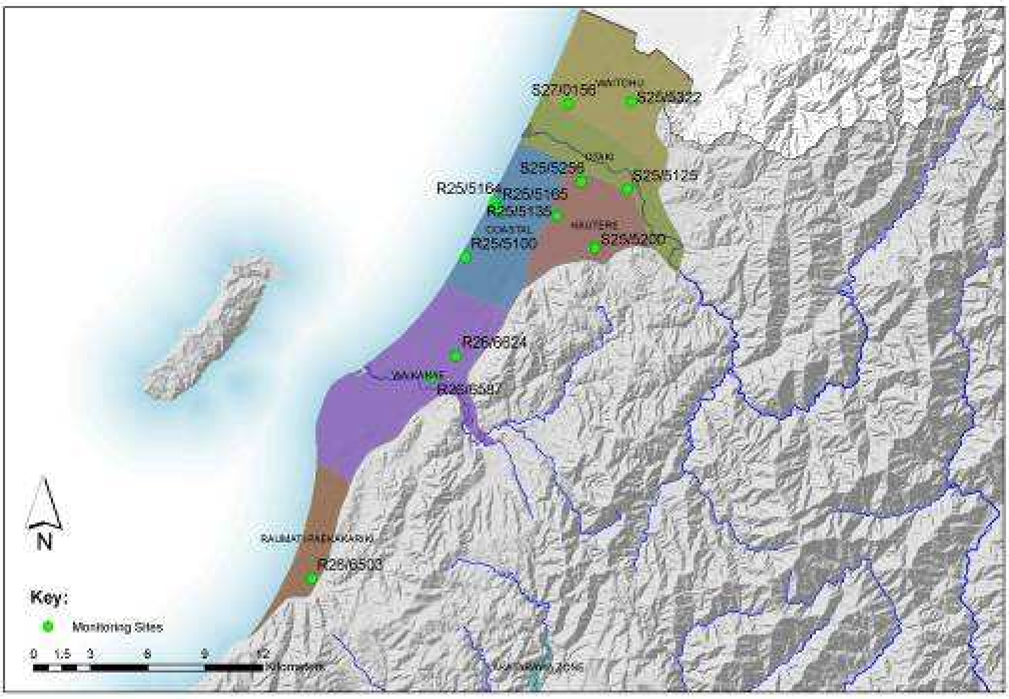


Figure 2: Wairarapa lower valley groundwater quality monitoring sites

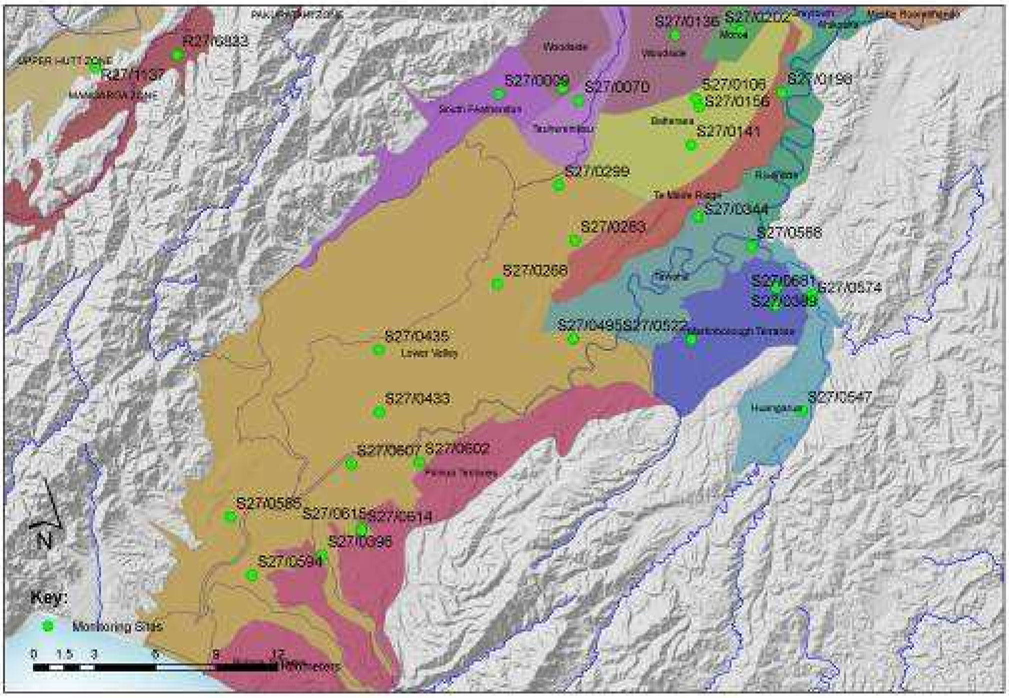
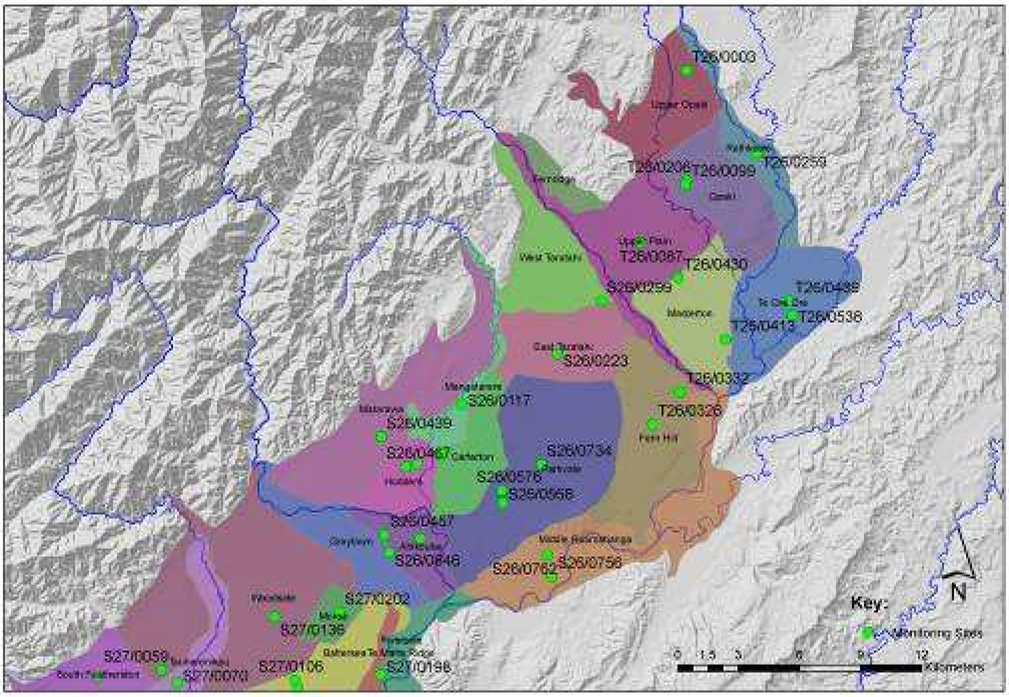


Figure 4: Wairarapa upper valley groundwater quality monitoring sites



Appendix E: Analysis Methodology

Table 1: Method of analysis for all analytes at Hill Laboratories

Analyte	Method	Detection limit
Total Anions	(mEquiv/L) - Calculation: sum of anions as mEquiv/L [Includes Alk, Cl, NOxN & SO4]	0.07 mEquiv/L
Dissolved Boron	(g.m-3) - Filtered sample. ICP-MS APHA 3125 B 20th ed. 1998	0.005 g.m-3
Bicarbonate	(g.m-3 at 25C) - Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO2 D 20th ed. 1998	1 g.m-3 at 25C
Bromide	(g.m-3) - Filtered sample. Ion Chromatography. APHA 4110 B 20th ed. 1998	0.05 g.m-3
Dissolved Calcium	(g.m-3) - Filtered sample, ICP-MS APHA 3125 B 20th ed. 1998	0.05 g.m-3
Total Cations	(mEquiv/L) - Calculation: sum of cations as mEquiv/L [Includes Ca, Mg, Na, K, Fe, Mn, Zn & NH4N]	0.06 mEquiv/L
Chloride	(g.m-3) - Filtered sample. Ion Chromatography. APHA 4110 B 20th ed. 1998	0.5 g.m-3
Free Carbon Dioxide	(g.m-3 at 25C) - Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO2 D 20th ed. 1998	1 g.m-3 at 25C
Dissolved Reactive Phosphorus	(g.m-3) - Molybdenum blue colorimetry. Flow injection analyser. APHA 4500-P G (Proposed) 20th ed. 1998	0.004 g.m-3
Flouride	(g.m-3) - Filtered sample. Ion Chromatography. APHA 4110 B 20th ed. 1998	0.05 g.m-3
Dissolved Iron	(g.m-3) - Filtered sample. ICP-MS APHA 3125 B 20th ed. 1998	0.02 g.m-3
Total Hardness	(g.m-3 as CaCO3) - Calculation: from Soluble Ca and Soluble Mg APHA 2340 B 20th ed. 1998	1 g.m-3 as CaCO3
% Difference in Ion Balance	Calculation from Sum of Anions and Cations APHA 1030 E 20th ed. 1998	0.10%
Dissolved Potassium	(g.m-3) - Filtered sample, ICP-MS APHA 3125 B 20th ed. 1998	0.05 g.m-3
Dissolved Magnesium	(g.m-3) - Filtered sample, ICP-MS APHA 3125 B 20th ed. 1998	0.02 g.m-3
Dissolved Maganese	(g.m-3) - Filtered sample. ICP-MS APHA 3125 B 20th ed. 1998	0.0005 g.m-3
Dissolved Sodium	(g.m-3) - Filtered sample, ICP-MS APHA 3125 B 20th ed. 1998	0.02 g.m-3
Total Ammoniacal-N	(g.m-3) - Phenol/hypochlorite colorimetry. Flow injection analyser. (NH4-N = NH4+-N + NH3-N) APHA 4500-NH3 G 20th ed. 1998	0.01 g.m-3
Nitrite-N	(g.m-3) - Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO3 - I (Proposed) 20th ed. 1998	0.002 g.m-3
Dissolved Lead	(g.m-3) - Filtered sample. ICP-MS APHA 3125 B 20th ed. 1998	0.0001 g.m-3
Reactive Silica	(g.m-3 as SiO2) - Colorimetric, Heteropoly Blue complex. Flow Injection Analyser (FIA) APHA 4500-SiO2 E 20th ed. 1998	0.1 g.m-3 as SiO2
Sulphate	(g.m-3) - Filtered sample. Ion Chromatography. APHA 4110 B 20th ed. 1998	0.5 g.m-3
Total Organic Carbon (TOC)	(g.m-3) - Catalytic oxidation, IR detection, for Total C. Acidification, purging fo	0.05 g.m-3
Nitrate-N + Nitrite-N (TON)	(g.m-3) - Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO3 - I (Proposed) 20th ed. 1998	0.002 g.m-3
Dissolved Zinc	(g.m-3) - Filtered sample. ICP-MS APHA 3125 B 20th ed. 1998	0.001 g.m-3
Nitrate-N	(g.m-3) - Calculation: (Nitrate-N + Nitrite-N) - Nitrite-N. Autoanalyser	Hills = 0.002 g.m-3
Total Alkalinity	(g.m-3 as CaCO3) - Titration to pH 4.5 (M-alkalinity), Radiometer autotitrator. APHA 2320 B (Modified for alk <20) 20th ed. 1998	1 g.m-3 as CaCO3
Conductivity (Lab)	APHA Standard Methods 1998, (20th Ed) 2510 B, Conductivity Meter	0.1 mS/m
pH (Lab)	APHA Standard Methods 1998, (20th ed.) 4500-H+, B Electrometric Method	0.1 pH units
Total Suspended Solids	APHA Standard Methods 1998, (20th Ed) 2540 D, Total Suspended Solids Dried at 103 - 105 °C	
Total Dissolved Solids	(g.m-3) - Filtration (GF/C, 1.2 μm), filtrate dried at 103 - 105 °C, Gravimetric. APHA 2540 C (modified) 20th ed. 1998	10 g.m-3

Appendix F: Statistical and analytical methods

The methods employed in this statistical analysis are taken from Daughney (2005) and are described in more detail by Helsel and Hirsch (1992) and Daughney and Reeves (2003a, 2003b) and are summarised below.

Charge balance error

The charge balance error (*CBE*) was calculated for each sample collected from each site, following the method of Freeze and Cherry (1979):

$$CBE = \frac{\sum zm_c - \sum zm_a}{\sum zm_c + \sum zm_a} \times 100\%$$

where z is the absolute value of the ionic valance, m_c is the molarity of the cationic species and m_a is the molarity of the anionic species. The following ionic species were considered in the calculation of *CBE*: Na^+, K^+, Ca^{2+}, Mg^{2+}, Fe^{2+}, Mn^{2+}, NH_4^+, HCO_3^-, CO_3^{2-}, Cl^-, NO_3^-, PO_4^{3-} and SO_4^{2-}. All *CBE* calculations were performed using dissolved concentrations of Fe, Mn and P (i.e. data from filtered samples) and total concentrations of all other analytes (i.e. data from unfiltered samples). In all cases, missing results and results below the analytical detection limit were assigned values of zero and ½ the detection limit, respectively, to permit calculation of *CBE*.

The acceptable limits for the *CBE* for each sample were calculated by propagation of analytical uncertainties through the *CBE* equation. The analytical uncertainty (two standard deviations around the mean) for each ion was assumed to relate to its concentration as described by Daughney and Reeves (2003a). In general, the analytical uncertainties for most ions were assumed to be between 2 and 5% over the range of concentrations relevant to the Greater Wellington GWSOE samples, though uncertainties were assumed to increase to roughly 20% at the analytical detection limit. Using this method, the acceptable limits for *CBE* were found to be on the order of 5% for most GW samples, but could be as low as 1.8% and as high as 10% for samples with very high or very low concentrations of total dissolved solids, respectively. These cut-off values are in reasonable agreement with the value of ±5%, suggested by Freeze and Cherry (1979).

Groundwater chemistry by analyte

The median, median absolute deviation (MAD), trend, deviation in the trend (TAD), and seasonality were assessed on a per-site and per-analyte basis. If no analyses were available OR if a calculation could not be performed (e.g. because 100% of the results were below the detection limit), then median, MAD, trend and TAD are recorded as ND, indicating "No Data". Samples identified as outliers were excluded from these calculations. Outliers were defined as having concentrations more than four times the MAD away from the median (Helsel and Hirsch, 1992). Samples with *CBE* outside the acceptable limits were not excluded during the calculation of the median, MAD, trend or TAD.

The median concentration of each analyte was calculated at each monitoring site, because it is less sensitive to extreme values in the dataset than the mean and thus provides a more resistant measure of central tendency (Helsel and Hirsch, 1992). Estimation methods are often required for calculation of median values for water quality data, because the dataset typically includes censored values reported as being less than some detection limit. In this analysis, a log-probability regression method (Helsel and Cohn, 1988) was employed to calculate the median. This method provides a reasonable estimate of the median even when up to 70% of the available results are reported as being below some detection limit. Median values of all parameters were compared to their respective Maximum Allowable Values (MAVs) or aesthetic guideline values based on the Drinking Water Standards for New Zealand (Ministry of Health, 2000).

The median absolute deviation (MAD) was calculated for each analyte at each monitoring site as a means of assessing variability. The MAD is a measure of the spread of analytical results and is analogous to the standard deviation, but the MAD is less subject to biasing by extreme values (Helsel and Hirsch, 1992). The MAD can be compared to the median to provide a measure of groundwater security.

The rate of change of each analyte was assessed statistically at each site. In this study, the term 'trend' is used to describe a monotonic (i.e. linear) increase or decrease in a parameter over time. It is important to note that an analyte may show significant variation, as manifested by a relatively large MAD, but if the variation does not follow a consistent direction over time, then a significant trend will not exist. Trends were identified using the Mann-Kendal test (Helsel and Hirsch, 1992) with a confidence interval of 95%. If a trend in any parameter at any site was significant at the 95% confidence interval, then the magnitude of the trend was assessed with Sen's slope estimator. This method was employed to determine the median rate of change in the analyte (units per year) for the entire historical record available for the site in question. Trends that are not significant at the 95% level are tabulated with an assigned value of zero.

The median absolute deviation of the trend (TAD) was also calculated for each analyte (units per year) for the entire historical record for each site. This provides a measure of the "dispersion" (i.e.

Relationships between total and dissolved concentrations

Special attention was paid to relationships between Total and Dissolved concentrations of B, Ca, Fe, K, Li, Mg, Mn, Na and P. Linear regressions were performed, using the Pearson coefficient (r) to measure the strength of the correlation. The T statistic was used to determine whether or not the regression slope and intercept differed from their ideal values of 1 and 0, respectively. These tests could not be performed for several minor elements, because the dissolved concentrations had been measured on too few occasions.

Multivariate analysis

The Water Type was determined for each site, based on the median concentrations (moles/L) of major cations and anions. Computations were performed using Aquachem.

Principal Components Analysis (PCA) was conducted to identify the major causes of variability in the data. PCA was conducted with log-transformed and scaled combined dissolved and total concentrations of Br, Ca, Fe, K, Mg, Mn, Na and total concentrations of NH_4-N, NO_3-N, SO_4, Cl, F, SiO_2, DRP

Following PCA, Hierarchical Cluster Analysis (HCA) was used to investigate factors controlling groundwater chemistry, and to partition the GWSOE monitoring sites into categories. HCA provides a means of dividing the monitoring sites into groups based on their chemical characteristics, without making any assumptions about site location, aquifer lithology, surrounding land use, etc. HCA was conducted using log-transformed and scaled median concentrations (mg/L), with the same analytes as used in PCA. HCA was conducted with Ward's linkage rule, and the square of the Euclidean distance was used as the separation measure.

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Appendix G: Guideline and Maximum allowable values

Table 1: Maximum Acceptable Values (MAVs) for micro-organisms of health significance (MoH, 2000)

Micro-organism	MAV
Escherischia coli (*E. coli*)	Less than 1 in 100 mL of sample
pathogenic bacteria	less than 1 in 100 mL of sample
Viruses	Less than 1 enteric virus in 100L of sample
Protozoa (pathogenic)	Less than 1 (oo)cyst in 100L sample
Helminths (pathogenic)	Less than 1 in 100L sample
Algae	Less than 1 toxic alga present in 10mL of sample
Cyanobacteria	Less than 1 potentially toxic cyanobacterium present in 10mL of sample

Table 2: Maximum Acceptable Values (MAVs) for inorganic determinands of health significance (MoH, 2000)

Name	MAV	Units	Remarks
Antimony	0.003	mg/L	
Aggressiveness			Any heavy metal has elevated concentration in first flush sample
Arsenic	0.01	mg/L	For excess lifetime skin cancer risk of 6 x 10^{-4} PMAV, because of analytical difficulties
Barium	0.7	mg/L	
Beryllium	0.004	mg/L	PMAV
Boron	1.4	Mg/L	
Bromate	0.025	mg/L	For excess lifetime cancer risk of 7 x 10^{-5}
Cadmium	0.003	mg/L	
Chlorate	0.3	mg/L	PMAV, disinfection must never be compromised
Chlorine (free)	5	mg/L as Cl_2	ATO, disinfection must never be compromised
Chlorite	0.3	mg/L as ClO_2	PMAV, disinfection must never be compromised
Chromium	0.05	mg/L	PMAV, limited information on health effects
Copper	2	mg/L	ATO
Cyanide (total)	0.08	mg/L	
Cyanogen chloride (as CN)	0.08	mg/L	
Fluoride *	1.5	mg/L	
Lead	0.01	mg/L	
Lithium	0.9	mg/L	PMAV
Manganese	0.5	mg/L	ATO
Mercury (total)	0.002	mg/L	
Molybdenum	0.07	mg/L	
Monochloramine	3	mg/L	
Nickel	0.02	mg/L	
Nitrate	50	mg/L expressed as NO_3	The sum of the ratio of the concentrations of nitrate and nitrite to each of their respective MAVs should not exceed 1
Nitrite	3	mg/L expressed as NO_2	The sum of the ratio of the concentrations of nitrate and nitrite to each of their respective MAVs should not exceed 1
Selenium	0.01	mg/L	
Silver	0.02	mg/L	U PMAV Australian provisional value
Tin	1	mg/L	U PMAV derived from WHO data
Uranium	0.002	mg/L	PMAV: WHO provisional

* The fluoride content recommended for drinking-water by the Ministry of Health for oral health reasons is 0.7–1.0 mg/L.

Table 3: Guideline values (GVs) for aesthetic determinands (MoH, 2000)

Determinand	Guideline Value	Units	Comments
Aluminium	0.15	mg/L	Depositions, discoloration
Ammonia	1.5	mg/L	Taste, odour
Calcium: see hardness			
Chloride	250	mg/L	Taste, corrosion
Chlorine	0.6	mg/L	Taste, odour (MAV 5mg/L)
1,2-dichlorobenzene	0.001	mg/L	Taste, odour (MAV 1.0mg/L)
1,4-dichlorobenzene	0.003	mg/L	Taste, odour (MAV 0.4mg/L)
2-Chlorophenol	0.0003	mg/L	Taste
Colour	10	TCU	Appearance
Copper	1	mg/L	Staining of laundry and sanitary ware (PMAV 2mg/L)
2,4-Dichlorophenol	0.0003	mg/L	Taste
Ethylbenzene	0.002	mg/L	For odour and taste (MAV 0.3mg/L)
Hardness (total) (Ca + Mg)	200	mg/L	High hardness causes scale deposition, scum formation. Low hardness possibly causes corrosion
Hydrogen sulphide	0.05	mg/L	Taste, odour
Iron	0.2	mg/L	Staining of laundry and sanitary ware
Magnesium (see hardness)			
Manganese	0.05	mg/L	Staining of laundry and sanitary ware (MAV 0.5mg/L)
Monochlorobenzene	0.01	mg/L	Taste, odour (MAV 0.3mg/L)
Odour	Threshold odour number 4		Odour
pH	7.0–8.5		Should be between 7.0 and 8.0. Low pH: aggressive water; high pH: taste, soapy feel. Preferably pH<8 for effective disinfection with chlorine
Sodium	200	mg/L	Taste
Styrene	0.004	mg/L	Taste, odour (MAV 0.03 mg/L)
Sulphate	250	mg/L	Taste, corrosion
Taste	should be acceptable to most consumers		
Temperature	should be acceptable to most consumers		
Toluene	0.024–0.17	mg/L	Taste, odour (MAV 0.8 mg/L)
Total dissolved solids	1000	mg/L	Taste
Trichlorobenzenes (total)	0.005	mg/L	(MAV 0.03mg/L)
2,4,6-trichlorophenol	0.002	mg/L	Taste, odour (MAV 0.2 mg/L)
Turbidity	2.5	NTU	Appearance, for effective terminal disinfection, median turbidity <1 NTU, single sample < 5 NTU
Xylene	0.02-1.8	mg/L	Taste, odour (MAV 0.6 mg/L)
Zinc	3	mg/L	Appearance, taste

Appendix H: GWSOE results and summary tables

Table 1: Conductivity and pH. Refer to Appendix I, Table 2 for notes on table formats.

					Cond Field							Cond Lab							pH Field							pH Lab						
Well Number	Site	#	CBE Calc	CBE OK	Med	MAD	Trend	TAD	#	Out	%BDL	Med	MAD	Trend	TAD	#	Out	%BDL	Med	MAD	Trend	TAD	#	Out	%BDL	Med	MAD	Trend	TAD	#	Out	%BDL
S27/0268	BARTON, S.A	16	16	16	604.50	13.50	-4.93	5.58	14	1	0	596.00	9.00	0.00	34.31	5	0	0	7.06	0.11	0.00	0.05	14	0	0	7.30	0.20	0.00	0.44	5	0	0
S27/0059	BERRY, D	1	1	1	205.00	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	7.36	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100
T26/0087	BISS, D	4	4	2	136.00	2.00	-19.82	10.33	3	1	0	143.50	0.50	0.00	0.00	2	1	0	6.56	0.02	0.00	0.00	2	1	0	6.80	0.00	0.00	0.00	2	1	0
S27/0495	BOSCH, F & W.M	16	16	16	816.00	26.50	-14.57	11.90	14	1	0	755.00	13.00	0.00	56.05	5	0	0	6.91	0.11	0.00	0.05	14	0	0	7.10	0.10	0.00	0.22	5	0	0
S26/0117	BUTCHER, G	2	2	2	139.50	4.50	0.00	0.00	2	0	0	155.00	ND	ND	ND	1	0	0	5.77	0.05	-0.02	0.00	2	0	0	6.00	ND	ND	ND	1	0	0
T26/0099	BUTCHER, M	4	4	3	175.00	7.00	-28.33	4.01	4	0	0	182.50	2.00	0.00	9.03	4	0	0	6.24	0.04	-0.43	0.00	2	0	0	6.50	0.05	0.00	0.34	4	0	0
S27/0547	CAMPBELL	3	3	3	236.00	2.00	0.00	0.00	2	1	0	253.50	0.50	-5.14	0.00	2	0	0	6.31	0.02	0.00	0.01	3	0	0	6.60	0.10	0.00	0.00	2	0	0
R25/5164	CARD	30	29	26	626.00	45.50	0.00	181.40	6	0	0	664.00	70.00	0.00	58.27	30	0	0	7.48	0.17	-0.57	0.33	5	0	0	7.90	0.10	0.03	0.05	28	2	0
S26/0824	CDC NORTHERN.	28	28	24	175.00	3.50	-1.53	2.20	26	0	0	178.50	2.50	0.00	5.60	6	0	0	6.14	0.11	-0.05	0.08	23	0	0	6.35	0.10	0.00	0.34	6	0	0
S26/0705	CDC SOUTHERN	28	28	25	166.50	3.50	-1.72	2.39	26	0	0	167.00	2.00	0.00	10.85	6	0	0	6.27	0.10	-0.05	0.09	23	0	0	6.45	0.05	0.00	0.21	6	0	0
S25/5200	COMMON PROPERTY	27	27	25	280.00	12.00	0.00	24.60	5	0	0	289.00	3.00	0.00	1.18	27	0	0	6.31	0.18	0.00	0.26	4	0	0	6.70	0.10	0.02	0.03	27	0	0
S26/0547	CRAIG, E.J	1	1	1	76.00	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	6.28	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100
S27/0202	CROAD, J.R & W.J	28	28	23	134.00	5.00	0.00	5.22	25	1	0	149.00	6.00	0.00	18.59	6	0	0	5.66	0.13	-0.07	0.09	23	0	0	5.90	0.05	0.00	0.15	6	0	0
S26/0568	DENBEE, J.M	16	16	14	272.00	6.00	-2.98	2.57	15	0	0	267.00	3.00	0.00	9.21	5	0	0	7.09	0.09	0.00	0.06	14	0	0	7.30	0.10	0.00	0.29	5	0	0
S27/0389	DIMATTINA, T	4	4	4	191.50	6.00	-11.68	10.32	4	0	0	198.00	4.00	-20.58	0.00	3	0	0	6.96	0.06	0.00	0.01	3	0	0	7.20	0.10	0.00	0.26	3	0	0
S27/0009	DONDERTMAN, A	1	1	1	198.00	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	5.81	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100
S26/0846	DRUZIANIC	1	1	1	89.00	ND	ND	ND	1	0	0	97.00	ND	ND	ND	1	0	0	6.62	ND	ND	ND	1	0	0	6.70	ND	ND	ND	1	0	0
T26/0489	DUFFY	28	28	27	270.00	8.00	0.00	4.45	25	0	0	280.00	3.50	0.00	10.76	6	0	0	6.11	0.14	-0.06	0.08	24	0	0	6.35	0.05	-0.31	0.16	6	0	0
S27/0522	DUGGAN	3	3	3	739.00	2.00	0.00	0.00	2	1	0	778.00	2.00	-13.78	0.00	2	1	0	6.64	0.04	0.00	0.00	2	0	0	6.70	0.00	0.00	0.00	2	1	0
S26/0734	DYKSTRA, ENGBERT	1	1	1	193.00	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	5.80	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100
T26/0332	EAST TARATAHI SHALLOW	2	2	2	186.50	1.50	0.00	0.00	2	0	0	202.50	2.50	-36.53	0.00	2	0	0	5.96	0.07	-1.02	0.00	2	0	0	6.20	0.00	0.00	0.00	2	0	0
S27/0607	FINDLAYSON, K	15	15	15	1273.00	101.50	0.00	48.36	14	0	0	1315.00	120.00	0.00	261.84	4	0	0	6.78	0.08	-0.04	0.03	13	0	0	7.05	0.05	0.00	0.11	4	0	0
S26/0400	FITZGERALD DEEP	2	2	2	188.00	8.00	-3.27	0.00	2	0	0	180.00	ND	ND	ND	1	0	0	6.96	0.06	-0.03	0.00	2	0	0	7.20	ND	ND	ND	1	0	0
S26/0467	FITZGERALD SHALLOW	2	2	2	147.50	5.50	-2.25	0.00	2	0	0	153.00	ND	ND	ND	1	0	0	6.05	0.01	-0.01	0.00	2	0	0	6.30	ND	ND	ND	1	0	0
S27/0344	GEORGE, B	17	17	16	292.00	7.00	0.00	4.79	13	3	0	313.00	11.00	0.00	38.38	5	0	0	6.24	0.13	-0.05	0.07	15	0	0	6.50	0.10	0.00	0.06	5	0	0
S26/0299	GRAHAM, D	28	28	23	128.50	8.00	-3.92	5.70	26	0	0	152.00	12.00	-39.26	14.41	6	0	0	5.80	0.15	-0.06	0.09	23	1	0	6.10	0.05	0.00	0.22	6	0	0
S27/0141	HARVEY, A. & L.	1	1	1	215.00	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	6.80	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100
R27/0320	IBM#1	52	42	40	176.50	10.00	0.00	15.14	6	0	0	188.00	1.00	0.00	0.62	48	4	0	6.93	0.08	0.00	0.37	6	0	0	7.40	0.10	0.00	0.04	51	1	0
R27/1265	IBM#2	48	39	34	131.15	0.10	0.00	1.38	4	2	0	114.50	1.50	0.00	1.06	44	4	0	6.47	0.25	0.00	0.32	6	0	0	6.80	0.10	0.00	0.04	47	1	0
S27/0299	JOHNSON, M.J & G	16	16	13	87.00	2.00	0.00	0.97	15	0	0	94.00	0.00	0.00	0.00	3	2	0	6.40	0.21	-0.08	0.07	14	0	0	6.70	0.20	0.00	0.26	5	0	0
S27/0435	LANDCORP 'WAIRIO'	16	16	16	370.00	5.00	0.00	4.36	15	0	0	344.00	0.00	0.00	0.91	3	2	0	6.83	0.06	0.00	0.07	14	0	0	7.10	0.10	0.00	0.44	5	0	0
T26/0003	LENTON	3	3	2	112.50	0.50	-6.76	0.00	2	1	0	118.00	4.00	0.00	34.06	3	0	0	5.86	0.07	-0.70	0.00	2	0	0	6.20	0.00	0.00	0.00	2	1	0
R26/6587	LIDDLE NURSERIES	45	44	42	150.00	20.00	-93.50	38.77	5	0	0	128.00	8.00	1.09	2.92	45	0	0	6.03	0.13	0.00	0.55	4	0	0	6.40	0.10	0.02	0.02	45	0	0
S27/0571	M/B GOLF CLUB	4	4	4	233.50	10.50	0.00	9.27	4	0	0	239.00	1.00	-10.29	0.00	2	1	0	6.51	0.02	-0.02	0.00	3	0	0	6.80	0.10	0.00	0.26	3	0	0
S27/0433	MAORI EDUCATION FOUNDATION	16	16	15	807.00	15.00	0.00	9.35	15	0	0	796.00	27.00	0.00	52.51	5	0	0	6.88	0.03	0.00	0.03	13	1	0	7.10	0.10	0.00	0.26	5	0	0
S27/0585	McCREARY, T.R	16	16	15	474.00	21.00	0.00	9.71	15	0	0	467.00	8.00	0.00	26.50	5	0	0	6.88	0.08	0.00	0.06	14	0	0	7.10	0.20	0.00	0.13	5	0	0
T26/0326	MCKAY, N & SONS	1	1	1	225.00	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	6.54	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100
S26/0576	MCNAMARA, J	16	16	16	213.00	4.00	-1.91	2.38	15	0	0	211.00	1.00	0.00	3.20	5	0	0	6.85	0.14	0.00	0.06	14	0	0	6.90	0.00	0.00	0.00	3	2	0
S26/0223	NICHOLSON	2	2	2	203.50	0.50	-7.31	0.00	2	0	0	212.00	5.00	0.00	0.00	2	0	0	5.88	0.23	-3.36	0.00	2	0	0	6.05	0.05	-0.73	0.00	2	0	0
R25/5100	O'MALLEY	30	30	8	344.00	10.00	0.00	36.95	5	0	0	337.00	6.00	1.33	1.69	30	0	0	6.71	0.13	0.00	0.31	4	0	0	7.10	0.10	0.00	0.04	29	1	0
S27/0106	O'NEALE	1	1	1	169.00	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	6.05	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100
S27/0156	O'NEALE NEW	1	1	1	133.00	ND	ND	ND	1	0	0	148.00	ND	ND	ND	1	0	0	6.78	ND	ND	ND	1	0	0	6.80	ND	ND	ND	1	0	0
S27/0156	OP TRUST	35	34	26	153.50	2.60	0.00	5.85	4	2	0	149.00	20.00	0.00	14.39	35	0	0	5.78	0.17	0.00	0.34	5	0	0	7.20	0.80	-0.17	0.23	35	0	0
T26/0259	OPAKI WATER SUP.	28	28	21	86.00	6.00	0.00	5.40	25	0	0	121.50	6.00	0.00	24.05	6	0	0	6.18	0.16	-0.05	0.10	23	1	0	6.35	0.10	0.00	0.16	6	0	0
S27/0283	OSBOURNE, A	16	16	16	359.00	21.00	-14.33	5.75	15	0	0	298.00	10.00	0.00	19.78	5	0	0	6.66	0.08	0.00	0.06	14	0	0	6.75	0.05	0.00	0.23	4	1	0
S26/0457	PALMER	16	16	15	81.00	2.00	0.00	1.66	14	1	0	95.00	5.00	0.00	10.46	5	0	0	6.02	0.15	0.00	0.07	14	0	0	6.40	0.20	0.00	0.26	5	0	0
T26/0538	PERCY	28	28	24	281.00	15.00	11.34	8.50	25	0	0	328.00	11.50	0.00	32.77	6	0	0	5.90	0.16	-0.08	0.08	23	1	0	6.20	0.10	0.00	0.17	6	0	0
S26/0439	ROGERS, W	2	2	2	162.00	5.00	-2.06	0.00	2	0	0	173.00	ND	ND	ND	1	0	0	6.33	0.08	-0.03	0.00	2	0	0	6.40	ND	ND	ND	1	0	0
R25/5165	SALTER	28	27	23	216.50	41.50	0.00	84.51	6	0	0	258.50	21.50	-11.03	11.68	28	0	0	6.48	0.09	0.00	0.29	5	0	0	6.70	0.10	0.00	0.05	27	1	0
S26/0762	SCHAEF, D	16	16	16	364.00	24.00	-8.03	8.72	15	0	0	342.00	15.00	0.00	30.10	5	0	0	6.49	0.09	0.00	0.05	14	0	0	6.60	0.00	0.00	0.00	3	2	0
R27/1182	SEAVIEW WOOLS	58	44	34	191.00	9.50	0.00	17.10	6	0	0	199.00	4.00	1.80	1.27	57	0	0	6.08	0.14	0.00	0.43	6	0	0	6.60	0.10	0.00	0.04	57	0	0
T26/0413	SEYMOUR, B.J & R.H	4	4	4	175.50	6.50	-6.08	4.46	4	0	0	184.00	1.00	0.00	14.30	3	0	0	7.38	0.00	0.00	0.00	2	1	0	7.50	0.00	0.00	0.00	2	1	0
R27/1171	SOMES ISLAND	34	22	13	183.00	ND	ND	ND	1	0	0	158.00	5.00	0.00	3.29	33	1	0	6.46	ND	ND	ND	1	0	0	6.90	0.10	0.00	0.07	33	0	0
S27/0615	SORENSON DEEP	16	15	15	417.00	11.00	0.00	8.71	13	1	0	457.00	2.00	-5.20	0.97	3	2	0	6.93	0.10	0.00	0.06	13	0	0	7.05	0.10	-0.27	0.07	4	1	0
S27/0614	SORENSON SHALLOW	15	15	14	305.00	29.00	0.00	13.97	14	0	0	275.00	4.00	0.00	32.70	3	1	0	6.81	0.14	0.00	0.08	13	0	0	6.95	0.15	0.00	0.62	4	0	0
S27/0070	SOUTH FEATHERSTON SCHOOL	2	2	1	74.50	1.50	0.00	0.00	2	0	0	82.00	ND	ND	ND	1	0	0	6.37	0.02	0.00	0.00	2	0	0	6.50	ND	ND	ND	1	0	0
S27/0136	SUGRUE, O	2	2	2	132.00	19.00	0.00	0.00	2	0	0	161.00	ND	ND	ND	1	0	0	5.65	0.23	0.00	0.00	2	0	0	5.70	ND	ND	ND	1	0	0
S27/0396	SWDC MARTINBOROUGH	25	25	25	445.00	11.00	0.00	9.15	21	2	0	515.50	33.50	0.00	50.81	6	0	0	6.97	0.13	0.00	0.08	21	0	0	7.15	0.05	0.00	0.10	6	0	0
S27/0588	SWDC PIRINOA	28	28	27	189.00	4.00	1.86	2.18	26	0	0	195.50	2.00	0.00	3.45	6	0	0	6.60	0.20	0.00	0.11	23	0	0	6.70	0.00	0.00	0.00	4	2	0
S27/0681	TE KAIRANGA NEW	3	3	3	436.00	11.00	0.00	126.24	3	0	0	461.50	1.50	0.00	0.00	2	1	0	6.93	0.02	0.00	0.00	2	0	0	7.20	0.10	0.00	0.25	3	0	0
S27/0574	TE KAIRANGA WINES LTD	1	1	1	377.00	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	6.72	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100
T26/0206	TOCHER, B	26	26	22	166.00	4.50	0.00	3.19	26	0	0	166.00	1.00	-11.33	2.72	3	0	0	6.43	0.17	0.00	0.16	24	0	0	7.50	0.00	0.00	0.00	2	1	0
T26/0430	TROUT HATCHERY	28	28	24	101.50	11.00	3.44	6.30	26	0	0	136.50	7.00	0.00	33.12	6	0	0	6.08	0.18	0.00	0.13	22	1	0	6.30	0.00	0.00	0.16	5	1	0
S27/0198	TUCKER, B	1	1	0	108.00	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	6.43	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100
S27/0594	WARREN, H	15	15	15	512.00	9.00	0.00	6.79	14	0	0	532.00	9.00	0.00	23.68	5	0	0	7.44	0.10	-0.03	0.05	12	0	0	7.50	0.00	0.00	0.00	3	2	0
S27/0602	WEATHERSTONE	16	16	16	385.00	34.00	0.00	19.04	15	0	0	378.00	7.00	0.00	14.41	5	0	0	7.07	0.06	0.00	0.07	14	0	0	7.30	0.10	-0.33	0.08	5	0	0
S26/0756	WENDON	16	16	12	246.00	10.00	0.00	5.43	15	0	0	265.00	24.00	0.00	13.05	5	0	0	6.51	0.09	-0.03	0.04	14	0	0	6.60	0.00	0.00	0.00	3	2	0
R25/5135	WINDSOR PARK	31	31	29	589.00	24.00	0.00	57.32	5	0	0	602.50	12.50	0.00	4.89	30	1	0	6.89	0.12	0.00	0.29	4	0	0	7.25	0.06	0.02	0.03	31	0	0

Table 2: Total dissolved solids, total organic carbon, alkalinity, carbon dioxide

Well Number	Site	TDS Med	TDS MAD	TDS Trend	TDS TAD	TDS #	TDS Out	TDS %BDL	TOC Med	TOC MAD	TOC Trend	TOC TAD	TOC #	TOC Out	TOC %BDL	Alk Med	Alk MAD	Alk Trend	Alk TAD	Alk #	Alk Out	Alk %BDL	CO2 Med	CO2 MAD	CO2 Trend	CO2 TAD	CO2 #	CO2 Out	CO2 %BDL
S27/0268	BARTON, S.A	350.00	5.00	0.00	18.62	5	0	0	3.38	0.68	0.00	1.40	5	0	0	305.70	2.95	0.00	2.15	16	0	0	53.75	10.30	-4.47	6.38	16	0	0
S27/0059	BERRY, D	ND	ND	ND	ND	0	0	100	ND	ND	ND	ND	0	0	100	87.40	ND	ND	ND	1	0	0	14.60	ND	ND	ND	1	0	0
T26/0087	BISS, D	90.00	4.00	0.00	32.36	3	0	0	2.73	0.07	-0.62	0.09	3	0	0	43.50	3.15	0.00	4.78	4	0	0	17.60	3.50	0.00	11.71	4	0	0
S27/0495	BOSCH, F & W.M	419.00	21.00	0.00	33.30	5	0	0	3.77	0.31	0.00	1.80	5	0	0	157.90	4.90	-2.58	1.72	16	0	0	35.15	6.45	0.00	4.87	16	0	0
S26/0117	BUTCHER, G	110.00	ND	ND	ND	1	0	0	3.44	ND	ND	ND	1	0	0	25.55	1.45	0.00	0.00	2	0	0	56.05	1.95	0.00	0.00	2	0	0
T26/0099	BUTCHER, M	124.00	1.00	0.00	6.82	3	1	0	0.45	0.36	0.00	1.69	4	0	25	30.00	0.00	0.00	0.00	3	1	0	19.50	2.50	0.00	15.51	4	0	0
S27/0547	CAMPBELL	187.00	0.00	0.00	0.00	2	0	0	2.25	0.46	-4.68	0.00	2	0	0	40.00	3.00	-3.01	0.44	3	0	0	23.00	8.00	-3.03	1.34	3	0	0
R25/5164	CARD	400.00	50.00	0.00	36.35	29	0	0	9.37	0.63	0.00	1.98	5	1	0	130.00	10.00	0.00	5.13	28	2	0	3.00	0.00	0.00	0.00	4	2	0
S26/0824	CDC NORTHERN.	129.00	3.00	0.00	13.42	6	0	0	2.35	0.31	0.00	0.61	6	0	0	30.90	0.75	-0.48	0.45	28	0	0	29.05	2.55	0.00	2.27	28	0	0
S26/0705	CDC SOUTHERN	115.00	4.00	0.00	14.59	6	0	0	2.16	0.26	0.00	1.00	6	0	0	32.10	0.80	0.21	0.46	28	0	0	24.15	2.55	0.00	1.49	28	0	0
S25/5200	COMMON PROPERTY	180.00	0.00	0.00	0.00	16	10	0	1.75	0.58	0.00	1.78	5	0	0	82.60	1.10	-0.41	0.42	27	0	0	31.00	4.00	0.00	12.47	5	0	0
S26/0547	CRAIG, E.J	ND	ND	ND	ND	0	0	100	ND	ND	ND	ND	0	0	100	28.20	ND	ND	ND	1	0	0	18.10	ND	ND	ND	1	0	0
S27/0202	CROAD, J.R & W.J	104.00	4.00	0.00	12.28	5	1	0	2.02	1.15	0.00	2.62	6	0	0	12.00	1.00	0.00	0.64	28	0	0	30.65	4.30	0.00	3.03	28	0	0
S26/0568	DENBEE, J.M	175.00	4.00	0.00	15.07	5	0	0	0.95	0.47	0.00	1.05	5	0	0	123.00	2.00	-0.91	0.72	16	0	0	17.75	1.90	0.00	1.80	16	0	0
S27/0389	DIMATTINA, T	135.00	0.00	0.00	0.00	2	1	0	2.15	0.32	0.00	10.03	3	0	0	58.50	0.50	0.00	0.18	4	0	0	8.00	2.00	-5.95	4.34	4	0	0
S27/0009	DONDERTMAN, A	ND	ND	ND	ND	0	0	100	ND	ND	ND	ND	0	0	100	28.70	ND	ND	ND	1	0	0	36.80	ND	ND	ND	1	0	0
S26/0846	DRUZIANIC	65.00	ND	ND	ND	1	0	0	0.48	ND	ND	ND	1	0	0	32.00	ND	ND	ND	1	0	0	14.00	ND	ND	ND	1	0	0
T26/0489	DUFFY	208.00	4.50	0.00	26.61	6	0	0	2.13	0.18	0.00	1.13	6	0	0	44.50	0.50	0.00	0.28	27	1	0	40.10	4.50	0.00	3.42	28	0	0
S27/0522	DUGGAN	450.00	10.00	-41.27	6.81	3	0	0	2.01	0.26	0.00	1.34	3	0	0	100.00	0.00	0.00	0.00	2	1	0	36.50	0.50	-2.06	0.00	2	1	0
S26/0734	DYKSTRA, ENGBERT	ND	ND	ND	ND	0	0	100	ND	ND	ND	ND	0	0	100	19.00	ND	ND	ND	1	0	0	43.20	ND	ND	ND	1	0	0
T26/0332	EAST TARATAHI SHALLOW	146.00	1.00	-14.61	0.00	2	0	0	2.95	0.15	0.00	0.00	2	0	0	37.50	0.50	-7.31	0.00	2	0	0	47.50	4.50	-65.75	0.00	2	0	0
S27/0607	FINDLAYSON, K	722.00	60.00	0.00	134.11	4	0	0	7.61	0.60	0.00	1.33	4	0	0	197.20	2.75	-1.18	2.81	14	1	0	64.30	12.50	-5.66	8.22	15	0	0
S26/0400	FITZGERALD DEEP	134.00	ND	ND	ND	1	0	0	2.09	ND	ND	ND	1	0	0	74.00	1.00	-0.41	0.00	2	0	0	16.50	6.50	-2.66	0.00	2	0	0
S26/0467	FITZGERALD SHALLOW	103.00	ND	ND	ND	1	0	0	2.43	ND	ND	ND	1	0	0	30.00	0.00	0.00	0.00	2	0	0	32.80	0.20	0.00	0.00	2	0	0
S27/0344	GEORGE, B	183.00	6.00	0.00	16.52	5	0	0	2.70	0.25	0.00	1.05	5	0	0	57.00	0.20	0.00	0.11	14	3	0	37.70	3.60	0.00	2.77	17	0	0
S26/0299	GRAHAM, D	105.50	10.00	-41.09	20.02	6	0	0	1.28	0.08	0.00	0.65	5	1	0	12.85	1.35	0.00	1.13	28	0	0	24.60	3.60	0.00	2.41	28	0	0
S27/0141	HARVEY, A. & L.	ND	ND	ND	ND	0	0	100	ND	ND	ND	ND	0	0	100	81.90	ND	ND	ND	1	0	0	19.80	ND	ND	ND	1	0	0
R27/0320	IBM#1	120.00	0.00	0.00	0.00	40	11	0	2.03	0.33	0.00	0.88	6	0	0	52.00	1.00	0.00	0.40	42	1	0	4.50	1.00	0.00	4.00	6	0	0
R27/1265	IBM#2	75.00	1.00	0.00	1.04	45	3	0	0.46	0.16	0.00	0.52	6	0	0	28.00	1.40	-0.24	0.64	37	3	0	11.00	0.00	0.00	0.00	4	2	0
S27/0299	JOHNSON, M.J & G	54.50	3.00	0.00	6.58	4	1	0	0.41	0.29	0.00	0.80	5	0	0	28.00	0.30	0.00	0.25	16	0	0	12.50	1.85	0.00	1.11	16	0	0
S27/0435	LANDCORP 'WAIRIO'	211.50	1.00	0.00	1.19	4	1	0	8.65	0.78	0.00	3.27	5	0	0	119.35	2.35	0.00	1.46	16	0	0	40.60	9.75	-3.93	4.67	16	0	0
T26/0003	LENTON	78.00	2.00	0.00	25.97	3	0	0	1.08	0.64	0.00	0.30	3	0	0	19.00	2.00	0.00	1.70	3	0	0	24.00	6.00	0.00	7.88	3	0	0
R26/6587	LIDDLE NURSERIES	81.00	4.00	0.00	1.73	44	0	0	0.70	0.15	0.00	0.52	5	0	0	22.00	1.00	0.00	0.43	44	1	0	17.00	2.00	0.00	9.22	5	0	0
S27/0571	M/B GOLF CLUB	166.00	1.00	0.00	10.29	3	0	0	2.15	0.38	0.00	10.49	3	0	0	38.30	0.50	0.00	1.44	4	0	0	13.00	3.50	-8.60	7.66	4	0	0
S27/0433	MAORI EDUCATION FOUNDATION	434.00	6.00	0.00	14.12	5	0	0	10.60	1.92	0.00	6.07	5	0	0	280.00	5.60	-2.61	3.31	16	0	0	72.20	15.55	-6.72	6.98	16	0	0
S27/0585	McCREARY, T.R	258.00	6.00	0.00	29.11	5	0	0	1.66	0.39	0.00	1.30	5	0	0	160.00	6.35	0.00	3.07	16	0	0	38.55	5.35	-2.46	3.48	16	0	0
T26/0326	MCKAY, N & SONS	ND	ND	ND	ND	0	0	100	ND	ND	ND	ND	0	0	100	72.60	ND	ND	ND	1	0	0	41.70	ND	ND	ND	1	0	0
S26/0576	MCNAMARA, J	143.00	4.00	0.00	3.38	5	0	0	2.47	0.04	0.00	0.05	3	2	0	79.70	0.80	-0.38	0.56	16	0	0	18.00	2.55	0.00	1.58	16	0	0
S26/0223	NICHOLSON	153.50	13.50	0.00	0.00	2	0	0	0.75	0.07	0.00	0.00	2	0	0	13.00	0.00	0.00	0.00	2	0	0	24.00	4.00	0.00	0.00	2	0	0
R25/5100	O'MALLEY	210.00	0.00	0.00	0.00	15	14	0	2.65	0.01	-0.07	0.05	3	2	0	110.00	0.00	0.00	0.00	18	12	0	15.00	7.00	17.99	3.32	5	0	0
S27/0106	O'NEALE	ND	ND	ND	ND	0	0	100	ND	ND	ND	ND	0	0	100	13.60	ND	ND	ND	1	0	0	30.10	ND	ND	ND	1	0	0
S27/0156	O'NEALE NEW	96.00	ND	ND	ND	1	0	0	2.19	ND	ND	ND	1	0	0	48.00	ND	ND	ND	1	0	0	14.00	ND	ND	ND	1	0	0
S27/0156	OP TRUST	96.00	12.50	0.00	8.66	34	0	0	2.48	0.04	0.00	0.19	5	1	0	44.00	9.00	0.00	5.13	34	1	0	36.50	10.00	0.00	23.79	6	0	0
T26/0259	OPAKI WATER SUP.	75.50	12.50	0.00	22.68	6	0	0	1.19	0.95	0.00	2.15	6	0	0	23.95	1.65	0.00	1.26	28	0	0	22.00	2.95	0.00	2.12	28	0	0
S27/0283	OSBOURNE, A	185.00	6.00	0.00	6.40	5	0	0	2.91	0.16	0.00	0.61	4	1	0	133.65	12.45	-6.13	6.69	16	0	0	55.20	10.25	-4.53	5.37	16	0	0
S26/0457	PALMER	55.00	2.00	0.00	11.82	5	0	0	<0.05	ND	ND	ND	3	2	100	20.70	1.30	0.00	0.67	16	0	0	18.75	2.15	0.00	1.45	16	0	0
T26/0538	PERCY	232.00	7.00	0.00	27.51	6	0	0	3.77	0.29	0.00	0.41	5	1	0	33.80	2.40	-1.04	1.35	28	0	0	52.70	4.30	0.00	3.13	27	1	0
S26/0439	ROGERS, W	120.00	ND	ND	ND	1	0	0	0.20	ND	ND	ND	1	0	0	35.65	1.65	-0.68	0.00	2	0	0	29.30	3.30	-1.36	0.00	2	0	0
R25/5165	SALTER	160.00	10.00	-4.86	6.07	27	0	0	5.60	0.35	0.00	0.74	6	0	0	33.00	2.00	0.00	1.29	28	0	0	9.50	2.50	0.00	6.46	6	0	0
S26/0762	SCHAEF, D	196.00	6.00	0.00	19.30	5	0	0	4.44	1.09	0.00	2.80	5	0	0	109.05	5.65	-2.63	1.76	16	0	0	59.05	4.40	0.00	2.88	14	2	0
R27/1182	SEAVIEW WOOLS	120.00	3.50	0.41	1.17	56	0	0	2.29	0.29	0.00	0.75	6	0	0	58.00	2.00	0.30	0.72	46	0	0	32.50	3.00	0.00	9.03	6	0	0
T26/0413	SEYMOUR, B.J & R.H	112.00	0.00	0.00	0.00	2	1	0	2.01	0.27	-1.95	0.67	3	0	0	77.00	0.00	0.00	0.00	3	1	0	6.50	1.50	0.00	0.64	4	0	0
R27/1171	SOMES ISLAND	100.00	2.00	0.00	1.62	32	1	0	1.73	0.92	-3.73	0.00	2	0	0	54.00	2.00	0.48	0.48	23	0	0	12.50	1.50	0.00	0.00	2	0	0
S27/0615	SORENSON DEEP	268.00	16.00	0.00	21.77	5	0	0	2.31	0.39	0.00	0.87	5	0	0	107.40	8.60	0.00	4.40	15	1	0	28.40	5.40	-2.21	3.52	15	0	0
S27/0614	SORENSON SHALLOW	184.00	11.50	0.00	26.23	4	0	0	2.07	0.63	0.00	1.96	4	0	0	47.00	6.00	0.00	5.52	15	0	0	22.50	7.50	-2.97	4.00	15	0	0
S27/0070	SOUTH FEATHERSTON SCHOOL	54.00	ND	ND	ND	1	0	0	1.08	ND	ND	ND	1	0	0	22.95	1.05	0.00	0.00	2	0	0	15.30	0.70	0.00	0.00	2	0	0
S27/0136	SUGRUE, O	130.00	ND	ND	ND	1	0	0	0.68	ND	ND	ND	1	0	0	10.80	0.20	0.00	0.00	2	0	0	32.95	7.05	0.00	0.00	2	0	0
S27/0396	SWDC MARTINBOROUGH	305.00	19.00	0.00	36.32	6	0	0	2.43	0.15	0.00	0.53	5	1	0	160.90	8.90	-2.56	3.16	25	0	0	24.00	4.20	0.00	2.55	25	0	0
S27/0588	SWDC PIRINOA	116.00	3.00	0.00	6.80	6	0	0	2.57	0.19	0.00	0.44	6	0	0	44.65	1.00	0.00	0.53	28	0	0	23.55	2.60	0.00	2.11	28	0	0
S27/0681	TE KAIRANGA NEW	273.00	15.00	0.00	146.89	3	0	0	3.30	0.08	-0.78	0.00	2	1	0	165.50	0.50	-5.14	0.00	2	1	0	21.50	0.50	-5.22	0.00	2	1	0
S27/0574	TE KAIRANGA WINES LTD	ND	ND	ND	ND	0	0	100	ND	ND	ND	ND	0	0	100	81.80	ND	ND	ND	1	0	0	33.10	ND	ND	ND	1	0	0
T26/0206	TOCHER, B	105.00	1.00	0.00	9.47	3	0	0	2.39	0.39	0.00	2.96	3	0	0	36.75	1.35	-0.74	0.79	22	4	0	26.00	1.20	0.00	1.09	22	4	0
T26/0430	TROUT HATCHERY	93.00	4.50	0.00	13.34	6	0	0	2.69	0.41	0.00	2.03	6	0	0	26.10	1.40	0.00	1.00	28	0	0	31.25	4.05	0.00	2.49	28	0	0
S27/0198	TUCKER, B	ND	ND	ND	ND	0	0	100	ND	ND	ND	ND	0	0	100	31.30	ND	ND	ND	1	0	0	23.80	ND	ND	ND	1	0	0
S27/0594	WARREN, H	289.00	4.00	0.00	10.33	5	0	0	2.02	0.23	0.00	0.91	5	0	0	139.40	1.80	0.99	0.99	15	0	0	12.70	3.70	0.00	2.24	15	0	0
S27/0602	WEATHERSTONE	228.00	8.00	0.00	17.06	5	0	0	3.06	0.20	0.00	0.69	5	0	0	101.15	5.85	0.00	3.24	16	0	0	22.10	4.50	-1.99	2.54	16	0	0
S26/0756	WENDON	164.00	12.00	30.38	6.70	5	0	0	3.26	1.50	0.00	3.39	5	0	0	93.50	2.30	0.00	1.22	15	1	0	42.70	4.25	0.00	2.65	16	0	0
R25/5135	WINDSOR PARK	360.00	10.00	0.00	3.52	29	1	0	1.62	0.59	0.00	1.40	5	0	0	120.00	0.00	0.00	0.00	16	15	0	12.00	1.00	0.00	3.95	5	0	0

Table 3: Bicarbonate, sulphate, chloride, bromide, fluoride

		HCO3							SO4							Cl							Br							F						
Well Number	Site	Med	MAD	Trend	TAD	#	Out	%BDL	Med	MAD	Trend	TAD	#	Out	%BDL	Med	MAD	Trend	TAD	#	Out	%BDL	Med	MAD	Trend	TAD	#	Out	%BDL	Med	MAD	Trend	TAD	#	Out	%BDL
S27/0268	BARTON, S.A	372.34	3.90	-1.67	2.47	16	0	0	0.09	0.07	-0.38	0.19	16	0	63	17.30	2.60	1.43	1.39	16	0	0	<0.05	ND	ND	ND	4	1	100	<0.05	ND	ND	ND	3	2	100
S27/0059	BERRY, D	106.63	ND	ND	ND	1	0	0	3.00	ND	ND	ND	1	0	0	12.20	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	ND	ND	ND	ND	0	0	100
T26/0087	BISS, D	53.00	3.78	0.00	4.75	4	0	0	5.70	0.15	0.00	0.77	4	0	0	8.00	1.15	0.00	1.78	4	0	0	<0.05	ND	ND	ND	3	0	100	0.12	0.02	0.00	0.28	3	0	33
S27/0495	BOSCH, F & W.M	192.64	5.98	-3.17	1.90	16	0	0	0.06	0.06	-0.08	0.08	11	5	64	162.70	4.85	0.00	3.79	16	0	0	0.55	0.03	0.00	0.11	4	1	0	0.18	0.01	0.00	0.04	4	1	0
S26/0117	BUTCHER, G	31.20	1.80	0.00	0.00	2	0	0	8.80	1.20	0.00	0.00	2	0	0	13.45	0.85	0.00	0.00	2	0	0	<0.05	ND	ND	ND	1	0	100	<0.05	ND	ND	ND	1	0	100
T26/0099	BUTCHER, M	36.00	0.50	0.00	1.37	4	0	0	7.45	0.35	0.00	0.73	4	0	0	12.85	0.60	0.00	3.49	4	0	0	0.05	ND	0.00	0.03	4	0	75	<0.05	ND	ND	ND	3	1	100
S27/0547	CAMPBELL	49.00	4.00	-3.70	0.59	3	0	0	5.10	0.00	0.00	0.00	2	1	0	31.20	3.10	0.00	0.63	3	0	0	0.08	ND	-0.28	0.00	2	0	50	<0.05	ND	ND	ND	2	0	100
R25/5164	CARD	130.00	10.00	3.98	5.58	28	2	0	12.00	3.00	0.00	2.32	29	1	0	120.00	20.00	0.00	16.08	30	0	0	0.35	0.05	0.00	0.03	30	0	0	0.23	0.03	0.01	0.01	28	2	0
S26/0824	CDC NORTHERN.	37.70	0.91	-0.63	0.56	28	0	0	9.30	0.70	0.00	0.56	28	0	0	13.10	0.30	0.15	0.21	27	1	0	0.04	0.02	0.00	0.06	6	0	50	0.16	0.02	0.00	0.07	6	0	0
S26/0705	CDC SOUTHERN	39.14	0.87	0.22	0.59	28	0	0	8.70	0.60	0.23	0.39	27	1	0	12.50	0.30	0.00	0.22	27	1	0	0.04	0.02	0.00	0.05	6	0	50	0.20	0.01	0.00	0.02	5	1	0
S25/5200	COMMON PROPERTY	83.00	0.70	0.00	0.41	21	6	0	3.70	0.10	0.00	0.04	24	3	0	37.00	0.10	0.00	0.10	23	4	0	0.14	0.00	0.00	0.00	23	3	0	0.25	0.01	0.00	0.00	24	1	0
S26/0547	CRAIG, E.J	34.40	ND	ND	ND	1	0	0	2.40	ND	ND	ND	1	0	0	6.50	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	ND	ND	ND	ND	0	0	100
S27/0202	CROAD, J.R & W.J	14.46	1.34	0.00	0.80	26	2	0	8.50	0.70	0.24	0.57	25	3	0	14.50	1.00	0.00	0.90	27	1	0	<0.05	ND	ND	ND	6	0	100	0.11	0.00	0.00	0.01	4	2	0
S26/0568	DENBEE, J.M	150.06	2.50	-1.12	0.98	16	0	0	0.39	0.35	-0.43	0.43	16	0	56	11.50	0.20	0.00	0.10	13	3	0	<0.05	ND	ND	ND	3	2	100	0.10	0.03	0.00	0.08	5	0	20
S27/0389	DIMATTINA, T	71.00	1.00	0.00	0.29	4	0	0	3.75	0.15	0.00	0.62	4	0	25	21.10	0.45	0.00	0.24	4	0	0	0.06	0.02	0.00	0.19	3	0	33	0.51	0.03	-0.26	0.10	3	0	0
S27/0009	DONDERTMAN, A	35.01	ND	ND	ND	1	0	0	6.40	ND	ND	ND	1	0	0	21.00	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	ND	ND	ND	ND	0	0	100
S26/0846	DRUZIANIC	39.00	ND	ND	ND	1	0	0	3.70	ND	ND	ND	1	0	0	6.10	ND	ND	ND	1	0	0	<0.05	ND	ND	ND	1	0	100	<0.05	ND	ND	ND	1	0	100
T26/0489	DUFFY	54.00	0.44	0.00	0.34	27	1	0	9.80	1.00	0.61	0.52	27	1	0	22.20	0.50	0.25	0.25	27	1	0	<0.05	ND	ND	ND	4	2	100	0.04	0.01	0.00	0.07	6	0	67
S27/0522	DUGGAN	122.00	1.00	0.00	4.83	3	0	0	37.60	2.10	0.00	10.14	3	0	0	159.00	1.00	0.00	0.00	2	1	0	<0.05	ND	ND	ND	2	1	100	0.30	0.05	-0.33	0.05	3	0	0
S26/0734	DYKSTRA, ENGBERT	23.18	ND	ND	ND	1	0	0	18.90	ND	ND	ND	1	0	0	18.50	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	ND	ND	ND	ND	0	0	100
T26/0332	EAST TARATAHI SHALLOW	45.50	0.50	-7.31	0.00	2	0	0	13.80	1.00	-14.61	0.00	2	0	0	28.15	0.25	0.00	0.00	2	0	0	<0.05	ND	ND	ND	2	0	100	0.25	0.03	-0.37	0.00	2	0	0
S27/0607	FINDLAYSON, K	240.58	3.69	-1.58	3.50	14	1	0	2.20	1.32	0.00	0.66	15	0	40	288.00	34.90	0.00	18.49	15	0	0	1.37	0.10	0.00	0.52	4	0	0	0.29	0.02	0.00	0.06	4	0	0
S26/0400	FITZGERALD DEEP	89.75	1.75	-0.72	0.00	2	0	0	4.20	3.40	-1.39	0.00	2	0	0	14.10	0.40	0.00	0.00	2	0	0	0.05	ND	ND	ND	1	0	0	0.10	ND	ND	ND	1	0	0
S26/0467	FITZGERALD SHALLOW	36.80	0.20	0.00	0.00	2	0	0	9.90	0.90	0.00	0.00	2	0	0	13.40	0.20	0.00	0.00	2	0	0	<0.05	ND	ND	ND	1	0	100	<0.05	ND	ND	ND	1	0	100
S27/0344	GEORGE, B	69.78	0.61	0.00	0.32	17	0	0	11.20	1.30	0.00	0.65	15	2	0	54.90	6.50	0.00	3.32	17	0	0	0.14	0.04	0.00	0.15	5	0	0	0.13	0.02	0.00	0.17	5	0	40
S26/0299	GRAHAM, D	15.68	1.68	0.00	1.37	28	0	0	8.95	2.05	0.54	1.07	28	0	7	10.15	1.00	0.00	0.86	28	0	0	<0.05	ND	ND	ND	5	1	100	0.07	0.02	0.00	0.06	6	0	50
S27/0141	HARVEY, A. & L.	99.92	ND	ND	ND	1	0	0	6.20	ND	ND	ND	1	0	0	12.50	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	ND	ND	ND	ND	0	0	100
R27/0320	IBM#1	52.00	1.00	0.00	0.42	36	7	0	2.80	0.10	0.00	0.04	46	5	0	25.00	0.60	0.00	0.23	51	1	0	0.09	0.00	0.00	0.00	30	22	0	0.14	0.00	0.00	0.00	28	21	0
R27/1265	IBM#2	30.00	2.00	0.00	0.73	38	2	0	4.40	0.20	0.05	0.08	40	8	0	14.00	0.00	0.00	0.00	29	19	0	0.06	0.00	0.00	0.00	31	17	0	0.18	0.00	0.00	0.00	25	21	0
S27/0299	JOHNSON, M.J & G	34.76	0.49	0.00	0.28	16	0	0	4.00	0.70	0.00	0.49	16	0	13	7.95	0.55	0.19	0.28	16	0	0	<0.05	ND	ND	ND	5	0	100	0.03	0.01	0.00	0.07	5	0	60
S27/0435	LANDCORP 'WAIRIO'	145.24	2.87	0.00	1.83	16	0	0	1.28	1.05	-0.37	0.59	16	0	56	34.75	1.15	0.00	0.80	16	0	0	0.12	0.01	0.00	0.09	4	1	0	0.30	0.03	0.00	0.08	5	0	0
T26/0003	LENTON	23.00	2.00	0.00	0.21	3	0	0	5.70	0.20	0.00	1.32	3	0	0	9.10	1.30	0.00	8.77	3	0	0	<0.05	ND	ND	ND	3	0	100	<0.05	ND	ND	ND	3	0	100
R26/6587	LIDDLE NURSERIES	22.00	1.00	0.00	0.57	43	2	0	7.10	0.80	0.13	0.29	44	1	0	17.00	1.00	0.05	0.32	45	0	0	0.07	0.01	0.00	0.00	42	0	5	0.08	0.01	0.00	0.00	42	0	5
S27/0571	M/B GOLF CLUB	47.00	0.00	0.00	0.00	3	1	0	8.30	0.60	0.00	0.55	4	0	0	25.25	1.35	0.00	1.54	4	0	0	<0.05	ND	ND	ND	2	1	100	0.28	0.03	-0.18	0.03	3	0	0
S27/0433	MAORI EDUCATION FOUNDATION	341.04	7.02	-3.34	4.00	16	0	0	0.18	0.14	-0.36	0.36	16	0	69	90.90	2.85	0.00	1.54	16	0	0	0.46	0.04	0.00	0.14	5	0	0	0.15	0.00	0.00	0.00	3	2	0
S27/0585	McCREARY, T.R	195.10	7.75	0.00	3.79	16	0	0	1.60	0.80	-0.27	0.32	15	1	13	53.00	1.65	0.00	0.91	16	0	0	0.14	0.03	0.00	0.15	5	0	0	0.55	0.01	0.00	0.02	3	2	0
T26/0326	MCKAY, N & SONS	88.57	ND	ND	ND	1	0	0	7.40	ND	ND	ND	1	0	0	19.70	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	ND	ND	ND	ND	0	0	100
S26/0576	MCNAMARA, J	96.93	0.98	-0.65	0.65	16	0	0	1.50	0.70	0.00	0.31	16	0	25	16.60	0.75	0.00	0.37	16	0	0	0.09	0.04	0.00	0.12	5	0	20	0.10	0.03	0.00	0.09	5	0	20
S26/0223	NICHOLSON	16.00	0.00	0.00	0.00	2	0	0	13.95	1.55	-22.65	0.00	2	0	0	18.60	0.90	0.00	0.00	2	0	0	<0.1	ND	ND	ND	2	0	100	<0.05	ND	ND	ND	2	0	100
R25/5100	O'MALLEY	110.00	0.00	0.00	0.00	17	13	0	1.95	0.70	0.14	0.26	30	0	17	34.00	1.00	0.46	0.33	28	2	0	0.16	0.01	0.00	0.00	27	3	0	0.14	0.00	0.00	0.00	26	2	0
S27/0106	O'NEALE	16.59	ND	ND	ND	1	0	0	10.30	ND	ND	ND	1	0	0	15.60	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	ND	ND	ND	ND	0	0	100
S27/0156	O'NEALE NEW	59.00	ND	ND	ND	1	0	0	3.30	ND	ND	ND	1	0	0	12.70	ND	ND	ND	1	0	0	<0.05	ND	ND	ND	1	0	100	0.25	ND	ND	ND	1	0	0
S27/0156	OP TRUST	44.00	5.00	0.00	3.28	31	4	0	7.50	1.10	0.00	0.68	35	0	0	11.00	1.90	0.00	0.85	35	0	0	0.01	0.01	0.00	0.00	34	1	59	0.05	0.01	0.00	0.00	33	0	9
T26/0259	OPAKI WATER SUP.	29.08	2.12	0.00	1.54	28	0	0	4.90	1.35	0.63	0.69	28	0	21	6.60	0.60	0.28	0.48	27	1	0	<0.05	ND	ND	ND	5	1	100	0.06	0.01	-0.05	0.03	6	0	50
S27/0283	OSBOURNE, A	163.05	15.19	-7.39	8.07	16	0	0	0.27	0.21	-0.36	0.36	16	0	75	32.60	4.35	0.00	1.91	16	0	0	0.10	0.02	0.00	0.07	4	1	0	0.19	0.01	0.00	0.02	4	1	0
S26/0457	PALMER	25.25	1.65	0.00	0.80	16	0	0	5.85	0.65	0.00	0.54	16	0	13	6.20	0.50	0.00	0.37	16	0	0	<0.05	ND	ND	ND	5	0	100	<0.05	ND	ND	ND	4	1	100
T26/0538	PERCY	41.24	2.93	-1.24	1.68	28	0	0	19.30	5.90	4.31	1.40	28	0	0	23.00	3.10	1.07	1.63	28	0	0	<0.05	ND	ND	ND	6	0	100	0.15	0.00	0.00	0.00	4	2	0
S26/0439	ROGERS, W	43.25	2.25	-0.93	0.00	2	0	0	10.40	0.80	0.00	0.00	2	0	0	14.65	0.45	-0.19	0.00	2	0	0	<0.05	ND	ND	ND	1	0	100	0.11	ND	ND	ND	1	0	0
R25/5165	SALTER	34.50	2.50	1.05	1.30	28	0	0	14.25	2.25	0.00	1.35	28	0	0	42.00	2.00	0.00	1.71	25	3	0	0.15	0.02	-0.01	0.01	26	2	4	0.14	0.01	0.00	0.01	27	1	0
S26/0762	SCHAEF, D	133.04	6.89	-3.20	2.15	16	0	0	1.43	1.16	-0.42	0.82	16	0	25	47.40	2.90	0.00	1.93	16	0	0	0.19	0.11	0.00	0.15	5	0	0	0.21	0.01	0.00	0.01	4	1	0
R27/1182	SEAVIEW WOOLS	59.75	2.95	0.89	0.89	46	0	0	8.60	0.40	0.09	0.27	56	1	0	18.00	0.00	0.00	0.06	43	14	0	0.10	0.00	0.00	0.00	35	22	0	0.08	0.01	0.00	0.00	51	0	4
T26/0413	SEYMOUR, B.J & R.H	94.00	0.50	-0.36	0.22	4	0	0	0.73	0.07	0.00	0.16	4	0	50	9.50	0.10	-0.04	0.01	3	1	0	<0.05	ND	ND	ND	2	1	100	0.13	0.04	0.00	0.39	3	0	33
R27/1171	SOMES ISLAND	54.00	2.00	0.69	0.69	22	1	0	1.20	0.87	-0.27	0.35	33	1	45	15.00	1.00	0.00	0.40	31	3	0	0.08	0.00	0.00	0.00	22	11	0	0.16	0.00	0.00	0.00	17	13	0
S27/0615	SORENSON DEEP	131.03	8.97	0.00	5.47	15	1	0	10.80	6.30	0.00	2.94	15	0	7	57.70	2.00	0.00	2.05	14	1	0	0.20	0.09	0.00	0.17	5	0	20	0.17	0.00	0.00	0.04	4	1	0
S27/0614	SORENSON SHALLOW	57.00	7.00	0.00	6.75	15	0	0	23.80	1.55	0.00	1.33	14	1	0	42.70	3.30	0.00	1.65	15	0	0	0.15	0.03	0.00	0.11	4	0	25	0.29	0.02	0.00	0.02	4	0	0
S27/0070	SOUTH FEATHERSTON SCHOOL	27.86	1.14	0.00	0.00	2	0	0	4.35	0.65	-0.27	0.00	2	0	0	8.00	0.50	0.00	0.00	2	0	0	<0.05	ND	ND	ND	1	0	100	<0.05	ND	ND	ND	1	0	100
S27/0136	SUGRUE, O	12.97	0.03	0.00	0.00	2	0	0	7.55	1.15	0.00	0.00	2	0	0	12.60	0.50	-0.21	0.00	2	0	0	<0.05	ND	ND	ND	1	0	100	<0.05	ND	ND	ND	1	0	100
S27/0396	SWDC MARTINBOROUGH	196.30	11.22	-3.14	3.75	25	0	0	22.00	4.70	2.36	0.89	25	0	0	33.80	1.40	0.84	0.92	24	1	0	0.01	0.01	0.00	0.04	5	1	60	0.13	0.00	0.00	0.01	4	2	0
S27/0588	SWDC PIRINOA	54.78	1.46	0.39	0.58	27	1	0	7.80	1.60	0.00	1.15	27	1	0	26.45	1.25	0.59	0.50	28	0	0	0.06	0.03	0.00	0.15	6	0	50	0.09	0.03	0.00	0.06	6	0	33
S27/0681	TE KAIRANGA NEW	201.50	0.50	-5.14	0.00	2	1	0	29.60	4.00	0.00	33.53	3	0	0	30.30	1.70	0.00	49.61	3	0	0	<0.05	ND	ND	ND	2	1	100	0.12	0.07	-0.43	0.06	3	0	33
S27/0574	TE KAIRANGA WINES LTD	99.80	ND	ND	ND	1	0	0	25.10	ND	ND	ND	1	0	0	39.90	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	ND	ND	ND	ND	0	0	100
T26/0206	TOCHER, B	44.84	1.65	-0.90	0.96	22	4	0	6.00	0.20	0.00	0.27	18	8	0	11.15	0.45	0.29	0.38	26	0	0	0.05	0.03	0.00	0.23	3	0	33	0.13	0.03	0.00	0.33	3	0	33
T26/0430	TROUT HATCHERY	31.84	1.71	0.00	1.27	28	0	0	4.55	0.90	0.40	0.61	28	0	14	7.00	0.90	0.44	0.58	27	1	0	<0.05	ND	ND	ND	6	0	100	<0.05	ND	ND	ND	4	2	100
S27/0198	TUCKER, B	38.19	ND	ND	ND	1	0	0	<5	ND	ND	ND	1	0	100	9.00	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	ND	ND	ND	ND	0	0	100
S27/0594	WARREN, H	170.07	2.20	1.08	1.08	15	0	0	0.01	0.01	0.00	0.16	11	4	64	76.20	3.10	0.79	1.56	15	0	0	0.29	0.08	0.00	0.18	5	0	0	0.26	0.04	0.00	0.08	5	0	0
S27/0602	WEATHERSTONE	123.18	7.70	0.00	3.92	16	0	0	1.00	0.41	-0.36	0.34	16	0	56	52.00	9.05	0.00	3.96	16	0	0	0.11	0.07	0.00	0.23	5	0	20	0.20	0.04	0.00	0.16	5	0	0
S26/0756	WENDON	114.07	2.81	0.00	1.49	15	1	0	7.30	1.35	0.00	1.30	16	0	6	17.10	1.30	0.63	0.79	15	1	0	<0.05	ND	ND	ND	3	2	100	0.10	0.00	0.00	0.00	3	2	0
R25/5135	WINDSOR PARK	120.00	0.00	-0.24	0.24	23	8	0	0.50	0.00	0.00	0.00	18	13	78	110.00	0.00	0.00	0.11	22	9	0	0.33	0.01	0.00	0.00	23	7	0	0.08	0.00	0.00	0.00	26	3	8

Table 4: Ammoniacal-nitrogen, nitrate, nitrite, phosphorus

		NH4							TON							NO3							NO2							PO4						
Well Number	Site	Med	MAD	Trend	TAD	#	Out	%BDL	Med	MAD	Trend	TAD	#	Out	%BDL	Med	MAD	Trend	TAD	#	Out	%BDL	Med	MAD	Trend	TAD	#	Out	%BDL	Med	MAD	Trend	TAD	#	Out	%BDL
S27/0268	BARTON, S.A	1.06	0.05	0.00	0.03	16	0	0	0.00	0.00	0.00	0.00	3	2	33	0.00	ND	0.00	0.00	13	3	92	<0.002	ND	ND	ND	9	7	100	0.31	0.13	-0.06	0.07	16	0	0
S27/0059	BERRY, D	0.39	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	<0.01	ND	ND	ND	1	0	100	0.00	ND	ND	ND	1	0	0	0.46	ND	ND	ND	1	0	0
T26/0087	BISS, D	0.01	ND	0.00	0.00	3	1	67	2.16	0.00	0.00	0.00	2	1	0	1.80	0.35	0.00	0.20	4	0	0	0.01	0.00	0.00	0.00	4	0	0	0.01	0.01	0.00	0.01	4	0	0
S27/0495	BOSCH, F & W.M	2.28	0.12	-0.04	0.04	16	0	0	0.00	0.00	0.00	0.00	4	1	25	0.00	0.00	0.00	0.00	15	1	87	0.00	0.00	0.00	0.00	14	2	50	0.85	0.21	-0.11	0.12	16	0	0
S26/0117	BUTCHER, G	<0.01	ND	ND	ND	2	0	100	4.49	ND	ND	ND	1	0	0	4.00	0.48	0.00	0.00	2	0	0	<0.002	ND	ND	ND	2	0	100	0.02	0.00	0.00	0.00	2	0	0
T26/0099	BUTCHER, M	<0.01	ND	ND	ND	3	1	100	7.52	0.21	0.00	0.65	4	0	0	7.51	0.21	0.00	0.66	4	0	0	<0.002	ND	ND	ND	3	1	100	0.02	0.00	0.00	0.00	3	1	0
S27/0547	CAMPBELL	<0.01	ND	ND	ND	2	1	100	7.64	0.37	0.00	0.00	2	0	0	7.46	0.19	0.00	0.13	3	0	0	<0.002	ND	ND	ND	3	0	100	0.02	0.00	0.00	0.00	3	0	0
R25/5164	CARD	0.17	0.03	-0.01	0.01	30	0	0	0.01	0.00	0.00	0.00	5	1	20	0.00	0.00	0.00	0.00	19	11	74	<0.002	ND	ND	ND	6	0	100	0.12	0.07	0.03	0.03	30	0	3
S26/0824	CDC NORTHERN.	<0.005	ND	ND	ND	16	12	100	6.62	0.07	-0.61	0.50	5	1	0	6.04	0.29	0.00	0.20	28	0	0	<0.002	ND	ND	ND	23	5	100	0.02	0.00	0.00	0.00	28	0	0
S26/0705	CDC SOUTHERN	<0.005	ND	ND	ND	18	10	100	4.64	0.10	0.00	0.22	6	0	0	4.97	0.45	-0.21	0.15	28	0	0	<0.002	ND	ND	ND	25	3	100	0.03	0.00	0.00	0.00	28	0	0
S25/5200	COMMON PROPERTY	<0.05	ND	ND	ND	17	9	100	0.02	0.01	0.00	0.03	5	0	20	0.01	ND	0.00	0.00	19	8	95	<0.002	ND	ND	ND	3	2	100	0.02	0.01	0.00	0.01	24	3	13
S26/0547	CRAIG, E.J	0.16	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	0.10	ND	ND	ND	1	0	0	0.01	ND	ND	ND	1	0	0	0.38	ND	ND	ND	1	0	0
S27/0202	CROAD, J.R & W.J	<0.005	ND	ND	ND	16	12	100	4.61	0.71	0.00	1.41	6	0	0	4.48	0.61	0.00	0.56	27	1	0	<0.002	ND	ND	ND	20	8	100	0.02	0.00	0.00	0.00	28	0	0
S26/0568	DENBEE, J.M	0.48	0.01	0.00	0.01	15	1	0	0.00	0.00	0.00	0.00	4	1	25	<0.002	ND	ND	ND	10	6	100	0.00	0.00	0.00	0.00	16	0	13	1.18	0.28	-0.17	0.13	16	0	0
S27/0389	DIMATTINA, T	0.20	0.00	0.00	0.00	3	1	0	<0.002	ND	ND	ND	2	1	100	<0.002	ND	ND	ND	3	1	100	<0.002	ND	ND	ND	4	0	100	1.20	0.03	-0.04	0.02	4	0	0
S27/0009	DONDERTMAN, A	<0.005	ND	ND	ND	1	0	100	ND	ND	ND	ND	0	0	100	7.48	ND	ND	ND	1	0	0	<0.002	ND	ND	ND	1	0	100	0.02	ND	ND	ND	1	0	0
S26/0846	DRUZIANIC	0.01	ND	ND	ND	1	0	0	0.75	ND	ND	ND	1	0	0	0.75	ND	ND	ND	1	0	0	0.00	ND	ND	ND	1	0	0	0.02	ND	ND	ND	1	0	0
T26/0489	DUFFY	<0.005	ND	ND	ND	19	9	100	10.65	0.55	0.00	1.44	6	0	0	10.65	0.45	0.00	0.27	27	1	0	<0.002	ND	ND	ND	24	4	100	0.02	0.00	0.00	0.00	26	2	0
S27/0522	DUGGAN	<0.01	ND	ND	ND	3	0	100	3.18	0.26	0.00	1.43	3	0	0	3.18	0.26	0.00	1.43	3	0	0	<0.002	ND	ND	ND	3	0	100	0.01	0.00	0.00	0.00	2	1	0
S26/0734	DYKSTRA, ENGBERT	<0.005	ND	ND	ND	1	0	100	ND	ND	ND	ND	0	0	100	5.28	ND	ND	ND	1	0	0	0.01	ND	ND	ND	1	0	0	0.01	ND	ND	ND	1	0	0
T26/0332	EAST TARATAHI SHALLOW	0.04	ND	0.00	0.00	2	0	50	1.24	0.05	-0.66	0.00	2	0	0	1.24	0.05	-0.66	0.00	2	0	0	0.00	0.00	-0.01	0.00	2	0	0	0.05	0.00	0.00	0.00	2	0	0
S27/0607	FINDLAYSON, K	9.33	0.77	0.00	0.37	15	0	0	0.00	0.00	0.00	0.02	3	1	33	<0.002	ND	ND	ND	8	7	100	0.00	0.00	0.00	0.00	12	3	50	3.37	0.19	0.00	0.24	11	4	0
S26/0400	FITZGERALD DEEP	0.77	0.00	0.00	0.00	2	0	0	0.00	ND	ND	ND	1	0	0	<0.01	ND	ND	ND	2	0	100	0.00	0.00	0.00	0.00	2	0	0	0.85	0.55	-0.22	0.00	2	0	0
S26/0467	FITZGERALD SHALLOW	0.01	ND	0.00	0.00	2	0	50	4.01	ND	ND	ND	1	0	0	3.94	0.07	0.00	0.00	2	0	0	<0.002	ND	ND	ND	2	0	100	0.02	0.00	0.00	0.00	2	0	0
S27/0344	GEORGE, B	0.08	0.01	0.00	0.00	17	0	0	0.02	0.01	0.00	0.02	4	1	0	0.00	0.00	0.00	0.00	14	3	71	<0.002	ND	ND	ND	12	5	100	0.05	0.01	0.00	0.01	17	0	0
S26/0299	GRAHAM, D	<0.005	ND	ND	ND	17	11	100	7.09	1.83	0.00	2.81	6	0	0	5.48	1.58	0.00	0.75	28	0	0	<0.002	ND	ND	ND	20	8	100	0.02	0.00	0.00	0.00	25	3	0
S27/0141	HARVEY, A. & L.	0.12	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	<0.002	ND	ND	ND	1	0	100	<0.002	ND	ND	ND	1	0	100	0.17	ND	ND	ND	1	0	0
R27/0320	IBM#1	0.11	0.01	0.00	0.00	38	4	0	0.01	ND	0.00	0.01	4	2	75	<0.01	ND	ND	ND	25	18	100	<0.002	ND	ND	ND	6	0	100	0.12	0.02	0.00	0.01	43	1	0
R27/1265	IBM#2	<0.05	ND	ND	ND	30	9	100	0.25	0.01	0.00	0.03	6	0	0	0.08	0.07	0.02	0.02	40	0	0	<0.002	ND	ND	ND	5	1	100	0.01	0.00	0.00	0.00	22	18	0
S27/0299	JOHNSON, M.J & G	<0.005	ND	ND	ND	9	7	100	0.17	0.02	0.00	0.02	5	0	0	0.15	0.01	0.01	0.01	14	2	0	<0.002	ND	ND	ND	14	2	100	0.01	0.00	0.00	0.00	16	0	0
S27/0435	LANDCORP 'WAIRIO'	7.81	0.27	0.00	0.16	16	0	0	0.01	0.00	0.00	0.00	4	1	0	0.00	0.00	0.00	0.00	14	2	64	<0.002	ND	ND	ND	9	7	100	5.13	0.23	-0.32	0.36	15	1	0
T26/0003	LENTON	<0.01	ND	ND	ND	2	1	100	4.38	0.45	0.00	4.77	3	0	0	4.37	0.46	0.00	4.80	3	0	0	<0.002	ND	ND	ND	3	0	100	0.02	0.00	0.00	0.02	3	0	0
R26/6587	LIDDLE NURSERIES	<0.05	ND	ND	ND	34	9	100	0.77	0.06	0.00	0.23	4	1	0	0.76	0.24	0.00	0.09	45	0	0	<0.002	ND	ND	ND	5	0	100	<0.01	ND	ND	ND	25	19	100
S27/0571	M/B GOLF CLUB	0.01	ND	0.00	0.00	3	1	67	7.26	0.05	-0.51	0.00	2	1	0	8.20	0.94	-0.45	0.22	4	0	0	<0.002	ND	ND	ND	4	0	100	0.02	0.00	0.00	0.00	4	0	0
S27/0433	MAORI EDUCATION FOUNDATIO	7.35	0.17	0.00	0.11	16	0	0	0.00	0.00	0.00	0.01	4	1	25	0.00	0.00	0.00	0.00	14	2	79	0.00	0.00	0.00	0.00	11	5	73	2.20	0.09	0.00	0.12	11	5	0
S27/0585	McCREARY, T.R	0.75	0.04	-0.02	0.02	16	0	0	0.00	0.00	0.00	0.01	4	1	25	0.00	0.00	0.00	0.00	14	2	79	0.00	0.00	0.00	0.00	16	0	38	0.35	0.09	-0.05	0.04	16	0	0
T26/0326	MCKAY, N & SONS	0.18	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	<0.002	ND	ND	ND	1	0	100	0.00	ND	ND	ND	1	0	0	0.21	ND	ND	ND	1	0	0
S26/0576	MCNAMARA, J	0.34	0.04	0.00	0.02	16	0	0	0.00	0.00	0.00	0.00	5	0	20	0.00	0.00	0.00	0.00	12	4	67	<0.002	ND	ND	ND	12	4	100	0.58	0.15	-0.06	0.06	16	0	0
S26/0223	NICHOLSON	0.03	ND	-0.15	0.00	2	0	50	11.45	0.15	0.00	0.00	2	0	0	11.45	0.15	0.00	0.00	2	0	0	<0.02	ND	ND	ND	2	0	100	0.02	ND	0.00	0.00	2	0	50
R25/5100	O'MALLEY	0.19	0.01	0.00	0.01	27	1	0	0.02	0.01	0.00	0.02	5	0	0	<0.01	ND	ND	ND	20	10	100	0.00	0.00	0.00	0.00	5	0	40	<0.01	ND	ND	ND	22	8	100
S27/0106	O'NEALE	0.01	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	7.44	ND	ND	ND	1	0	0	<0.002	ND	ND	ND	1	0	100	0.01	ND	ND	ND	1	0	0
S27/0156	O'NEALE NEW	0.03	ND	ND	ND	1	0	0	0.01	ND	ND	ND	1	0	0	0.01	ND	ND	ND	1	0	0	<0.002	ND	ND	ND	1	0	100	0.06	ND	ND	ND	1	0	0
S27/0156	OP TRUST	<0.05	ND	ND	ND	29	6	100	2.64	0.04	0.00	0.19	4	2	0	1.70	0.76	0.00	0.31	35	0	0	<0.002	ND	ND	ND	6	0	100	0.01	0.00	0.00	0.00	35	0	31
T26/0259	OPAKI WATER SUP.	<0.005	ND	ND	ND	21	7	100	1.97	0.86	0.00	1.08	6	0	0	0.86	0.34	0.00	0.26	27	1	0	<0.002	ND	ND	ND	27	1	100	0.01	0.00	0.00	0.00	26	2	0
S27/0283	OSBOURNE, A	0.99	0.04	-0.01	0.02	16	0	0	0.01	0.01	0.00	0.02	5	0	0	0.00	0.00	0.00	0.00	12	4	67	0.00	0.00	0.00	0.00	14	2	21	0.28	0.23	0.00	0.09	16	0	0
S26/0457	PALMER	<0.005	ND	ND	ND	9	7	100	1.25	0.81	0.00	1.01	5	0	0	1.16	0.47	0.00	0.27	16	0	0	<0.002	ND	ND	ND	15	1	100	0.01	0.00	0.00	0.00	14	2	0
T26/0538	PERCY	<0.005	ND	ND	ND	19	9	100	12.30	0.95	0.00	3.36	6	0	0	10.43	2.13	0.53	0.97	28	0	0	<0.002	ND	ND	ND	26	2	100	0.01	0.00	0.00	0.00	26	2	0
S26/0439	ROGERS, W	0.01	ND	0.00	0.00	2	0	50	3.51	ND	ND	ND	1	0	0	3.79	0.28	-0.12	0.00	2	0	0	<0.002	ND	ND	ND	2	0	100	0.03	0.00	0.00	0.00	2	0	0
R25/5165	SALTER	0.29	0.04	0.00	0.03	28	0	0	0.03	0.01	0.00	0.01	4	2	0	0.04	0.03	0.00	0.04	19	9	26	0.00	0.00	0.00	0.00	5	1	0	<0.01	ND	ND	ND	19	9	100
S26/0762	SCHAEF, D	0.55	0.02	0.00	0.01	16	0	0	0.03	0.01	0.00	0.02	5	0	0	0.00	0.00	0.00	0.00	15	1	60	0.00	0.00	0.00	0.00	14	2	14	0.91	0.05	0.00	0.05	11	5	0
R27/1182	SEAVIEW WOOLS	<0.05	ND	ND	ND	36	9	100	0.89	0.02	0.00	0.07	6	0	0	0.84	0.07	0.02	0.03	40	6	0	0.01	0.00	0.00	0.00	6	0	0	0.01	ND	0.00	0.00	40	6	98
T26/0413	SEYMOUR, B.J & R.H	0.04	0.00	0.00	0.00	3	1	0	<0.002	ND	ND	ND	2	1	100	<0.002	ND	ND	ND	3	1	100	<0.002	ND	ND	ND	3	1	100	0.02	0.00	0.00	0.01	4	0	0
R27/1171	SOMES ISLAND	0.31	0.04	0.00	0.03	22	0	0	0.00	ND	0.00	0.00	2	0	50	<0.01	ND	ND	ND	12	11	100	<0.002	ND	ND	ND	2	0	100	0.02	0.01	-0.01	0.01	23	1	35
S27/0615	SORENSON DEEP	0.82	0.05	0.00	0.03	15	0	0	0.02	0.01	0.00	0.03	4	1	0	0.00	0.00	0.00	0.00	12	3	67	<0.002	ND	ND	ND	8	7	100	0.68	0.04	0.00	0.04	10	5	0
S27/0614	SORENSON SHALLOW	0.41	0.04	-0.02	0.02	15	0	0	0.01	0.00	0.00	0.01	3	1	0	0.00	0.00	0.00	0.00	13	2	69	0.00	0.00	0.00	0.00	14	1	50	0.55	0.18	-0.10	0.08	15	0	0
S27/0070	SOUTH FEATHERSTON SCHOOL	0.02	ND	0.00	0.00	2	0	50	0.29	ND	ND	ND	1	0	0	0.22	0.07	0.00	0.00	2	0	0	<0.002	ND	ND	ND	2	0	100	0.01	0.00	0.00	0.00	2	0	0
S27/0136	SUGRUE, O	0.02	ND	0.00	0.00	2	0	50	8.60	ND	ND	ND	1	0	0	6.38	2.22	0.00	0.00	2	0	0	<0.002	ND	ND	ND	2	0	100	0.01	0.00	0.00	0.00	2	0	0
S27/0396	SWDC MARTINBOROUGH	0.00	0.00	0.00	0.00	20	5	65	0.90	0.45	0.00	0.84	6	0	0	0.14	0.09	0.00	0.06	22	3	5	<0.002	ND	ND	ND	19	6	100	0.02	0.00	0.00	0.00	23	2	0
S27/0588	SWDC PIRINOA	0.10	0.01	0.00	0.00	26	2	0	0.01	0.01	0.00	0.01	6	0	0	0.00	0.00	0.00	0.00	26	2	62	0.00	0.00	0.00	0.00	27	1	33	0.16	0.01	0.00	0.01	20	8	0
S27/0681	TE KAIRANGA NEW	<0.01	ND	ND	ND	2	1	100	1.51	0.21	0.00	3.58	3	0	0	1.51	0.21	0.00	3.59	3	0	0	0.00	0.00	0.00	0.00	2	1	0	0.02	0.00	0.00	0.01	3	0	0
S27/0574	TE KAIRANGA WINES LTD	0.02	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	1.59	ND	ND	ND	1	0	0	0.00	ND	ND	ND	1	0	0	0.05	ND	ND	ND	1	0	0
T26/0206	TOCHER, B	<0.005	ND	ND	ND	20	6	100	1.71	0.01	-0.07	0.00	2	1	0	5.53	0.46	0.18	0.35	22	4	0	<0.002	ND	ND	ND	18	8	100	0.02	0.00	0.00	0.00	22	4	0
T26/0430	TROUT HATCHERY	<0.005	ND	ND	ND	20	8	100	4.16	0.65	0.00	2.11	6	0	0	2.23	0.95	0.00	0.49	28	0	0	<0.002	ND	ND	ND	28	0	100	0.01	0.00	0.00	0.00	26	2	0
S27/0198	TUCKER, B	0.02	ND	ND	ND	1	0	0	ND	ND	ND	ND	0	0	100	<0.002	ND	ND	ND	1	0	100	0.01	ND	ND	ND	1	0	0	0.18	ND	ND	ND	1	0	0
S27/0594	WARREN, H	0.75	0.03	0.00	0.01	15	0	0	<0.002	ND	ND	ND	3	2	100	0.00	0.00	0.00	0.00	13	2	77	<0.002	ND	ND	ND	11	4	100	0.64	0.02	0.00	0.02	10	5	0
S27/0602	WEATHERSTONE	2.46	0.13	0.00	0.08	16	0	0	0.00	0.00	0.00	0.01	4	1	50	0.00	0.00	0.00	0.00	14	2	71	0.00	0.00	0.00	0.00	13	3	62	1.93	0.35	-0.13	0.17	16	0	0
S26/0756	WENDON	0.08	0.03	0.00	0.02	14	2	0	0.01	0.01	0.00	0.00	4	1	0	0.00	0.00	0.00	0.00	13	3	54	0.00	0.00	0.00	0.00	16	0	25	0.14	0.05	-0.02	0.03	15	1	0
R25/5135	WINDSOR PARK	0.30	0.01	0.00	0.00	23	5	0	<0.002	ND	ND	ND	3	2	100	<0.01	ND	ND	ND	21	10	100	0.00	0.00	0.00	0.00	5	0	40	0.11	0.05	0.00	0.02	31	0	3

Table 5: Silica, Calcium, magnesium, hardness, sodium

		SiO2							Ca							Mg							Hardness							Na						
Well Number	Site	Med	MAD	Trend	TAD	#	Out	%BDL	Med	MAD	Trend	TAD	#	Out	%BDL	Med	MAD	Trend	TAD	#	Out	%BDL	Med	MAD	Trend	TAD	#	Out	%BDL	Med	MAD	Trend	TAD	#	Out	%BDL
S27/0268	BARTON, S.A	28.60	0.40	0.00	1.44	5	0	0	52.50	1.40	0.00	1.19	16	0	0	22.00	0.80	0.00	0.65	16	0	0	221.90	4.90	0.00	2.04	16	0	0	48.25	0.95	0.00	0.59	16	0	0
S27/0059	BERRY, D	ND	ND	ND	ND	0	0	100	14.60	ND	ND	ND	1	0	0	5.80	ND	ND	ND	1	0	0	60.10	ND	ND	ND	1	0	0	23.00	ND	ND	ND	1	0	0
T26/0087	BISS, D	13.00	0.20	0.00	1.33	3	0	0	11.15	0.85	0.00	1.53	4	0	0	2.79	0.19	0.00	0.39	4	0	0	38.50	1.40	0.00	4.10	4	0	0	11.40	0.00	0.00	2.85	3	1	0
S27/0495	BOSCH, F & W.M	30.30	0.15	0.00	0.59	4	1	0	39.30	2.95	0.00	1.66	16	0	0	14.00	0.60	-0.46	0.48	15	1	0	160.60	7.60	-3.72	3.72	16	0	0	97.25	2.75	0.00	1.69	16	0	0
S26/0117	BUTCHER, G	16.60	ND	ND	ND	1	0	0	10.50	0.10	0.00	0.00	2	0	0	3.01	0.91	0.00	0.00	2	0	0	38.80	4.20	0.00	0.00	2	0	0	10.90	0.60	0.00	0.00	2	0	0
T26/0099	BUTCHER, M	18.70	0.25	0.00	1.17	4	0	0	10.30	0.10	-0.28	0.08	3	1	0	5.82	0.01	0.00	0.13	3	1	0	50.00	0.00	0.00	0.60	3	1	0	13.75	0.35	0.00	2.33	4	0	0
S27/0547	CAMPBELL	22.50	0.30	-3.09	0.00	2	0	0	22.90	0.40	0.00	0.48	3	0	0	2.48	0.11	0.00	0.02	3	0	0	68.30	0.30	-0.10	0.00	2	1	0	21.50	0.50	0.00	0.12	3	0	0
R25/5164	CARD	26.90	0.10	-1.82	0.91	5	1	0	43.50	7.00	0.00	5.90	30	0	0	11.00	1.00	0.00	0.84	27	3	0	152.50	22.50	0.00	18.38	30	0	0	66.00	7.00	0.00	4.42	29	0	0
S26/0824	CDC NORTHERN.	24.00	0.45	0.00	3.07	6	0	0	10.90	0.85	0.00	0.49	28	0	0	4.72	0.50	0.00	0.37	28	0	0	46.10	1.50	-0.78	0.78	27	1	0	16.00	0.50	-0.26	0.26	28	0	0
S26/0705	CDC SOUTHERN	26.10	0.60	0.00	2.42	6	0	0	9.80	0.70	0.00	0.48	28	0	0	3.93	0.27	0.00	0.22	28	0	0	40.45	1.65	-0.65	0.95	28	0	0	17.10	0.55	-0.34	0.31	28	0	0
S25/5200	COMMON PROPERTY	38.20	1.10	0.00	3.77	5	0	0	11.20	0.80	0.16	0.22	27	0	0	8.00	0.17	0.00	0.05	27	0	0	61.00	2.00	0.31	0.56	27	0	0	31.00	0.00	0.00	0.00	14	13	0
S26/0547	CRAIG, E.J	ND	ND	ND	ND	0	0	100	7.30	ND	ND	ND	1	0	0	2.30	ND	ND	ND	1	0	0	27.60	ND	ND	ND	1	0	0	6.40	ND	ND	ND	1	0	0
S27/0202	CROAD, J.R & W.J	14.70	0.20	0.00	0.51	6	0	0	9.20	1.20	0.00	0.65	28	0	0	3.00	0.60	0.00	0.31	28	0	0	35.10	2.50	0.00	1.80	28	0	0	11.50	0.50	0.00	0.33	28	0	0
S26/0568	DENBEE, J.M	36.50	2.00	0.00	7.07	5	0	0	21.40	0.40	0.00	0.60	14	2	0	9.16	0.54	-0.31	0.21	15	1	0	93.30	3.10	-1.29	1.33	16	0	0	22.00	1.00	0.00	0.41	16	0	0
S27/0389	DIMATTINA, T	35.60	0.00	0.00	0.00	2	1	0	7.66	0.26	0.00	0.06	4	0	0	4.55	0.06	0.00	0.35	4	0	0	37.80	1.00	0.00	2.99	4	0	0	25.75	1.15	0.00	3.21	4	0	0
S27/0009	DONDERTMAN, A	ND	ND	ND	ND	0	0	100	14.00	ND	ND	ND	1	0	0	3.80	ND	ND	ND	1	0	0	50.70	ND	ND	ND	1	0	0	19.50	ND	ND	ND	1	0	0
S26/0846	DRUZIANIC	15.30	ND	ND	ND	1	0	0	8.29	ND	ND	ND	1	0	0	2.16	ND	ND	ND	1	0	0	30.00	ND	ND	ND	1	0	0	7.81	ND	ND	ND	1	0	0
T26/0489	DUFFY	31.15	0.55	0.00	1.79	6	0	0	26.65	0.65	0.00	0.54	28	0	0	4.30	0.30	0.00	0.25	28	0	0	83.80	2.20	0.00	1.74	28	0	0	19.00	0.50	0.00	0.30	27	1	0
S27/0522	DUGGAN	23.20	0.00	0.00	0.00	2	1	0	30.30	0.60	0.00	5.37	3	0	0	17.45	0.15	-1.54	0.00	2	1	0	144.00	5.00	-22.70	5.47	3	0	0	96.20	2.70	0.00	22.85	3	0	0
S26/0734	DYKSTRA, ENGBERT	ND	ND	ND	ND	0	0	100	11.60	ND	ND	ND	1	0	0	2.90	ND	ND	ND	1	0	0	40.90	ND	ND	ND	1	0	0	19.00	ND	ND	ND	1	0	0
T26/0332	EAST TARATAHI SHALLOW	40.15	0.35	0.00	0.00	2	0	0	11.00	0.30	0.00	0.00	2	0	0	4.82	0.06	0.00	0.00	2	0	0	47.00	1.00	0.00	0.00	2	0	0	20.15	1.45	0.00	0.00	2	0	0
S27/0607	FINDLAYSON, K	37.50	0.40	0.00	0.05	3	1	0	47.40	3.50	0.00	2.39	15	0	0	20.60	3.20	0.00	2.25	15	0	0	202.00	22.20	0.00	13.09	15	0	0	168.00	9.00	0.00	4.71	15	0	0
S26/0400	FITZGERALD DEEP	40.40	ND	ND	ND	1	0	0	12.95	0.85	-0.35	0.00	2	0	0	5.41	0.40	-0.16	0.00	2	0	0	54.70	3.70	-1.51	0.00	2	0	0	16.70	0.80	-0.33	0.00	2	0	0
S26/0467	FITZGERALD SHALLOW	20.80	ND	ND	ND	1	0	0	8.36	0.45	-0.18	0.00	2	0	0	2.34	0.84	0.00	0.00	2	0	0	30.65	2.35	0.00	0.00	2	0	0	18.60	1.40	-0.57	0.00	2	0	0
S27/0344	GEORGE, B	24.00	0.40	0.00	1.38	5	0	0	17.20	1.40	0.00	0.85	17	0	0	7.19	0.71	0.00	0.45	17	0	0	71.30	3.70	0.00	2.82	17	0	0	33.00	2.00	0.00	1.07	17	0	0
S26/0299	GRAHAM, D	12.80	0.15	0.00	0.52	6	0	0	9.85	0.76	0.00	0.40	28	0	0	3.36	0.65	0.00	0.39	28	0	0	38.55	2.85	-0.74	2.03	28	0	0	9.00	0.55	0.00	0.33	28	0	0
S27/0141	HARVEY, A. & L.	ND	ND	ND	ND	0	0	100	13.60	ND	ND	ND	1	0	0	6.10	ND	ND	ND	1	0	0	59.10	ND	ND	ND	1	0	0	24.50	ND	ND	ND	1	0	0
R27/0320	IBM#1	19.80	0.80	0.00	0.18	15	0	0	3.93	0.33	0.06	0.12	43	0	0	2.10	0.04	0.00	0.02	42	1	0	19.00	1.00	0.00	0.42	52	0	0	30.00	0.20	0.00	0.25	40	2	0
R27/1265	IBM#2	18.00	0.00	0.00	0.00	8	6	0	4.15	0.25	0.06	0.12	39	1	0	2.40	0.10	0.00	0.04	39	1	0	20.00	1.00	0.00	0.44	47	1	0	13.30	0.70	0.00	0.35	38	1	0
S27/0299	JOHNSON, M.J & G	14.40	0.10	0.00	0.57	5	0	0	6.44	0.16	0.00	0.20	14	2	0	2.44	0.19	0.00	0.19	14	2	0	26.00	1.00	0.00	0.57	14	2	0	7.49	0.11	0.07	0.07	16	0	0
S27/0435	LANDCORP 'WAIRIO'	38.50	0.50	0.00	0.91	5	0	0	14.40	0.80	0.00	0.77	16	0	0	6.31	0.85	-0.23	0.33	16	0	0	63.05	2.05	-0.83	1.16	16	0	0	38.00	1.95	-0.61	0.79	16	0	0
T26/0003	LENTON	12.20	0.10	0.00	1.19	3	0	0	7.66	0.03	0.00	0.76	3	0	0	2.40	0.06	0.00	0.59	3	0	0	29.00	0.00	0.00	0.00	2	1	0	7.86	0.04	0.00	0.00	2	1	0
R26/6587	LIDDLE NURSERIES	13.40	0.30	0.00	0.77	5	0	0	6.70	0.50	0.16	0.25	45	0	0	2.41	0.19	0.00	0.08	44	1	0	27.00	2.00	0.38	0.81	43	1	0	12.00	0.30	0.00	0.23	43	1	0
S27/0571	M/B GOLF CLUB	27.20	0.00	0.00	0.00	2	1	0	12.50	0.80	0.00	1.51	4	0	0	5.15	0.12	0.00	0.39	4	0	0	53.45	2.50	0.00	5.32	4	0	0	25.90	1.50	0.00	1.11	4	0	0
S27/0433	MAORI EDUCATION FOUND	39.85	0.10	0.00	0.21	4	1	0	51.65	1.85	0.00	0.81	16	0	0	21.05	1.45	0.00	1.19	16	0	0	217.30	8.95	0.00	5.74	16	0	0	72.85	2.60	0.00	1.09	16	0	0
S27/0585	McCREARY, T.R	24.70	0.60	0.00	1.10	5	0	0	17.85	2.80	0.00	1.50	16	0	0	12.05	1.00	-0.36	0.64	16	0	0	97.90	5.35	-2.24	3.35	16	0	0	64.75	1.90	0.00	1.24	16	0	0
T26/0326	MCKAY, N & SONS	ND	ND	ND	ND	0	0	100	11.70	ND	ND	ND	1	0	0	8.30	ND	ND	ND	1	0	0	63.30	ND	ND	ND	1	0	0	25.00	ND	ND	ND	1	0	0
S26/0576	MCNAMARA, J	34.60	1.50	0.00	5.81	5	0	0	14.85	0.45	0.00	0.34	16	0	0	5.59	0.32	0.00	0.19	16	0	0	60.45	2.00	-0.91	1.10	16	0	0	20.75	0.75	-0.41	0.41	16	0	0
S26/0223	NICHOLSON	16.50	0.40	0.00	0.00	2	0	0	13.35	0.85	0.00	0.00	2	0	0	6.36	0.25	0.00	0.00	2	0	0	59.50	3.50	0.00	0.00	2	0	0	14.60	1.90	0.00	0.00	2	0	0
R25/5100	O'MALLEY	37.30	1.70	0.00	4.28	5	0	0	10.00	0.25	0.08	0.15	28	2	0	12.00	0.00	0.00	0.00	18	12	0	75.00	3.00	0.63	0.69	30	0	0	31.00	1.00	0.22	0.22	30	0	0
S27/0106	O'NEALE	ND	ND	ND	ND	0	0	100	8.90	ND	ND	ND	1	0	0	5.20	ND	ND	ND	1	0	0	43.60	ND	ND	ND	1	0	0	13.00	ND	ND	ND	1	0	0
S27/0156	O'NEALE NEW	23.50	ND	ND	ND	1	0	0	7.36	ND	ND	ND	1	0	0	2.86	ND	ND	ND	1	0	0	30.00	ND	ND	ND	1	0	0	17.70	ND	ND	ND	1	0	0
S27/0156	OP TRUST	14.20	0.30	0.00	0.44	5	1	0	10.50	1.50	0.00	0.83	35	0	0	2.81	0.48	0.00	0.24	35	0	0	38.00	6.00	0.00	3.09	35	0	0	16.50	5.50	0.00	3.04	34	0	0
T26/0259	OPAKI WATER SUP.	9.35	0.05	0.00	0.06	4	2	0	9.25	1.05	0.00	0.58	28	0	0	1.75	0.26	0.00	0.18	28	0	0	28.90	2.25	0.00	1.77	28	0	0	5.65	0.55	0.00	0.23	28	0	0
S27/0283	OSBOURNE, A	34.50	0.40	0.00	0.82	5	0	0	18.00	2.35	0.00	1.04	16	0	0	8.20	1.00	-0.43	0.40	16	0	0	79.20	7.35	-3.18	3.80	16	0	0	37.50	4.75	-2.02	1.06	16	0	0
S26/0457	PALMER	8.80	0.20	0.00	0.88	5	0	0	8.07	0.58	0.22	0.22	16	0	0	1.68	0.17	0.00	0.16	14	2	0	26.40	1.75	0.78	0.98	16	0	0	5.40	0.10	0.08	0.08	15	1	0
T26/0538	PERCY	18.50	0.20	0.00	0.64	6	0	0	24.80	1.35	1.09	0.85	28	0	0	5.95	0.65	0.33	0.40	28	0	0	86.65	4.90	3.98	2.22	28	0	0	18.10	1.10	0.29	0.61	28	0	0
S26/0439	ROGERS, W	22.90	ND	ND	ND	1	0	0	11.95	1.15	-0.47	0.00	2	0	0	4.35	0.45	0.00	0.00	2	0	0	47.80	0.80	-0.33	0.00	2	0	0	14.40	0.60	-0.25	0.00	2	0	0
R25/5165	SALTER	34.00	2.25	0.00	2.53	6	0	0	8.50	0.70	0.00	0.68	27	1	0	4.30	0.60	-0.19	0.32	28	0	0	40.00	3.00	0.00	2.87	27	1	0	30.00	1.00	0.00	0.79	25	2	0
S26/0762	SCHAEF, D	23.10	0.60	0.00	2.57	5	0	0	23.10	2.15	-0.86	0.93	16	0	0	6.90	0.79	0.00	0.45	15	1	0	88.75	5.70	-2.59	3.03	16	0	0	36.40	1.60	-0.76	0.94	16	0	0
R27/1182	SEAVIEW WOOLS	18.00	1.00	0.00	0.30	16	1	0	10.75	0.75	0.19	0.19	48	0	0	5.97	0.17	0.06	0.06	48	0	0	51.00	3.00	0.77	0.77	57	0	0	18.00	0.70	0.16	0.16	47	0	0
T26/0413	SEYMOUR, B.J & R.H	21.15	0.05	0.00	0.00	2	1	0	13.00	0.30	0.00	2.38	3	1	0	5.16	0.01	0.00	1.44	3	1	0	54.30	0.50	0.00	1.62	4	0	0	16.45	0.60	0.00	0.70	4	0	0
R27/1171	SOMES ISLAND	23.00	1.00	0.00	0.58	10	1	0	4.85	0.55	0.17	0.20	26	0	0	4.60	0.10	0.04	0.06	25	1	0	31.00	2.00	0.59	0.78	34	0	0	18.00	0.00	0.00	0.00	17	8	0
S27/0615	SORENSON DEEP	49.60	0.80	0.00	2.56	5	0	0	23.10	1.10	0.00	0.71	15	0	0	7.10	1.00	0.00	0.66	15	0	0	88.20	5.80	0.00	3.51	15	0	0	51.50	1.50	0.00	0.93	15	0	0
S27/0614	SORENSON SHALLOW	30.65	0.50	0.00	1.56	4	0	0	12.40	2.40	0.00	1.47	15	0	0	5.10	0.90	0.00	0.52	15	0	0	50.00	8.00	0.00	4.60	15	0	0	36.00	2.30	-0.99	1.52	15	0	0
S27/0070	SOUTH FEATHERSTON SC	9.70	ND	ND	ND	1	0	0	7.43	0.08	-0.03	0.00	2	0	0	2.71	1.19	-0.49	0.00	2	0	0	29.85	4.85	-1.99	0.00	2	0	0	5.86	0.26	0.00	0.00	2	0	0
S27/0136	SUGRUE, O	13.40	ND	ND	ND	1	0	0	8.59	0.69	0.00	0.00	2	0	0	3.25	0.95	0.00	0.00	2	0	0	34.50	5.50	0.00	0.00	2	0	0	10.40	1.30	0.00	0.00	2	0	0
S27/0396	SWDC MARTINBOROUGH	10.60	0.00	0.00	0.11	5	1	0	59.80	1.20	0.00	0.73	23	2	0	6.80	0.60	0.00	0.38	24	1	0	176.60	3.90	0.00	2.63	23	2	0	25.50	0.50	0.00	0.48	23	2	0
S27/0588	SWDC PIRINOA	13.70	0.15	-0.47	0.25	6	0	0	9.78	0.48	0.23	0.33	27	1	0	3.97	0.35	-0.12	0.20	28	0	0	40.55	1.20	0.00	1.00	28	0	0	19.20	0.50	0.00	0.31	28	0	0
S27/0681	TE KAIRANGA NEW	9.90	0.00	0.00	0.00	2	1	0	59.30	5.80	0.00	2.85	3	0	0	6.91	0.37	0.00	1.70	3	0	0	176.00	18.00	0.00	1.90	3	0	0	26.90	1.90	0.00	28.07	3	0	0
S27/0574	TE KAIRANGA WINES LTD	ND	ND	ND	ND	0	0	100	30.30	ND	ND	ND	1	0	0	6.70	ND	ND	ND	1	0	0	103.30	ND	ND	ND	1	0	0	33.50	ND	ND	ND	1	0	0
T26/0206	TOCHER, B	15.60	0.00	0.00	0.00	2	1	0	10.85	1.30	0.00	0.74	26	0	0	4.85	0.55	-0.17	0.27	26	0	0	47.80	2.45	0.00	1.93	26	0	0	14.80	0.30	0.00	0.35	23	3	0
T26/0430	TROUT HATCHERY	12.05	0.35	0.00	0.63	6	0	0	9.70	1.15	0.32	0.55	28	0	0	2.20	0.41	0.00	0.23	27	1	0	33.00	4.25	1.41	1.64	28	0	0	7.65	0.55	0.16	0.27	28	0	0
S27/0198	TUCKER, B	ND	ND	ND	ND	0	0	100	5.10	ND	ND	ND	1	0	0	1.50	ND	ND	ND	1	0	0	18.80	ND	ND	ND	1	0	0	16.00	ND	ND	ND	1	0	0
S27/0594	WARREN, H	25.20	0.20	0.00	0.86	5	0	0	32.80	1.90	0.00	1.05	15	0	0	10.30	0.60	0.00	0.35	15	0	0	124.00	2.60	0.95	1.37	15	0	0	57.00	1.50	0.00	0.90	15	0	0
S27/0602	WEATHERSTONE	50.10	0.30	0.00	1.50	5	0	0	18.90	2.50	0.00	1.55	16	0	0	6.40	0.85	0.00	0.49	16	0	0	77.95	8.40	0.00	4.77	16	0	0	40.10	2.85	0.00	1.68	16	0	0
S26/0756	WENDON	19.60	1.00	0.00	1.98	5	0	0	26.00	1.40	0.65	0.73	16	0	0	5.38	0.52	0.00	0.70	15	1	0	89.55	4.45	0.00	3.10	16	0	0	17.00	1.50	0.00	0.66	15	1	0
R25/5135	WINDSOR PARK	27.00	0.60	0.00	1.96	5	0	0	30.00	1.00	0.00	0.30	30	1	0	12.00	0.25	0.00	0.11	28	3	0	129.00	3.50	0.00	1.50	30	1	0	65.00	1.90	0.37	0.69	30	1	0

Table 6: Potassium, iron, manganese, boron, lead

		K							Fe							Mn							B							Pb						
Well Number	Site	Med	MAD	Trend	TAD	#	Out	%BDL	Med	MAD	Trend	TAD	#	Out	%BDL	Med	MAD	Trend	TAD	#	Out	%BDL	Med	MAD	Trend	TAD	#	Out	%BDL	Med	MAD	Trend	TAD	#	Out	%BDL
S27/0268	BARTON, S.A	2.20	0.10	0.00	0.06	16	0	0	7.29	0.40	0.00	0.21	16	0	0	1.13	0.01	0.00	0.01	11	5	0	0.03	0.02	0.00	0.01	15	1	13	0.00	0.00	0.00	0.00	16	0	88
S27/0059	BERRY, D	1.30	ND	ND	ND	1	0	0	1.51	ND	ND	ND	1	0	0	0.29	ND	ND	ND	1	0	0	<0.05	ND	ND	ND	1	0	100	<0.001	ND	ND	ND	1	0	100
T26/0087	BISS, D	1.09	0.06	0.00	0.07	4	0	0	0.38	0.07	0.00	0.94	3	1	0	0.01	0.00	-0.01	0.00	4	0	25	0.02	0.00	0.00	0.02	3	1	0	<0.0001	ND	ND	ND	3	1	100
S27/0495	BOSCH, F & W.M	3.02	0.17	0.00	0.08	16	0	0	5.95	0.47	0.00	0.24	16	0	0	0.76	0.01	0.00	0.02	13	3	0	0.07	0.03	0.00	0.02	15	1	0	<0.003	ND	ND	ND	16	0	100
S26/0117	BUTCHER, G	2.87	0.07	0.00	0.00	2	0	0	<0.05	ND	ND	ND	2	0	100	0.00	ND	0.00	0.00	2	0	50	0.02	ND	0.00	0.00	2	0	50	0.00	ND	0.00	0.00	2	0	50
T26/0099	BUTCHER, M	1.33	0.01	0.00	0.14	3	1	0	<0.02	ND	ND	ND	4	0	100	0.00	0.00	0.00	0.00	4	0	0	0.01	0.00	0.00	0.00	4	0	0	<0.0001	ND	ND	ND	4	0	100
S27/0547	CAMPBELL	1.60	0.06	0.00	0.01	3	0	0	<0.02	ND	ND	ND	2	1	100	0.00	0.00	0.00	0.00	2	1	0	0.02	0.00	0.00	0.00	2	1	0	0.00	0.00	0.00	0.00	3	0	33
R25/5164	CARD	6.59	0.49	0.00	0.36	27	2	0	0.78	0.41	-0.12	0.23	29	0	0	0.11	0.02	0.00	0.02	28	1	0	0.10	0.04	-0.02	0.01	24	0	0	<0.05	ND	ND	ND	24	6	100
S26/0824	CDC NORTHERN.	1.20	0.01	0.00	0.01	26	2	0	0.02	ND	0.00	0.00	15	13	93	<0.05	ND	ND	ND	22	6	100	0.05	0.03	0.00	0.02	28	0	21	0.00	0.00	0.00	0.00	27	1	59
S26/0705	CDC SOUTHERN	1.10	0.00	0.00	0.00	18	10	0	0.03	0.02	-0.01	0.01	25	3	64	<0.05	ND	ND	ND	22	6	100	0.03	0.02	0.00	0.01	26	2	27	0.00	0.00	0.00	0.00	18	10	67
S25/5200	COMMON PROPERTY	1.30	0.00	0.00	0.00	17	10	0	1.32	0.55	0.00	0.21	27	0	0	0.88	0.03	0.00	0.01	27	0	0	0.03	0.01	0.00	0.00	10	5	30	<0.05	ND	ND	ND	18	9	100
S26/0547	CRAIG, E.J	0.70	ND	ND	ND	1	0	0	2.27	ND	ND	ND	1	0	0	0.13	ND	ND	ND	1	0	0	0.05	ND	ND	ND	1	0	0	<0.001	ND	ND	ND	1	0	100
S27/0202	CROAD, J.R & W.J	1.50	0.10	0.00	0.06	28	0	0	0.05	0.03	0.00	0.01	25	3	32	<0.05	ND	ND	ND	21	7	100	0.00	0.00	0.00	0.00	26	2	65	0.00	0.00	0.00	0.00	28	0	75
S26/0568	DENBEE, J.M	1.20	0.10	0.00	0.05	16	0	0	3.45	0.14	0.00	0.11	14	2	0	0.64	0.05	0.03	0.03	15	1	0	0.02	0.01	0.00	0.01	15	1	33	0.00	ND	0.00	0.00	16	0	94
S27/0389	DIMATTINA, T	1.20	0.04	0.00	0.06	4	0	0	0.22	0.10	0.00	0.13	4	0	0	0.42	0.03	0.00	0.04	4	0	0	0.04	0.00	0.00	0.01	3	1	0	0.00	ND	0.00	0.00	3	1	67
S27/0009	DONDERTMAN, A	1.80	ND	ND	ND	1	0	0	0.32	ND	ND	ND	1	0	0	<0.05	ND	ND	ND	1	0	100	0.08	ND	ND	ND	1	0	0	<0.001	ND	ND	ND	1	0	100
S26/0846	DRUZIANIC	0.83	ND	ND	ND	1	0	0	0.04	ND	ND	ND	1	0	0	0.00	ND	ND	ND	1	0	0	0.02	ND	ND	ND	1	0	0	<0.0001	ND	ND	ND	1	0	100
T26/0489	DUFFY	1.60	0.07	0.00	0.03	28	0	0	0.03	0.03	-0.01	0.02	25	3	52	<0.05	ND	ND	ND	22	6	100	0.02	0.01	0.00	0.01	28	0	36	0.00	0.00	0.00	0.00	27	1	59
S27/0522	DUGGAN	2.24	0.06	-0.27	0.03	3	0	0	0.03	0.00	0.00	0.00	2	1	0	0.00	0.00	0.00	0.01	3	0	0	0.05	0.00	0.00	0.02	3	0	0	<0.0001	ND	ND	ND	2	1	100
S26/0734	DYKSTRA, ENGBERT	3.20	ND	ND	ND	1	0	0	0.86	ND	ND	ND	1	0	0	<0.05	ND	ND	ND	1	0	100	0.07	ND	ND	ND	1	0	0	<0.001	ND	ND	ND	1	0	100
T26/0332	EAST TARATAHI SHALLO	1.10	0.03	0.00	0.00	2	0	0	<0.02	ND	ND	ND	2	0	100	1.26	0.02	0.00	0.00	2	0	0	0.02	0.00	0.00	0.00	2	0	0	0.00	0.00	0.00	0.00	2	0	0
S27/0607	FINDLAYSON, K	7.60	0.51	0.27	0.26	15	0	0	13.40	1.51	0.00	0.97	15	0	0	1.01	0.21	0.07	0.08	15	0	0	0.17	0.06	-0.02	0.02	15	0	0	0.00	0.00	0.00	0.00	15	0	87
S26/0400	FITZGERALD DEEP	1.81	0.19	-0.08	0.00	2	0	0	3.84	0.09	0.00	0.00	2	0	0	0.76	0.08	0.00	0.00	2	0	0	0.11	0.07	-0.03	0.00	2	0	0	<0.001	ND	ND	ND	2	0	100
S26/0467	FITZGERALD SHALLOW	1.78	0.08	0.00	0.00	2	0	0	<0.05	ND	ND	ND	2	0	100	0.00	ND	0.00	0.00	2	0	50	0.03	ND	0.00	0.00	2	0	50	0.00	ND	0.00	0.00	2	0	50
S27/0344	GEORGE, B	1.70	0.06	0.00	0.03	17	0	0	0.87	0.09	0.00	0.05	16	1	0	0.37	0.07	0.00	0.03	17	0	0	0.04	0.02	0.00	0.01	14	2	14	0.00	ND	0.00	0.00	16	0	94
S26/0299	GRAHAM, D	1.17	0.09	0.00	0.07	28	0	0	0.16	0.14	-0.06	0.10	28	0	32	<0.05	ND	ND	ND	21	7	100	0.01	0.00	0.00	0.00	21	7	57	0.00	0.00	0.00	0.00	28	0	36
S27/0141	HARVEY, A. & L.	1.00	ND	ND	ND	1	0	0	0.81	ND	ND	ND	1	0	0	0.23	ND	ND	ND	1	0	0	0.07	ND	ND	ND	1	0	0	<0.001	ND	ND	ND	1	0	100
R27/0320	IBM#1	0.73	0.02	0.00	0.01	41	1	0	0.10	0.02	0.00	0.01	36	6	0	0.06	0.00	0.00	0.00	26	16	0	0.03	0.00	0.00	0.00	17	5	18	<0.05	ND	ND	ND	33	10	100
R27/1265	IBM#2	1.00	0.03	0.00	0.01	34	5	0	0.12	0.02	-0.01	0.01	31	8	0	0.03	0.00	0.00	0.00	24	15	0	0.03	0.01	-0.01	0.01	17	2	0	<0.05	ND	ND	ND	29	11	100
S27/0299	JOHNSON, M.J & G	0.75	0.05	0.00	0.02	16	0	0	0.03	0.01	0.00	0.00	11	5	55	<0.05	ND	ND	ND	11	5	100	0.02	0.01	0.00	0.01	14	2	43	0.00	0.00	0.00	0.00	15	1	73
S27/0435	LANDCORP 'WAIRIO'	4.21	0.19	0.00	0.12	16	0	0	6.30	0.29	0.00	0.19	15	1	0	0.39	0.07	0.02	0.03	16	0	0	0.10	0.04	0.00	0.02	16	0	0	0.00	0.00	0.00	0.00	13	3	46
T26/0003	LENTON	0.79	0.01	0.00	0.00	2	1	0	<0.02	ND	ND	ND	3	0	100	0.00	0.00	0.00	0.00	2	1	0	0.01	0.00	0.00	0.00	2	1	0	0.00	0.00	0.00	0.00	2	1	0
R26/6587	LIDDLE NURSERIES	1.10	0.10	0.00	0.02	44	0	0	0.02	0.01	0.00	0.00	38	6	58	<0.03	ND	ND	ND	31	12	100	0.02	0.01	0.00	0.00	22	5	32	<0.05	ND	ND	ND	33	11	100
S27/0571	M/B GOLF CLUB	1.48	0.04	0.00	0.02	4	0	0	0.06	0.02	-0.01	0.01	4	0	50	0.01	0.00	0.00	0.00	4	0	25	0.03	0.00	0.00	0.00	3	1	0	0.00	ND	0.00	0.00	4	0	75
S27/0433	MAORI EDUCATION FOUI	7.80	0.33	0.19	0.14	16	0	0	12.32	0.17	0.00	0.22	15	1	0	1.29	0.14	0.00	0.09	16	0	0	0.10	0.04	0.00	0.02	16	0	0	<0.003	ND	ND	ND	16	0	100
S27/0585	McCREARY, T.R	1.78	0.09	0.00	0.07	16	0	0	1.35	0.30	0.00	0.14	16	0	0	1.01	0.07	0.00	0.04	15	1	0	0.04	0.02	0.00	0.01	16	0	6	0.00	ND	0.00	0.00	16	0	94
T26/0326	MCKAY, N & SONS	1.10	ND	ND	ND	1	0	0	0.88	ND	ND	ND	1	0	0	0.28	ND	ND	ND	1	0	0	0.10	ND	ND	ND	1	0	0	<0.001	ND	ND	ND	1	0	100
S26/0576	MCNAMARA, J	1.00	0.08	0.00	0.05	16	0	0	1.46	0.22	0.00	0.16	16	0	0	0.46	0.05	0.00	0.03	15	1	0	0.02	0.01	0.00	0.01	13	3	46	<0.003	ND	ND	ND	16	0	100
S26/0223	NICHOLSON	1.25	0.06	0.00	0.00	2	0	0	<0.02	ND	ND	ND	2	0	100	0.00	0.00	0.00	0.00	2	0	0	0.01	0.00	0.00	0.00	2	0	0	0.00	0.00	0.00	0.00	2	0	0
R25/5100	O'MALLEY	9.40	0.40	0.11	0.06	30	0	0	4.86	2.90	-0.42	0.80	30	0	0	1.60	0.10	-0.04	0.02	30	0	0	0.08	0.02	0.00	0.01	16	1	0	<0.05	ND	ND	ND	21	9	100
S27/0106	O'NEALE	0.90	ND	ND	ND	1	0	0	0.64	ND	ND	ND	1	0	0	<0.05	ND	ND	ND	1	0	100	0.07	ND	ND	ND	1	0	0	<0.001	ND	ND	ND	1	0	100
S27/0156	O'NEALE NEW	0.82	ND	ND	ND	1	0	0	0.27	ND	ND	ND	1	0	0	0.48	ND	ND	ND	1	0	0	0.02	ND	ND	ND	1	0	0	<0.0001	ND	ND	ND	1	0	100
S27/0156	OP TRUST	1.20	0.28	0.06	0.08	34	0	0	<0.03	ND	ND	ND	28	6	100	<0.03	ND	ND	ND	28	6	100	0.03	0.00	0.00	0.00	21	6	33	<0.05	ND	ND	ND	29	6	100
T26/0259	OPAKI WATER SUP.	0.80	0.10	0.00	0.05	27	1	0	0.00	0.00	0.00	0.00	21	7	86	<0.05	ND	ND	ND	22	6	100	0.01	0.01	0.00	0.01	27	1	48	0.00	0.00	0.00	0.00	22	6	55
S27/0283	OSBOURNE, A	1.80	0.10	0.00	0.05	16	0	0	9.32	1.31	0.00	0.67	16	0	0	0.51	0.02	0.00	0.01	15	1	0	0.03	0.02	0.00	0.02	15	1	13	<0.003	ND	ND	ND	16	0	100
S26/0457	PALMER	0.81	0.06	0.00	0.02	16	0	0	<0.05	ND	ND	ND	9	7	100	<0.05	ND	ND	ND	11	5	100	0.02	0.01	0.00	0.00	15	1	53	0.00	ND	0.00	0.00	16	0	94
T26/0538	PERCY	3.15	0.25	0.09	0.11	28	0	0	0.01	0.01	-0.01	0.01	26	2	73	<0.05	ND	ND	ND	22	6	100	0.03	0.02	-0.01	0.01	28	0	29	0.00	0.00	0.00	0.00	28	0	50
S26/0439	ROGERS, W	1.22	0.08	-0.03	0.00	2	0	0	0.02	ND	0.00	0.00	2	0	50	0.00	ND	0.00	0.00	2	0	50	0.02	ND	0.00	0.00	2	0	50	0.00	ND	0.00	0.00	2	0	50
R25/5165	SALTER	3.10	0.20	-0.09	0.09	26	1	0	3.50	1.10	-0.40	0.64	27	0	0	0.10	0.01	-0.01	0.01	26	1	0	0.06	0.03	-0.01	0.01	22	0	5	0.01	0.00	0.00	0.00	24	4	46
S26/0762	SCHAEF, D	2.03	0.08	0.00	0.05	16	0	0	7.84	0.64	0.00	0.38	16	0	0	0.83	0.04	0.02	0.02	16	0	0	0.06	0.02	-0.01	0.01	16	0	13	<0.003	ND	ND	ND	16	0	100
R27/1182	SEAVIEW WOOLS	1.70	0.10	0.01	0.01	46	0	0	0.20	0.16	0.00	0.07	38	7	11	0.05	0.00	0.00	0.00	24	21	0	0.03	0.01	-0.01	0.01	19	2	5	<0.05	ND	ND	ND	34	12	100
T26/0413	SEYMOUR, B.J & R.H	0.92	0.00	0.00	0.06	3	1	0	0.27	0.02	-0.23	0.06	3	1	0	0.12	0.01	0.00	0.08	3	1	0	0.02	0.00	0.00	0.02	3	1	0	<0.0001	ND	ND	ND	3	1	100
R27/1171	SOMES ISLAND	1.70	0.10	0.00	0.08	25	1	0	1.55	0.61	0.00	0.28	24	0	0	0.23	0.02	0.00	0.01	23	1	0	0.05	0.03	-0.01	0.01	9	0	0	<0.05	ND	ND	ND	20	4	100
S27/0615	SORENSON DEEP	3.50	0.31	0.00	0.15	15	0	0	4.40	0.71	0.00	0.43	15	0	0	0.50	0.05	0.00	0.04	14	1	0	0.05	0.02	0.00	0.01	15	0	13	<0.003	ND	ND	ND	15	0	100
S27/0614	SORENSON SHALLOW	2.10	0.20	0.00	0.10	15	0	0	5.22	0.43	0.00	0.48	15	0	0	0.33	0.06	0.00	0.03	15	0	0	0.03	0.02	0.00	0.02	15	0	27	<0.003	ND	ND	ND	15	0	100
S27/0070	SOUTH FEATHERSTON S	0.83	0.03	0.00	0.00	2	0	0	0.13	ND	-0.02	0.00	2	0	50	0.00	ND	0.00	0.00	2	0	50	0.08	0.07	-0.03	0.00	2	0	0	0.00	ND	0.00	0.00	2	0	50
S27/0136	SUGRUE, O	1.18	0.08	0.00	0.00	2	0	0	0.53	ND	-0.11	0.00	2	0	50	0.02	ND	0.00	0.00	2	0	50	0.04	0.03	-0.01	0.00	2	0	0	0.00	ND	0.00	0.00	2	0	50
S27/0396	SWDC MARTINBOROUGH	2.10	0.10	0.04	0.04	25	0	0	0.01	0.01	0.00	0.00	18	7	61	0.00	0.00	0.00	0.00	15	10	67	0.04	0.02	0.00	0.02	25	0	24	0.00	0.00	0.00	0.00	24	1	50
S27/0588	SWDC PIRINOA	1.50	0.10	0.01	0.03	28	0	0	4.46	0.08	0.00	0.08	25	3	0	0.12	0.02	0.01	0.01	28	0	7	0.03	0.02	0.00	0.01	24	4	29	0.00	0.00	0.00	0.00	28	0	86
S27/0681	TE KAIRANGA NEW	2.00	0.03	0.00	0.39	3	0	0	<0.02	ND	ND	ND	3	0	100	0.01	0.00	-0.02	0.01	3	0	0	0.03	0.00	0.00	0.00	2	1	0	0.00	0.00	0.00	0.00	2	1	0
S27/0574	TE KAIRANGA WINES LTI	3.00	ND	ND	ND	1	0	0	0.14	ND	ND	ND	1	0	0	<0.05	ND	ND	ND	1	0	100	0.11	ND	ND	ND	1	0	0	<0.001	ND	ND	ND	1	0	100
T26/0206	TOCHER, B	1.20	0.10	0.00	0.05	24	2	0	0.03	0.02	0.00	0.00	17	9	82	<0.05	ND	ND	ND	23	3	100	0.01	0.00	0.00	0.00	20	6	70	0.00	0.00	0.00	0.00	26	0	85
T26/0430	TROUT HATCHERY	1.20	0.10	0.00	0.04	28	0	0	0.03	0.02	-0.01	0.01	26	2	69	<0.05	ND	ND	ND	22	6	100	0.02	0.01	-0.01	0.01	28	0	36	0.00	0.00	0.00	0.00	28	0	82
S27/0198	TUCKER, B	0.90	ND	ND	ND	1	0	0	1.62	ND	ND	ND	1	0	0	<0.05	ND	ND	ND	1	0	100	0.10	ND	ND	ND	1	0	0	0.01	ND	ND	ND	1	0	0
S27/0594	WARREN, H	2.50	0.10	0.00	0.07	15	0	0	1.67	0.05	0.00	0.07	10	5	0	0.17	0.02	0.01	0.01	13	2	0	0.08	0.02	0.00	0.01	15	0	0	0.00	ND	0.00	0.00	15	0	93
S27/0602	WEATHERSTONE	4.74	0.44	0.00	0.14	16	0	0	2.90	0.40	0.00	0.25	15	1	0	0.39	0.07	0.03	0.03	16	0	0	0.06	0.03	0.00	0.01	15	1	7	<0.003	ND	ND	ND	16	0	100
S26/0756	WENDON	1.52	0.12	0.04	0.07	16	0	0	2.43	0.37	0.00	0.29	14	2	0	0.66	0.08	0.05	0.06	14	2	0	0.03	0.02	0.00	0.01	16	0	25	<0.003	ND	ND	ND	15	1	100
R25/5135	WINDSOR PARK	1.40	0.02	0.00	0.01	29	2	0	1.00	0.26	0.00	0.12	29	2	0	0.84	0.02	0.00	0.01	30	1	0	2.51	0.21	0.00	0.12	15	1	0	<0.05	ND	ND	ND	19	12	100

Table 7: Zinc

Well Number	Site	Med	MAD	Zn Trend	TAD	#	Out	%BDL
S27/0268	BARTON, S.A	0.01	0.00	0.00	0.00	4	1	0
S27/0059	BERRY, D	ND	ND	ND	ND	0	0	100
T26/0087	BISS, D	0.02	0.00	-0.05	0.02	3	0	0
S27/0495	BOSCH, F & W.M	0.07	0.01	0.00	0.05	5	0	0
S26/0117	BUTCHER, G	0.02	ND	ND	ND	1	0	0
T26/0099	BUTCHER, M	<0.001	ND	ND	ND	3	1	100
S27/0547	CAMPBELL	0.01	0.01	-0.07	0.00	2	0	0
R25/5164	CARD	0.05	0.04	-0.01	0.01	28	1	14
S26/0824	CDC NORTHERN.	0.00	0.00	0.00	0.02	5	1	0
S26/0705	CDC SOUTHERN	0.04	0.01	0.03	0.01	5	1	0
S25/5200	COMMON PROPERTY	0.00	0.00	0.00	0.00	21	5	57
S26/0547	CRAIG, E.J	ND	ND	ND	ND	0	0	100
S27/0202	CROAD, J.R & W.J	0.01	0.00	0.00	0.01	6	0	0
S26/0568	DENBEE, J.M	0.00	0.00	0.00	0.00	5	0	20
S27/0389	DIMATTINA, T	0.01	0.00	0.00	0.02	3	0	0
S27/0009	DONDERTMAN, A	ND	ND	ND	ND	0	0	100
S26/0846	DRUZIANIC	0.00	ND	ND	ND	1	0	0
T26/0489	DUFFY	0.01	0.00	0.00	0.00	5	1	0
S27/0522	DUGGAN	0.02	0.00	0.00	0.00	3	0	0
S26/0734	DYKSTRA, ENGBERT	ND	ND	ND	ND	0	0	100
T26/0332	EAST TARATAHI SHALLOW	0.00	0.00	-0.01	0.00	2	0	0
S27/0607	FINDLAYSON, K	0.00	0.00	0.00	0.00	3	1	33
S26/0400	FITZGERALD DEEP	<0.001	ND	ND	ND	1	0	100
S26/0467	FITZGERALD SHALLOW	0.01	ND	ND	ND	1	0	0
S27/0344	GEORGE, B	0.03	0.01	0.00	0.02	5	0	0
S26/0299	GRAHAM, D	0.01	0.00	0.00	0.00	6	0	0
S27/0141	HARVEY, A. & L.	ND	ND	ND	ND	0	0	100
R27/0320	IBM#1	<0.03	ND	ND	ND	32	10	100
R27/1265	IBM#2	0.02	ND	0.00	0.00	28	10	96
S27/0299	JOHNSON, M.J & G	0.01	0.00	0.00	0.01	5	0	0
S27/0435	LANDCORP 'WAIRIO'	0.02	0.01	0.00	0.02	5	0	0
T26/0003	LENTON	0.01	0.00	0.00	0.00	2	1	0
R26/6587	LIDDLE NURSERIES	<0.03	ND	ND	ND	25	19	100
S27/0571	M/B GOLF CLUB	0.03	0.00	-0.01	0.00	2	1	0
S27/0433	MAORI EDUCATION FOUNDATION	0.00	0.00	0.00	0.00	5	0	0
S27/0585	McCREARY, T.R	0.01	0.00	0.00	0.01	5	0	0
T26/0326	MCKAY, N & SONS	ND	ND	ND	ND	0	0	100
S26/0576	MCNAMARA, J	0.01	0.00	0.00	0.00	5	0	0
S26/0223	NICHOLSON	0.01	0.00	0.00	0.00	2	0	0
R25/5100	O'MALLEY	0.10	0.06	-0.01	0.03	25	4	0
S27/0106	O'NEALE	ND	ND	ND	ND	0	0	100
S27/0156	O'NEALE NEW	0.02	ND	ND	ND	1	0	0
S27/0156	OP TRUST	<0.03	ND	ND	ND	29	6	100
T26/0259	OPAKI WATER SUP.	0.06	0.02	0.00	0.07	6	0	0
S27/0283	OSBOURNE, A	0.01	0.00	0.00	0.00	5	0	0
S26/0457	PALMER	0.02	0.00	0.00	0.01	5	0	0
T26/0538	PERCY	0.02	0.01	0.00	0.04	6	0	0
S26/0439	ROGERS, W	0.03	ND	ND	ND	1	0	0
R25/5165	SALTER	<0.03	ND	ND	ND	15	12	100
S26/0762	SCHAEF, D	0.01	0.00	0.00	0.01	5	0	0
R27/1182	SEAVIEW WOOLS	<0.03	ND	ND	ND	30	15	100
T26/0413	SEYMOUR, B.J & R.H	0.03	0.01	-0.11	0.08	3	0	0
R27/1171	SOMES ISLAND	0.01	0.01	0.00	0.00	19	4	63
S27/0615	SORENSON DEEP	0.00	0.00	0.00	0.00	4	1	25
S27/0614	SORENSON SHALLOW	0.01	0.00	0.00	0.00	4	0	0
S27/0070	SOUTH FEATHERSTON SCHOOL	0.01	ND	ND	ND	1	0	0
S27/0136	SUGRUE, O	0.01	ND	ND	ND	1	0	0
S27/0396	SWDC MARTINBOROUGH	0.01	0.00	0.00	0.01	6	0	0
S27/0588	SWDC PIRINOA	0.00	0.00	0.00	0.00	6	0	17
S27/0681	TE KAIRANGA NEW	0.03	0.00	0.00	0.00	3	0	0
S27/0574	TE KAIRANGA WINES LTD	ND	ND	ND	ND	0	0	100
T26/0206	TOCHER, B	0.01	0.00	0.00	0.00	2	1	0
T26/0430	TROUT HATCHERY	0.00	0.00	0.00	0.00	6	0	50
S27/0198	TUCKER, B	ND	ND	ND	ND	0	0	100
S27/0594	WARREN, H	<0.001	ND	ND	ND	3	2	100
S27/0602	WEATHERSTONE	0.00	0.00	0.00	0.00	5	0	0
S26/0756	WENDON	0.02	0.00	0.00	0.01	5	0	0
R25/5135	WINDSOR PARK	0.10	0.03	0.00	0.01	30	0	0

Appendix I: NGMP results and summary tables

Table 1: All NGMP sites. Refer to Table 2 for notes on table formats.

Well Number	Name	From	To	#	CBE Calc	CBE OK	# ND+BDL	Br Dissolved, mg/L Med	MAD	Trend	TAD	#	Out	%BDL	Ca Dissolved, mg/L Med	MAD	Trend	TAD	#	Out	%BDL	Cl Dissolved, mg/L Med	MAD	Trend	TAD	#	Out	%BDL	F Dissolved, mg/L Med	MAD	Trend	TAD	#	Out	%BDL
R27/1183	AVALONSTUDIOS	12/95	06/04	19	18	18	4	0.05	0.00	0.00	0.00	11	5	64	5.30	0.25	0.00	0.10	18	0	0	13.40	0.40	0.00	0.15	19	0	0	0.07	0.01	0.00	0.00	14	2	0
S25/5125	BETTYS	03/96	06/04	20	18	18	3	0.04	0.01	0.00	0.01	18	0	56	5.60	1.15	0.00	0.66	18	1	0	13.00	2.70	0.00	1.35	20	0	0	0.09	0.01	0.00	0.01	17	0	0
R26/6624	BOFFA	03/96	06/04	18	17	17	2	0.16	0.01	0.00	0.00	12	3	0	11.30	0.80	-0.31	0.20	17	0	0	26.00	1.00	-0.50	0.33	17	1	0	0.18	0.01	0.00	0.00	15	0	0
S25/5322	EDHOUSE	06/95	06/04	19	17	17	2	0.18	0.01	0.00	0.01	14	2	0	19.50	1.20	-0.39	0.29	17	0	0	31.00	1.00	-0.30	0.30	19	0	0	0.07	0.02	0.01	0.01	15	0	7
R27/1180	MAHOEST	06/95	06/03	21	19	19	3	0.07	0.01	0.00	0.01	17	0	24	8.00	0.50	0.00	0.28	19	0	0	15.00	0.30	0.16	0.22	21	0	0	0.06	0.01	0.00	0.01	16	1	13
R27/6833	MANGAROA	06/96	06/04	19	18	17	2	0.07	0.03	0.00	0.01	18	0	28	7.95	0.60	0.00	0.29	18	0	0	13.30	0.25	0.00	0.20	18	1	0	0.17	0.02	0.00	0.01	17	0	0
S25/5265	PENRAY	03/95	12/03	21	19	19	2	0.11	0.01	0.00	0.01	12	5	0	11.00	0.60	-0.24	0.24	19	0	0	23.00	1.00	-0.47	0.32	21	0	0	0.16	0.01	0.00	0.01	14	1	0
R26/6503	QEPARK	06/95	03/04	19	18	18	0	0.11	0.04	-0.01	0.01	16	0	25	17.20	1.50	0.00	0.57	18	0	0	36.00	1.00	0.00	0.56	18	1	0	0.13	0.02	0.00	0.01	14	0	0
R27/1137	SPTYRES	09/96	06/04	25	23	22	4	0.05	0.00	0.00	0.00	13	9	54	6.00	0.30	0.00	0.20	22	1	0	11.80	0.30	0.09	0.17	24	0	0	0.06	0.01	0.00	0.00	19	0	5
R27/6418	WAINUIOMATAGC	03/96	06/04	19	18	18	4	0.11	0.02	0.00	0.01	16	0	19	7.00	0.65	0.00	0.23	18	0	0	27.00	1.00	0.50	0.65	18	0	0	0.06	0.01	0.00	0.01	15	0	13

Well Number	Name	Fe Dissolved, mg/L Med	MAD	Trend	TAD	#	Out	%BDL	HCO3 Total, mg/L Med	MAD	Trend	TAD	#	Out	%BDL	K Dissolved, mg/L Med	MAD	Trend	TAD	#	Out	%BDL	Mg Dissolved, mg/L Med	MAD	Trend	TAD	#	Out	%BDL	Mn Dissolved, mg/L Med	MAD	Trend	TAD	#	Out	%BDL
R27/1183	AVALONSTUDIOS	0.04	0.01	0.00	0.01	17	1	29	25.00	1.00	0.00	0.49	19	0	0	0.98	0.08	0.00	0.03	19	0	0	1.90	0.10	0.00	0.03	18	0	0	<0.005	ND	ND	ND	11	6	100
S25/5125	BETTYS	<0.02	ND	ND	ND	11	8	100	21.00	1.00	0.00	0.59	20	1	0	1.90	0.30	0.00	0.15	19	1	0	3.00	0.70	0.00	0.36	18	1	0	<0.005	ND	ND	ND	12	6	100
R26/6624	BOFFA	0.01	0.00	0.00	0.00	11	6	73	74.50	7.40	-2.47	1.62	18	0	0	1.70	0.10	0.00	0.04	18	0	0	7.12	0.58	-0.20	0.10	17	0	0	<0.02	ND	ND	ND	11	5	100
S25/5322	EDHOUSE	0.01	ND	0.00	0.00	12	6	92	82.00	1.00	0.00	0.54	19	0	0	2.50	0.10	-0.03	0.05	19	0	0	9.50	0.40	-0.17	0.11	17	0	0	<0.005	ND	ND	ND	10	6	100
R27/1180	MAHOEST	<0.02	ND	ND	ND	13	7	100	36.00	1.00	-0.29	0.51	18	3	0	1.20	0.10	0.00	0.05	21	0	0	3.00	0.20	0.00	0.11	19	0	0	<0.005	ND	ND	ND	12	6	100
R27/6833	MANGAROA	0.13	0.11	-0.04	0.06	17	1	18	83.00	8.00	0.00	4.50	19	0	0	0.85	0.15	0.00	0.05	19	0	0	5.40	0.30	0.00	0.21	17	1	0	0.51	0.10	0.00	0.06	18	0	6
S25/5265	PENRAY	0.02	0.01	0.00	0.01	17	3	29	28.00	1.00	0.00	0.47	19	2	0	1.70	0.20	0.00	0.09	21	0	0	6.60	0.30	-0.13	0.12	19	0	0	0.00	0.00	0.00	0.00	18	0	78
R26/6503	QEPARK	0.93	0.22	0.00	0.15	18	0	11	53.00	4.00	0.00	1.66	19	0	0	2.70	0.20	0.06	0.09	19	0	0	6.25	0.50	0.00	0.18	18	0	0	0.03	0.01	0.00	0.00	15	1	7
R27/1137	SPTYRES	0.03	0.01	0.00	0.01	22	2	27	28.00	1.00	0.00	0.70	25	0	0	1.00	0.11	0.00	0.08	24	1	0	2.20	0.10	0.00	0.05	21	2	0	<0.005	ND	ND	ND	13	10	100
R27/6418	WAINUIOMATAGC	<0.02	ND	ND	ND	11	7	100	29.00	5.00	0.00	2.90	19	0	0	2.80	0.20	0.00	0.14	19	0	0	4.60	0.20	0.08	0.11	18	0	0	<0.005	ND	ND	ND	12	5	100

Well Number	Name	Na Dissolved, mg/L Med	MAD	Trend	TAD	#	Out	%BDL	NH4 Dissolved, mg/L as N Med	MAD	Trend	TAD	#	Out	%BDL	NO2 Dissolved, mg/L as N Med	MAD	Trend	TAD	#	Out	%BDL	NO3 Dissolved, mg/L as N Med	MAD	Trend	TAD	#	Out	%BDL	PO4 Dissolved, mg/L as P Med	MAD	Trend	TAD	#	Out	%BDL
R27/1183	AVALONSTUDIOS	10.00	0.60	0.00	0.28	19	0	0	<0.01	ND	ND	ND	16	2	100	0.02	ND	ND	ND	1	0	0	0.37	0.03	0.00	0.02	17	2	0	<0.05	ND	ND	ND	8	1	100
S25/5125	BETTYS	10.85	1.20	0.00	0.66	20	1	0	<0.01	ND	ND	ND	17	4	100	0.00	ND	0.00	0.00	2	0	50	2.80	1.10	0.00	0.61	19	1	0	0.02	ND	0.00	0.00	10	2	90
R26/6624	BOFFA	30.30	1.70	-0.71	0.51	18	0	0	<0.01	ND	ND	ND	13	5	100	0.00	ND	0.00	0.00	2	1	50	3.70	0.20	0.00	0.11	17	1	0	0.02	ND	0.00	0.00	8	2	88
S25/5322	EDHOUSE	34.00	1.00	0.00	0.82	19	0	0	<0.01	ND	ND	ND	15	3	100	0.00	ND	0.00	0.00	3	0	67	12.90	0.66	-0.36	0.17	19	0	0	0.03	0.01	0.00	0.01	11	0	64
R27/1180	MAHOEST	12.30	0.60	0.00	0.33	21	0	0	<0.01	ND	ND	ND	17	3	100	0.00	0.00	0.00	0.00	4	0	50	1.00	0.10	0.00	0.07	21	0	0	0.01	0.00	0.00	0.00	14	1	86
R27/6833	MANGAROA	21.00	1.00	0.00	0.56	18	1	0	<0.01	ND	ND	ND	13	6	100	0.00	0.00	0.00	0.00	2	0	0	0.23	0.15	0.00	0.11	16	3	6	<0.04	ND	ND	ND	6	5	100
S25/5265	PENRAY	24.00	1.00	-0.50	0.50	21	0	0	<0.01	ND	ND	ND	13	7	100	0.03	ND	-0.08	0.00	2	0	50	11.20	0.90	-0.50	0.22	21	0	0	<0.04	ND	ND	ND	8	7	100
R26/6503	QEPARK	24.90	1.10	0.00	0.40	19	0	0	0.06	0.01	0.00	0.01	18	0	28	0.00	ND	0.00	0.00	2	1	50	0.01	0.01	0.00	0.00	18	1	56	0.01	0.00	0.00	0.00	10	2	80
R27/1137	SPTYRES	10.10	0.50	0.00	0.27	25	0	0	<0.01	ND	ND	ND	18	7	100	<0.005	ND	ND	ND	1	0	100	0.98	0.12	0.00	0.08	21	3	0	<0.05	ND	ND	ND	11	3	100
R27/6418	WAINUIOMATAGC	19.20	0.80	0.00	0.59	19	0	0	<0.01	ND	ND	ND	18	1	100	<0.002	ND	ND	ND	1	0	100	2.80	0.70	0.00	0.33	19	0	0	0.01	0.00	0.00	0.00	11	1	82

Well Number	Name	SiO2 Dissolved, mg/L as SiO2 Med	MAD	Trend	TAD	#	Out	%BDL	SO4 Dissolved, mg/L Med	MAD	Trend	TAD	#	Out	%BDL	pH Lab Measurement, pH units Med	MAD	Trend	TAD	#	Out	%BDL	pH Field Measurement, pH units Med	MAD	Trend	TAD	#	Out	%BDL	Conductivity Lab Measurement, uS/cm Med	MAD	Trend	TAD	#	Out	%BDL
R27/1183	AVALONSTUDIOS	10.60	0.61	0.00	0.31	19	0	0	4.20	0.30	0.00	0.16	19	0	0	6.37	0.10	0.00	0.06	19	0	0	6.16	0.07	-0.05	0.06	14	1	0	100.00	6.00	0.00	2.58	16	0	0
S25/5125	BETTYS	13.30	1.20	0.00	0.60	20	0	0	8.65	1.50	0.00	0.83	20	1	0	6.15	0.18	0.00	0.09	21	0	0	5.74	0.11	-0.14	0.09	12	1	0	110.00	20.00	0.00	14.39	17	1	0
R26/6624	BOFFA	19.55	1.15	0.00	0.54	18	0	0	12.40	0.35	0.00	0.17	16	2	0	6.58	0.20	0.00	0.11	18	0	0	6.23	0.11	0.00	0.16	12	0	0	265.00	15.00	-5.11	5.11	16	0	0
S25/5322	EDHOUSE	55.00	1.43	0.00	0.75	19	0	0	7.70	0.15	0.00	0.08	18	1	0	6.67	0.18	0.00	0.17	18	1	0	6.22	0.12	-0.13	0.08	10	0	0	350.00	10.00	0.00	5.77	17	0	0
R27/1180	MAHOEST	15.75	0.45	0.00	0.25	20	0	0	7.55	0.40	0.00	0.29	20	1	0	6.25	0.10	-0.05	0.06	21	0	0	5.88	0.16	0.00	0.20	12	0	0	140.00	0.00	0.00	0.00	11	10	0
R27/6833	MANGAROA	24.00	1.00	0.00	0.55	18	1	0	2.55	0.15	0.00	0.08	19	0	0	6.72	0.15	-0.08	0.09	18	1	0	6.41	0.22	-0.11	0.15	10	0	0	175.00	15.00	0.00	8.42	16	0	0
S25/5265	PENRAY	22.00	1.00	0.00	0.48	21	0	0	12.80	0.80	0.48	0.26	21	0	0	6.17	0.06	0.00	0.07	18	3	0	5.81	0.24	0.00	0.20	9	0	0	250.00	10.00	-4.11	4.11	20	0	0
R26/6503	QEPARK	19.80	0.40	0.00	0.35	19	0	0	27.00	3.50	1.26	1.61	19	0	0	6.53	0.16	-0.07	0.06	19	0	0	6.61	0.37	0.00	0.32	13	0	0	260.00	10.00	0.00	5.93	17	0	0
R27/1137	SPTYRES	13.20	0.58	0.00	0.32	24	0	0	4.70	0.20	0.00	0.13	20	4	0	6.33	0.09	0.00	0.06	24	1	0	5.80	0.03	0.00	0.07	10	3	0	108.50	8.50	1.74	3.94	22	0	0
R27/6418	WAINUIOMATAGC	16.80	0.80	0.00	0.41	19	0	0	7.90	0.70	0.34	0.27	19	0	0	6.07	0.16	0.00	0.13	19	0	0	5.58	0.23	0.00	0.16	15	0	0	180.00	10.00	3.73	3.98	17	0	0

Table 2: Interpretation information for Appendix H and Appendix I.

Data Record
Length: Since Start: The categorisation or labeling was based on medians or trends calculated using the entire historical dataset for the site in question (Record length varied from 1 to 10+ years). Since Jan 00: The categorisation or labeling was based
Since Jan 00: The categorisation or labeling was based on medians or trends calculated using only the last 3 years of the data record.
From and To: Date of collection of earliest (oldest) and most recent sample
#: The number of samples in the time window available for calculation of median, median absolute deviation (MAD) or trend.
CBE Calc: The number of samples collected in the time window for which the Charge Balance Error can be calculated (calculation of CBE requires analysis of at least Na, K, Ca, Mg, HCO3, Cl and SO4)
CBE OK: The number of samples collected in the time window for which Charge Balance Error is within acceptable limits (ca. +/- 5%)
Chemistry by Analyte
In all fields, "ND" indicates that insufficient data were available (e.g. not enough samples collected, or all analyses below the dection limit)
Note: some of the columns may be 'hidden' when the spreadsheet is first opened.
Med: Median concentration. Where % Censored was greater than 50, median was calculated using log-probability regression. Results shown in red text are above relevant health-related or aesthetic water quality guideline values (Drinking Water Standards fo
MAD: Median Absolute Deviation. This is a measure of "dispersion", like the standard deviation, but it is not strongly affected by outlying values. Results shown in orange text are above 10% of the corresponding median value. Results shown in italics we
Trend: This is the monotonic (i.e. linear) rate of concentration change (units/year), determined using Sen's slope estimator. If the trend was not significant at the 95% confidence level (Mann-Kendal test), the trend is assigned a value of zero. Negative
TAD: Median Absolute Deviation of the Trend. This is a measure of the variability of the rate of change (units/year). Results shown in orange text are above 10% of the corresponding Trend. Results shown in italics were calculated based on eight or fewer
#: The number of samples in the time window available for calculation of median, MAD or trend for the analyte in question. Note that samples with Charge Balance Error outside acceptable limits not were excluded, but outliers (identified as being outside
Out: The number of samples that were identified as outliers (being outside 4*MAD of the median). These samples were not included during calculation of medians, MADs, trends, etc.
%BDL: The percentage of samples used that were below the analytical detection limit. A log-probability regression method was used to calculate medians where %BDL > 50%. To calculate trends, censored values were replaced with 1/2 the detection limit.

Appendix J: GWSOE site descriptions, cluster thresholds, water types

Figure 1: Classification diagram for anion and cation facies in terms of major ion percentages. Water types are designated according to which domain they fall in on the diagram. Source: Freeze and Cherry (1979).

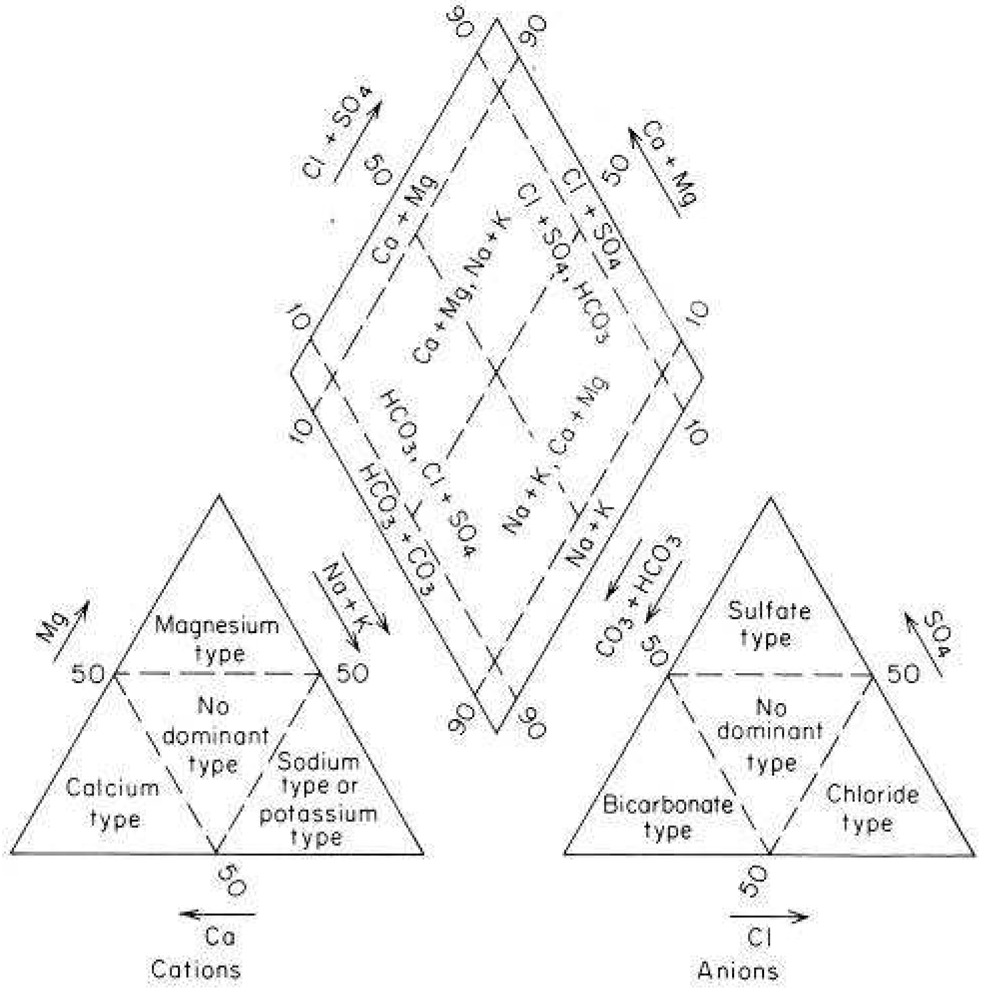


Table 1: Cluster designations and water types

Well Number	Site	Threshold 1	Threshold 2	Threshold 3	water Type
R27/1183	AVALONSTUDIOS	2	4	9	Na-Mg-Ca-HCO3-Cl
S27/0268	BARTON, S.A	2	2	4	Na-Ca-HCO3-Cl
S27/0059	BERRY, D	2	3	7	Na-Ca-HCO3-Cl
S25/5125	BETTYS	2	3	7	Na-HCO3-Cl
T26/0087	BISS, D	2	4	9	Na-Mg-Ca-Cl-HCO3
R26/6624	BOFFA	2	2	4	Na-Ca-HCO3-Cl
S27/0495	BOSCH, F & W.M	2	3	7	Na-Mg-Ca-HCO3-Cl
S26/0117	BUTCHER, G	2	2	4	Na-Mg-Ca-Cl-HCO3
T26/0099	BUTCHER, M	2	4	9	Na-Ca-Mg-HCO3-Cl
S27/0547	CAMPBELL	2	3	6	Na-Mg-Ca-HCO3-Cl
R25/5164	CARD	1	1	1	Na-Ca-HCO3-Cl
S26/0824	CDC NORTHERN.	2	4	9	Na-Ca-Mg-Cl-HCO3
S26/0705	CDC SOUTHERN	2	4	9	Na-Ca-Mg-HCO3-Cl
S25/5200	COMMON PROPERTY	1	1	2	Na-Ca-HCO3-Cl
S26/0547	CRAIG, E.J	2	2	4	Ca-Na-Mg-HCO3-Cl
S27/0202	CROAD, J.R & W.J	2	2	4	Ca-Na-Mg-Cl
S26/0568	DENBEE, J.M	2	2	4	Ca-Na-Mg-Cl-HCO3
S27/0389	DIMATTINA, T	2	3	5	Na-Ca-Mg-HCO3
S27/0009	DONDERTMAN, A	2	4	9	Na-Ca-Mg-HCO3-Cl
S26/0846	DRUZIANIC	2	2	3	Ca-Na-HCO3-Cl
T26/0489	DUFFY	2	2	3	Ca-Na-HCO3-Cl
S27/0522	DUGGAN	2	3	5	Na-Mg-Ca-HCO3-Cl
S26/0734	DYKSTRA, ENGBERT	2	2	4	Na-Ca-HCO3-Cl
T26/0332	EAST TARATAHI SHALLOW	2	4	9	Na-Ca-Mg-Cl-HCO3
S25/5322	EDHOUSE	2	3	6	Na-Ca-Mg-Cl-HCO3-SO4
S27/0607	FINDLAYSON, K	2	2	3	Ca-Na-Mg-HCO3-Cl
S26/0400	FITZGERALD DEEP	2	3	5	Ca-Na-Mg-HCO3
S26/0467	FITZGERALD SHALLOW	2	3	5	Na-Ca-Mg-HCO3-Cl
S27/0344	GEORGE, B	2	4	9	Na-Ca-Mg-HCO3-Cl
S26/0299	GRAHAM, D	2	4	9	Na-Ca-Cl-SO4-HCO3
S27/0141	HARVEY, A. & L.	2	3	5	Ca-Na-HCO3
R27/0320	IBM#1	1	1	1	Na-Cl-HCO3
R27/1265	IBM#2	1	1	2	Na-Ca-Cl-HCO3
S27/0299	JOHNSON, M.J & G	1	1	2	Na-Ca-HCO3-Cl
S27/0435	LANDCORP 'WAIRIO'	2	4	9	Na-Ca-Mg-HCO3-Cl
T26/0003	LENTON	2	3	7	Na-Ca-Mg-HCO3
R26/6587	LIDDLE NURSERIES	1	1	2	Na-Ca-HCO3-Cl
S27/0571	M/B GOLF CLUB	2	2	3	Ca-Na-HCO3
R27/1180	MAHOEST	2	2	4	Na-Ca-Cl-HCO3
R27/6833	MANGAROA	2	3	6	Na-Ca-Mg-HCO3-Cl
S27/0433	MAORI EDUCATION FOUNDATION	2	4	9	Na-Ca-Cl-HCO3
S27/0585	McCREARY, T.R	2	3	5	Na-Ca-Mg-HCO3
T26/0326	MCKAY, N & SONS	2	2	3	Ca-Na-Mg-HCO3-Cl
S26/0576	MCNAMARA, J	2	2	4	Na-Ca-Mg-Cl-HCO3
S26/0223	NICHOLSON	2	2	3	Ca-Na-HCO3-Cl
R25/5100	O'MALLEY	1	1	2	Na-Mg-HCO3-Cl
S27/0106	O'NEALE	2	2	4	Na-Ca-Mg-Cl-HCO3
S27/0156	O'NEALE NEW	2	4	9	Ca-Na-Mg-HCO3-Cl
S27/0156	OP TRUST	2	4	8	Ca-Na-HCO3
T26/0259	OPAKI WATER SUP.	2	3	5	Na-Ca-Mg-HCO3
S27/0283	OSBOURNE, A	2	3	7	Na-Ca-HCO3-Cl
S26/0457	PALMER	2	2	4	Na-Ca-HCO3-Cl
S25/5256	PENRAY	2	3	6	Na-Cl-HCO3
T26/0538	PERCY	2	3	7	Na-Ca-HCO3-Cl
R26/6503	QEPARK	1	1	2	Na-Ca-Cl-HCO3
S26/0439	ROGERS, W	2	2	4	Na-Ca-Mg-Cl-HCO3

Table 2: Cluster designations and water types (cntd.)

Well Number	Site	Threshold 1	Threshold 2	Threshold 3	water Type
R25/5165	SALTER	2	2	3	Ca-Na-Mg-HCO3-Cl
S26/0762	SCHAEF, D	1	1	1	Ca-Na-Mg-HCO3
R27/1182	SEAVIEW WOOLS	2	2	4	Ca-Na-HCO3
T26/0413	SEYMOUR, B.J & R.H	1	1	2	Na-Ca-HCO3-Cl
R27/1171	SOMES ISLAND	2	2	4	Na-Ca-Mg-HCO3-Cl
S27/0615	SORENSON DEEP	2	2	3	Na-Ca-Mg-HCO3-Cl
S27/0614	SORENSON SHALLOW	2	3	6	Na-Ca-Mg-Cl-HCO3
S27/0070	SOUTH FEATHERSTON SCHOOL	2	3	5	Na-Ca-HCO3-Cl
R27/1137	SPTYRES	2	3	7	Na-Mg-HCO3-Cl
S27/0136	SUGRUE, O				Ca-Na-HCO3-Cl
S27/0396	SWDC MARTINBOROUGH	1	1	1	Na-Ca-Mg-HCO3-Cl
S27/0588	SWDC PIRINOA	1	1	2	Na-Ca-HCO3-Cl
S27/0681	TE KAIRANGA NEW	2	4	9	Ca-Na-HCO3-Cl
S27/0574	TE KAIRANGA WINES LTD	1	1	1	Na-Ca-Cl-HCO3
T26/0206	TOCHER, B	2	4	8	Na-Ca-Cl-HCO3
T26/0430	TROUT HATCHERY	2	2	4	Ca-Na-Cl-HCO3
S27/0198	TUCKER, B	2	4	9	Na-Ca-Mg-HCO3-Cl
R27/6418	WAINUIOMATAGC	2	2	4	Na-Ca-Mg-HCO3-Cl
S27/0594	WARREN, H	2	4	8	Ca-Na-HCO3-Cl
S27/0602	WEATHERSTONE	1	1	2	Na-Mg-HCO3-Cl
S26/0756	WENDON	2	3	5	Na-Ca-HCO3-Cl
R25/5135	WINDSOR PARK	1	1	2	Na-Ca-Cl-HCO3

Table 3: Median analyte concentrations of all clusters at Thresholds 1, 2 & 3.at resulting from Hierarchical Cluster Analysis

Cluster	n	%n	Br	Ca	Cl	F	Fe	HCO3	K	Mg	Mn	Na	NH4-N	NO3-N	PO4-P	SiO2	SO4
1	15	19.23	0.20	25.50	62.74	0.18	4.15	158.18	3.37	10.53	0.58	54.42	1.08	0.00	0.50	32.65	0.83
2	63	80.77	0.04	10.62	16.12	0.09	0.11	44.04	1.32	3.98	0.03	16.16	0.01	0.31	0.03	19.21	6.31
1	15	19.23	0.20	25.50	62.74	0.18	4.15	158.18	3.37	10.53	0.58	54.42	1.08	0.00	0.50	32.65	0.83
2	25	32.05	0.03	8.41	10.96	0.04	0.05	26.84	1.10	2.72	0.01	9.98	0.01	1.63	0.02	14.23	6.02
3	21	26.92	0.06	10.26	18.30	0.15	0.80	69.71	1.28	4.80	0.20	21.40	0.09	0.00	0.08	23.96	3.87
4	17	21.79	0.05	15.59	24.31	0.14	0.03	51.70	1.81	5.55	0.01	23.17	0.00	4.75	0.02	22.73	12.34
1	5	6.41	0.30	44.04	89.10	0.14	6.54	251.23	3.97	16.89	0.72	79.98	2.62	0.00	1.05	31.82	0.12
2	9	11.54	0.02	7.35	7.25	0.03	0.06	28.47	0.80	2.13	0.01	6.66	0.01	0.58	0.02	12.42	4.04
3	9	11.54	0.04	13.84	16.21	0.14	1.54	93.51	1.27	5.84	0.37	21.30	0.23	0.00	0.40	25.81	3.46
4	16	20.51	0.04	9.08	13.83	0.05	0.04	25.97	1.32	3.11	0.01	12.54	0.01	2.92	0.02	15.36	7.53
5	14	17.95	0.05	12.88	20.20	0.13	0.03	42.09	1.71	4.97	0.02	20.17	0.00	5.74	0.02	24.38	10.18
6	5	6.41	0.13	12.48	35.36	0.14	0.94	57.58	1.99	6.21	0.14	26.77	0.06	0.02	0.01	25.65	10.65
7	10	12.82	0.17	19.40	52.65	0.21	3.31	125.52	3.10	8.31	0.52	44.89	0.69	0.00	0.34	33.07	2.18
8	7	8.97	0.05	6.08	13.36	0.17	0.31	54.78	0.95	3.10	0.12	18.36	0.04	0.01	0.04	20.75	2.17
9	3	3.85	0.04	37.90	57.71	0.20	0.03	134.87	2.38	9.31	0.01	44.26	0.01	1.97	0.02	16.38	30.34

Figure 2: Radial plots of major chemistry at Threshold 2

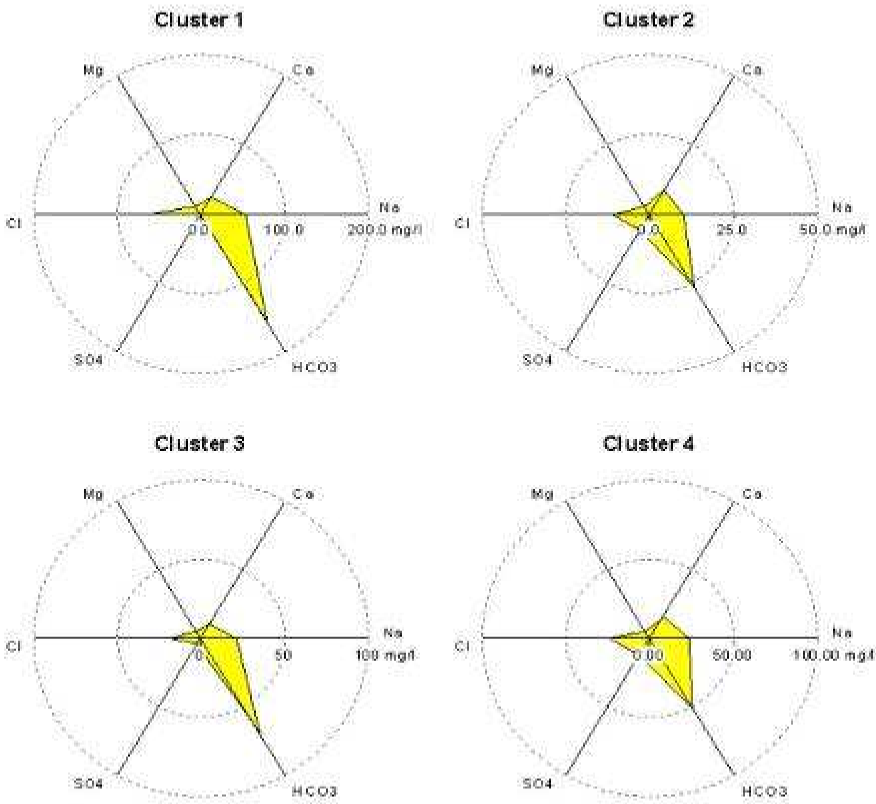


Table 4: Box and Whisker plots of all analytes used in Hierarchical Cluster Analysis at Threshold 1 (Daughney, 2005b).

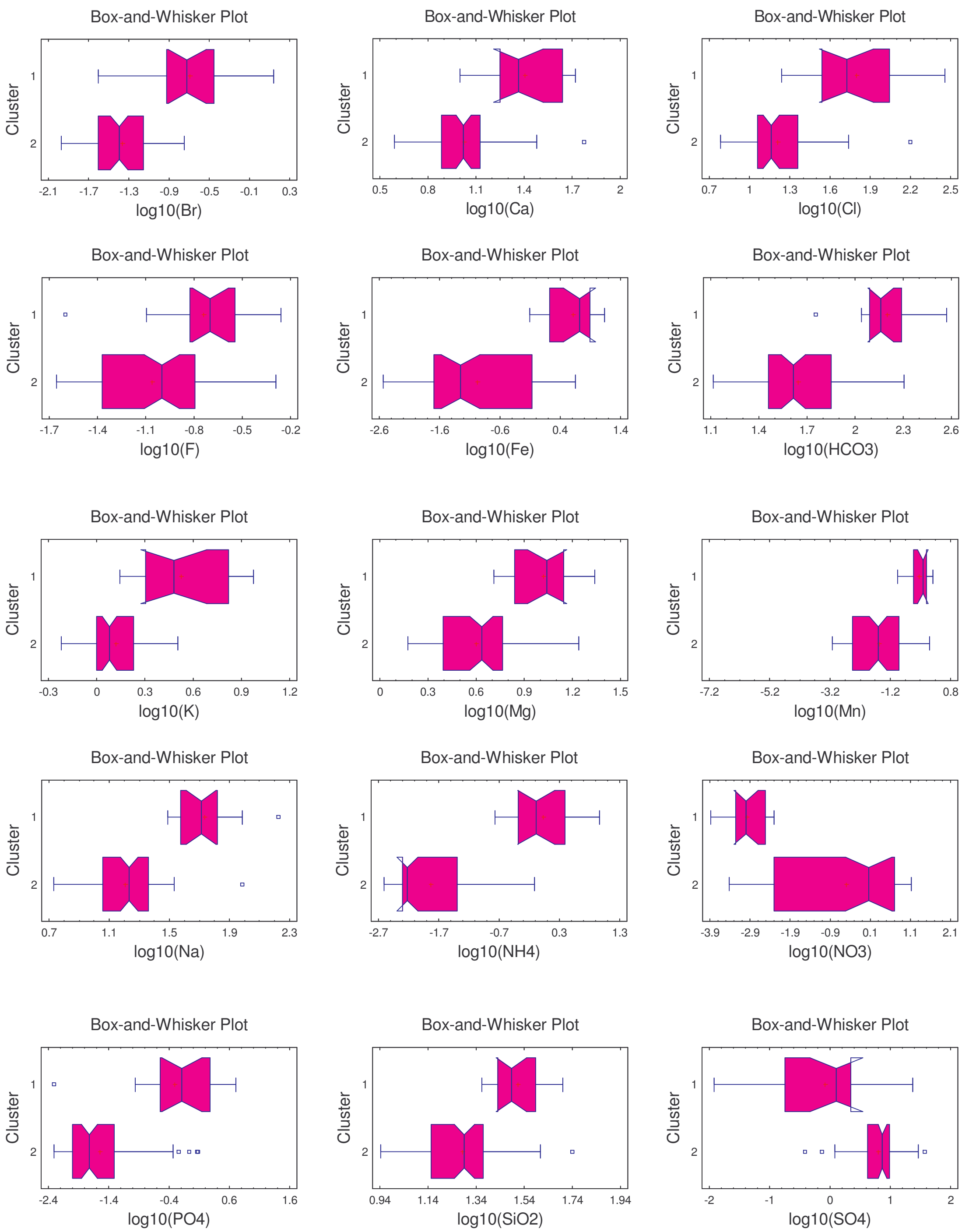


Table 5: Box and Whisker plots of all analytes used in Hierarchical Cluster Analysis at Threshold 2 (Daughney, 2005b).

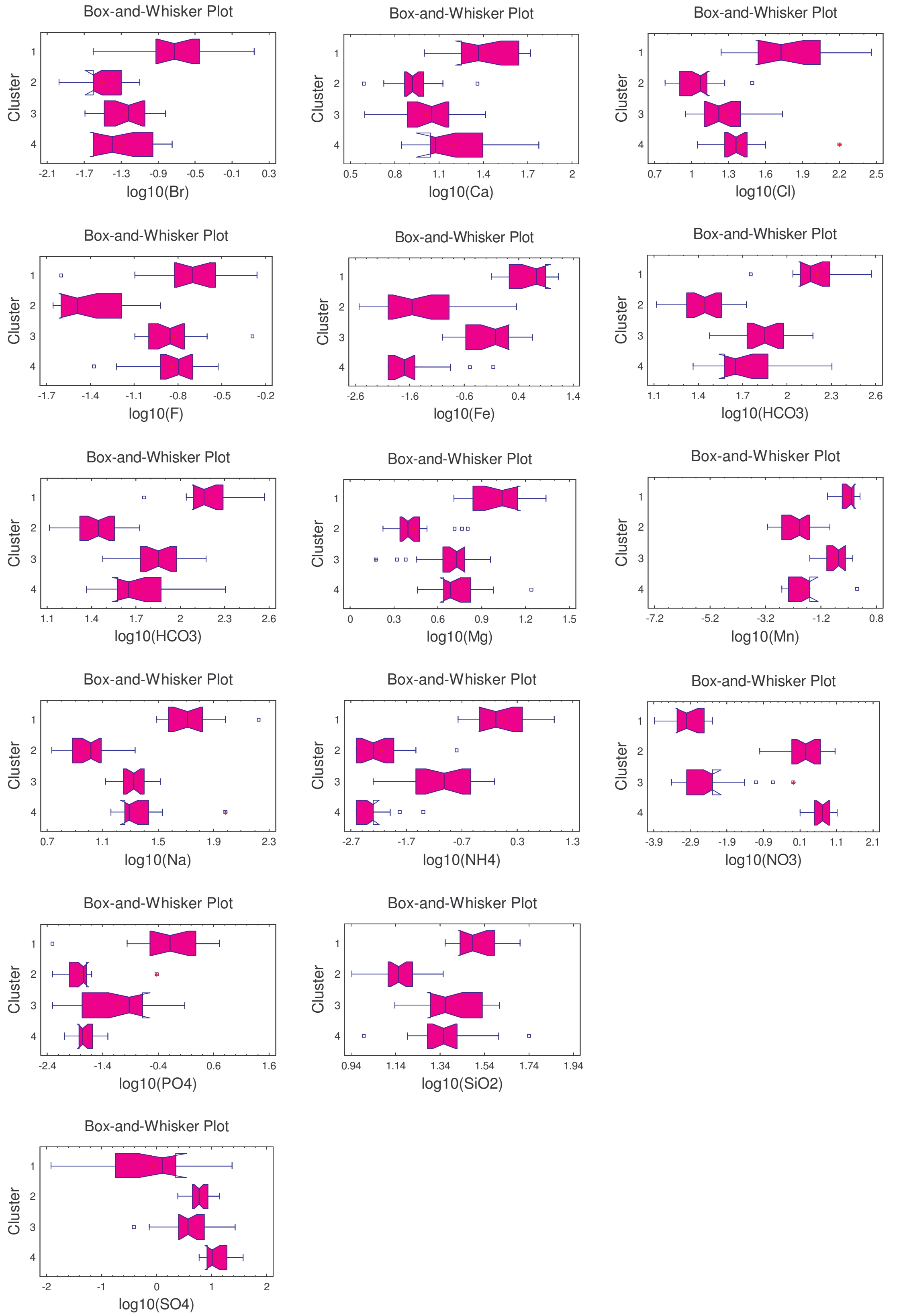
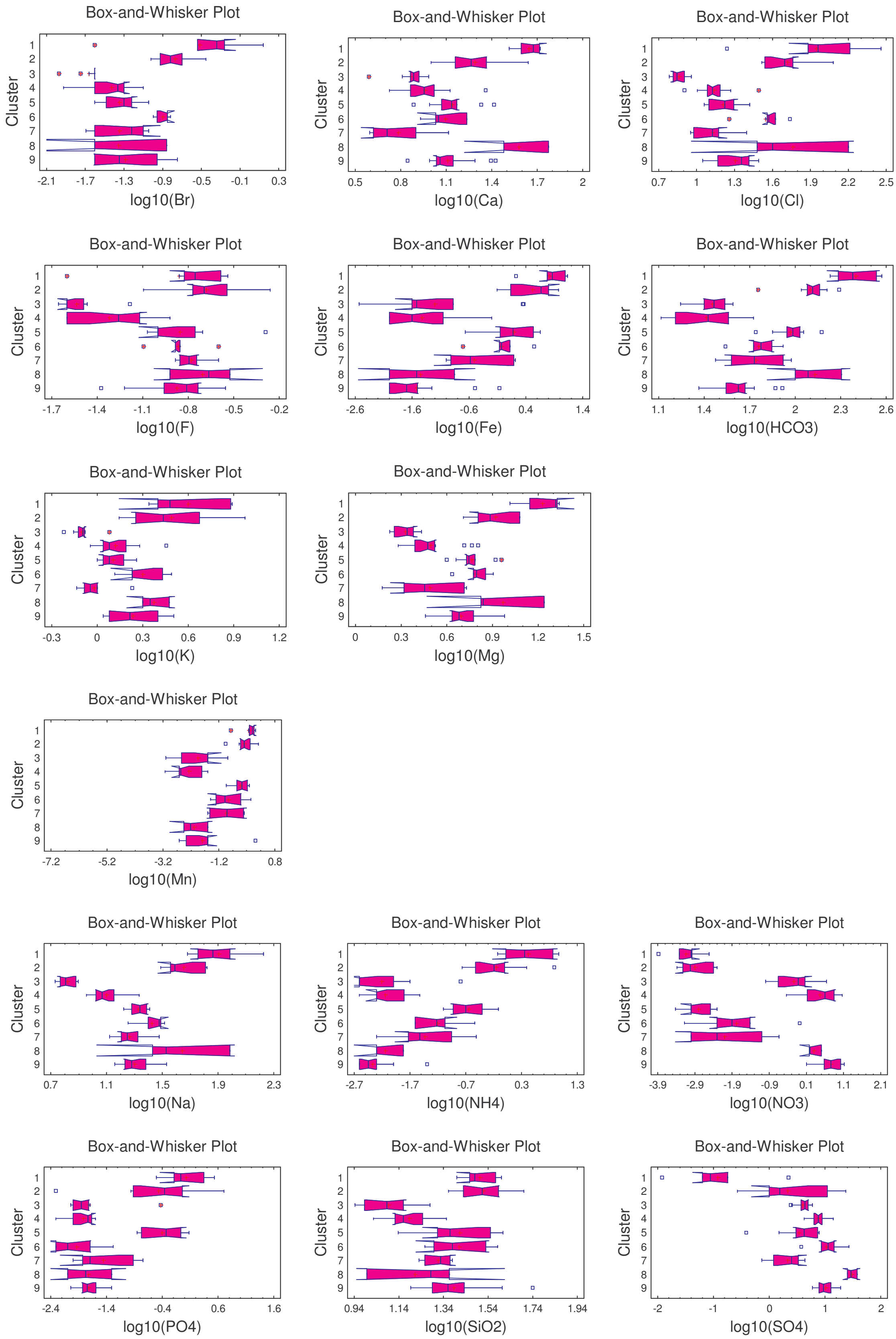


Table 6: Box and Whisker plots of all analytes used in Hierarchical Cluster Analysis at Threshold 3 (Daughney, 2005b).



Appendix K: Bacterial results

Table 1: All positive coliform results

Well No.	Site Name	Time	E-Coli (cfu/100ml)	Faecal Coliforms (cfu/100ml)
S26/0299	GRAHAM, D	18/05/1999		2
S27/0202	CROAD, J.R & W.J	17/02/1998		1
S27/0202	CROAD, J.R & W.J	21/05/1998		2
S27/0202	CROAD, J.R & W.J	02/12/1999		144
S27/0202	CROAD, J.R & W.J	17/08/2000		1
S27/0202	CROAD, J.R & W.J	12/06/2001		1
S27/0202	CROAD, J.R & W.J	27/03/2003		1
S27/0202	CROAD, J.R & W.J	25/03/2004	1	1
S27/0202	CROAD, J.R & W.J	10/06/2004	2	2
S27/0202	CROAD, J.R & W.J	17/12/2004	0	1
S27/0202	CROAD, J.R & W.J	06/04/2005	250	480
S27/0299	JOHNSON, M.J & G	07/12/2004	1	1
S27/0389	DIMATTINA, T (Ata Rangi Wi	07/10/2004	5	5
S27/0389	DIMATTINA, T (Ata Rangi Wi	17/12/2004	12	15
S27/0389	DIMATTINA, T (Ata Rangi Wi	29/03/2005	0	0
S27/0574	TE KAIRANGA WINES LTD	18/03/1999		200
S27/0574	TE KAIRANGA WINES LTD	29/03/2005	0	1
S27/0614	SORENSON, M & S	31/03/2004	10	10
T26/0430	TROUT HATCHERY	16/02/1998		5
T26/0430	TROUT HATCHERY	16/11/1998		1
T26/0430	TROUT HATCHERY	18/05/1999		1
T26/0430	TROUT HATCHERY	15/05/2000		5
T26/0430	TROUT HATCHERY	15/10/2003	12	13
T26/0201	TOCHER, B	14/02/2000		2
R26/6503	Wellington Regional Council	26/03/2001		1
R26/6587	Liddle, Don	23/11/1993		19
R26/6587	Liddle, Don	07/04/1994		2
R26/6587	Liddle, Don	06/10/1994		2
R26/6587	Liddle, Don	27/01/1995		2
R26/6587	Liddle, Don	02/05/1995		1
R26/6587	Liddle, Don	15/06/1998		3
R26/6587	Liddle, Don	19/06/2000		1
R26/6587	Liddle, Don	19/06/2000		1
R26/6587	Liddle, Don	18/12/2001		1
R26/6587	Liddle, Don	17/09/2002		9
R26/6587	Liddle, Don	01/10/2003	11	16
R26/6624	Boffa	26/03/2003		12
R27/1137	South Pacific Tyres	18/09/2002		3
R27/1171	Greater Wellington	21/09/2000		49

Table 2: All positive coliform results cntd.

Well No.	Site Name	Time	E-Coli (cfu/100ml)	Faecal Coliforms (cfu/100ml)
R27/6418	Wainuiomata Golf Course	28/03/1996		16
R27/6418	Wainuiomata Golf Course	17/09/1996		59
R27/6418	Wainuiomata Golf Course	09/12/1996		5
R27/6418	Wainuiomata Golf Course	18/03/1997		13
R27/6418	Wainuiomata Golf Course	16/06/1998		6
R27/6418	Wainuiomata Golf Course	15/12/1998		9
R27/6418	Wainuiomata Golf Course	23/03/1999		2
R27/6418	Wainuiomata Golf Course	14/09/1999		5
R27/6418	Wainuiomata Golf Course	21/12/1999		1
R27/6418	Wainuiomata Golf Course	20/06/2000		6
R27/6418	Wainuiomata Golf Course	19/09/2000		5
R27/6418	Wainuiomata Golf Course	12/12/2000		260
R27/6418	Wainuiomata Golf Course	26/06/2001		4
R27/6418	Wainuiomata Golf Course	19/12/2001		300
R27/6418	Wainuiomata Golf Course	27/06/2002		1
R27/6418	Wainuiomata Golf Course	16/12/2002		2
R27/6418	Wainuiomata Golf Course	24/06/2003		3
R27/6418	Wainuiomata Golf Course	02/10/2003	3	26
R27/6418	Wainuiomata Golf Course	23/03/2004	2	3
R27/6418	Wainuiomata Golf Course	29/09/2004	26	61
R27/6833	Mangaroa School	31/01/1996		10
R27/6833	Mangaroa School	09/12/1996		3
R27/6833	Mangaroa School	24/06/1997		28
R27/6833	Mangaroa School	23/09/1997		7
S25/5125	Betty Partnership	17/03/1997		5
S25/5125	Betty Partnership	22/09/1997		1
S25/5125	Betty Partnership	20/12/1999		6
S25/5200	Common Property	27/01/1995		2
S25/5200	Common Property	02/05/1995		1
S25/5200	Common Property	11/12/1995		1
S25/5256	Bertelsen, Ray PENRAY	12/05/1993		1
S25/5256	Bertelsen, Ray PENRAY	24/11/1993		2
S25/5256	Bertelsen, Ray PENRAY	06/10/1994		2
S25/5256	Bertelsen, Ray PENRAY	27/01/1995		2
S25/5256	Bertelsen, Ray PENRAY	15/06/1998		1
S25/5256	Bertelsen, Ray PENRAY	13/09/1999		1
S25/5256	Bertelsen, Ray PENRAY	20/12/1999		9
S25/5256	Bertelsen, Ray PENRAY	18/09/2000		22
S25/5256	Bertelsen, Ray PENRAY	18/12/2001		8
S25/5256	Bertelsen, Ray PENRAY	01/10/2003	4	4
S25/5322	Edhouse	06/10/1994		2
S25/5322	Edhouse	27/01/1995		2
S25/5322	Edhouse	02/05/1995		1