Chapter 24: Riverlands Aquifer

Introduction

The Riverlands area is underlain by two aquifer systems that are hydraulically connected. The more northern of these is the highly productive Wairau Aquifer. The southernmost system, known as the Riverlands Aquifer is low-yielding by comparison and shares many similarities with the Southern Valleys aquifers located further west. Both aquifers are confined by the Dillons Point Formation. The boundary between the two aquifers is not obvious from the surface.

The Riverlands Aquifer is located beneath the south east corner of the Wairau Plain between the Wither Hills and the coast (Fig. 24.1).

The Riverlands Aquifer is not geologically separate from the Wairau Aquifer and shares the Wairau River as a common recharge source. The aquifer does however have a number of characteristics which make it distinct from the Wairau Aquifer. These distinctions include lower yields, older and poorer water quality, close proximity to the sea and a long distance from the main recharge source. The Riverlands Aquifer was first defined as a separate groundwater system from the Wairau Aquifer in 2008.

The Riverlands aquifer has a unique mix of water users not found anywhere else on the Wairau Plain. These include community or stock supplies, domestic drinking, meat or wine processing and crop irrigation.

Due to its low lying topography relative to the sea, it is an area where the MDC closely monitor groundwater because of the potential for seawater intrusion.

The location of the northern boundary of the Riverlands Aquifer is based on knowledge of the subsurface hydrogeology gained through testing of wells over many years (Fig. 24.2). Aquifer transmissivity for the Wairau Aquifer are greater than those of the Riverlands Aquifer.

The western boundary of the Riverlands Aquifer is marked by the Taylor Fan which separates the Riverlands Aquifer from the Benmorven Aquifer. Near Blenheim the Riverlands Aquifer is overlain by alluvial material forming the Taylor Fan. There may be some interfingering of the Taylor Fan with the Riverlands Aquifer and also the Dillons Point Formation.

The coastal boundary of the Riverlands Aquifer underlies the Lagoons or is offshore in Cloudy Bay, but like the Wairau Aquifer, its exact position remains uncertain.

Groundwater systems

The Riverlands Aquifer consists of clay-rich poorly sorted glacial outwash gravels. The gravels of the Riverlands aquifer are likely to represent Speargrass Formation gravels that have been reworked by the Taylor River. The base of the Riverlands Aquifer is typically marked by a layer of sticky clay or glacial loess material forming the lower part of the Speargrass Formation.

The Riverlands Aquifer is overlain by marine or lagoonal clays or sands of the Dillons Point Formation (Fig. 24.3). These marine sediments form a confining layer which becomes thicker and the sediments more fine grained towards the coast. As a result the confining layer is more leaky in western parts, and becomes less leaky further east.

The Rapaura Formation and upper component of the Speargrass Formation constitute the most productive gravels and host the Wairau and Riverlands aquifers respectively. The sedimentary sequence is bounded to the south by the Hillersden Gravel and Wairau Conglomerate. These gravels are well cemented and as a consequence do not contain viable amounts of groundwater.

Recharge and flow patterns

Oxygen isotope results show that the Riverlands Aquifer receives recharge from a number of sources although the majority comes from the Wairau

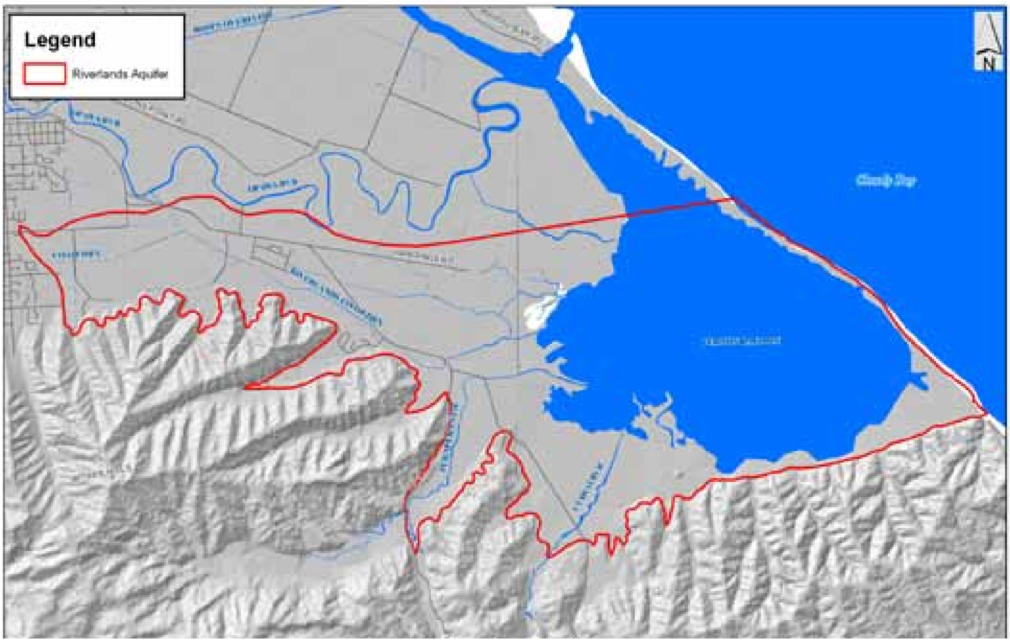

Figure 24.1: Riverlands Aquifer boundary

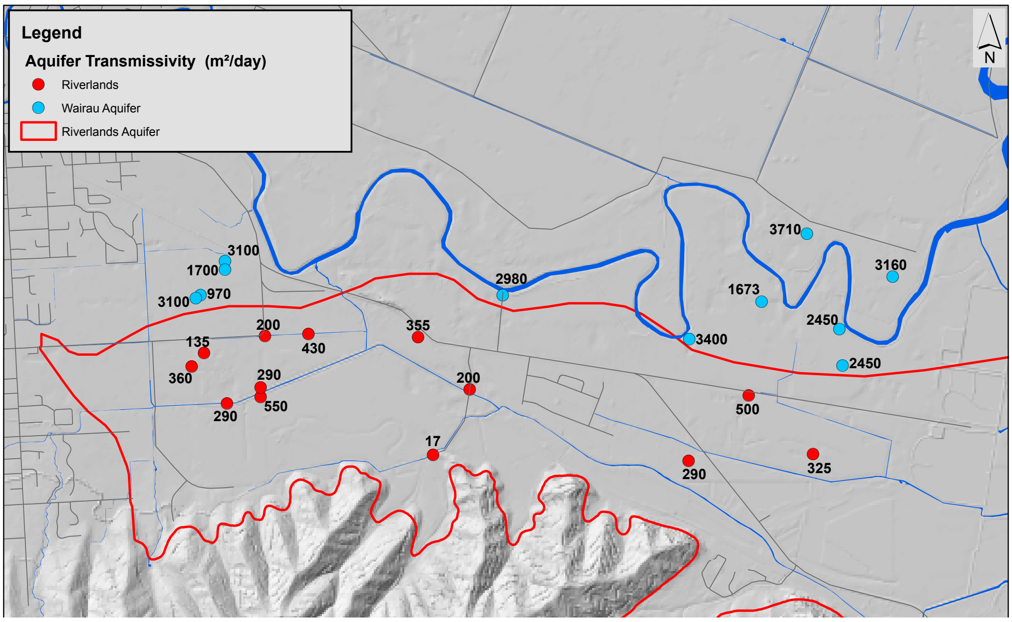

Figure 24.2: Riverlands and Wairau Aquifer boundary. The numbers represent values of aquifer transmissivity for the Wairau Aquifer in blue and the Riverlands Aquifer in red

River. Lesser amounts of recharge are sourced from the Taylor River, Southern Springs and local rainfall infiltration. Rainfall enters the Riverlands Aquifer through the unconfined aquifers forming the Taylor Fan and Southern Springs on the western outskirts of Blenheim.

Wairau River recharge water is known to follow a deep flowpath to get to the Riverlands area. The Wairau River recharge has no sign of land-use influences and retains a highly negative ^{18}O isotope value after travelling the length of the Wairau Plain. (Taylor et al - 1992).

It is likely that recharge to the Riverlands Aquifer varies from about 4,500 m^3/day in summer, to 8,000 m^3/day in winter (Fig. 24.4). Groundwater leaves the Riverlands Aquifer by leaking upwards through the confining layer to become part of the Opawa River or springs, and as abstraction from wells. During winter the majority of groundwater leaves as natural vertical leakage whereas during summer most is from abstraction. When the aquifer is pumped, there is proportionately less leakage to the surface.

Aquifer recovery after pumping is slow compared to the Wairau Aquifer because of the low transmissivity of the Riverlands Aquifer which slows the rate at which it refills.

The rate of offshore flow is expected to be very low because groundwater flow is being driven vertically upwards rather than sideways. The rate of upwards leakage is greatest in Blenheim where the aquitard is thin, and least near the coast where the aquitard is thickest.

Groundwater pumping

The dominant water use in the Riverlands area is for crop irrigation. Viticulture is the dominant crop type with community supply and pasture irrigation the next highest usage.

A significant portion of groundwater is also used for food processing and manufacturing which is supplied from the MDC Malthouse Road wellfield.

There has been a steady increase in demand over time and is fully utilised during periods of peak demand.

Riverlands irrigators tend to use less water than elsewhere on the Wairau Plain, mainly because of the heavier soil types. Riverlands soils have a greater water holding capacity, and hence require less frequent irrigation. In addition to the consented water use there are many permitted uses of groundwater such as for drinking or stock supply.

Water abstractions have a significant but acceptable effect on groundwater levels in the Riverlands

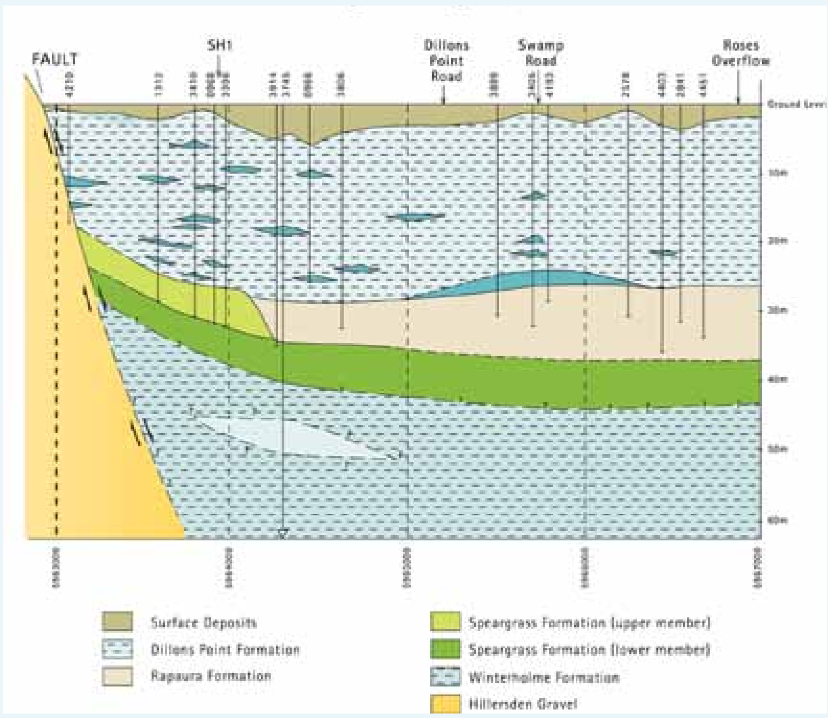

Figure 24.3: Riverlands Aquifer geological cross section. Marine sediments are marked by the dashed pattern.

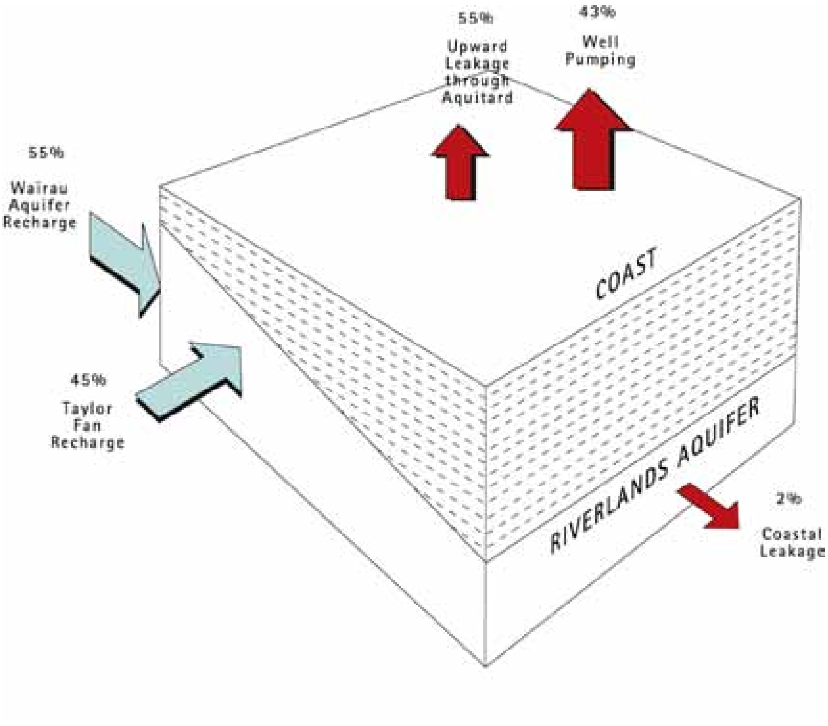

Figure 24.4: Riverlands Aquifer conceptual water balance

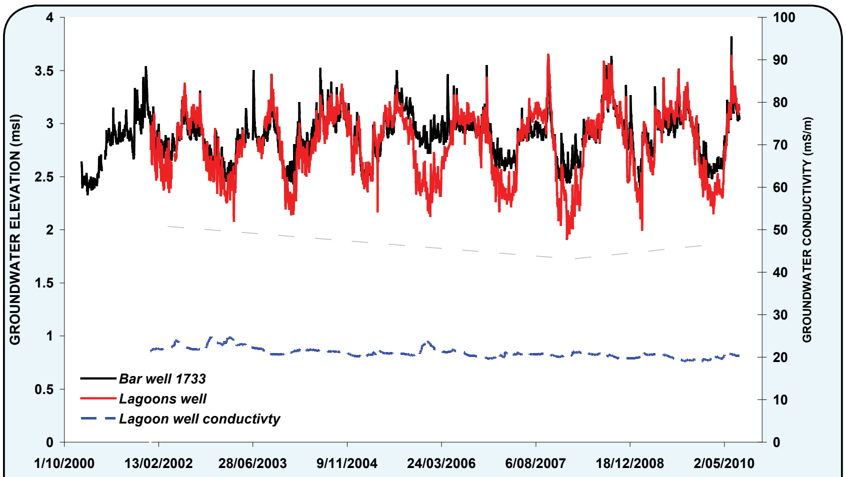

Figure 24.5: Water level and conductivity observations. The summer divergence between the Bar well and the Lagoon well water levels represents the pumping effect. The Bar well is used as an indicator of natural water level variations as it is isolated from the influence of other wells.

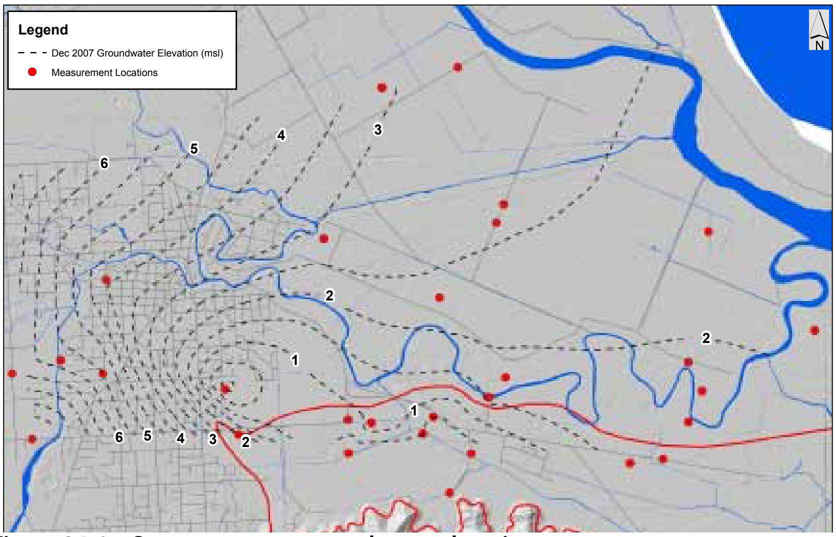

Figure 24.6: Summer survey groundwater elevations

Aquifer. Groundwater elevations have remained relatively high at two metres or more above mean sea-level, and more importantly, recover from pumping each spring (Fig. 24.5). Groundwater conductivity levels measured at the coastal Lagoons well (0708) are stable, showing there is no change in the salinity of groundwater due to pumping.

Flow and recharge patterns

The first survey of groundwater elevations in the Riverlands and Lower Wairau areas was carried out by the MCRWB during the relatively dry conditions experienced during March 1978. The survey identified the low elevations of groundwater associated with the Riverlands Aquifer and its wells for the first time.

The low groundwater elevations reflect the backwater nature of the Riverlands Aquifer away from the main axis of groundwater flow beneath the Wairau Plain. Flow is sluggish because the confining layer forms a ceiling which along with lateral boundaries on two sides such as the Wither Hills, essentially forms a closed groundwater system. Few natural outlets and the frictional effects of these boundaries slow groundwater flow considerably. These factors, along with the large distance to the Wairau River recharge source and low transmissivity, mean that water levels within the Riverlands Aquifer do not fully recover to their natural state rapidly. A unique characteristic of the Riverlands Aquifer and its deeper counterpart system at Rarangi is that groundwater levels are controlled by drainage from the aquifer via vertical leakage and pumping, as there is very little flow within the confined aquifer.

More detailed surveys have been carried out by the MDC since 2004 as demand for groundwater at Riverlands has increased and with it the need for more information about the mechanics of the system. They provide more definition of local flow patterns and how these change seasonally (Fig. 24.6 and Fig. 24.7).

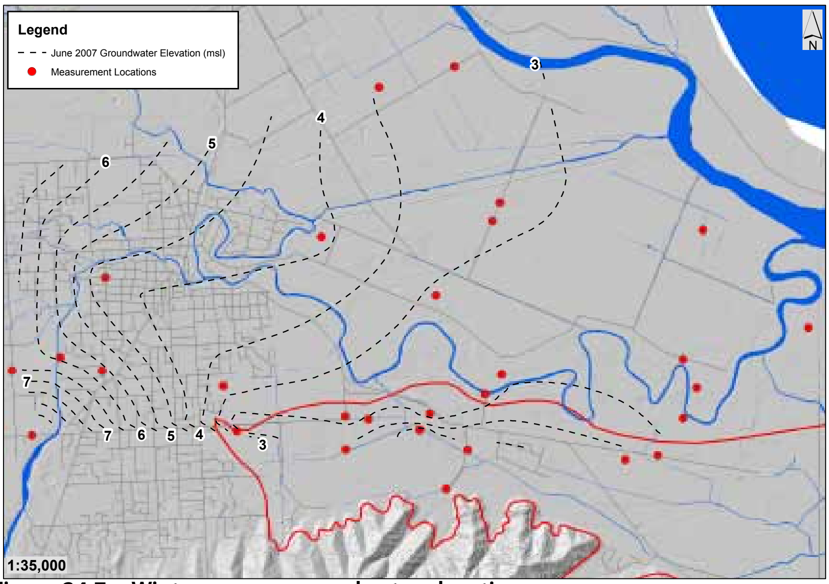

Figure 24.7: Winter survey groundwater elevations

The surveys also identified the presence of a groundwater divide along the southern margin of the Wairau Aquifer with its boundary coinciding with Swamp Road. The divide is a hydrological boundary separating groundwater flowing east towards the coast, from that moving south into the Riverlands Aquifer. The degree to which this reflects the natural flow pattern versus the effect of pumping inducing water to move further south than it otherwise would, is still uncertain. Lower aquifer levels at the inland well 4402 near Alabama Road compared to the lagoon well 708 support it being influenced by pumping.

Care is needed interpreting groundwater elevation maps in areas where groundwater levels are known to vary with well depth, and aquifer hydraulic properties are not homogeneous. Under these conditions well levels are influenced by aquifer permeability and pressure variations.

Another pattern in groundwater levels that wasn't evident in the 1978 survey is an inflection of the 3.5 metre contour around the Taylor River in Blenheim. This indicates an area where channel flow is increasing at the expense of groundwater which is being forced upwards under pressure through the river bed.

Seasonal differences include a steeper gradient in summer when well levels are lowest due to pumping. The steepening grade is also most pronounced in the Hardings Road area where aquifer capacity is naturally lowest.


Figure 24.8: Extended well casing on MDC monitoring well 4402

Groundwater level patterns

The MDC well 4402 located off the end of Alabama Road was drilled in 2004 to observe long term water levels within the Riverlands Aquifer. The well is screened within the Riverlands Aquifer at a depth of 22.3 to 25 metres. To accommodate the high artesian levels in the well that occur in winter or spring, the well casing has been extended well above ground level (Fig. 24.8). The aquifer level recorder sits within the grey cabinet.

Groundwater levels are typically artesian, meaning the well free flows, and fluctuate on an annual basis by up to two metres. During high flow events in the Opawa River the level increases rapidly then subsides when flow recedes. These extremely high levels are caused by the extra loading of river water squeezing the aquifer, causing a short term change in water pressure but not a bulk transfer of water to the aquifer.

Water levels start to fall after the onset of the irrigation season in November to December, and remain low throughout summer unless there is significant rainfall to reduce demand for water (Fig. 24.9). Aquifer levels

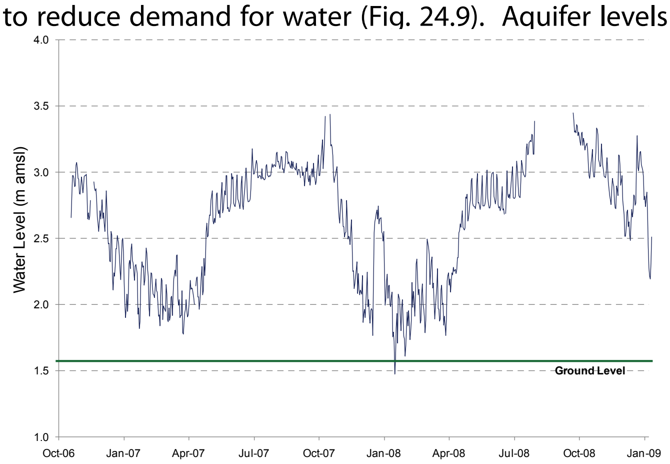

Figure 24.9: Water levels at MDC monitoring well 4402

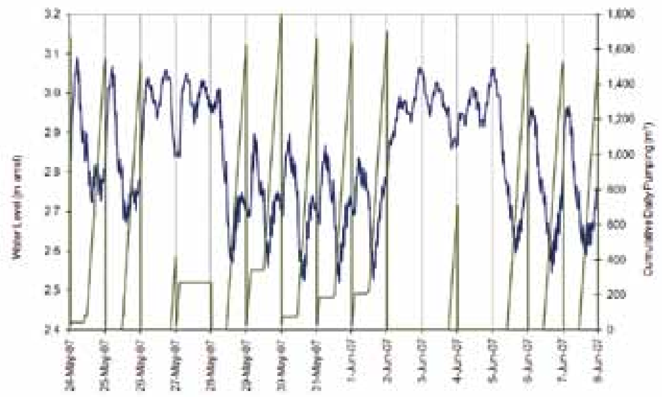

Figure 24.10: MDC well 4402 outside irrigation season versus daily cumulative use at MDC Malthouse Road

start to recover in late March to early April when vineyard irrigators turn off before harvesting, and the response in well 4402 can be quite rapid.

There are very few occasions when water level record for well 4402 is not affected by pumping interference of some description, even outside of the irrigation season. This is because pumping continues year round unlike other areas on the Wairau Plain.

Abstraction from the MDC wellfield at Malthouse Road creates the most obvious interference effect in the hydrograph of well 4402 (Fig. 24.10). While the Malthouse Road well is 1400m to the north, its drawdown at well 4402 is about 400 millimetres when pumping at a rate of 1,600 m^3/day. Its effect on the hydrograph is so pronounced that it is difficult to discern drawdown from the closer Canterbury Meat Packers Ltd (CMP) plant, or any tidal fluctuations.

The CMP plant on the corner of Alabama Road and SH1, sources groundwater from a well screened in the Wairau Aquifer, and located 850 metres to the north-west of the MDC monitoring well 4402. During processing the plant uses around 600 m^3/day of groundwater, which results in a fall of about 100 millimetres at well 4402. During July to September the CMP Ltd plant closes down and the drawdown effect of the Malthouse Road well can be seen more clearly in well 4402 hydrograph (Fig. 24.11).

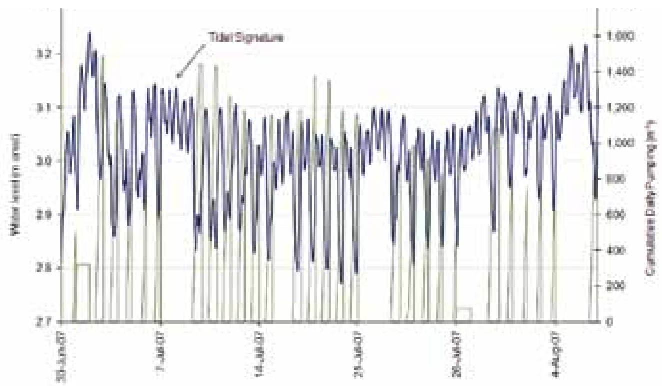

Figure 24.11: MDC well 4402 when CMP plant closed versus daily cumulative use at MDC Malthouse Road

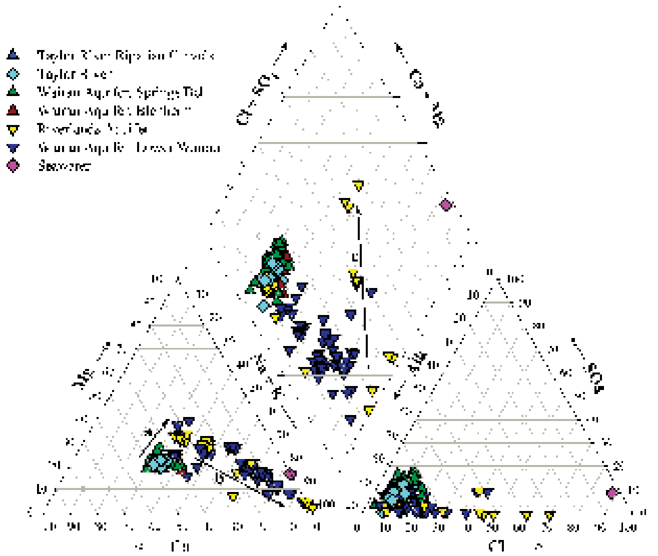

Figure 24.12: Piper diagram of south-eastern Wairau Plain groundwaters

Water levels at the well 0708 and well 4402 are quite similar for much of the year, with the inland well typically being lower by about 100 millimetres. Well 4402 shows more pumping drawdown effects than the other wells. This is mainly due to the high concentration of consented demand near the well 4402, and conversely the relative isolation of well 0708. Wells 0708 and 4402 rapidly recover at the end of the irrigation season, towards the end of April.

Hydraulic properties

Riverlands Aquifer transmissivity values typically fall between 300 m^2/day and 350 m^2/day. This is an order of magnitude lower than the Wairau Aquifer. Storativity is extremely low in the Riverlands Aquifer at around 7 x 10^{-5}, which is slightly lower than the typical Wairau Aquifer value at Riverlands of 1 x 10^{-4}. In general, storativity decreases from the Southern Springs area to the coast as the aquifer becomes less leaky and more confined.

Groundwater Chemistry

Plotting the relative proportions of the major ions present in groundwater is a useful way to characterise groundwater chemistry and see how groundwater evolves over time or from site to site. To do this, the relative percentage concentration of the major

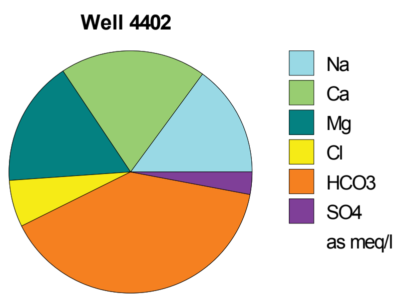

Figure 24.13: Well 4402 groundwater composition

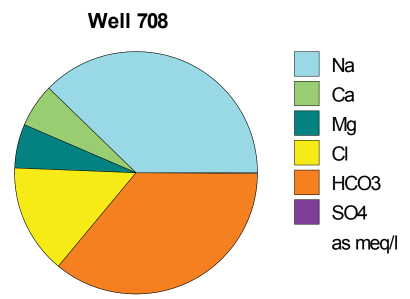

Figure 24.14: Well 0708 groundwater composition

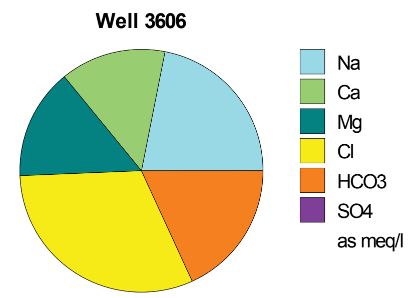

Figure 24.15: Well 3606 groundwater composition

cations (calcium, magnesium, sodium and potassium) and anions (chloride, sulphate and bicarbonate) are plotted on separate triangles, which are then projected onto a diamond-shaped field to illustrate its overall composition. The units are standardised to give their relative proportion rather than their concentration. This method of displaying major element chemistry is called a piper diagram (Fig. 24.12).

Young to medium aged groundwater

Groundwater in the vicinity of Blenheim has a chemical signature that differs very little from its recharge source which is a mix of Wairau River, Taylor River and Southern Springs waters. Young groundwater is typical of groundwater in the Taylor Fan and Southern Fan Deposits. This water is dilute meaning that its mineral content is low. It commonly shows the influence of overlying landuses in the form of sulphate or nitrate.

The chemical composition of groundwater from the MDC monitoring well 4402 is moderately evolved, but retains the overall signature of its recharge source. The presence of sulphate demonstrates the aquifer is not fully confined nor oxygen deficient, and influenced by overlying landuses (Fig. 24.13).

Evolved groundwater

As water enters the confined portion of the Wairau Aquifer or Riverlands Aquifer it becomes more isolated from the atmosphere, and oxygen deficient or anaerobic conditions prevail. This leads to reducing conditions causing sulphate or nitrate to be chemically consumed, and iron or manganese to become soluble in groundwater. Bicarbonate, chloride or sodium concentrations typically increase as groundwater enters this zone. The composition of groundwater from the MDC Lagoons monitoring well 0708 tapping the Wairau Aquifer is representative of this water type (Fig. 24.14). All traces of sulphate have disappeared by this stage and levels of calcium have fallen relative to sodium and chloride.

Moderately saline groundwater

Some of the more evolved groundwater underlying the Wairau Plain exists in the Hardings Road area. It is highly mineralised meaning it has high concentrations of dissolved salts as a result of long residence times below the surface in contact with local rocks. High levels of sodium and chloride are more likely the result of mixing with connate groundwater rather than seawater. Surprisingly the chemical composition reverses with an increase in the percentage of calcium (Fig. 24.15). This reflects the marine origin of the sediments forming the confining layer which contains shells rich in calcium, and residual chloride or sodium in the pore spaces. This mineralised groundwater has a distinctively high conductivity which can be used to map its distribution as many more conductivity values exist than chemistry results (Fig. 24.16). Groundwater

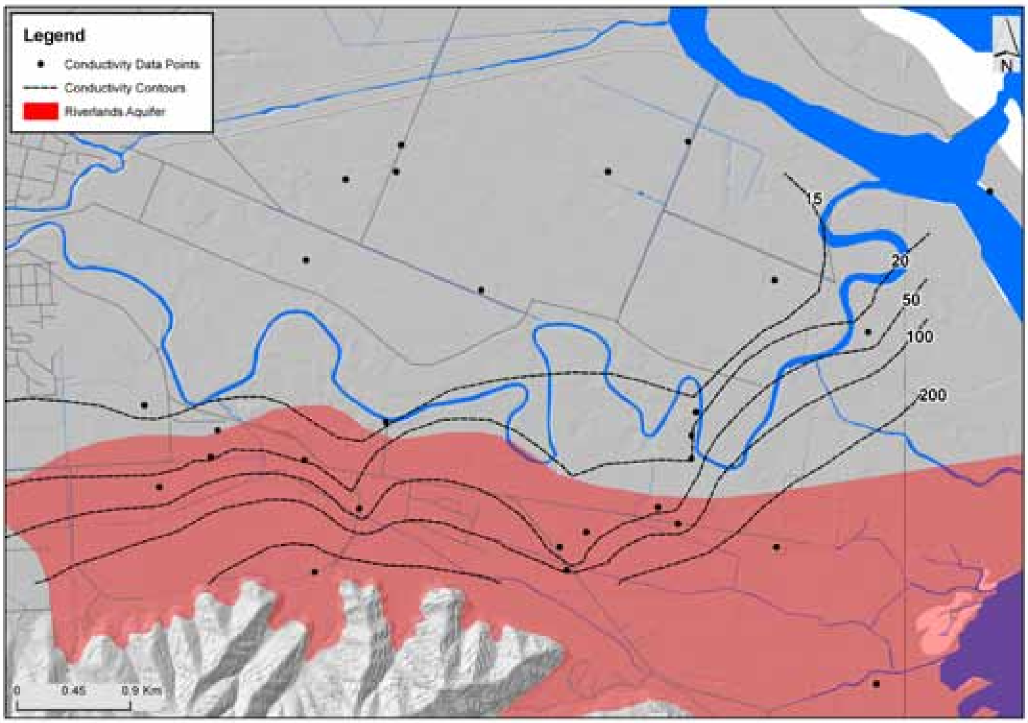

Figure 24.16: Contours of groundwater conductivity in mS/m

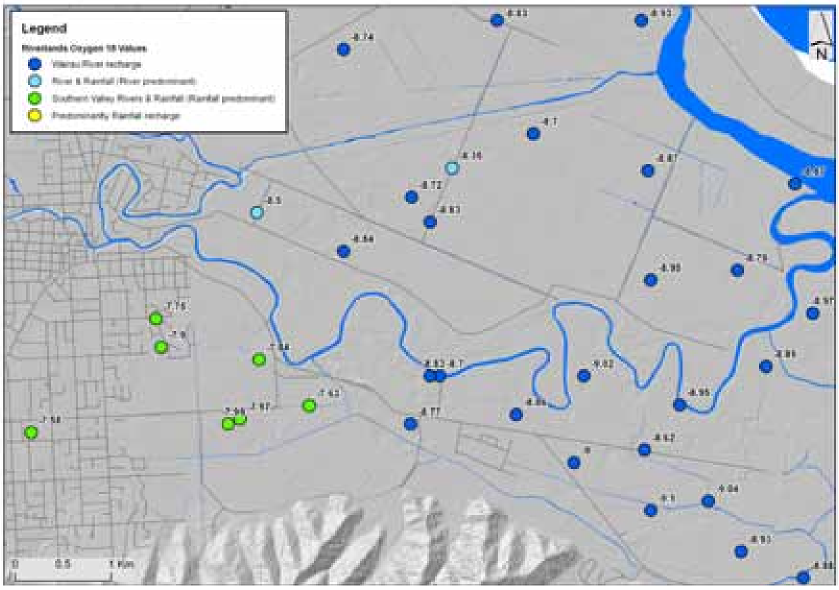

Figure 24.17: δ¹⁸O isotope values for Riverlands groundwaters

Groundwater and soils

In 2005 the MDC commissioned a report to assess the effect of applying chemically evolved groundwater to soils at Riverlands and the Lower Wairau area (Neal - 2005). The soils in these areas are silt loams with a high water holding capacity and poor drainage. The Neal report found that there are two potential issues affecting lower Wairau soils. Firstly, the irrigation of saline water on non-saline soils caused a gradual accumulation of salt in the soil. Secondly, the application of clean water to saline soils can mobilise sodium into groundwater and affect soil structure.

conductivity values in the Riverlands Aquifer are typically greater than 20 mS/m. Conductivity values of more than 100 mS/m correspond with highly evolved groundwater and conductivity is lower around areas of higher pumping as fresher water is being drawn in from the Wairau Aquifer to the north.

Groundwater potability

The Riverlands and Wairau Aquifers are considered to be microbiologically secure water sources from a human health perspective because they are protected from landuse influences by the presence of the natural confining layer. However, confinement causes reducing chemical conditions which results in higher concentrations of naturally occurring metals in some well waters. Some of the more evolved groundwater is unsuitable for drinking.

A 2004 community questionnaire found that about a third of well owners at Riverlands experienced problems with groundwater quality for domestic uses. Most water quality problems are due to elevated concentrations of manganese or iron causing staining of whiteware. This occurs when concentrations are above 0.04 g/m^3 and 0.2 g/m^3 respectively. These levels exceed the guidelines of the Ministry of Health (2005). Most wells in the Riverlands Aquifer also have manganese concentrations above the taste threshold of 0.1 g/m^3. In some cases levels are high and require treatment to reduce the concentration so they are safe to drink.

The major potential risk to Riverlands groundwater quality is seawater intrusion. The MDC operate a coastal monitoring network to warn of seawater intrusion, but based on conductivity measurements made at well 0708 since 2001, there has been no evidence of seawater intrusion occurring.

Environmental isotope studies

Oxygen-18 is a useful tracer for determining the source of groundwater and has been applied to the Riverlands groundwater as part of two comprehensive studies. The initial work was carried out by C.B. Taylor of the NZGS in 1992. This was recently revised by M.K. Stewart of GNS Science in 2008 to incorporate more recent results.

The more dynamic, leaky area of the Riverlands Aquifer west of Malthouse Road has ^{18}O values which are characteristic of Wairau Aquifer groundwater mixed with low-altitude rainfall and Taylor River water. Rainfall makes a small but identifiable contribution to Riverlands Aquifer recharge along the hill margin and near the Taylor Fan, where the diluting influence of Wairau River derived recharge water is lessened (Fig. 24.17).

Oxygen-18 values become more negative with increasing confinement for both the Riverlands Aquifer and Wairau Aquifer due to high altitude Wairau River water being the dominant source of aquifer recharge. Water originating from lower elevations such as the Taylor River or Southern Springs and having a less negative signature, departs the aquifer through the bed of the Opawa River west of Malthouse Road.

As a result, locally recharged groundwater is restricted to the Blenheim-Alabama Road area. The dominant flow direction in the Wairau Aquifer is south or east. This means that groundwater moving towards the coast is progressively recharged by water originally sourced from the Wairau River. At Hardings Road almost all groundwater originated from the Wairau River.

In general the age of groundwater within the confined Wairau Aquifer increases towards the valley margins. Residence times range from ten years for the younger water in less isolated parts of the aquifer, to sixty years or more south-eastwards of Hardings Road within the highly confined sector. The oldest water below Wairau Lagoons is likely to have been recharged by the Wairau River up to 500 years earlier.

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