# Chapter 33: Wairau Valley Groundwater Resources

## Introduction

The Wairau River and its associated valley extend from the Spencer Mountains in the west, to the Wairau Plain at the Cloudy Bay coast near Blenheim. The Wairau Valley groundwater resources are defined as a much smaller area centred on the south bank of the Wairau River around the Wairau Valley township, extending from the Wye River in the west to opposite the Narrows just above the Waihopai confluence in the east.

The south bank of the Wairau Valley is distinct hydrologically to the north bank as the south bank has lower rainfall and runoff, potentially higher water demand and is greatly influenced by the Wairau Fault. For these reasons the groundwater resources of the south bank are treated separately than those on the north bank.

Little was known about the hydrogeology of the Wairau Valley area until relatively recently. This was because the demand for irrigation water from groundwater was low as most water was traditionally sourced from the Wairau River and no specific investigations were carried out by the MDC or its predecessors.

Saline groundwater was known to exist, but in general there were few water quantity management issues apart from seasonal shortages of stock or drinking water. Landuse intensification since the 1990s has increased demand for water and subsequently led to deeper explorations for groundwater. The exploration has been mainly focused on areas where Wairau River water is unavailable to landowners because their land doesn't border the river channel.

Traditional sheep and cattle farms have been replaced by vineyard or dairy farms on the flats, and plantation

**Figure 33.2: Irrigated pasture in the Wairau Valley. Looking east with the Wye River in foreground**

forestry on the south bank hill country and vineyards and dairy farms require greater volumes of irrigation water than the traditional uses (Fig. 33.2). In addition there has also been an increase in rural residential or lifestyle blocks in the area.

The potential for increased demand on water resources and the Trustpower Ltd hydro electric power proposal has initiated several major hydrological studies by both private interests and the MDC. The information gained through these processes has advanced the knowledge of groundwater resources in the area considerably.

## Geology

Geology has a significant influence on the hydrology of the Wairau Valley. Variations in gravel permeability affect groundwater flow and well yields, while the Wairau Fault influences the drainage pattern above and below the surface (Fig. 33.1).

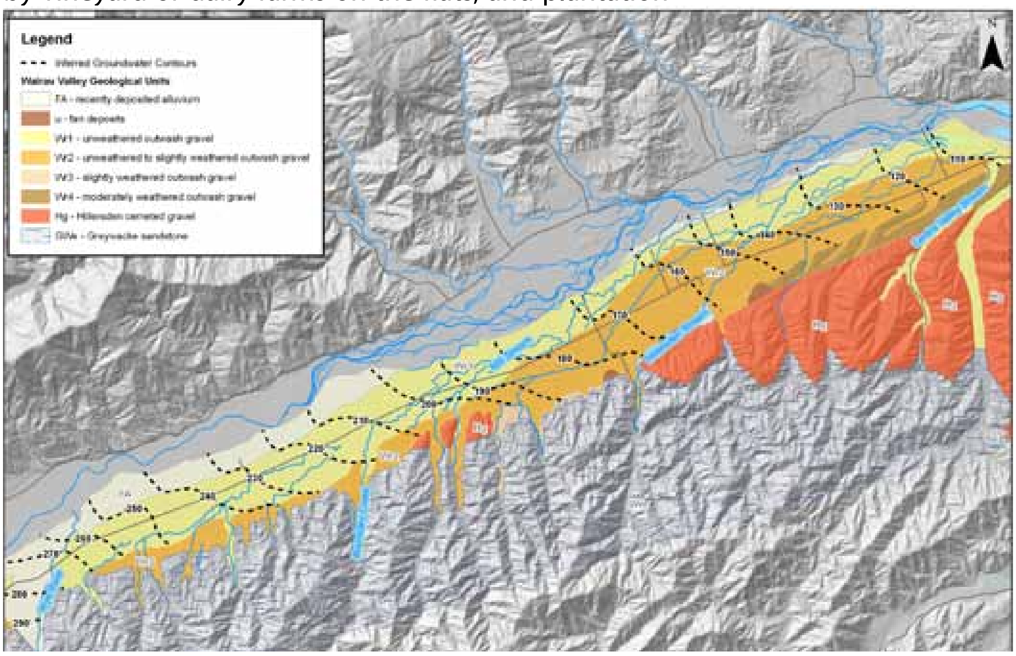


**Figure 33.1: Wairau Valley gravel formations and contours of piezometric elevation (PDP - 2005)**

The most permeable gravels which host the most productive wells are the recently deposited alluvium or unweathered outwash gravels. The more permeable gravel formations are closest to the Wairau River where groundwater flow is more rapid. The least permeable material is the cemented gravels of the Hillersden Formation further from the river.

The Alpine Fault is a large scale structural feature stretching the length of

**Figure 33.3: Looking west along the Wairau Fault**

the South Island. The Wairau Fault is a branch of the main Alpine Fault that runs down the Wairau Valley (Fig. 33.3). The Wairau Fault separates the predominantly greywacke sandstone or argillite mudstone on the south side of the Wairau Valley, from a combination of schist and sandstone on the northern side.

Where the Wairau Fault breaks the surface it has a direct localised effect on the local topography and as a consequence it influences the drainage patterns of streams and wetlands. For example, from Wairau Valley township east to near Renwick it diverts south-bank hill catchment runoff or groundwater sideways rather than allowing it to flow directly to the Wairau River.

The Wairau River itself has been responsible for creating a series of terraces, the largest of which is up to three metres high, and separates recent channel gravels from older alluvium.

## Recharge and flow patterns

Recent investigations by the MDC have reviewed groundwater flow and its interaction with the Wairau River in the Wairau Valley area. Previously it had been assumed that Wairau River water dominated the entire braided river floodway between the Wairau River and the main terrace due to the high permeability of the gravels in conjunction with large river flows.

It is now known that groundwater on both the upper and lower terraces is recharged by runoff originating from the south bank catchments (Fig. 33.4). The alluvium forming the lower terraces were thought to be sufficiently permeable to allow Wairau River water to permanently saturate them. However analysis shows these gravels contain mostly south bank hill country derived water, even relatively close to the Wairau River channel. Isotope analysis has shown that the influence of Wairau River water is restricted to the localised area around the active river channel (Fig. 33.5). However, the river's influence does vary seasonally depending on flow conditions and the channel location.

A dynamic boundary exists between Wairau River water and groundwater with the interface shifting seasonally depending on the relative contribution of flow from either source. Local south bank hill country derived water is likely to be dominant in winter or spring when there is excess runoff. Wairau River water dominates during large floods or under summer conditions, when the southbank catchments generate less runoff.

### Groundwater throughflow and springs

Some of the most significant wetlands outside of the Wairau Plain occur at Wairau Valley. Those on the upper terrace are caused predominantly by the damming effect of the Wairau Fault on local surfacewater runoff. Those on the lower terrace such as Mill Stream, are fed from groundwater under medium to low flows.

Mill Stream gains around several hundred litres per second of channel flow from groundwater between west of Mill Road and where it joins the Wairau River opposite the Golf Course. Springs are caused by a narrowing of the gravels forming the lower terrace opposite the township, which reduces their carrying capacity and forces groundwater upwards.

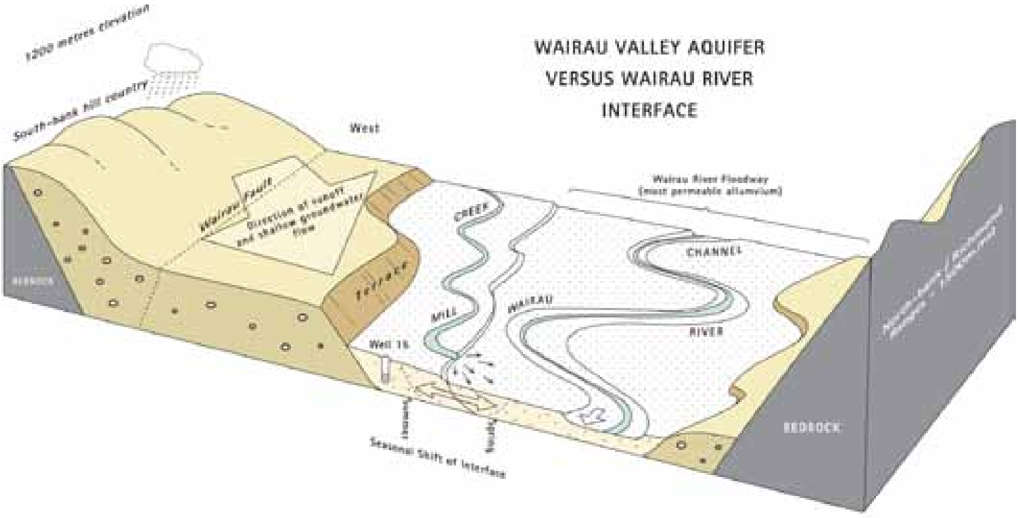


**Figure 33.4: Wairau Valley conceptual flow model**

Figure 33.5: Wairau River looking upstream

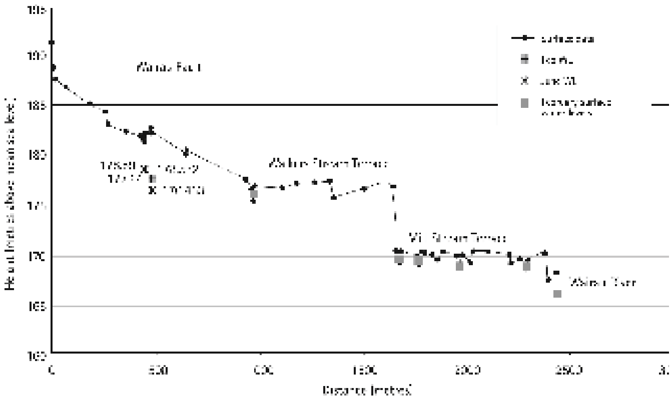


Figure 33.6: Wairau Valley surface and groundwater elevations

While Wairau Valley groundwater is recharged predominantly by runoff from the south bank ranges, the transmitting capacity of the upper terrace gravel formations are low relative to the flow of Mill Stream. One explanation is the existence of more transmissive gravels which transport groundwater from the south bank hills to the Wairau River.

In an attempt to map the direction of groundwater flow and the influence of the Wairau Fault, the MDC commissioned two surveys of water levels relative to the land surface, along two lines west of Wairau Valley township in 2002 (Fig. 33.6). The survey showed that groundwater levels on the upper terrace are more likely to be further below the surface than on the lower terrace, although the localised damming effect of the Wairau Fault caused levels to vary significantly over short distances. A large fall existed between the lower terrace and the Wairau River.

## Groundwater systems

Wairau Valley groundwater resources have traditionally been split into two categories depending on whether they occur above or below the main terrace, on the basis of geology and well yield. While both terraces are formed of alluvium, the material forming the lower terrace is more permeable with fewer fines clogging the matrix and supporting higher producing wells (Fig. 33.7).

Well O28w/0004 drilled on the lower terrace in August 1985 yielded water in sufficient quantity for a large scale pastoral irrigation system. Earlier in 1981, wells were drilled further downstream in the same type of formation on the lower terraces to successfully provide water for the Centre Valley Rural Water Supply Scheme.

However, experience has shown that finding water on the lower terrace is not a certainty. Several drilling attempts were made north of the Wairau Valley golf club to find water for the Wairau Valley community supply in the late 1980s before sufficient water of good quality was found. The larger volumes of water required for the public water supply were unlikely to be available on the upper terrace so groundwater is pumped up a pipeline to supply houses from the lower terrace.

While water wells have always existed on the upper terrace, most provide relatively small quantities of water, primarily for stock or domestic purposes. It is known that historically there have been seasonal problems with water supply from wells in the Wairau Valley area, from recent times, all the way back to the series of droughts in successive years during the great depression of the 1930s.

### Hydraulic properties

A number of aquifer tests have been carried out at Wairau Valley, mostly to support water permit applications for crop irrigation. There is a significant range in transmissivity values depending on location. Higher values are associated with the more permeable gravels on the lower terrace, although there are local anomalies. Transmissivity values for wells on the upper terrace vary by two orders of magnitude and are particularly low south of the Wairau Valley township itself.

Two separate aquifer tests were conducted on medium depth wells 10103 and O28w/0217, located on the southern side of SH6 opposite the township in 2009. Transmissivity values ranging from 10 to 95 $m^2$/day were reported. This compares with an average value of 1,630 $m^2$/day based on the testing of a 14 metre deep well O28w/0226, at Parsons Road (MWH – 2007).

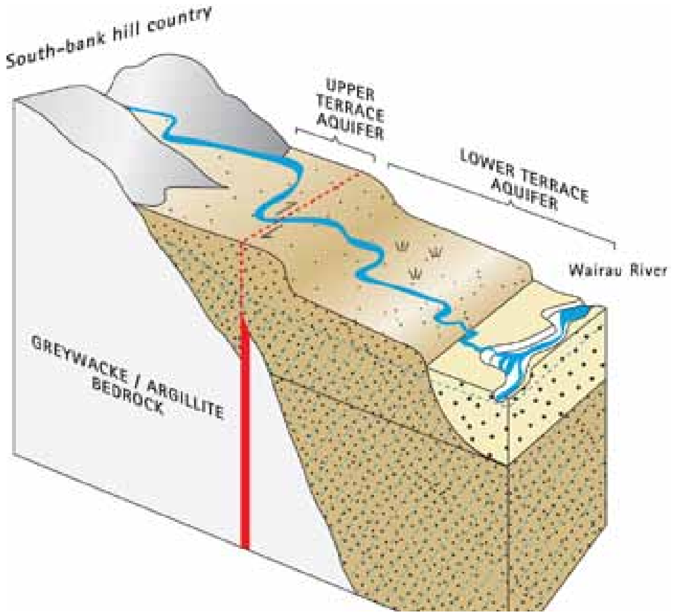


**Figure 33.7: Wairau Valley geological section**

The spatial variation in aquifer yield on the upper terrace may reflect variations in geology, with higher transmissivity values in the Parsons Road area corresponding with more permeable gravels. This would help explain the movement of groundwater from the upper to lower terrace, and why it doesn't appear as surface flow.

Transmissivity values for the lower terrace are of the order of 1,000 to 2,000 m$^2$/day. These include a value of 835 m$^2$/day for a 2001 test carried out on well O28w/0124 near Mill Road. This was more likely however, to reflect the recharge effect of the nearby Mill Stream rather than the aquifer alone.

Values ranging from 1,030 to 2,000 m$^2$/day were measured during the three day test of the MDC monitoring well O28w/0220 in December 2006 (MDC - 2007). These are consistent with values measured for the Wairau Aquifer around Renwick.

Storage values are around 10$^{-2}$ to 10$^{-3}$, indicating an intermediate aquifer structure between fully confined and unconfined. This is unexpected based on the geology described in well logs, especially for the more permeable gravels making up the lower terrace which appear to be unconfined.

The hydraulic properties of the deeper saline groundwater layer have not been measured, but well O28w/0219 is very low yielding. Based on its specific capacity value this well is likely to have a transmissivity value of less than 10 m$^2$/day.

## Groundwater chemistry

A major advance in knowledge of groundwater quality at Wairau Valley has occurred over the past 20 years. Of particular interest has been the presence of saline water both in streams and underground. While historically there has always been an awareness of the existence of saline water amongst the local community, its source and occurrence were largely unexplained until recently. As long ago as 1934, the Erina School at Wairau Valley drilled a new well to improve their water supply. Saline water was encountered as the following quote from the Marlborough Express illustrates.

*"At 47 feet a wonderful supply of clear water was encountered, and it was imagined that the school's water troubles were solved for all time, for it was believed that such a supply in the midst of a drought would be vastly improved in ordinary seasons. When the water was tasted, however, it proved anything but palatable, and, upon analysis, was found to have 64 per cent salt content."*

The depth of the salt water at 14 metres is consistent with modern experiences. The article goes on to say that the well would probably be blown off at the shallower level where groundwater was first intercepted, suggesting an upper layer of freshwater overlying saltwater.

The Wairau Fault appears to be the ultimate source of the saline water and affects wells over a large area (Fig. 33.8). Its ability to influence wells distant from the surface fault trace and close to the diluting effect of the Wairau River, implies that a large body of highly saline water exists beneath the entire Wairau Valley area (Fig. 33.9).

The mechanism for producing the saline water remains unclear, but the most plausible explanation is the natural process of water-rock interaction over

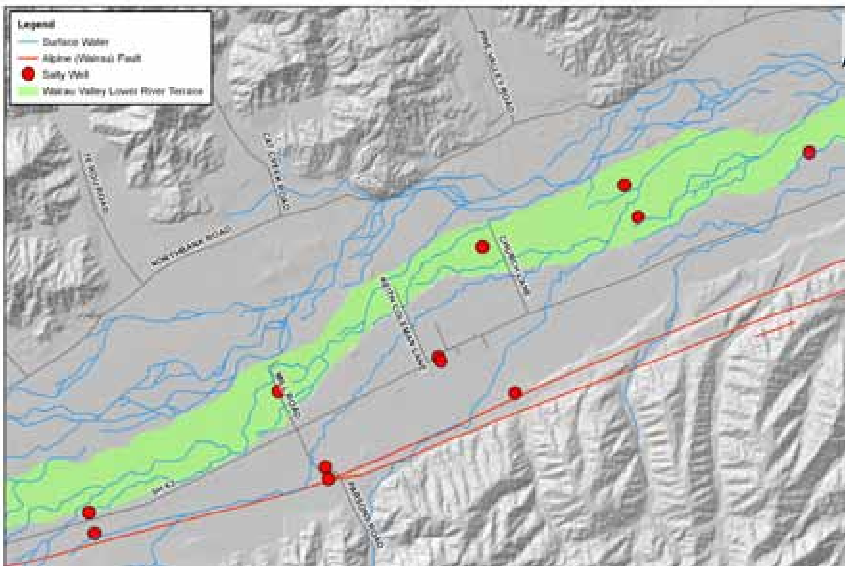

**Figure 33.8: Distribution of known saline wells in the Wairau Valley**

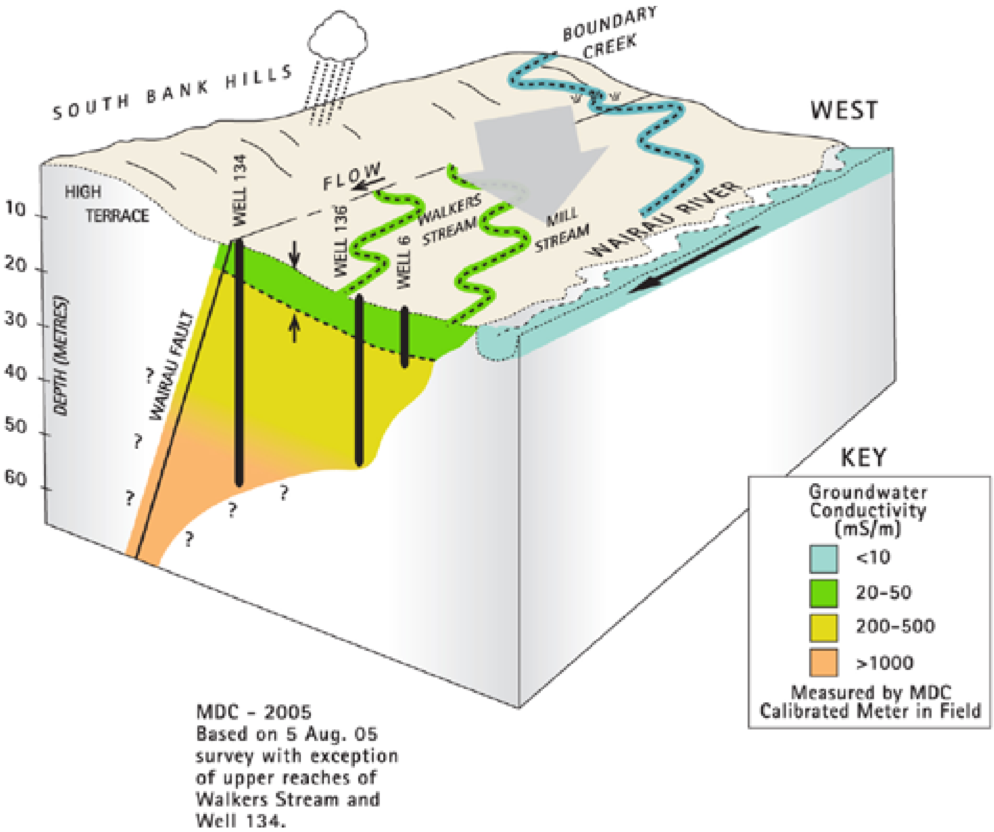


**Figure 33.9: Conceptual model of the origin and distribution of saline groundwater**

thousands of years causing fault fluids to become highly mineralised. These highly evolved waters eventually seep out or get shunted along the fault as new water arrives from the Wairau River further upstream where it crosses the fault. Due to its higher density the saline water underlies the freshwater. Saltwater is generally found beyond depths of around 15 metres below the surface. There are no signs of the saline wedge having any effect on downstream Wairau Plain groundwater.

Walkers Stream is a well known salty waterway to residents of the Wairau Valley township and the saline nature of the stream flow is now well understood based on an MDC investigation programme which began in 2002. Shallow saline water is forced to the surface near the south-western end of Parsons Road, due to the damming effect of the fault. Through the process of evaporation a build-up of deposits forms a salt pan (Fig. 33.10). During rainfall the build-up of salts is then washed down Walkers Stream.

The salt pan at the head of Walkers Stream supports an assemblage of salt tolerant plant species that are typically associated with a coastal environment. The presence of salt tolerant species such as native musk (*Mimulus repens*) in an inland situation is very rare.

A 2006 study shows that the conductivity of Walkers Stream channel at Parsons Road bridge peaks with rainfall events (Fig. 33.11). As a follow-up to this work the vertical salinity profile of groundwater from the surface to a depth of about 50 metres was mapped using a resistivity survey. The study found that the area nearest the Wairau Fault is dominated by saline water, confirming the fault as the source (McCarthy – 2008).

The concentration of natural salts present varies from being obvious in some cases from the taste of the water or corrosion of metal drilling equipment, to requiring a meter to detect lower levels.

## Wairau Valley test bores

To test the theory of the existence of a regional scale saline wedge underlying the entire Wairau Valley area, the MDC drilled two test wells at Mill Road in late 2006 (Fig. 33.12). Well O28w/0219 was drilled to a depth of 50 metres below the surface while well O28w/0220 was drilled to ten metres (Fig. 33.13). The two wells were both initially drilled to a

**Figure 33.10: Walkers Creek salt pan**

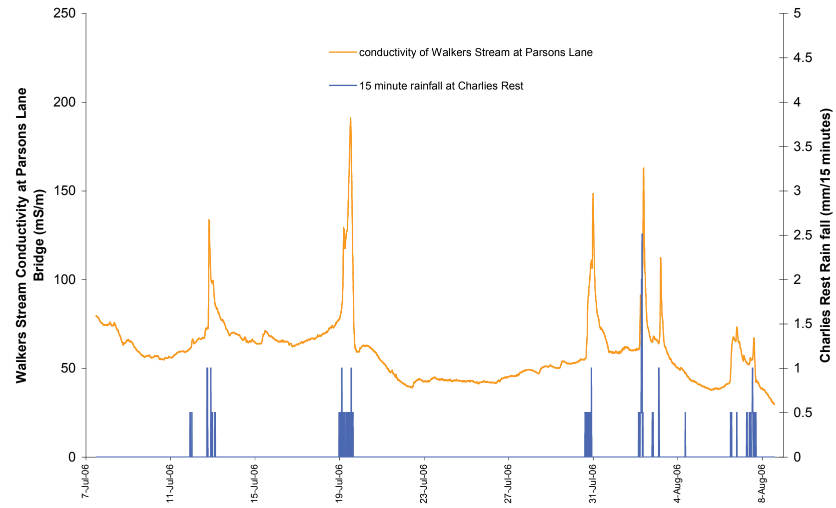


**Figure 33.11: Walkers Creek conductivity versus rainfall**

depth of ten metres and tested to measure the aquifer properties of the shallow aquifer layer. The depth of well O28w/0219 was then extended to 50 metres to record the lithology of the deeper alluvium and the variation in groundwater salinity. During the drilling of well O28w/0219, moderately saline water was first intercepted at 14 metres depth and increased to reach a maximum electrical conductivity of 5,840 mS/m at 50 metres depth. This deeper water is more saline than seawater and explains why it influences such a large area of Wairau Valley. It also implies the existence of a very large volume of saline groundwater underlying the Wairau Valley area.

Drilling showed a trend of decreasing permeability with depth.

The groundwater originating from well O28w/0219 is distinctive in terms of its chemistry with high levels of arsenic, boron, manganese, iron and chloride. The water also has a cloudy nature with a green tinge. This is a result of the various precipitates oxidising after they come into contact with oxygen at the surface for possibly the first time in thousands of years (Fig. 33.14).

The major ion composition of a sample of groundwater taken from well O28w/0219 in January 2008 showed the water is dominated by sodium and chloride with concentrations that are relatively consistent at 18,000 to 20,000 g/m$^3$, and similar to its concentration in seawater (Fig. 33.15).

The mean residence time of groundwater sampled from well O28w/0219 has been estimated at 25,000 years based on an analysis by GNS Science of its $\delta^{14}C$ content, which showed there was very little modern carbon present. A long residence time is also supported by the fact that the deep groundwater contains no tritium. The presence of methane gas is consistent with ancient water sourced from an isolated aquifer and advanced reducing conditions. More samples are required to confirm this age given the practical difficulties of satisfactorily purging the well of the water in its casing, and the variable results collected so far.

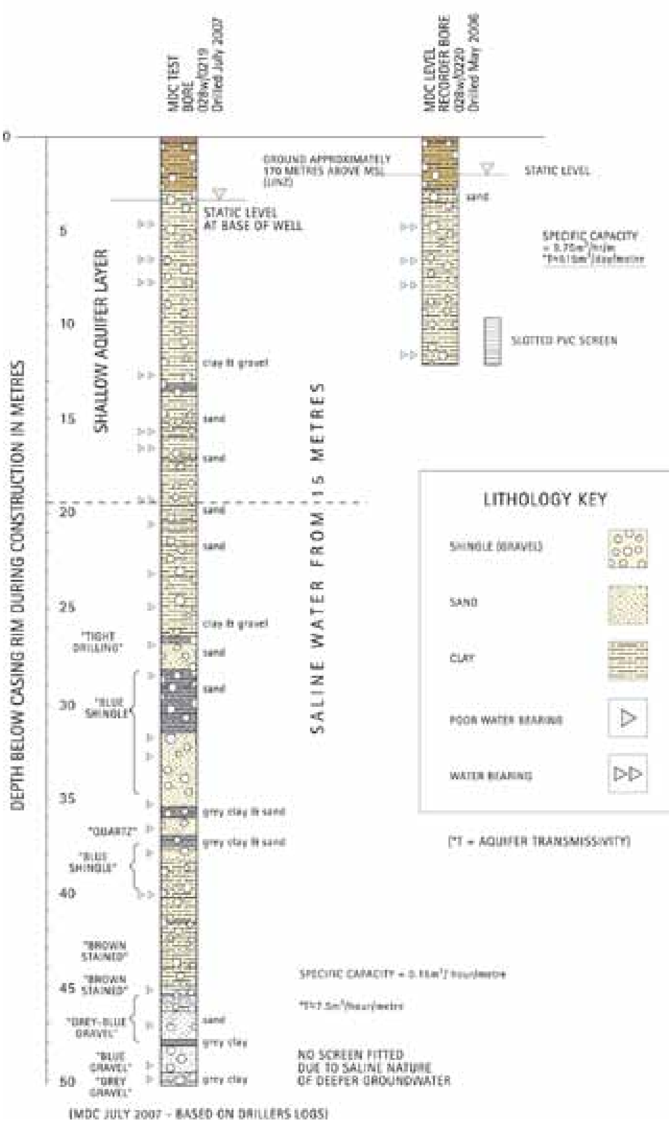


**Figure 33.12: Test bore geological logs**

**Figure 33.13: MDC Wairau Valley monitoring wells**

Figure 33.14: Well O28w/0219 water sample

The chemical composition of O28w/0219 is dramatically different to that of groundwater from the neighbouring MDC monitoring well O28w/0220. Well O28w/0220 has a more balanced composition that is similar to rainfall or surface waters (Fig. 33.16). The mean residence time of this shallow groundwater is less than two years old and has an identical chemistry to Mill Stream water.

Shallow Wairau Valley groundwaters commonly have a higher chloride fraction than other dilute waters in Marlborough and this is thought to reflect the general influence of saline water underlying the area. This is also apparent when its composition is compared to the Wairau River water (Fig. 33.17). The shallow groundwater has higher nitrate and chloride concentrations than Wairau River water, supporting the isotope evidence which point to a south bank hill country source of recharge with its agricultural influences.

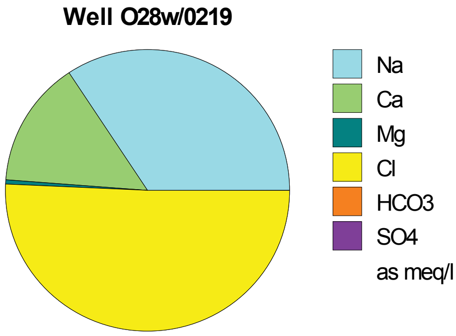


Figure 33.15: Well O28w/0219 groundwater composition

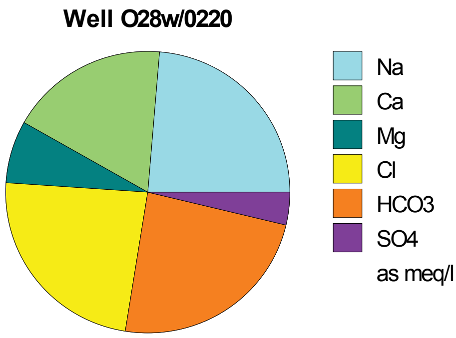


Figure 33.16: Well O28w/0220 groundwater composition

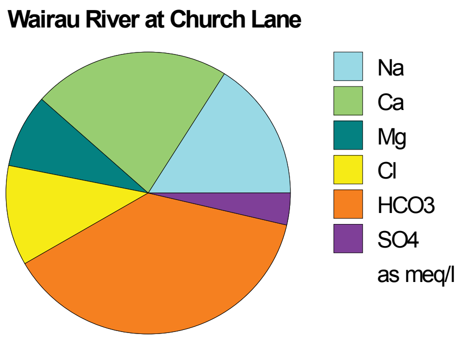


Figure 33.17: Wairau River composition

The chemistry of different water sources can be summarised on a Piper diagram (Fig. 33.18). Saline deep groundwater plots in the same position as seawater, while Mill Stream and shallow groundwater are more alike than Wairau River water. This is consistent with both a south bank source of recharge, and up-welling groundwater supplying the increase in channel flow of Mill Stream.

The Wairau Valley Township has a community supply well O28w/0015 which sources groundwater from the lower terrace. Being an unconfined aquifer the water supply is insecure due to nearby agricultural landuses and human settlement. For this reason groundwater is treated to remove

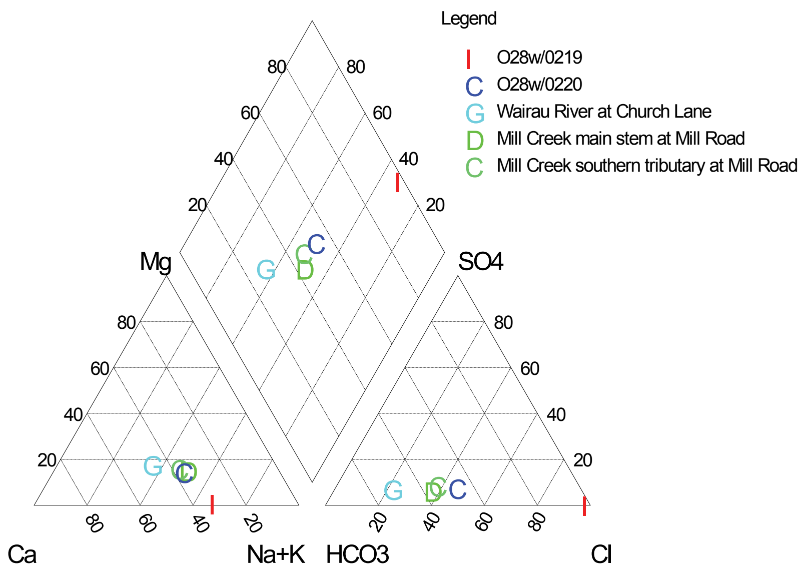


Figure 33.18: Wairau Valley groundwater piper diagram

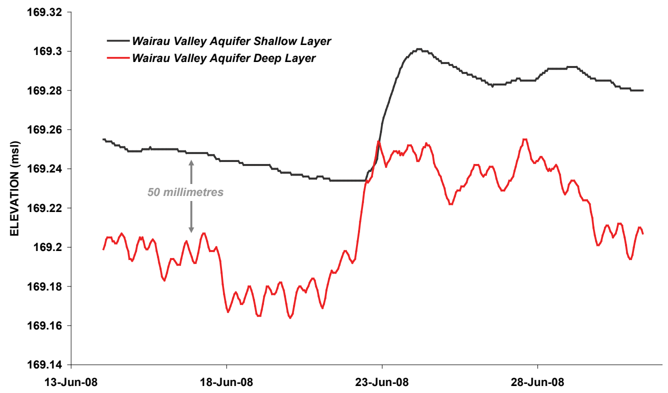


**Figure 33.19: Wairau Valley aquifer level variation**

potentially harmful microbes before it is used for human consumption.

The ongoing reliability of this well has proved the early Hillersden farm settlement pioneers right. They frequently ran short of groundwater on their upper terrace block and probably unknowingly consumed water high in arsenic.

Given the growth in water demand at Wairau Valley, the MDC established a permanent water level monitoring instrument at well O28w/0220. This ten metre deep well represents the shallow aquifer, which is the predominant source of irrigation water in the valley.

Records from the shallower well O28w/0220 have been used to assess the interaction between groundwater, the Wairau River, Mill Stream and south bank hill country runoff. Analysis shows a general rise in shallow groundwater levels and an increase in Mill Stream flow accompanies Wairau River flood events. This reflects a backing up of groundwater by higher Wairau River levels rather than recharge, except very close to the channel. A strong hydraulic link exists between shallow groundwater and Mill Stream flow, which is not surprising as they are effectively the same water body. The hydraulic connection between shallow and deep groundwater at Wairau Valley is not fully understood (Fig. 33.19).

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