DEEP WAIRAU AQUIFER SUSTAINABILITY REVIEW 2008

Part 1: Aquifer Response to Abstraction 1998-2008

MARLBOROUGH
DISTRICT COUNCIL

1. Background

The Deep Wairau Aquifer (DWA) represents the most recently exploited, but poorly understood underground water resource in Marlborough. It was discovered during the 1997/98 summer drought following the construction of a series of deep wells drilled to replace shallower ones that had failed due to higher than normal water demand, and below average recharge during that season.

It is currently known to occur beneath the Fairhall, Woodbourne and Southern Valleys Aquifer areas, although future drilling may show it extends elsewhere. Generally speaking the Deep Wairau Aquifer exists at depths of greater than 150 metres below the surface. This means it is relatively isolated from surface hydrological processes such as rainfall or river recharge. As a consequence there are likely to be fewer pumping induced effects on other parts of the hydrological cycle, such as spring flows or shallow aquifer levels.

Deep Wairau Aquifer water is very old meaning that it has been underground for a considerable period of time. This implies groundwater flow rates are low or the aquifer is blind with no recharge of recent, younger water.

Its name was coined by Marlborough District Council staff to distinguish it from the overlying Wairau Aquifer which represents the predominant groundwater system underlying the Wairau Plain and primary source of water for all purposes.

While it shares the same name as the Wairau Aquifer, it is known to partially underlie the fully allocated and heavily committed Southern Valleys Aquifers. For this reason it represents a potentially valuable water resource. Its recent discovery can be attributed to the fact that historically more accessible water was more available closer to the surface.

The dynamics of the Deep Wairau Aquifer remain more poorly understood than for any other local groundwater resource and this is reflected in the current cautious management approach. The Deep Wairau Aquifer isn't referred to in the PWARMP, and no policy or rules exist to govern its use.

Only a small number of consents exist to take directly from the DWA, although indirect demand via deeper wells in the Southern Valleys means that overall demand is likely to be of the order of 100,000 m^3 per season. With the introduction in 2004 of an augmentation scheme to supply irrigation water to the overlying Southern Valleys Catchment area, demand on this resource is unlikely to increase significantly in the future.

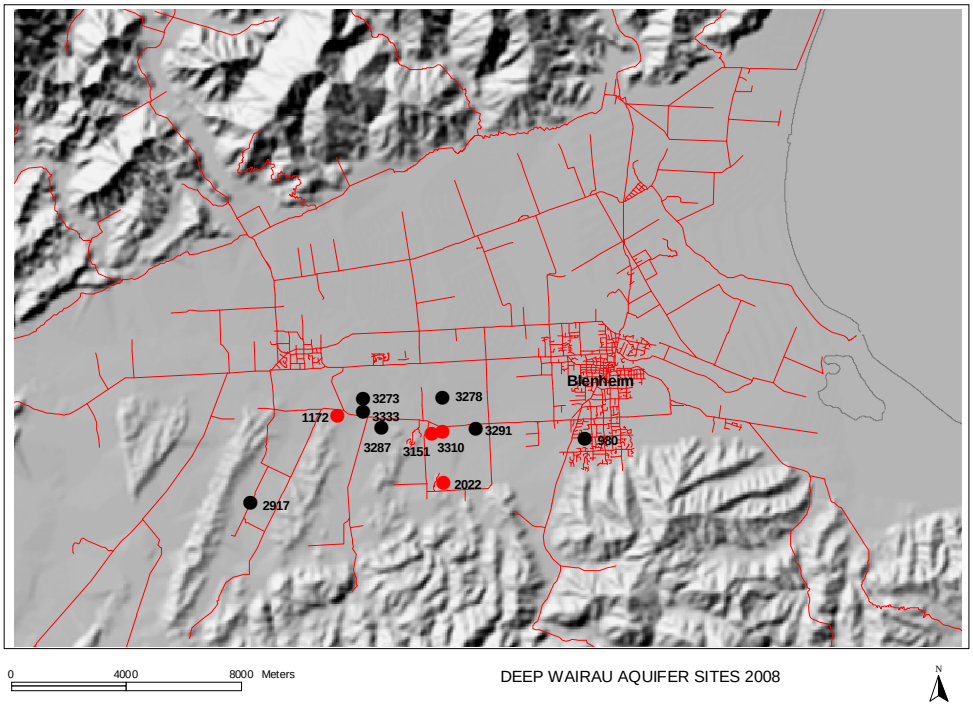

Figure 1 : Known Deep Wairau Aquifer Wells 2008

Figure 1 is a plan view of the Wairau Plain shows the location of wells penetrating the Deep Wairau Aquifer in black, and hydraulically linked wells representing the Southern Valleys Aquifers in red. Figure 2 shows only those wells used recently for sampling or supplying key data used in this review.

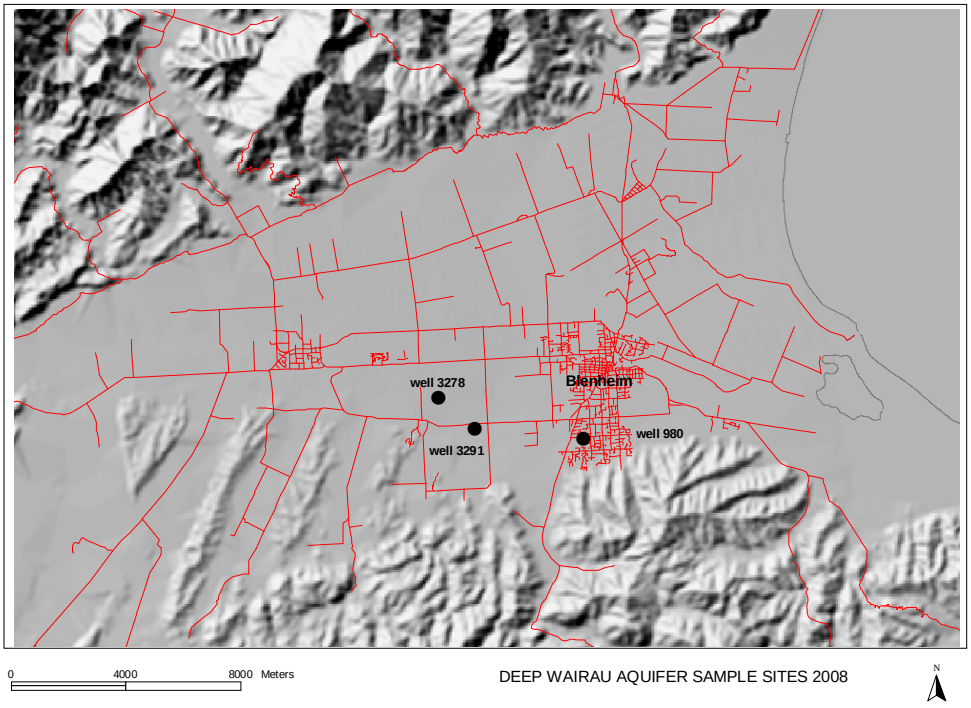

Figure 2 : Deep Wairau Aquifer Wells With Recent Record

2. Review & Technical Report

The purpose of this report is to document the review of the long-term sustainable yield of the Deep Wairau Aquifer (DWA), 10 years after its discovery, and following a decade of abstraction by resource consent holders. The review process involves refining community understanding of aquifer dynamics and the implications for future aquifer management.

A significant amount of hydrological data now exists for the Deep Wairau Aquifer including metered water use, continuous well level record, and measurements of groundwater chemistry and environmental isotope concentrations. The review compares trends in aquifer behaviour and properties over the past decade in response to abstraction.

This report is the first in a series of 3 being produced for the Marlborough District Council. Two external reports focusing specifically on the geochemistry and isotope hydrology have been funded by central government ENVIROLINK grants, and are being carried out independently of this staff report by ESR and GNS Science Ltd respectively.

This review forms part of a wider examination of the sustainable yield of various Marlborough groundwater systems by the Marlborough District Council, each of which is underpinned by a technical report on the hydrology of the water resource.

It was initiated in 2007 by the Marlborough District Council to coincide with the expiry of the largest consented abstraction, and forms part of the review of the freshwater components of the Proposed Wairau-Awatere Resource Management Plan (PWARMP). As such it is an opportune time to assess the response of this poorly understood aquifer system to consented water use from the Deep Wairau Aquifer, given the availability of a significant data series.

3. Previous Findings

Given the situation that existed in 1999 with a lack of knowledge of its hydrology or safe yield, coupled with the potential for increases in water demand; Marlborough District Council commissioned a series of external technical reports on the Deep Wairau Aquifer. The aim of this advice was to identify management issues. Details of all material or publications produced or commissioned by the Marlborough District Council in relation to the Deep Wairau Aquifer are listed in the bibliography.

The first priority from a science perspective was to develop a conceptual model of the aquifer. This involved understanding its geological structure, groundwater flow path, recharge mechanism and where it drains to. Because too few wells exist then or now to define its boundaries and reservoir capacity, indirect assessment methods were used to evaluate its key properties. These included isotopic tracers, geochemistry and pumping tests. Unfortunately a far from complete picture still exists and is likely to remain so given it is unlikely significant new demand or drilling will occur.

The following is a summary of the conclusions drawn from the previous series of research projects in the late 1990s:

1. *Stable isotope concentrations of the Deep Wairau Aquifer groundwater show it originated from a high altitude source, but the identity of the river remains uncertain. Assuming it was recharged from a river which currently exists, this narrows it down to the Wairau or Waihopai Rivers*

2. *The ^{18}O ratio is similar to current water from the Wairau River Catchment, although it is slightly more negative due possibly to cooler temperatures during the Otiran Glaciation when recharge occurred*

3. *Dating methods using the known decay rate of carbon isotopes indicate a mean residence time for Deep Wairau Aquifer water of 22,000 years before present for up-gradient wells closer to the supposed source of recharge in the west, and approximately 40,000 years for the hospital well near Blenheim at the downstream end of the flow-path*

4. *It remains unclear from the existing data whether there is ongoing slow recharge to the Deep Wairau Aquifer system, or whether all the recharge occurred at some time in the past and the recharge paths have since become blocked*

5. *The partial recovery of Deep Wairau Aquifer levels at Marlborough District Council monitoring wells, despite the abstraction of approximately 500,000 cubic metres of groundwater; implies recharge is occurring to some degree via pumping induced recharge of younger water*

6. *The exact nature of the aquifer boundaries and the source of recharge water remain uncertain*

7. *The nature of aquifer outflow is uncertain but is probably akin to the upwards seepage which occurs in the Wairau Aquifer at the Cloudy Bay coast*

8. *Natural groundwater flow is slow and reflects the highly evolved nature of groundwater chemistry due to the extended period of water/rock interaction over thousands of years. While water quality is acceptable for human health purposes, the concentrations of many parameters are high making the water less than ideal for some uses*

9. *Groundwater chemistry is typical of water that has been isolated from the atmosphere for a long period of time and has extended contact with local rocks, especially saline marine deposits*

10. *In common with groundwaters sourced from aquifers on the periphery of the main axis of aquifer flow beneath the Wairau Plain, it is generally potable but has elevated concentrations of minerals in solution which may cause aesthetic issues such as staining, corrosion or taste problems*

4. Water Management Issues

The unique physical attributes of the Deep Wairau Aquifer including its ancient water and isolation from surface sources of recharge, pose questions as to its long-term viability as an economic aquifer for supplying crop irrigation water. The key management question centres on whether the Deep Wairau Aquifer represents a significant natural water reservoir in terms of volume, and whether it is linked to an active source of recharge to sustain current or increased rates of withdrawal.

These same aquifer properties provide opportunities for identifying pumping induced changes to the Deep Wairau Aquifer. If it is a blind aquifer, then abstraction will be drawing down old water that has been in storage, and levels are likely to fall over time. Conversely, if a connection to a present day river exists, then withdrawals will be continually replaced by younger water. Both water types have distinctive fingerprints which provide tools for identifying the recharge mechanism.

Also of relevance from a management perspective is the hydraulic link between the Deep Wairau Aquifer and the heavily committed Southern Valleys Aquifers, demonstrated by the results from a series of aquifer tests in the late 1990s (Woodward-Clyde – 1999). High demands on these Southern Valleys Aquifers and catchments lead to the introduction of the Southern Valleys Irrigation Scheme (SVIS) in 2004 to augment the traditional groundwater sources of irrigation water. Symptomatic of the state of these aquifers is the fact that no new resource consents to take groundwater have been granted since 2000. A special water management zone was designated in the PWARMP to recognise their special management issues.

5. Aquifer Records & Information

Various hydrological data have been collected since 1998 to provide a baseline for identifying trends associated with abstraction of groundwater over the initial 10 year term of consent. As was mentioned earlier, a number of reports were produced externally and in-house, with some published as papers in international science journals. It is fair to say that a significant amount of high quality science is available for comparative purposes.

Factors complicating the analysis process include the existence of long screens in wells tapping the Deep Wairau Aquifer and the existence of multiple water bearing layers making up the Deep Wairau Aquifer, as shown in the Marlborough District Council cross section (MDC - 1999). This structure introduces uncertainty as to the origin of groundwater, and the representativeness of chemistry or isotope samples.

For example well 3278 is screened over a distance of 89 metres from below a depth of 100 metres, meaning water could originate from anywhere within this band (Figure 1). While downhole gauging measurements confirm a high proportion of flow originated from depth, care must be taken in interpreting these data as the potential exists for recent water to influence samples (MDC – 1999). Table 1 summarises details of those wells which provided the bulk of the information used in the review.

6. Review Components

There are a number of components to the science review, some of which will be done in-house, while others will require specialist skills. Marlborough District Council is a small unitary authority with a strong hydrology science group, however it relies on outside expertise for advice on isotope physics and groundwater geochemistry as part of its research programme.

The Marlborough District Council staff contribution to the review is the subject of this technical report. It involves an analysis of trends in groundwater levels in relation to water use and climate. Current water permit holders are aware of the existence of this review and are awaiting the release of the technical reports.

7. Environmental Benefits & Application of Review

The key environmental benefit of the science review will be a clearer conceptual understanding of the Deep Wairau Aquifer and its water management issues. First and foremost the advice will be used to improve understanding amongst current water permit holders, Councillors, staff and the wider community of this aquifer resource, through the series of technical publications.

It will lay a knowledge based platform for defining the issues, options and future level of use of the Deep Wairau Aquifer. Finally, this report will also assist with decision making for two water permit which are expiring in 2008.

8. Review of Aquifer Response to Abstraction and Climate

The role of this report is to analyse trends in aquifer behaviour over the past decade and in particular the long-term response of aquifer levels to abstraction or climate patterns. Table 1 summarises details of key wells used as sources of information for hydrological studies of the Deep Wairau Aquifer.

Well 3278 located at the Pernod Ricard Fairhall Estate vineyard is the most studied well. Information exists on how water level, groundwater chemistry, isotope and aquifer hydraulic properties have varied since 1998. It is representative of the eastern lithologic sequence which includes a mix of terrestrially and marine derived sediments, although the deepest well is 2917 (Figure 1). Further west, the Deep Wairau Aquifer comprises exclusively of terrestrially derived material.

Marlborough District Council have operated continuous water level recording instruments at 4 wells representing the Deep Wairau Aquifer to record the impact of consented abstraction and response to climate or river flows. Records began earlier at the Marlborough District Council exploratory well 2917 in December 1995, before the existence of a larger deep aquifer became apparent. Figure 1 shows the location of these monitoring wells.

MDC Well Number	Owner	Screen Depth (metres below surface)	Location	Start of Record & Well Details
3333	Pernod Ricard Ltd	200 - 318	Boulevard just north of New Renwick Road	Irrigation well that was subsequently refused resource consent for use as a source of vineyard irrigation water. Water level record dates from December 1998
2917	MDC	60 - 400	Hawkesbury Road in Omaka-Hawkesbury Valley	Exploratory bore drilled by MDC in 1995. Currently the deepest water well in Marlborough. Water level record dates from December 1995
3287	Fairbourne Subdivision	43 - 250	Opposite Fairhall Cemetery, south of New Renwick Road	Rural residential community water supply well. No continuous monitoring of level or chemistry
3278	Pernod Ricard Ltd	100 - 189	Eastern end of Fairhall Estate vineyard	Production irrigation well for Booker block at southern end of Fairhall-Brancott Valley. Water level record dates from November 1998
3291	Korere Water Services Ltd	81 - 151	South of New Renwick Road	Well drilled in spring 1998 to an overall depth of 168 metres, and screened over 3 layers between 81 and 151 metres. Initial artesian pressure in well was measured at 9 metres above ground-level. Irrigation well that was subsequently refused resource consent for vineyard. Water level record dates from August 1999
3273	Woodbourne Farm	60 - 168	North of New Renwick Road near Woodbourne	Well drilled in early 1998 and used as a source of crop irrigation water
980	Wairau Hospital/MDC	87 overall with screen details uncertain	Redwoodtown, Blenheim	Well drilled in 1916 for hospital supply. Still retains small artesian flow in 2008. Water level record dates from April 1999 but has been interrupted since

Table 1 : Key Deep Wairau Aquifer Well Details

9. Interaction between Wells and Aquifer Extent

A series of 3 aquifer tests were carried out in 1998 or 1999 by the then Montana Wines Ltd and Marlborough District Council, to quantify the effects of proposed water permit applications, and measure aquifer hydraulic properties.

Testing demonstrated that most wells penetrating the Deep Wairau Aquifer are hydraulically linked. Because the aquifer is so large this couldn't be determined directly by the short term aquifer test procedures, but by implication based on overlapping interference effects at mutually used observation wells. For example well 3278 was affected by the testing of well 3291 (MDC – 1998), which in turn affected well 3287 when it was tested (Woodward-Clyde 1999); which was affected by the testing of well 3333 (Woodward-Clyde 1999). Well 980 located in the Blenheim urban area is too isolated to respond to any of the 3 aquifer tests (Figure 1).

Another key finding was the existence of a hydraulic link between the Deep Wairau Aquifer and the Southern Valleys Aquifers. For example the pumping of Deep Wairau Aquifer well 3333 at the boulevard affected Brancott Aquifer well levels to the south (Woodward-Clyde 1999). Testing of Deep Wairau Aquifer well 3278 at the Pernod Ricard Fairhall Estate caused groundwater levels to fall at the Fairhall Golf Club well 3151, representing the Benmorven Aquifer (Woodward-Clyde 1999). These linkages are summarised in Table 2.

Pumped Well	**Observation Well**	**1172 (Brancott Aquifer)**	**3273 (Deep Wairau Aquifer)**	**3287 (Deep Wairau Aquifer)**	**3310 (Benmorven Aquifer)**	**3151 (Benmorven Aquifer)**	**2022 (Benmorven Aquifer)**	**3278 (Deep Wairau Aquifer)**
3333		**YES**	**YES**	**YES**				
3378				**YES**	**YES**	**YES**		
3291							**YES**	**YES**

Table 2 : Aquifer Test Linkages

10. Aquifer Trends & Climate

Figure 3 shows the change in groundwater elevation at 5 monitoring wells representing the Deep Wairau Aquifer and 1 site representing the Southern Valleys Aquifer, for the period from 1995 to 2008. Unfortunately record for the benchmark well 3278 is truncated due to the operational nature of this site, while record for the hospital well 980 is incomplete from 2006 onwards.

The close correlation between records supports the concept of a single, interconnected aquifer system. The exception is well 980 which exhibits a much more subdued response. All 5 sites show a downward trend in groundwater level since 1999, although levels have recovered in recent seasons, due probably to an increase in the use of Southern Valleys Irrigation Scheme water relative to local groundwater. A net fall of 3 to 5 metres has occurred across all sites since 1999.

Also included to provide a longer term climatic context for regional trends in aquifer behaviour, is record from the long-standing Benmorven Aquifer well 2022, known to be hydraulically connected to the Deep Wairau Aquifer (Figure 4). Included in this period are 2 significant drought events in 1997-1998 and 2000-2001.

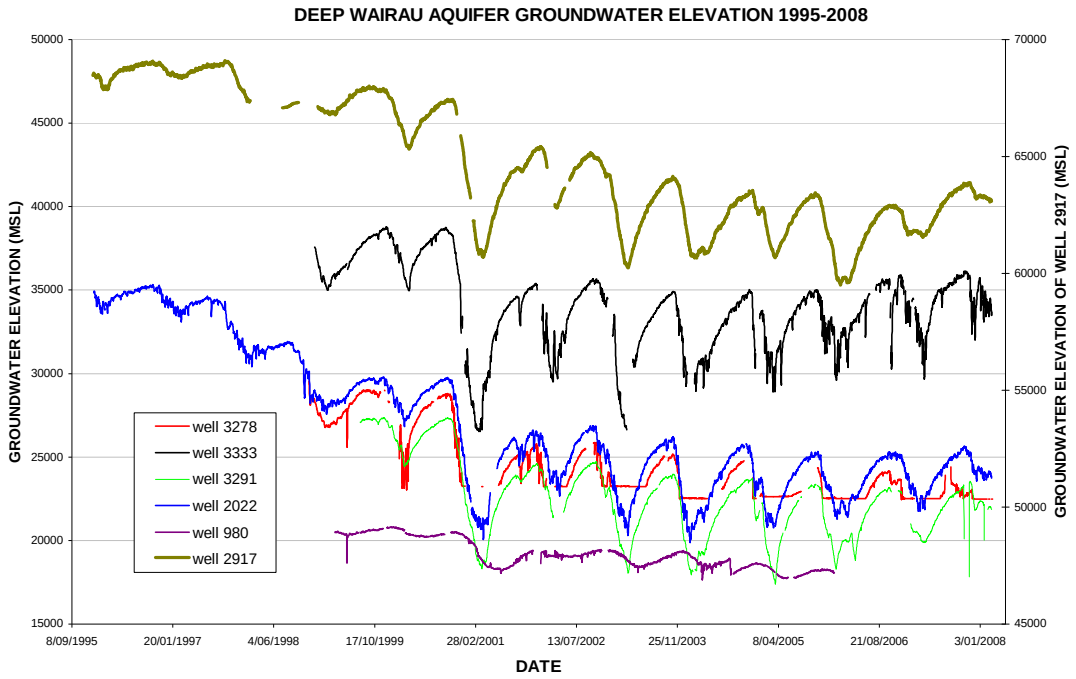

Figure 3 : Groundwater Elevation Time Series

Ground water elevation is shown on the vertical axis in millimetres above mean sea-level (MDC Rivers & Drainage datum), with the date along the horizontal axis in both plots. This record shows the mid 1990s experienced some of the wettest seasons in recent times, while the late 1990s were some of the driest seasons and this is reflected in the variation in groundwater levels at all sites to varying degrees.

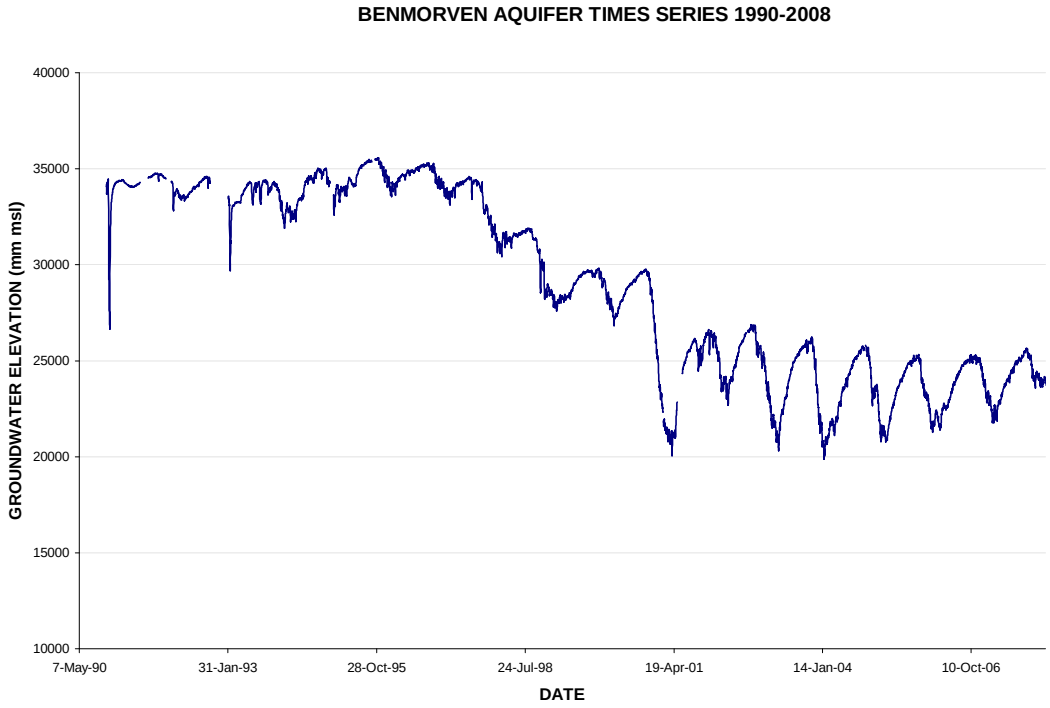

Figure 4 : Long-term variation in Southern Valleys Aquifer Level

The close relationship between groundwater levels representing the Deep Wairau Aquifer and Southern Valleys Aquifers is illustrated by the close correlation in Figure 5 between groundwater elevations at Deep Wairau Aquifer well 3291 and Benmorven Aquifer well 2022.

The fact that the Deep Wairau Aquifer levels recover from seasonal abstraction and the similarity with shallower well patterns suggest the Deep Wairau Aquifer is not blind, but interacting with surface processes to some degree. This should be reflected in time by a change in the chemical constituents of Deep Wairau Aquifer groundwater.

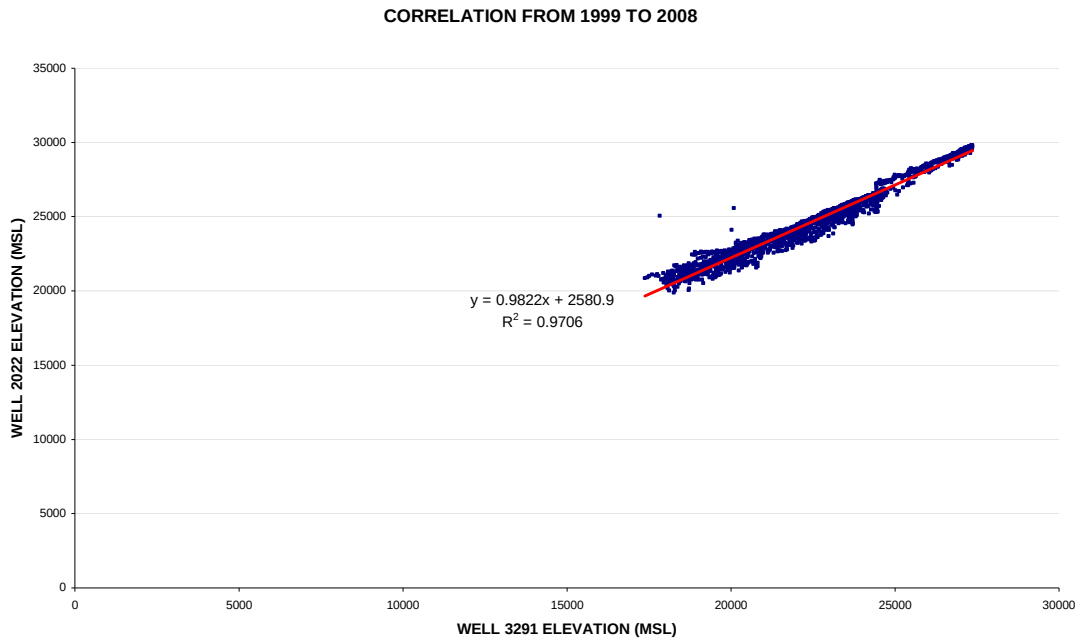

Figure 5 : Correlation of Groundwater Elevation

11. Groundwater Abstraction

The single largest user of groundwater direct from the Deep Wairau Aquifer is Pernod Ricard, which has resource consent to abstract up to 1,000 m^3/day from well 3278 at their Fairhall Estate, to irrigate a 77 hectare vineyard in the Upper Brancott Valley.

Based on meter readings collected as a condition of consent, approximately 500,000 m^3 of groundwater has been pumped between the 2000/01 and part-way through the 2007/08 summer irrigation seasons. In addition other consents will be indirectly sourcing water from the Deep Wairau Aquifer by intercepting flows that would otherwise recharge this system. For this reason it is difficult to define which consents directly rely on the deep Wairau Aquifer.

Assuming the Deep Wairau Aquifer underlies an area of the Wairau Plain of 150 km^2 and has a storativity of $1x10^{-4}$, the drawdown required to release the metered volume of 500,000 m^3 of water pumped from well 3278 alone would be about 35 metres. The observed net fall in aquifer level at the supply well 3278 is only around 5 metres for the period from 1997 to 2008.This implies the Deep Wairau Aquifer is receiving recharge from an external source, or is larger than envisaged.

12. Conclusions

- *No overall downward trend in groundwater levels suggests active recharge is occurring to some extent, perhaps as a result of pumping*

- *Similar trends in aquifer levels to those of shallower systems indicate the Deep Wairau Aquifer is less isolated than originally thought*

13. Bibliography

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