Chapter 23: Taylor River Related Aquifers

Introduction

Under the southern residential suburbs of Blenheim and the Burleigh area, a vertical sequence of aquifers exists. These aquifers are known as the Taylor Fan and Taylor River Gravels Aquifers (Fig. 23.1). They extend from the Wither Hills north to near Middle Renwick Road. They are bounded in the east by the Riverlands Aquifer, and in the west by the Benmorven Aquifer and the Southern Springs. The aquifers in this area are all reliant on Taylor River water recharge.

The area is defined by the outline of the Taylor Fan, a geological feature representing the sediments deposited by the Taylor River although the surface of the Taylor Fan gravels only define the shallower or upper levels of the aquifer sequence. This geologically complex area represents the coalescing of sedimentary material deposited by three different processes. The aquifer bearing sediments extend down to a depth of 100 metres or more below the surface. The structure of the area is also further complicated by faulting.

Not only is the Taylor Fan area geologically diverse but so are the overlying landuses which include residential properties, municipal landfills, pastoral agriculture, viticulture, manufacturing and rural small holdings. It is interesting to note that historically Blenheim was supplied by Taylor River water pumped from the Borough weir located three kilometres south of the Taylor Dam.

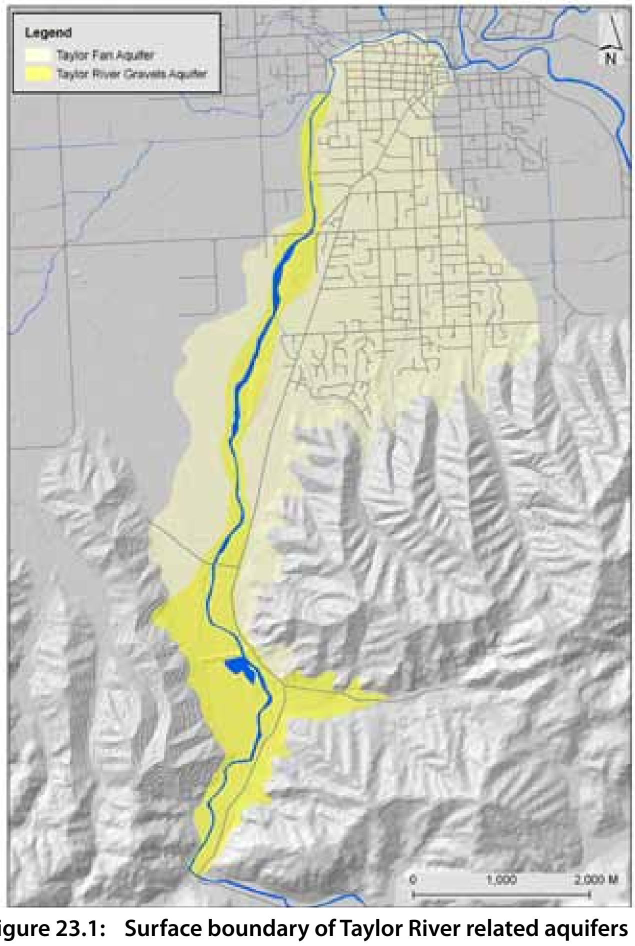

Figure 23.1: Surface boundary of Taylor River related aquifers

As Blenheim expands to incorporate farmland, the importance of groundwater and dependence on individual water wells is lessening. In the past Blenheim's water was supplied from medium depth municipal supply wells at Beaver Road, Eltham Road and Graham Street. These wells were gradually closed as the public water supply was centralised at higher yielding sites in northern Blenheim.

With the advent of the Blenheim water supply the majority of historical individual household wells in Blenheim were abandoned. One surviving shallow well (1477) provides groundwater to irrigate the grounds of Redwoodtown School. The Marlborough Boys College also use groundwater for irrigating their playing fields. Shallow irrigation wells are also known to exist on the fringes of Blenheim in the Burleigh and Riverlands areas.

The largest use of groundwater is for vineyard irrigation on the western flanks of the Taylor Fan although the increased availability of the Southern Valleys Irrigation Scheme (SVIS) is further reducing demand on groundwater in this area.

The Taylor River Aquifers form part of the very low yielding Southern Valleys Aquifer suite stretching along the southern edge of the Wairau Plain from the Waihopai River to Riverlands.

Groundwater systems

Previously this area was referred to as the Taylor-Burleigh Aquifer. As hydrological knowledge has improved, a separate family of Taylor River related aquifers have been defined. These are distinct from the Southern Springs sector around Doctors Creek to the north and the Riverlands Aquifer to the east.

Generally groundwater sources on the southern side of the Taylor River are lower yielding and less reliable than the Wairau Aquifer. This reflects the higher clay content of the gravels, and the ephemeral nature of the Taylor River over the summer months which provides most of the recharge water.

Three distinct aquifer systems occur within the Taylor Fan, overlying each other in a vertical sequence (Fig. 23.2). The Taylor River Gravels Aquifer (TRGA) represents the uppermost aquifer with the youngest water. The TRGA is essentially Taylor River channel flow moving through the very permeable gravels. Shallow wells tapping the Taylor River Gravels Aquifer are relatively high yielding, but are dependant on channel flow.

An intermediate water bearing layer known as the Taylor Fan Aquifer (TFA) occurs at depths of 20 to 30 metres below the surface. The TFA aquifer is partially

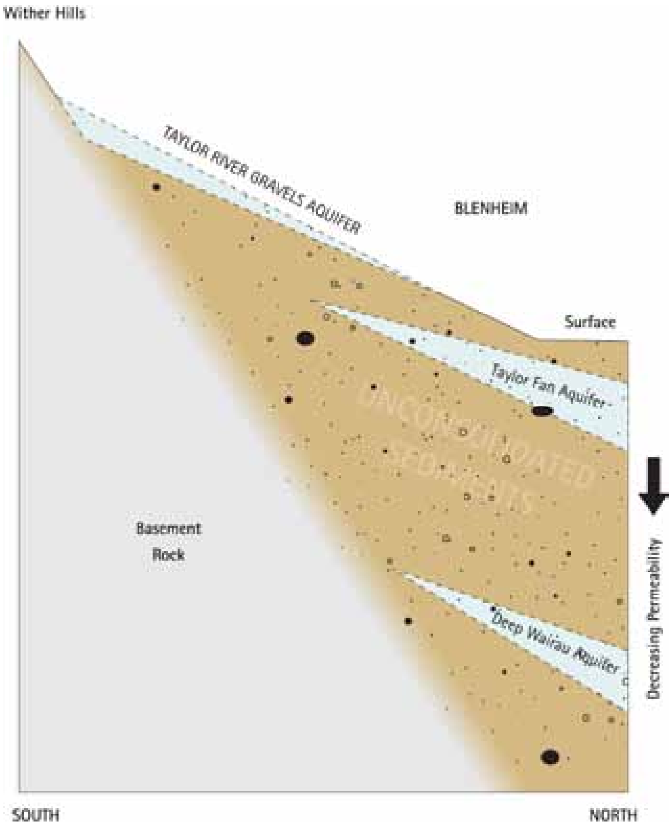

Figure 23.2: Taylor Fan Aquifer sequence

connected to the overlying Taylor River Gravels Aquifer in the area between Alabama Road and Athletic Park (Fig. 23.3). The Dillons Point Formation partially confines the TFA in the more northerly reaches and this confinement gives rise to artesian pressures within the aquifer (Fig. 23.4).

The deepest groundwater system hosted by the Taylor Fan is known as the Deep Wairau Aquifer (DWA) layer. The DWA is located at depths of around 50 metres and is intercepted by well 0980. This low yielding well taps very impermeable gravels and is at best indirectly linked to Taylor River flows. Well 0980 was drilled in 1918 as a backup water supply well for the hospital. Naturally occurring levels of arsenic however make it unsuitable for human consumption.

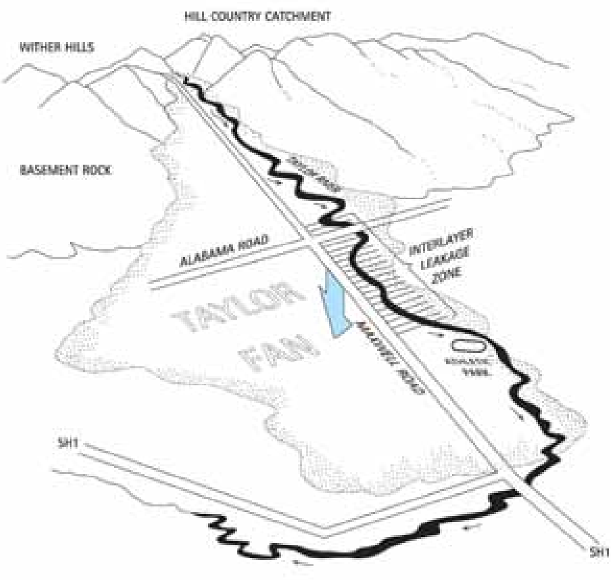

Figure 23.3: Conceptual model of Taylor Fan and Taylor River interaction

A large range in groundwater age exists across the three aquifers. Residence times vary from several hours to days in the case of the shallow unconfined TRGA aquifer, to 39,500 years for groundwater in the Deep Wairau Aquifer, which is currently the oldest in New Zealand.

Geology

The formations hosting the Taylor Fan aquifers are the dominant influence on the local hydrology, especially at depth. Following a recent detailed geological review, significantly more information about these rocks and how they influence groundwater behaviour is available.

While the area is referred to as the Taylor Fan, not all of the material originates from the Taylor River with Wairau River and coastal depositional processes also having an influence (Fig. 23.5 and Fig. 23.6). The geology can be split between the upper Taylor River catchment, and the more northern Blenheim area. The area south of the dam supports a limited thickness of gravels and as a consequence only the Taylor River Gravels Aquifer exists there.

Figure 23.4: Aerial view of Taylor Fan looking south up the Taylor River

The basement geology of the upper Taylor River catchment is predominantly greywacke rock, which can be seen outcropping through the thin mantle of gravels on the roadside south of the Taylor Dam. The greywacke basement is overlain by the Hillersden Formation, a clay-rich gravel conglomerate forming the Wither Hills. The valley floor consists of alluvial outwash gravels belonging to the Speargrass Formation. Fluvially reworked Speargrass Formation material forms the active Taylor River channel and represents the most permeable sediments in the sequence.

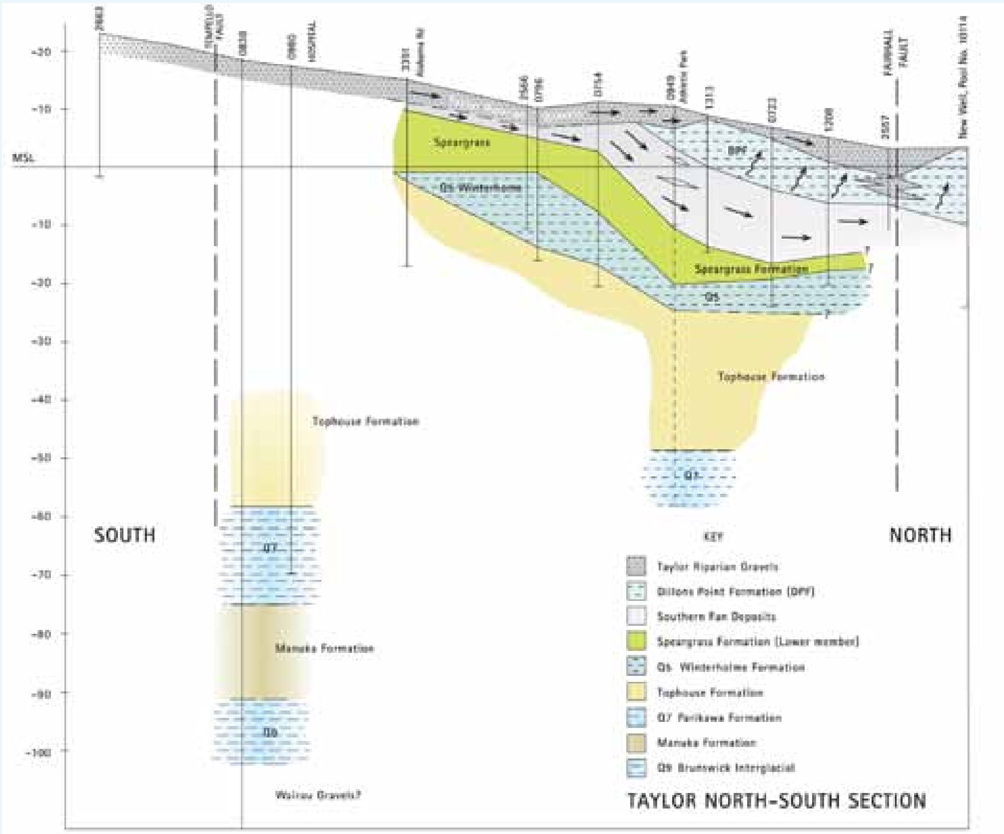

Figure 23.5: North to south geological section of Taylor Fan. Blue shaded formations with the dashed pattern represent marine deposits

Downstream of the Taylor Dam the sediments forming the Taylor Fan thicken as the depth to basement rock increases in a northerly direction, and their lateral extent broadens. Downstream of the dam the geological sequence is also more complex with the appearance of clay beds. These clays were deposited by the sea when it flooded the Lower Wairau Plain during interglacial periods corresponding with high sea-levels.

The Tophouse Formation is the deepest unit of hydrological significance and hosts the DWA. This is in turn overlain by the fine grained clays of the Winterhome Formation which creates the distinctive artesian flows in the MDC monitoring well 0980 at Wairau Hospital. This older sedimentary material is overlain by the Speargrass Formation which supplies the bulk of groundwater in the Southern Valleys Aquifers. The Speargrass Formation formed a terrace along New Renwick Road and Alabama Road. It consists of a gravel matrix with a fairly high proportion of fine material within it making it less productive than the gravels closer to the surface.

Over the last 13,000 years the Taylor River has incised into the Speargrass Formation gravels, reworked and re-deposited them further down the valley to form the Southern Fan Deposits (Fig. 23.7).

The fluvially reworked gravels have a much higher permeability than the Speargrass Formation and they supply many wells in the area. This is the principal formation that hosts the Taylor Fan Aquifer.

Gravels originating from the Taylor River catchment are richer in clay compared to those deposited further north by the Wairau River. As a result, well yields in southern parts of Blenheim tend to be lower than for wells tapping the Wairau Aquifer to the north.

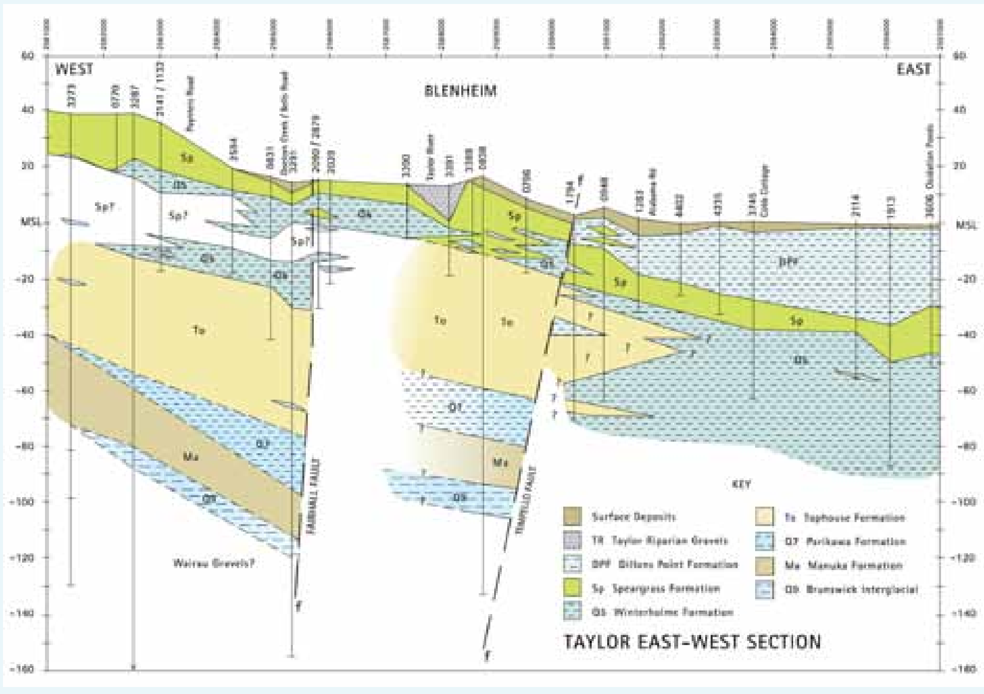

Figure 23.6: East to west geological section of Taylor Fan. Blue shaded formations with the dashed pattern represent marine deposits

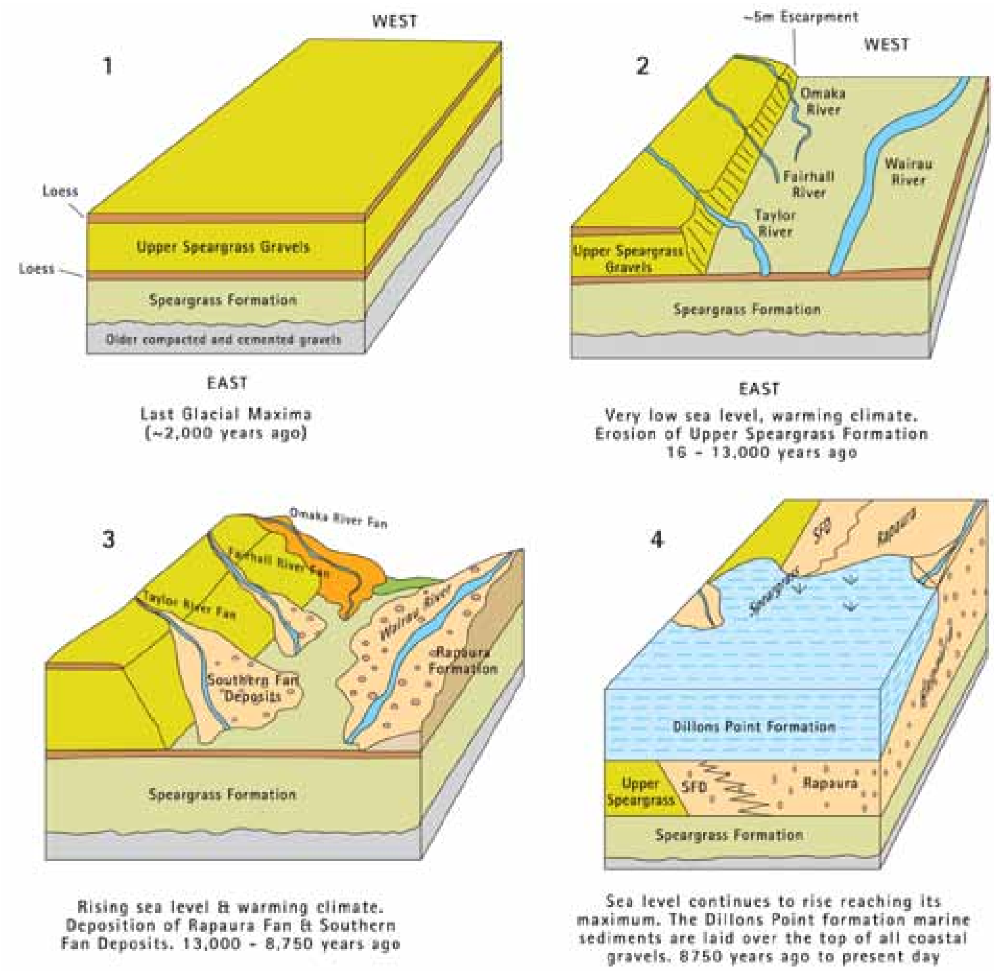

Figure 23.7: Southern Valleys catchments river outwash fan development

The gravels forming the active floodway surrounding the Taylor River are the most permeable of the sedimentary sequence by virtue of the flushing effect of Taylor River flows. These gravels host the riparian Taylor River Gravels Aquifer.

Only the three uppermost geological formations are hydraulically connected to Taylor River channel flows. Lower formations are of much lower permeability, which tends to isolate them. This is reflected in the older age of groundwaters in the deeper sediments.

The Taylor Fan is cut by a regional fault-line, known as the Tempello Fault (Fig. 23.8). This fault marks the southern margin of the Wairau Basin along the edge of the Wither Hills. Movement of the Tempello Fault has thinned the Taylor Fan on the upstream side of the fault trace.

The Taylor Fan Aquifer has a thickness of about four metres upstream of the fault and about nine metres downstream of the fault. A second fault system to the north has been inferred from cross sections and the distribution of well yields. It has tentatively been named the Fairhall Fault.

Marine sediments in the Burleigh and Fairhall areas are situated at a higher elevation than present day sea level, which indicates that land to the south of the Tempello and Fairhall faults has been uplifted and there is evidence of about five metres of vertical displacement across the Tempello Fault system over the last 13,000 years.

Recharge and flow patterns

Shallow to medium depth groundwater is recharged from a combination of direct rainfall and Southern

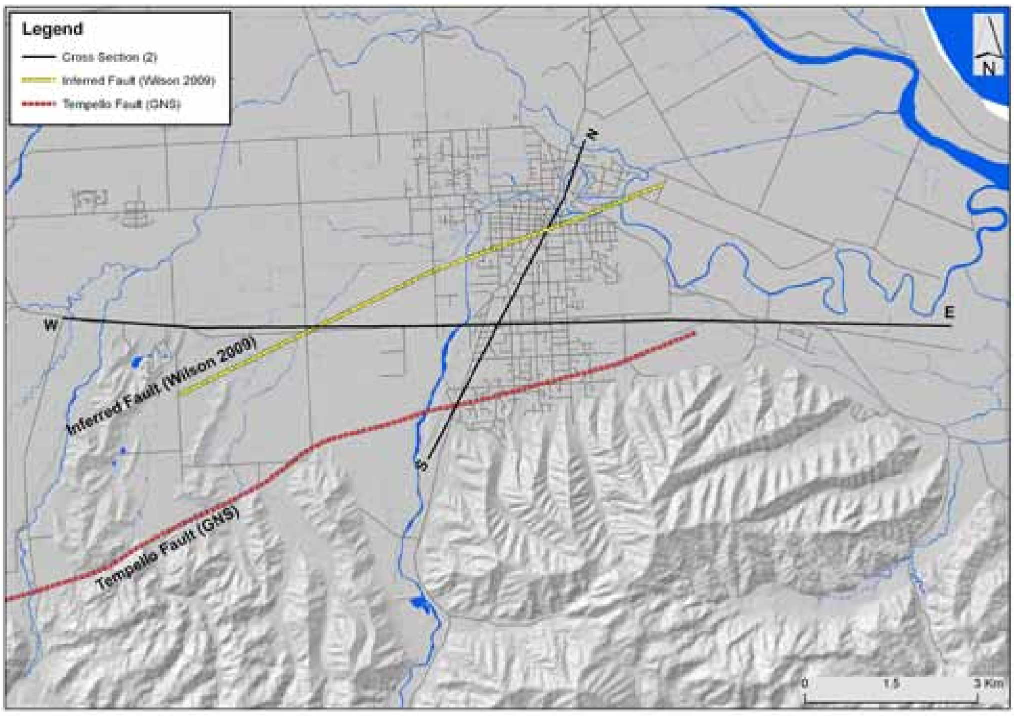

Figure 23.8: Taylor Fan cross sections locations and faults. Black lines show cross sections depicted in Fig. 23.5 and Fig. 23.6.

Figure 23.9: Taylor Dam

Valleys Catchment streams based on results from a small number of Oxygen-18 values. The Southern Valleys river contributions vanish abruptly on the main Wairau Plain due to the overwhelming influence of Wairau River derived groundwater (Taylor et al – 1992).

Very old deep groundwater sourced from well 0980 is recharged from a high altitude source based on Oxygen-18 values of -8.88 and -8.71.

The Taylor River plays the dominant role in recharging medium depth strata and groundwater underlying the western flank of the Taylor Fan. Rainfall is the main source of recharge for shallow wells and groundwater further east, outside the direct influence of the Taylor River.

Soil moisture balance modelling indicates that approximately 85% of annual recharge to the Taylor Fan comes from the Taylor River. The remaining 15% is sourced from rainfall that falls directly onto the Taylor Fan.

The role the Taylor River catchment plays in recharging groundwater along the southern margin of the Wairau Plain is clear when the distribution of Oxygen-18 values are studied across the wider Southern Springs, Blenheim and Riverlands area. Oxygen-18 values rapidly become more negative north of Main Street and Malthouse Road. This is because the relative contribution of Taylor River catchment water diminishes with distance from the Taylor Fan, relative to Wairau River inputs.

The aquifers associated with the Taylor Fan provide water for only a handful of wells and galleries, but they play an important role in distributing recharge to the southern margin of the Wairau Plain. The area acts as a storage medium for river and rainfall recharge which is released into the Taylor Fan Aquifer beneath Blenheim, and ultimately flows downstream to Riverlands and to a lesser extent the southern springs.

A major change to the hydrology of the Taylor Fan occurred in 1966 with the construction of the Taylor Dam (Fig. 23.9). Since that time the dam has captured all of the groundwater and surface flow in the upper Taylor catchment. MDC staff are anecdotally aware of significant changes in well performance in the Green Lane area since that time.

The Taylor River is ephemeral, with the bed drying up for around four to five months each year between the Taylor Dam and the confluence with Doctors Creek in Blenheim. The reason the river goes dry is that groundwater in the Taylor Fan is naturally draining faster than it can be replenished by catchment runoff. During summer and autumn when the Taylor River is dry in these reaches, all of the flow across the Taylor Dam is lost to groundwater. Under these conditions groundwater recharge from the Taylor River ranges from five l/s up to about 80 l/s.

Peizometric surveys show that Taylor Fan groundwater drains northwards towards the Southern Springs, Wairau Aquifer and Riverlands Aquifers throughout the year. The rate of groundwater drainage is likely to average around 80 l/s and is a continuous process regardless of whether there is channel flow.

During winter when flow in the Taylor River increases, the Taylor Fan aquifers become fully saturated and the rate of recharge from river losses is greater than the Taylor Fan Aquifer can accommodate. This allows

	Distance (m)	16-Jul-07		17-Jul-07		16-Sep-09		16-Dec-09	
		Flow	Change	Flow	Change	Flow	Change	Flow	Change
Borough Weir	-	**117**	-	**125**	-	**150**	-	**237**	-
Meadowbank	5,050	207	90	195	70	70	-80	227	-10
Benmorven Extension	1,650					48	-22	202	-25
George Conroy Drive	600					53	5		
Burleigh	380	171	-36	178	-17				
Burleigh Bridge	1,400					0	-53	77	-125
Athletic Park	870	**86**	-85	**82**	-96	**12**	12	**88**	11
Total Flow Loss	**9,950**	**-31**		**-43**		**-138**		**-149**	

Table 23.1: Taylor River flow gauging surveys

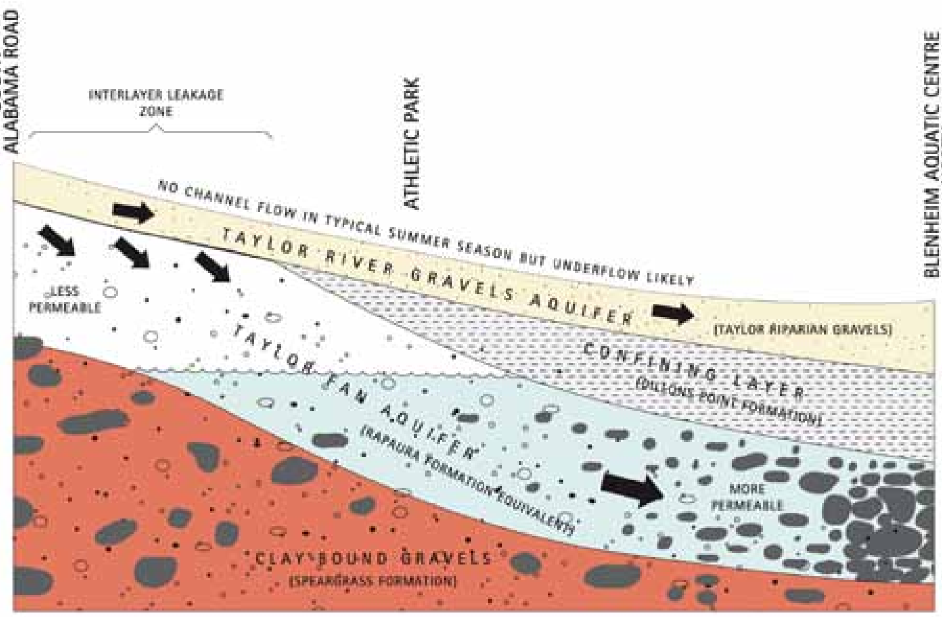

Figure 23.10: Shallow groundwater flow-path

the Taylor River to flow continuously. Concurrent flow gaugings along the Taylor River show the greatest flow losses occur over a distance of about two kilometres between Athletic Park and Brayshaw Park (Table 23.1). This reach marks the transition in subsurface geology from Speargrass Formation to the more permeable Southern Fan Deposits and results in greater leakage of Taylor River flow downwards to groundwater.

The medium depth gravels forming the Taylor Fan Aquifer become more permeable in a downstream direction and act as a conduit for Taylor River water to leak downwards into these gravels (Fig. 23.10). Taylor River flow downstream of Alabama Road only occurs when these gravels are saturated and can't store any more water. From a municipal water supply perspective, only the gravels located north of central Blenheim are useful for providing the high flows required.

Groundwater levels in medium depth wells tapping the Taylor Fan Aquifer respond to changes in Taylor River flow. For example, the MDC wells situated close to the Taylor River at Athletic Park (0949) and Eltham Road (1313) show a rapid response to rising river levels (Fig. 23.11). While this response could partially be due to loading of the Dillons Point Formation aquitard by the Taylor River, the aquifer does maintain these high levels after channel flows recede, suggesting that aquifer storage has been recharged. The relationship is particularly clear if the quickflow component is removed from the Taylor River record to show baseflow and plotted against groundwater elevation at the Athletic Park well (Fig. 23.12). The point at which the Taylor Fan aquifers are fully saturated is clearly marked by a change in slope when Taylor River baseflow reaches about 80 l/s, and well level reaches about 6.2 metres elevation above mean sea level. Under these conditions there is likely to be continuous channel flow throughout the entire Taylor River system.

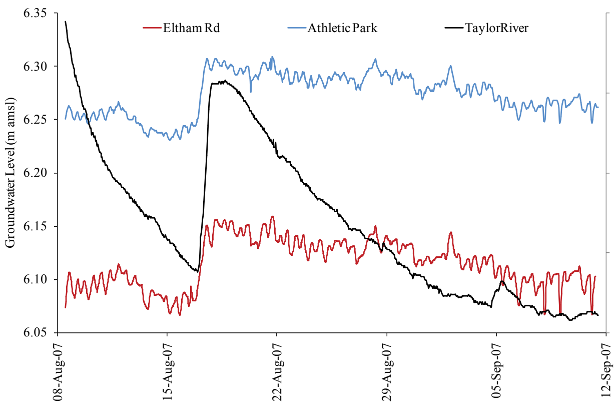

Figure 23.11: Well response to Taylor River flow

A detailed water level survey of the Taylor Fan was carried out in June 1999 by Kate Harvey, a student from the Geological Sciences Department of the University of Canterbury (Harvey - 2000). She was commissioned by the MDC to assess the extent of landfill leachate in the Taylor Fan. Water levels from this study were incorporated with MDC autumn water level surveys in the neighbouring Southern Springs and Riverlands Aquifer systems to provide a regional appreciation of groundwater flow patterns (Fig. 23.13).

The piezometric contours consistently diverge down the Taylor Fan indicating that at the time of the survey the sediments are being recharged by the river. The survey shows a steep hydraulic gradient down the Taylor River Valley, flattening rapidly in the vicinity of Brayshaw Park. This coincides with the presence

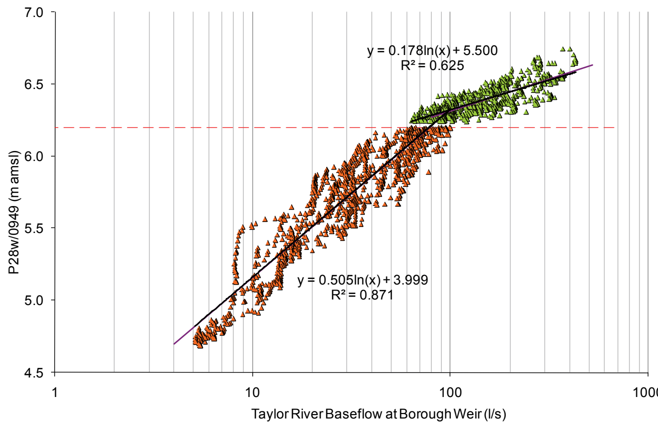

Figure 23.12: Athletic Park well 949 level versus Taylor River baseflow

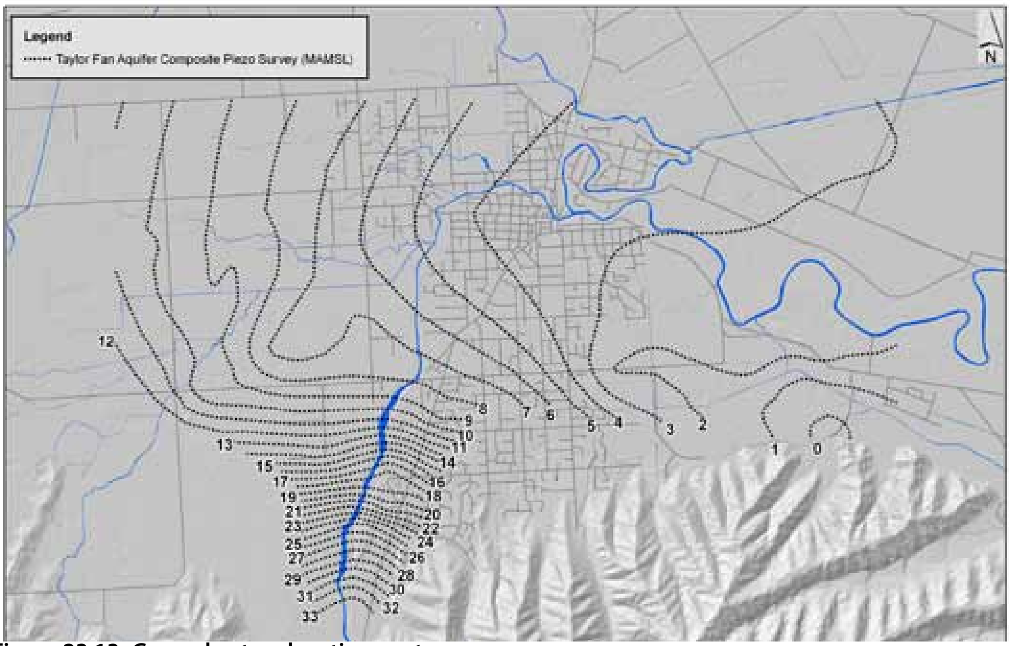

Figure 23.13: Groundwater elevation contour map

of the more permeable Southern Fan Deposits and corresponding with increased leakage of Taylor River flows to groundwater.

An inflection in the contours in the vicinity of Waters Avenue marks the north-western extent of Taylor Fan recharge. Inflow from the Wairau Aquifer to the northwest begins to dominate the flow pattern in Riverlands to the east of Redwood Street. This interpretation of the flow pattern is supported by the distribution of Oxygen-18 isotope values.

Hydraulic properties

There is very little information available on the hydraulic properties of the Taylor Fan aquifers. The productivity of wells close to the Taylor River is expected to be largely influenced by channel flow and vary seasonally with runoff. Pumping tests carried out on municipal supply wells in the Taylor Fan Aquifer have returned transmissivity values of 1,700 to 2,900 m^2/day.

The transmissivity of the Speargrass Formation in eastern areas has been measured at values of 100 to 300 m^2/day (Cunliffe - 1988). This suggests that the Taylor River has removed some of the finer material from the Speargrass Formation during its deposition in this area and improved its permeability. However higher permeability sediments are likely to be localised.

Pumping effects are visible in the aquifer level record for well 0949 of several hundreds of millimetres. They are most likely to be related to local irrigation wells as the effects are restricted to the summer months. Pumping effects show water level drops of between 50 and several hundred millimetres, and have a distinctive shape involving a rapid fall followed by a gradual recovery (Fig. 23.14).

Well level trends

The MDC has been monitoring well 0949 at Athletic Park, representing the Taylor Fan Aquifer, since 1977. Water levels have been monitored at well 0980 since April 1999, but the pattern bears little resemblance to the Athletic Park record, highlighting the isolated nature of the DWA and the lack of connection between the two aquifer systems (Fig. 23.15). The highly confined nature of the DWA tapped by well 0980 generates artesian pressures. The static level in well 0980 is still artesian in 2011, but has fallen from the 4.3 metres observed at the time of drilling in 1918.

Groundwater at the Athletic Park well is young and levels fluctuate quickly in response to fluctuations in Taylor River flow. Old, sluggish water tapped by the Hospital well is unresponsive by comparison. This is borne out by a time delay in water level fluctuations at the Hospital well of about 100 days compared to when they occur in the Athletic Park well 0949. This delay reflects the lower permeability of the Deep Wairau Aquifer at the very edge of the Wairau Plain. As a result high aquifer levels at the Athletic Park well don't coincide with the peaks of the Hospital well record.

Another interesting phenomena exhibited by the Hospital well are six hourly fluctuations caused by earth tides. These match ocean tides, but are caused by the compression of inland fine grained clay beds due to changes in the moons gravitational pull (Fig. 23.16). This is slightly different to the direct loading effect of oscillating tides that cause coastal well levels to vary. The variation in the Hospital well level has a range of 20 millimetres and matches the pattern of the level at the inland deep well 2917.

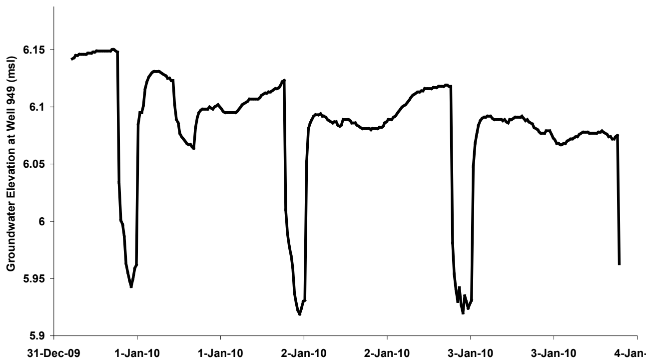

Figure 23.14: Athletic Park well pumping effects

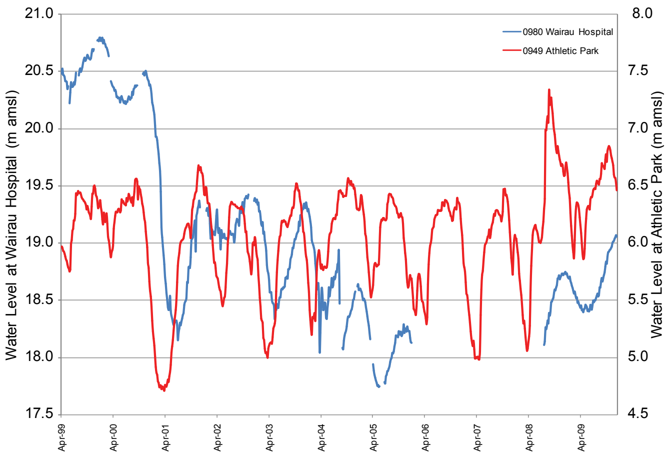

Figure 23.15: Wairau Hospital and Athletic Park well record

Groundwater chemistry

The chemical composition of Taylor Fan groundwaters originating from different depths in the Taylor Fan is highly variable and reflects the degree of natural confinement. Young groundwater from the Taylor River Gravels Aquifer has a chemistry similar to the Taylor River recharge source (Fig. 23.17). It is oxidised and relatively dilute due to limited interaction with its host sediments. This water is classed as Calcium-Sodium-Magnesium-Bicarbonate type. This composition is typical of young groundwater across all Wairau Plain aquifers, apart from a lower than normal proportion of chloride.

Groundwaters in the deeper lying Taylor Fan Aquifer beneath Blenheim are slightly more evolved due to their longer interaction with local sediments and confinement from the atmosphere, but are not significantly different from Taylor River water. The composition of groundwater from the Hospital well 0980 is by comparison highly evolved, which is not surprising given it was recharged tens of thousands of years ago (Fig. 23.18). This water is dominated by sodium and chloride, reflecting the long interaction with local sediments. It has no sulphate which indicates ancient groundwater with depleted oxygen and advanced reducing conditions.

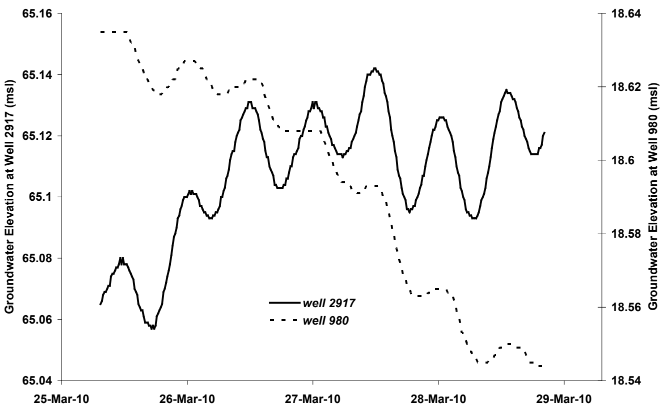

Figure 23.16: Hospital well 0980 earth tides

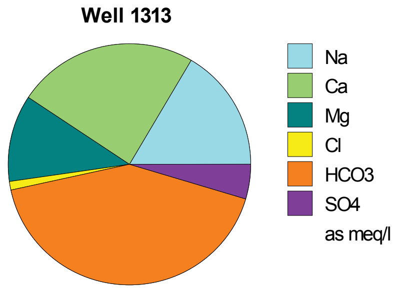

Figure 23.17: Well 1313 groundwater chemical composition

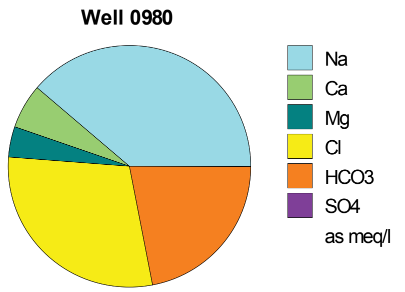

Figure 23.18: Well 0980 Groundwater chemical composition

References

Begg, J. G. and Johnstone, M.R. (compilers), 2000. Geology of the Wellington area. Institute of Geological and Nuclear Sciences 1:250 000 Geological Map 10. Institute of Geological and Nuclear Sciences, Lower Hutt, 1 sheet + 64p.

Brown, L. J., 1981a. Water Well Data Northern Marlborough, Part Sheet P28 Wairau Plain (Geology and water wells), 1:25000. New Zealand Geological Report 93.

Cunliffe, J.J., 1988. Water and Soil Resources of the Wairau Volume Two: Groundwater. Marlborough Catchment and Regional water Board, 107p.

Harvey, K.D., 2000. Hydrogeologic Investigations of the Taylor Pass Landfill, Blenheim, New Zealand

Taylor, C.B., Brown, L.J., Cunliffe, J.J. and Davidson, P.W. 1992. Environmental tritium and ^{18}O applied in a hydrological study of the Wairau Plain and its contributing mountain catchments, Marlborough, New Zealand, Journal of hydrology, 138, (1992) 269-319