STAFF REPORT

TO: Environment and Planning Subcommittee

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REFERENCE: W326

SUBJECT: **INVESTIGATION OF GROUNDWATER IN THE UPPER MOTUEKA CATCHMENT – REPORT EP06/08/11** – Report prepared for 28 August Meeting

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1. BACKGROUND

The area upstream of the Wangapeka confluence of the Motueka River catchment has a sizeable area of fertile alluvial river terrace land that is suitable for irrigated agriculture. Since the mid 90's there has been an increasing demand for irrigation water especially from groundwater in these terraces. Very little hydrogeological work had been undertaken in the past in this area to quantify the groundwater availability in these river terraces, their link to the river, the recharge components (river and rainfall as well as its quality). This data is critical in the evaluation of river depletion effects due to groundwater abstraction as well as to determine holistic and integrated allocation limits for the resource i.e. surface & groundwater. The drought in the summer of 1998/99 added extra pressure in terms of water allocation with the Nelson Marlborough Fish & Game Council seeking minimum flow requirements for the Motueka River and significant tributaries through the National Water Conservation Order Process. The catchment now is covered by a Water Conservation Order which specifies a flow sharing regime with more specific flow provisons for some rivers e.g. Wangapeka. Council has used the provisons of the order and known hydrological data to set allocation limits in the interim for the defined zones in the catchment. Council initiated investigations into the water resource of the area in late 1999. This report is the stage one output from the studies that have commenced since then and covers the investigations into the hydrogeology of the valley, the occurrence of groundwater, aquifer hydraulic properties and connectivity to river and storage and recharge processes.

1.1. Study Area/Monitoring

Figure 1 shows the extent of the groundwater investigations area. The hydrological monitoring network consists of seven groundwater level and groundwater chemistry monitoring bores, 11 isotope monitoring sites, six river flow recorder sites and eight rainfall sites (Figure 2)

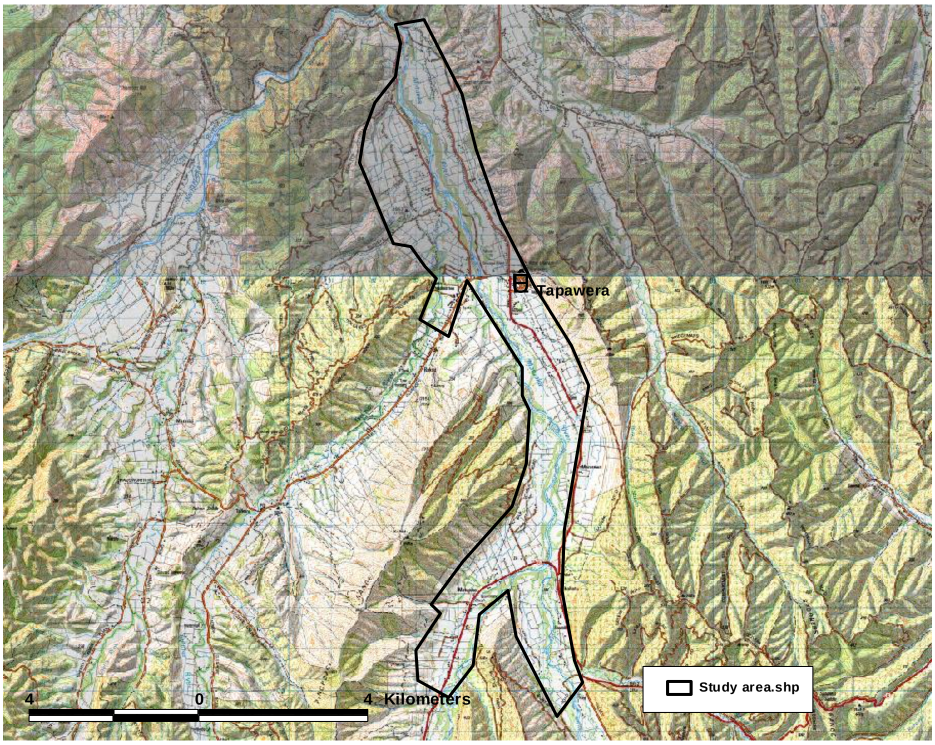

Figure 1: Location of groundwater Study Area

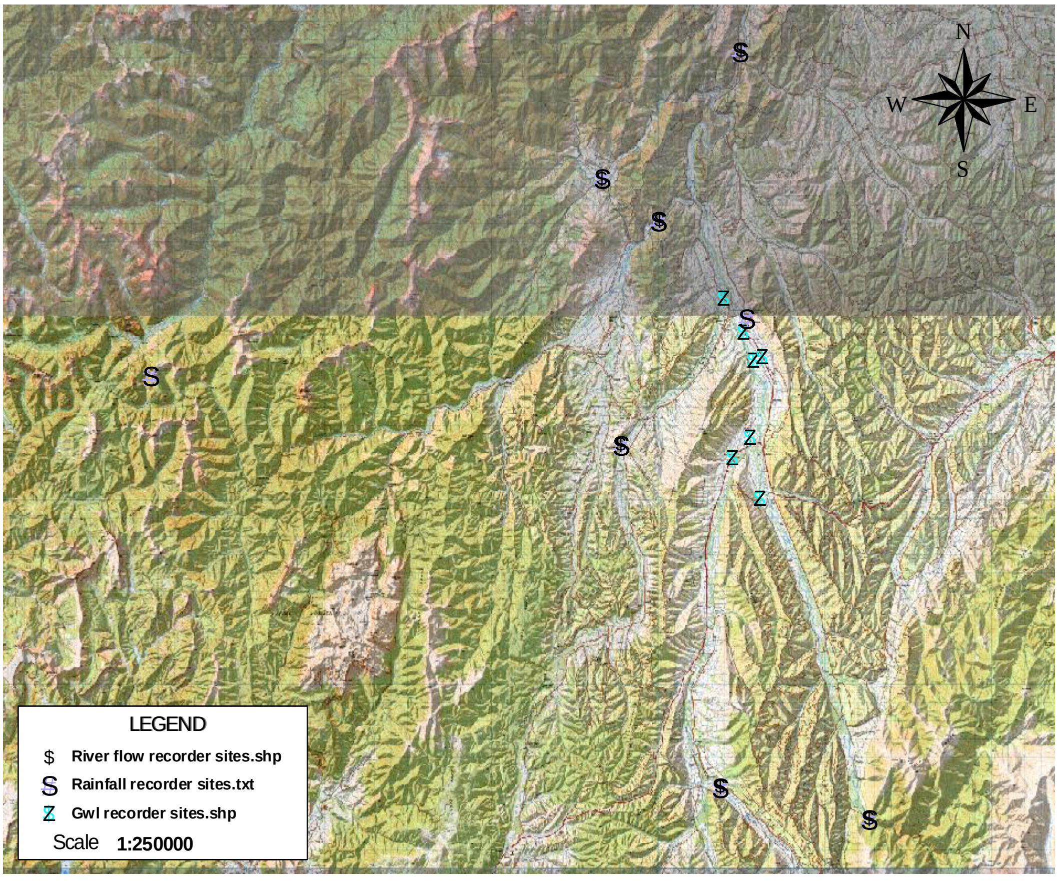

Figure 2: Monitoring Network

2. HYDROGEOLOGY

Hydrogeological mapping of the area has been carried out and this included field mapping and assessments as well as examination of all available bore/well logs from the area. Groundwater is primarily abstracted from shallow unconfined alluvial aquifers that occur in the Quaternary river terrace formations and modern river deposits. Five gravel formations have been identified upstream of the Wangapeka confluence. These are (from oldest to youngest) the Moutere Gravels, Manuka, Tophouse, Speargrass and modern river gravel formations. The Quaternary Gravels are underlain by the Moutere Gravel Formation. Figure 3 shows the simplified geology of the area.

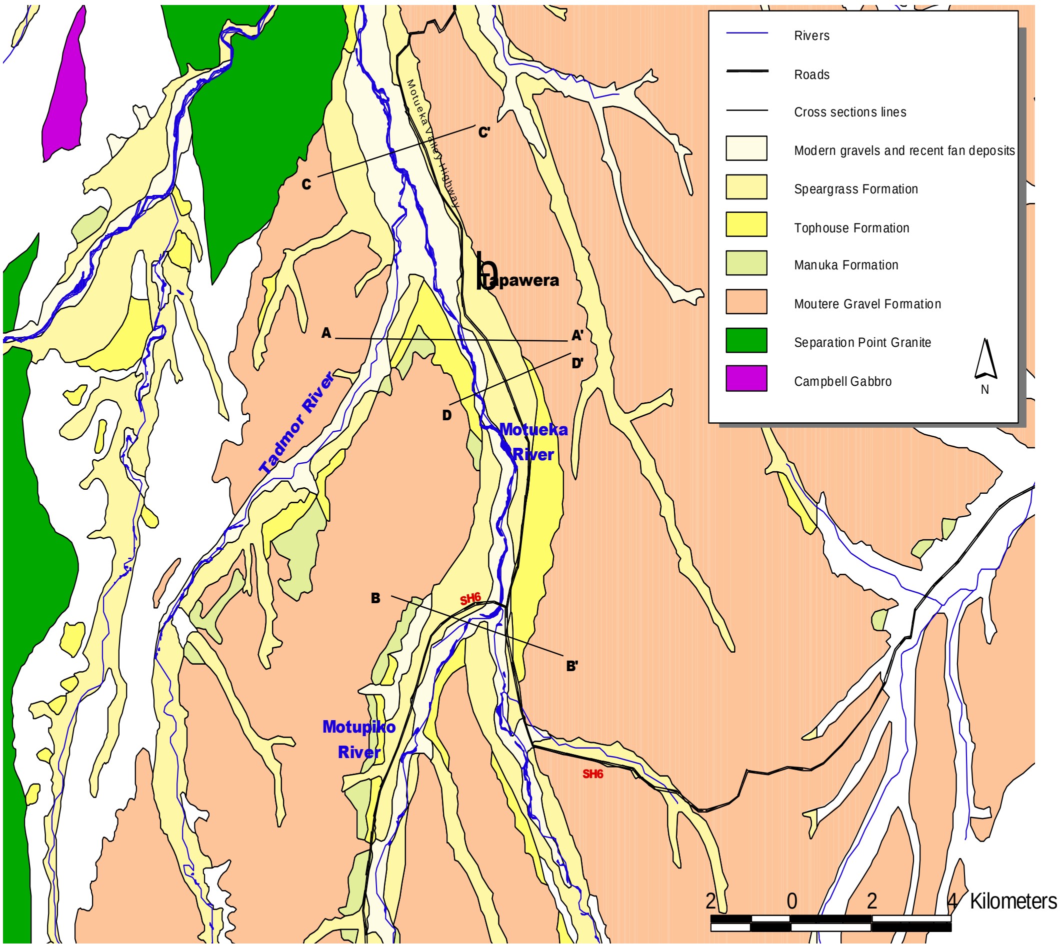

Figure 3: Simplified geology of the Upper Motueka area with locations of cross section lines

Table 1 shows the summary of the assessment and descriptions of each of the formations mapped in the area. Figure 4 shows one geological cross section AA' near Tapawera.

Formation	Approximate height above river level (m)	Description	Distribution	Saturated thickness	Groundwater potential
Modern Gravels	0 to 8	Silty sandy greywacke gravel.	Widespread throughout the Tadmor, Motueka, Motupiko valleys	3.5 to 9.0	Good
Speargrass	8	Slightly weathered greywacke gravel with clasts typically 0.2 m diameter in silty clay matrix. Overtopped by minor fans.	Widespread throughout the Tadmor, Motueka, Motupiko valleys	5 to 8.5	Good
Tophouse	25	Partly weathered greywacke gravel with clasts typically 0.2 m diameter in silty clay matrix. Overtopped by fan gravels and covered with loess up to 0.8 m thick.	Moderately widespread throughout the Tadmor, Motueka, Motupiko valleys	estimated 0 to 12 m*	Poor (from few available bore log data)
Manuka	65 to 70	Weathered greywacke gravel with clasts typically 0.2 m diameter in silty clay matrix. Overtopped by fans and covered with widespread loess up to 1.2 m thick.	Isolated distribution in the Tadmor and Motupiko valleys	estimated 0 to 20 m*	Unknown, but suspected poor
Moutere Gravel	0 to >70	Clay-bound gravel containing partly weathered, dominantly greywacke pebbles	Wide spread throughout the Tadmor, Motueka, Motupiko valleys	Unknown	Unknown

* These saturated thicknesses were estimated from extrapolation of groundwater level data in geological cross sections

Table 1: Summary of Quaternary river terrace formation

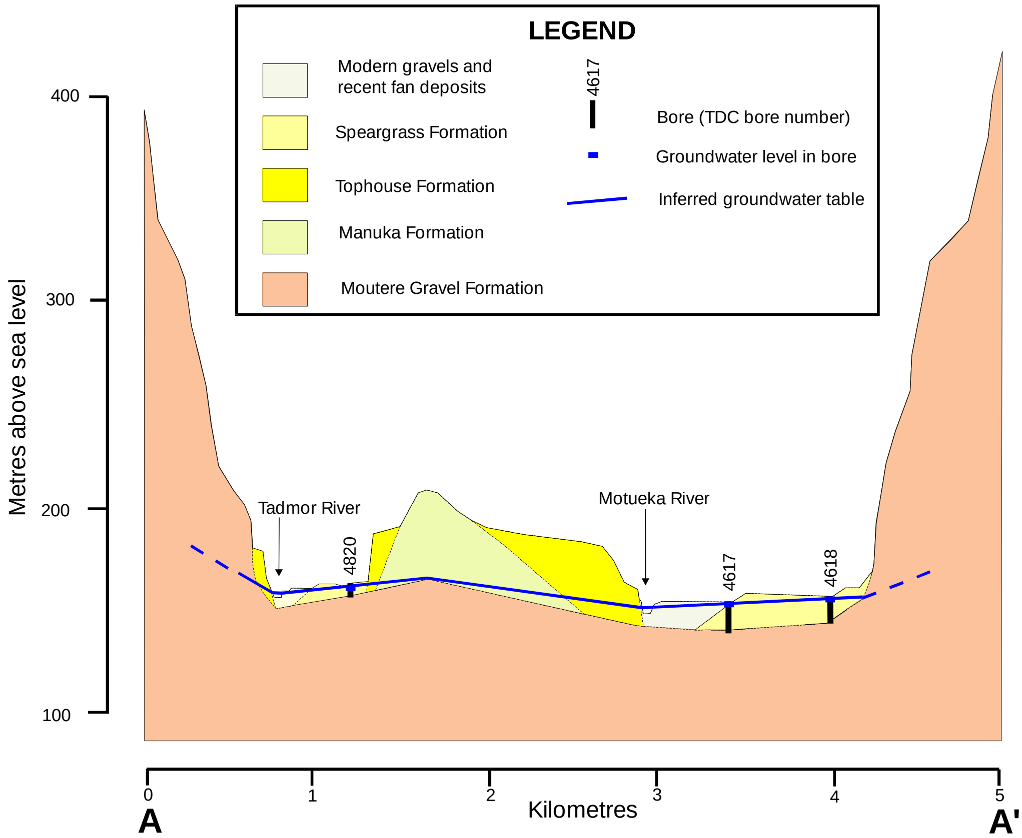

Figure 4: Cross Section AA’ near Tapawera

2.1 Groundwater Recharge

There are three sources identified for groundwater recharge for the river terrace formations here i.e. groundwater discharge from the Moutere Gravels, rainfall infiltration and river flow loss. Due to the tight nature of the Moutere Gravels underlying the river terrace formation groundwater recharge from the Moutere Gravel is small. Rainfall infiltration based on mean rainfall of 1100 mm at Tapawera assuming infiltration just from the Speargrass and modern gravels is estimated at 350 l/s based on a recharge coefficient of 0.3. A mean annual rainfall recharge rate of 350 l/s (11 million m^3/yr) is about 36 % of the estimated groundwater through flow rate in the Motueka River Valley downstream of Tadmor River during dry summer low flow conditions.

The three main river systems that contribute to flow in the Motueka Upstream of the Wangapeka River confluence are the Motueka, Tadmor and Motupiko rivers. Flow losses and gains have been identified from river gaugings and piezometric (water level in bores/wells/river) survey undertaken in the area. Figure 5 shows river loss and gains from gaugings carried out in February 2002.

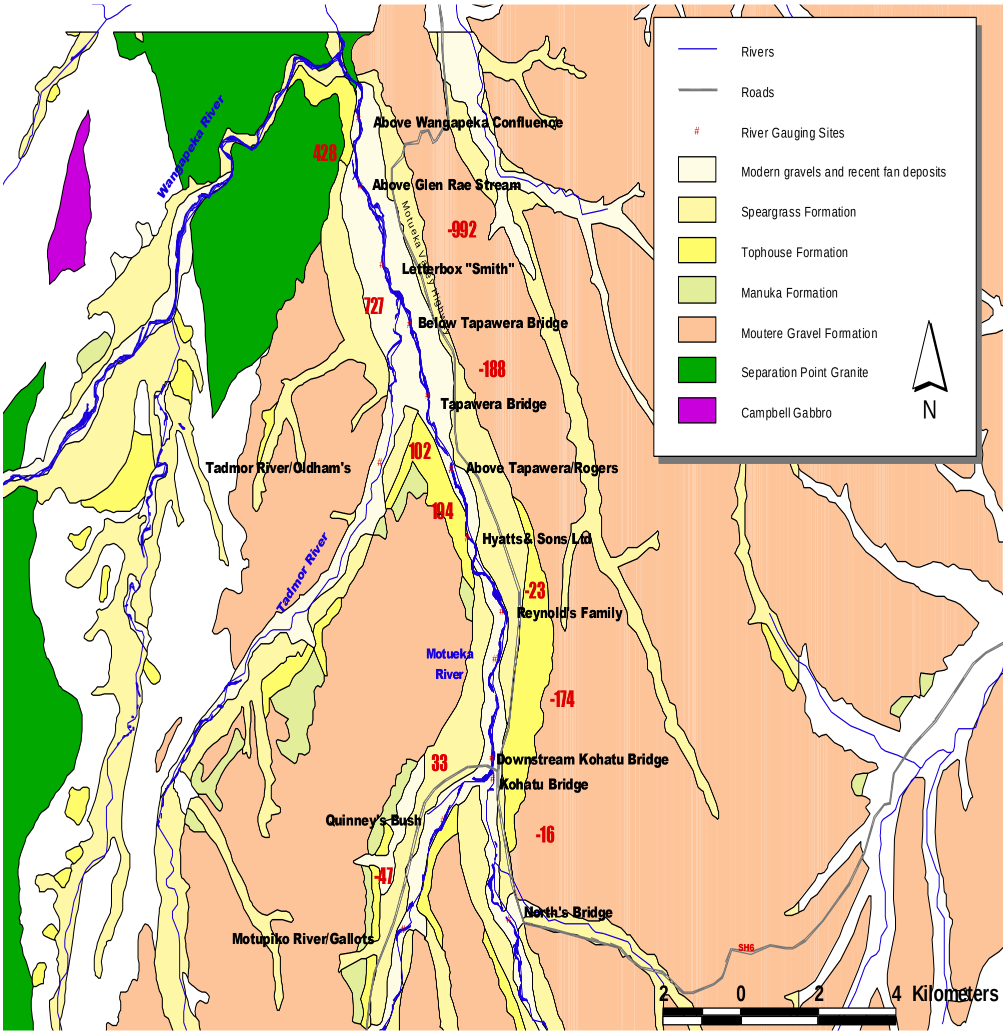

Figure 5: River flow loss and gain from gaugings in February 2002

Figure 6 shows the groundwater flow patterns monitored via the piezometric survey in February 2002.

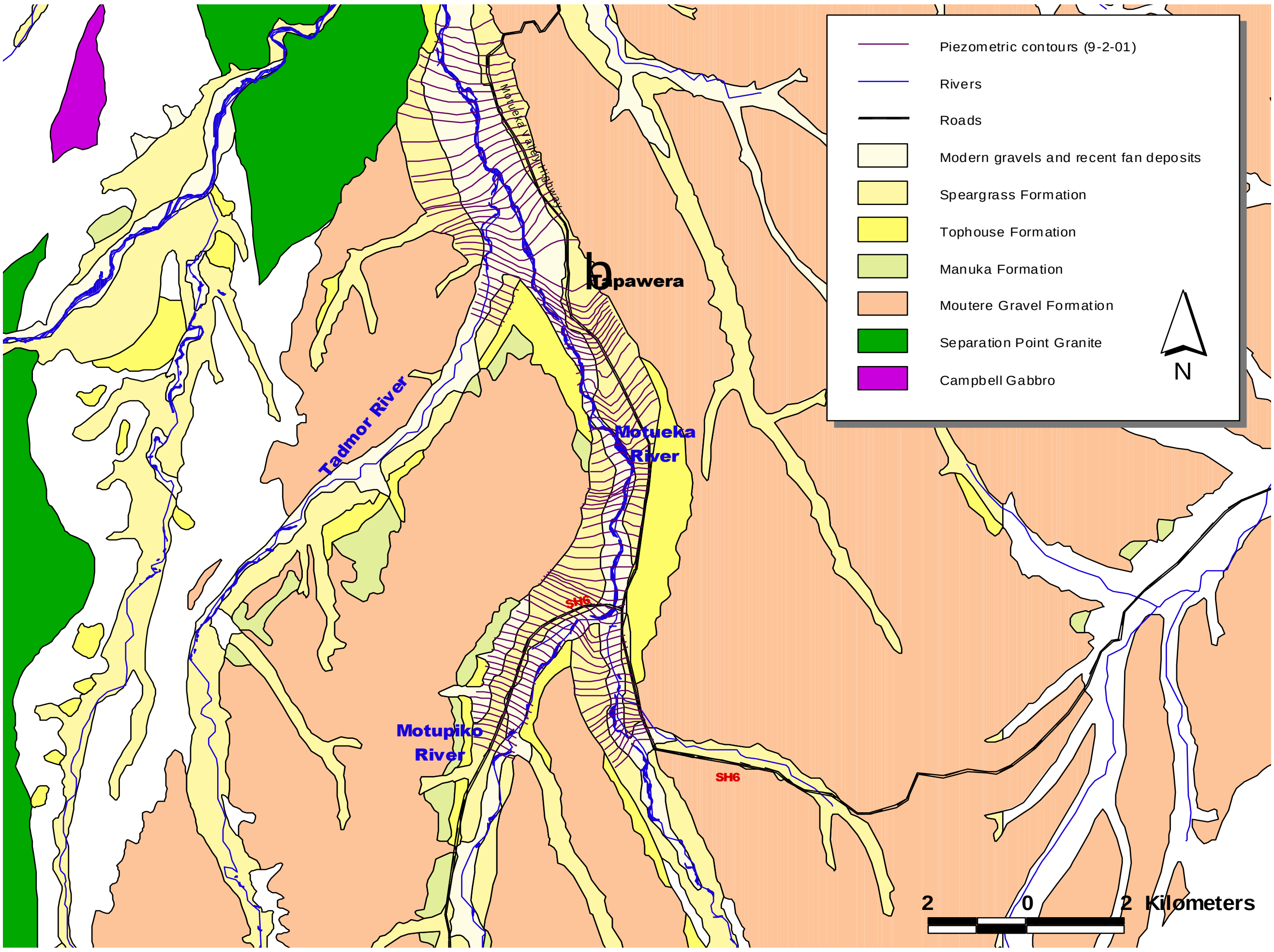

Figure 6: Piezometric map showing groundwater flow patterns in Upper Motueka February 2002

The piezometric and gauging data shows a complex flow pattern occurring between the rivers and aquifers. Overall river flow is lost to groundwater in reaches where the river valley widens and the cross sectional area of the aquifer increases. Conversely groundwater generally discharges into the river along the reaches where the river valley becomes narrower. Using the piezometric survey and aquifer hydraulic data surface and groundwater flow rates through the Modern Gravels and Speargrass Formation have also been calculated for different sections of the Upper Motueka area.

2.2 Groundwater Storage

Groundwater storage volume for the Modern Gravels and Speargrass Formation aquifers during low flow conditions has been estimated at 9.7 x 10^6 m^3 (9.7 million cubic metres) for the area covered by the piezometric map data. The storage was calculated from the average saturated thickness of 4.7 m based on groundwater levels in February 2001. The groundwater level at that time was below mean annual values for all sites; hence the storage volume estimate is representative of storage during dry summer conditions. Storage volumes will increase during non-drought conditions.

2.3. Stream Depletion

River/aquifer interactions are a significant issue in interconnected water resource systems. Understanding this correlation is important to managing the total resource. The abstraction of groundwater from the modern gravels and/or Speargrass Formation has the potential to cause depletion of the Upper Motueka River flow. Stream depletion curves have been developed for different reaches of the river based on test bore data and stream bed leakage calculated from flow gaugings. The rate of stream depletion from groundwater pumpage increases downstream in the Motueka River. This is due to the bed conductance increasing downstream, most likely as a function of stream width increasing downstream. Figure 7 shows the location of stream reaches along the Motueka River used in the stream depletion calculations. Figure 8 shows the depletion curves after I day pumping from the Modern gravels.

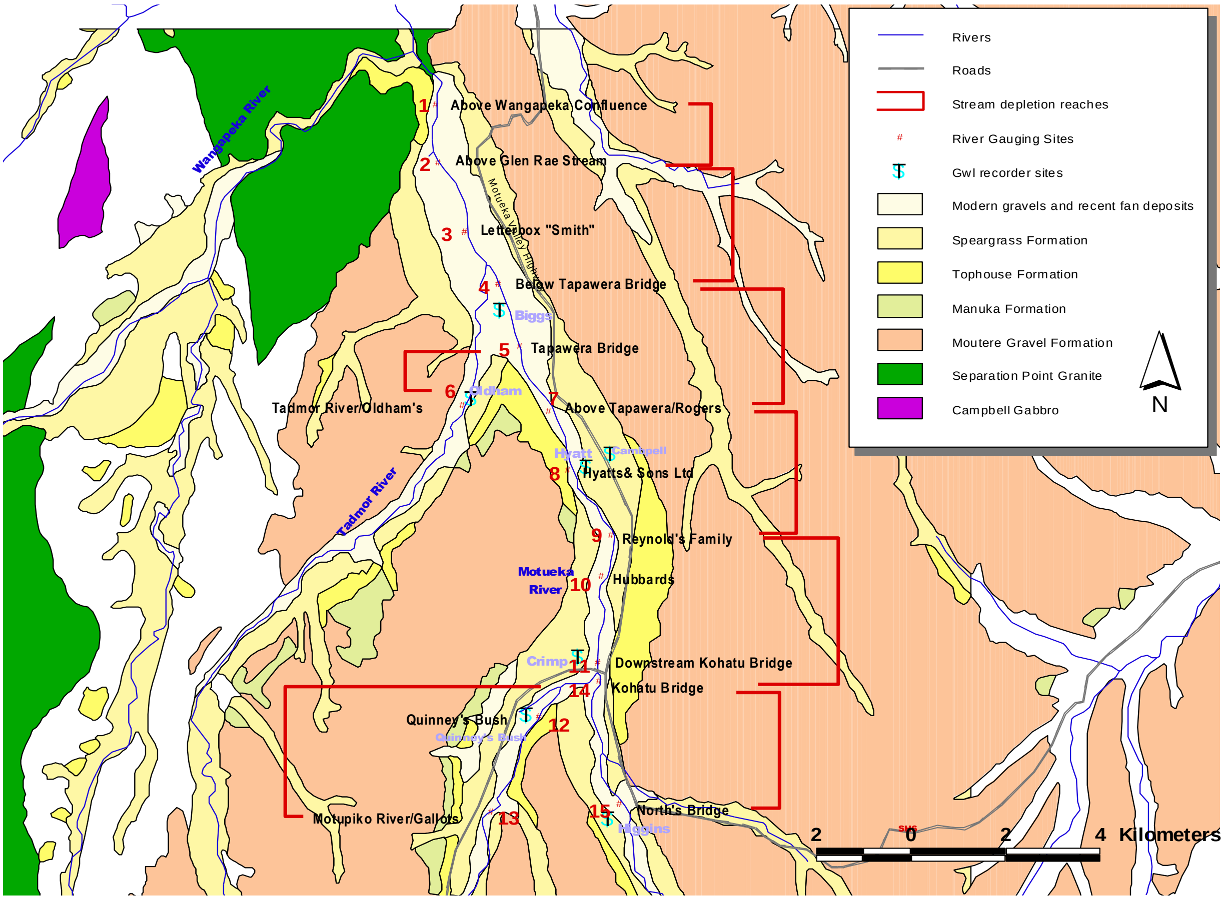

Figure 7: Stretches of Motueka Rivers used in stream depletion calculations

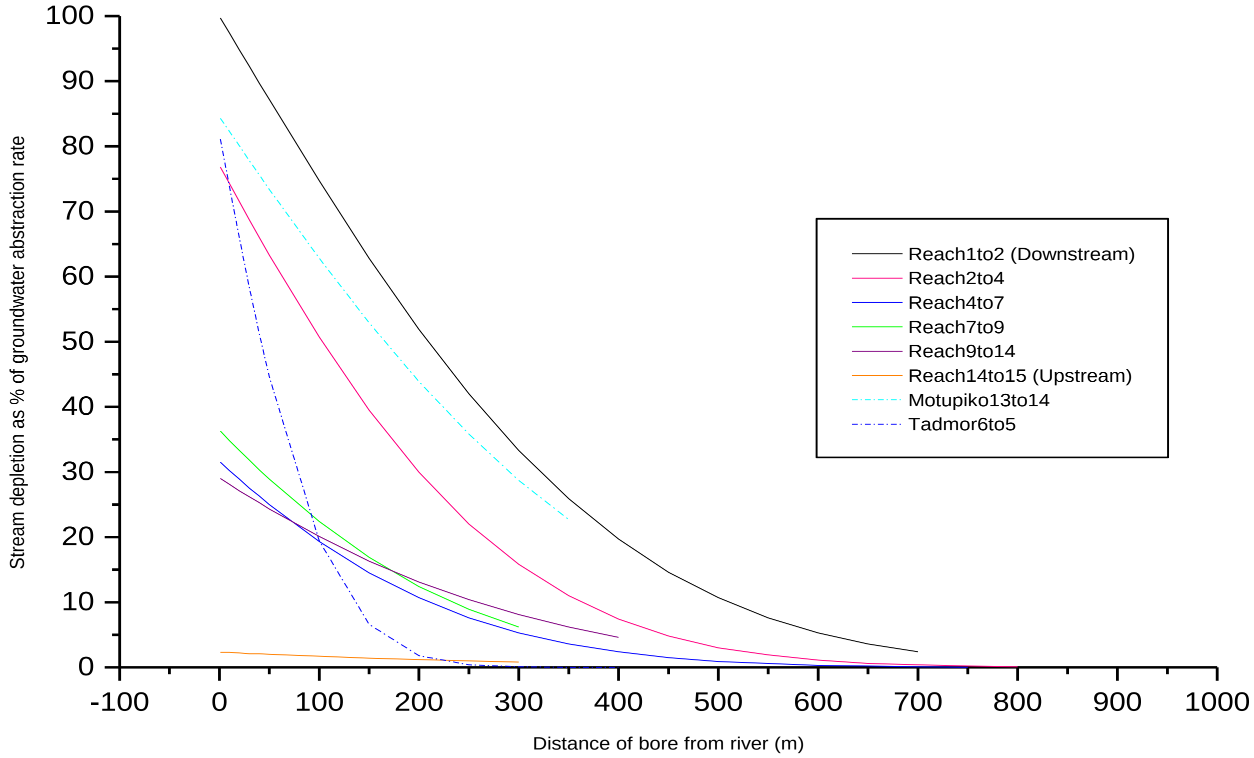

Figure 8: Stream depletion when pumping from within the Modern Gravels

2.4 Groundwater-River-Rainfall Modelling

In the first phase of this study an artificial neural network technique has been used to identify the correlation between river flow groundwater and rainfall. A predictive model was also developed of the relationship of groundwater levels (at Quinneys Bush and North's Bridge), the river flow rate (Motupiko & Motueka Gorge) and rainfall in the period 11 Sept 2000 to 31 July 2002. The relative strengths of the input variables i.e. groundwater level to flow and rainfall was also able to be assessed. The primary aim of this preliminary modelling work was to a broad understanding of the systems and its inter-correlation prior to development of a more refined spatial model of river aquifer interaction for the area. Figure 9 shows an example of the modelling of groundwater levels at Quninneys Bush based on rainfall and flow variable over the duration of the model run. Table 2 shows the sensitivity of groundwater at Quinneys to rainfall and flow.

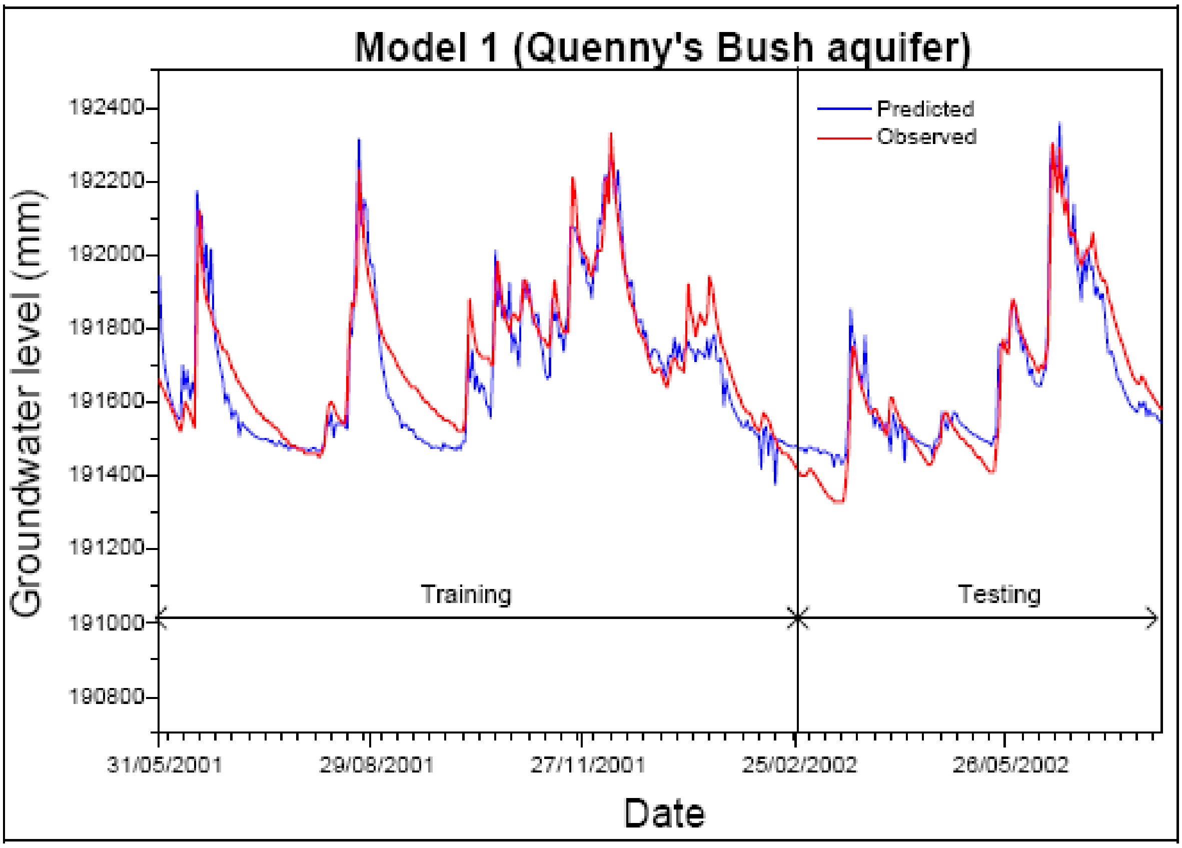

Figure 9: Results of neural network model at Quinneys Bush

Inputs	Groundwater level at Quinneys Bush
Rainfall	0.13
Motupiko River flow rate	0.87

Table 2: Relative variables sensitivity of Quinneys Bush Groundwater to flow and rainfall

3. GEOCHEMISTRY

The geochemistry of waters in the Upper Motueka Catchment was studied to gain understanding of the sources, flowpaths and residence times of waters in the catchment. Chemical measurements gave information on the major element chemistry in relation to aquifer geology and landuses. Isotopic analysis was also used to evaluate groundwater residence times. This geochemistry work contributes further to the development of the conceptual model of the groundwater-river interaction.

Groundwater samples were collected from eight bores and two springs. Surface water data was collected at both the Motueka River (3 sites) and Motupiko (1 site) and was integrated into this study. General analysis of the water quality data shows two major types of water. The Motupiko River and groundwater's from the Motupiko and Tadmor Valleys and on the west bank of the Motueka River downstream of the confluences with the Motupiko and Tadmor Rivers are all different from the Motueka type waters i.e. water from Upper Motueka through the Tapawera Plains. The waters here reflect the interaction with Moutere Gravel and terrace gravels derived from it. The Motueka Type water reflects a clear influence of the ultramafic geology and a higher magnesium/calcium/bicarbonate level occurring in those waters. The area around Kohatu and around the Tapawera Bridge by the Tadmor shows a mixed nature reflecting the influence of the Motueka Type Water.

Various isotopic techniques were also used to assess the source of recharge and residence times in the aquifers. Oxygen-18 data shows distinct differences between the Motueka Type water and the Motupiko-Type waters. The lower oxygen-18 value of the Motueka Type water reflects the source at a higher altitude i.e. above Motueka Gorge. Both river and groundwater displays these differences in oxygen-18 results. This shows the strong influence of the rivers on groundwater in the respective areas. Age evaluation using both Oxggen-18 variations over time (groundwater/river/rainfall) and also tritium show good agreement with ages ranging from 0-12 months. Near river groundwater has a young age and groundwater further away from the river in the board river terraces (i.e. above Tapawera) older at 7-12 months.

4. SUMMARY

- The hydrogeological investigations have provided a whole host of important base data in terms of the nature, extent and the nature of the recharge mechanism and river/groundwater/rainfall interactions.

- The sensitivity modelling has provided technical data in terms of degree of influence of different sources of recharge on groundwater

- The geochemistry analysis has identified distinct type of groundwater and their age, recharge and residence times.

- The thee key base outputs described above are critical to developing a holistic interactive surface/groundwater interaction model for refining water allocation and triggers in the Upper Motueka area.

5. RECOMMENDATION

Council receives this report.

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