STAFF REPORT

TO: Environment & Planning Subcommittee

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REFERENCE: W323

SUBJECT: **RIVER/GROUNDWATER MODELLING IN THE UPPER MOTUEKA FOR MANAGEMENT - THE STEADY STATE MODEL – REPORT EP06/08/13** – Report prepared for 28 August EPC Special Meeting

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1. BACKGROUND

The Upper Motueka area (The Motueka Catchment from the Wangapeka confluence upwards) has a sizeable area of fertile alluvial river terrace land that is suitable for irrigated agriculture. There is concern that extraction of shallow groundwater for irrigation may lower groundwater levels and consequently the baseflow of rivers/streams during the summer season due to strong shallow aquifer-surface water interactions in this area. This would reduce the availability of surface water to existing users and add pressure in terms of water allocation to keep minimum baseflow requirements for the Motueka River in compliance with the requirements of the Motueka River Conservation Order.

In order to manage the water resources of the Upper Motueka Catchment in a holistic manner the development of a three-dimensional groundwater flow model is required to analyse the effects of groundwater abstraction on rivers/streams flow and groundwater levels. The model is being developed in a joint study, conducted with the Institute of Geological and Nuclear Sciences (GNS), Landcare Research and Tasman District Council (TDC). The project is funded by Tasman District Council and Landcare Research through the Foundation for Research Science and Technology (FRST) funded Integrated Catchment Management (ICM) programme.

2. THE NUMERICAL MODEL

Many methods have been devised to simulate the interactions between a shallow aquifer and stream, ranging from relatively simple analytical methods to site-specific 3-dimensional numerical models. Models that describe water movement between shallow aquifer and stream systems at large spatial and temporal scales are comparatively new and still at the stage of development and improvement. In this study, a state-of-art adaptive finite element groundwater modelling system is implemented to simulate the relations and interactions between shallow aquifer and stream systems in the Upper Motueka River catchment. At this stage of the study the groundwater flow model is a steady-state; in future it will be progressed into a dynamic simulation model.

The model boundary of the Motueka groundwater flow model focuses from Korere, 15 km upstream of the Motupiko and Motueka confluence (i.e. Kohatu) to immediately above the Motueka/Wangapeka confluence. It also includes 8km of the Motueka upstream of Kohatu and 3 km of the Tadmor River upstream from its confluence with the Motueka River (Figure 1). The model boundary includes the majority of groundwater extraction in the Upper Motueka River catchment. The triangular mesh used in the model is deliberately designed to have greater sensitivity (smaller cells) nearest to the river where the groundwater-surface water interaction will be greatest.

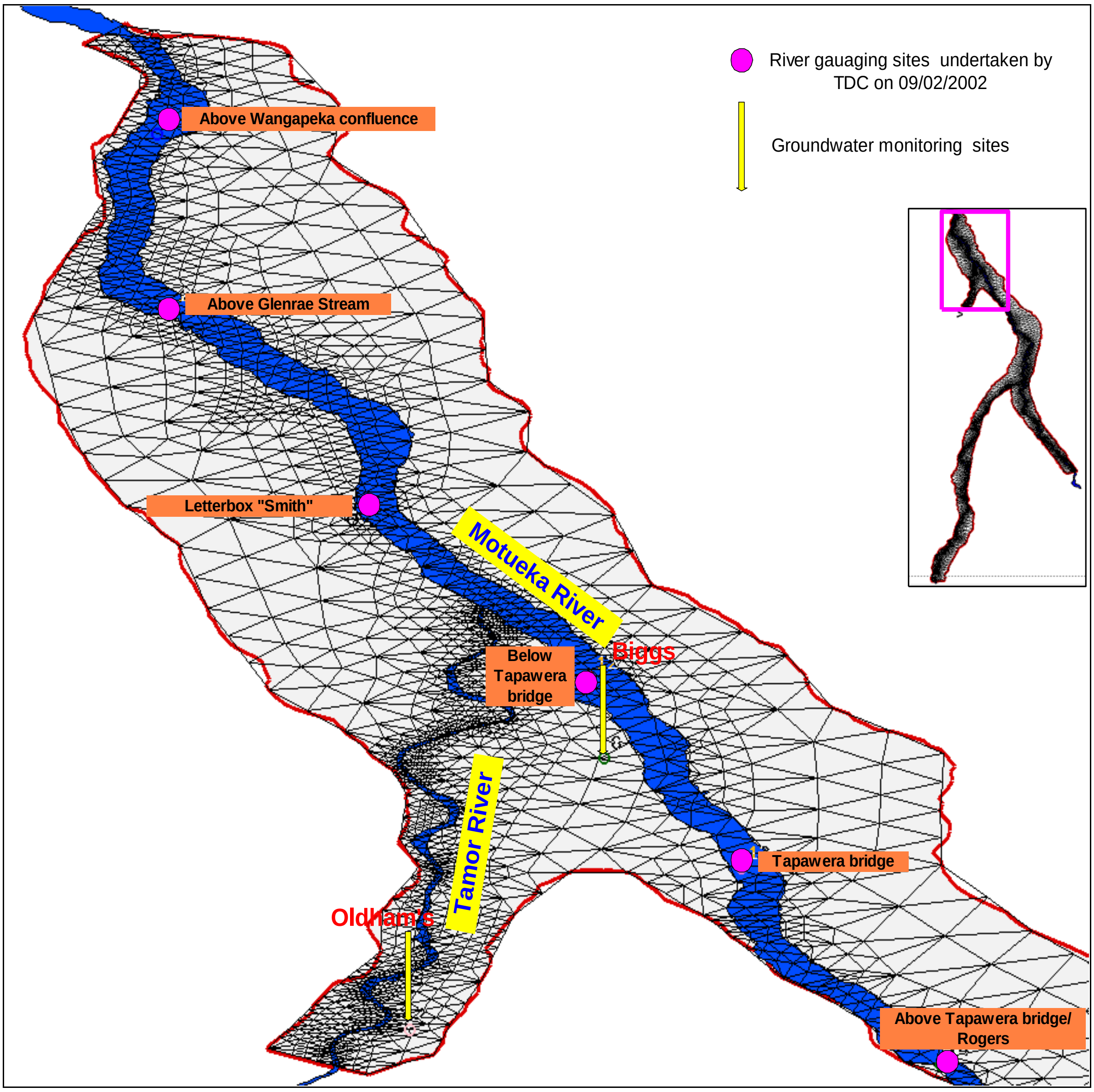


Figure 1 Close up two-dimensional view of the Upper Motueka groundwater model domain with aquifer discretization and a finite element mesh. Total area of model domain is shown in inset box. The blue area is river channel. N.B. the finer mesh immediately adjacent to the river channel.

3. PARAMETERS AND VARIABLES USED TO RUN THE MODEL

In order to simulate a groundwater flow system with a numerical finite element model, the hydraulic characteristics of the aquifer and confining beds must be specified for each nodal point of triangular elements evident in figure 1. The hydraulic characteristics normally required to simulate a groundwater flow system are aquifer thickness, hydraulic conductivity, and specific storage. Specific storage is not specified for this study because all simulations are for the steady-state conditions. The aquifer thickness in the model domain is described in the previous report. Hydraulic conductivity was first estimated from a priori knowledge of the groundwater system and then used as an adjustable parameter to calibrate the model.

The main variable used in the model is rainfall, which is used by the model to calculate surface recharge. The annual average rainfall at Tapawera site for the period 1993 to 2001 years is 1100mm. To generate the regional recharge model in the model domain, the recharge coefficient is estimated to be 0.3 on the basis of the rainfall recharge data in the Canterbury Plains. The mean annual rainfall recharge to aquifers is estimated at $0.121*10^{-4}$m/day (350 l/sec) on recharge coefficient of 0.3. The spatial distribution of annual average rainfall is strongly correlated to the topographic elevation. Therefore it is assumed that the recharge in the high elevation area is a little higher than the recharge in the lower valleys in the model domains. The recharge is assigned to each finite element mesh of the model. The regional rainfall recharge distribution is shown in Figure 2.

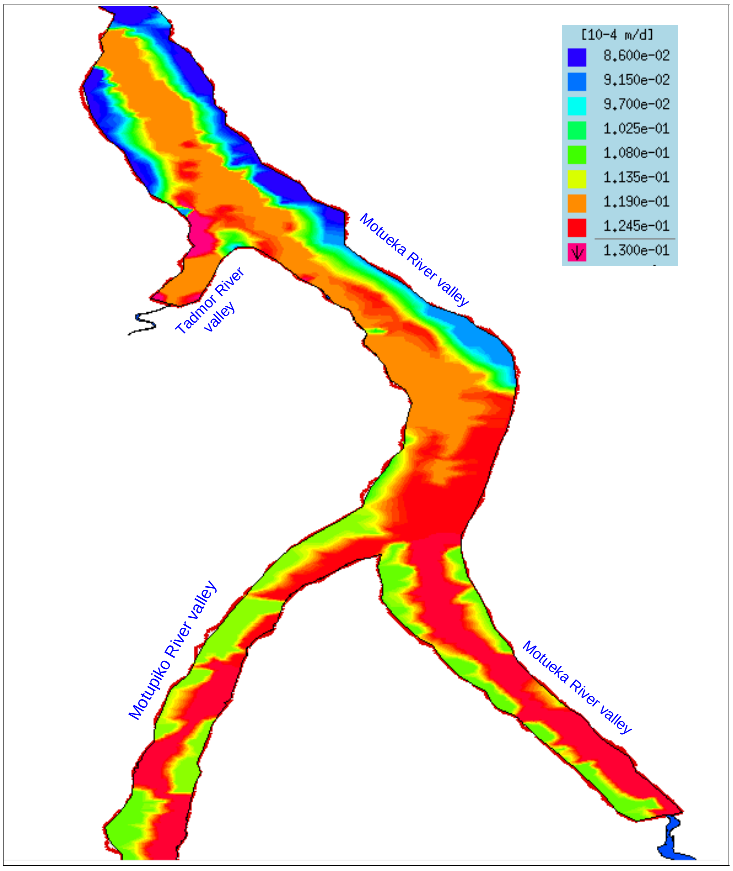


Figure 2 Spatial distribution of rainfall recharge used in the model.

The second major variable used in the model is river flow, i.e. the water flowing into the model domain from upstream of the model boundary. These were estimated using information from nearby TDC flow gauges (Motupiko at Christies; Motueka at Gorge; Tadmor at Mudstone).

4. CALIBRATION OF THE MODEL

Groundwater flow modelling needs to establish a best fit between observed and predicted head distribution through a phase of model calibration process. The model used here has been calibrated using water level recording from eight TDC groundwater monitoring wells. The model has been calibrated using visual comparison of the match between predicted and observed values at each of monitoring wells. The part of the model concerned with the river was also calibrated on the basis of eleven river gauging sites and piezometric survey. undertaken by TDC staff (particularly 09/02/02). In order to match river flows loss and gain through the flow budget analysis. The following parameters in the groundwater model were optimised:

- spatial hydraulic conductivity
- spatial in-transfer coefficient and out-transfer coefficient between river and aquifer

The results from the calibration are shown in tables 1 and 2. The model calibration shows good results in terms of both groundwater levels and river flow loss and gain. For example, the February 2002 gauging data shows that the Motueka River reaches between Tapawera bridge and Hyatts and between Above Wangapeka confluence and Above Glenrae Stream gain flows of approximately 25573 m^3/day (295 l/sec) and 36979 m^3/day (428 l/sec) from groundwater, respectively. The Upper Motueka groundwater flow model predicts that there is a flow gain of 25932 m^3/day (300 l/sec) between Tapawera bridge and Hyatt (Figures 23 and 24) and of 36102 m^3/day (418 l/sec) between Above Wangapeka confluence and Above Glenrae Stream.

Table 1 Observed River flow loss and gain and predicted after calibration. + and – represent river flow gain and loss, respectively.

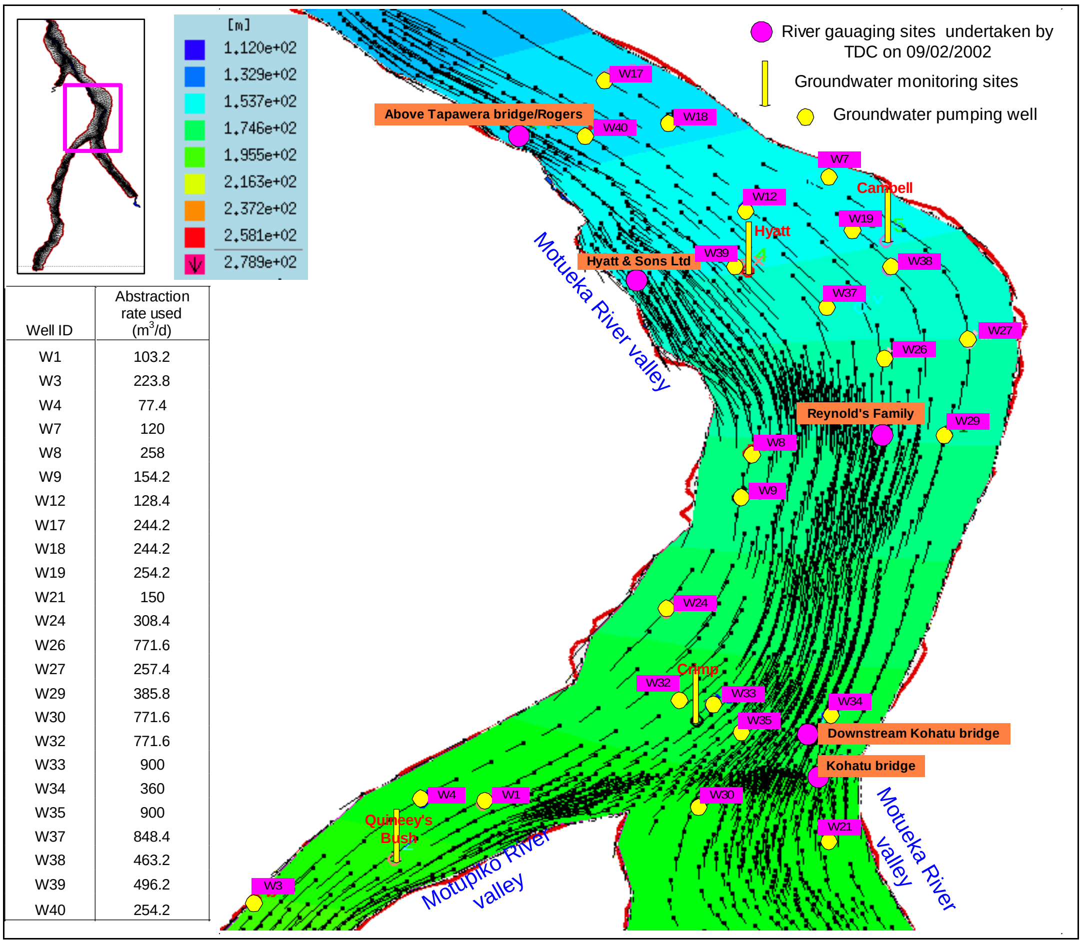
Reach	X	Y	Discharge (m^3/day)	Observed river loss or gain (m^3/day)	Predicted river loss or gain (m^3/day)
Kohatu bridge	2496187	5972915	132969	No gauging	??
Downstream Kohatu	2496152	5973305	153878	No gauging	??
Reynolds	2496422	5976055	138844	-15034	-16217 between Hyatt and Downstream Kohatu
Hyatts	2495515	5977426	136857	-1987	
Rogers	2495102	5978701	153619	16761	17031
Tapawera	2494499	5980096	162432	8812	8901

bridge					
Below Tapawera	2494040	5981439	146188	-16243	-16436
Smiths	2493328	5982558	209002	62813	60498
Glenrae	2492777	5984045	123292	-85708	-83452
Above Wangapeka confluence	2492737	5985290	160272	36979	36102

Table 2 Observed groundwater levels and predicted groundwater levels after calibration for the eight monitoring sites.

Site Name	**Grid Ref**	**X**	**Y**	**Observed GWL (m)**	**Predicted GWL (m)**
Oldham	N28:9350-7895	2493500	5978950	150.35	149.1
Biggs	N27:9409-8087	2494085	5980869	136.62	137.1
Campbell	N28:9643-7777	2496432	5977765	155.58	156.2
Hyatt	N28:9593-7750	2495927	5977500	154.97	155.3
Crimp	N28:9574-7343	2495743	5973426	179.11	181.6
Quinney's Bush	N28:9465-7217	2494645	5972174	191.30	191.7
Higgins	N28:9638-6996	2496379	5969958	201.51	199.23

Figure 3 show the contour map of predicted groundwater head distribution with vectors indicating groundwater flow direction at the area of the confluence of the the Motupiko River and the Motueka River, respectively. This is included to show the type of model output that can be expected in a dynamic model currently being developed.



Well ID	Abstraction rate used (m^3/d)
W1	103.2
W3	223.8
W4	77.4
W7	120
W8	258
W9	154.2
W12	128.4
W17	244.2
W18	244.2
W19	254.2
W21	150
W24	308.4
W26	771.6
W27	257.4
W29	385.8
W30	771.6
W32	771.6
W33	900
W34	360
W35	900
W37	848.4
W38	463.2
W39	496.2
W40	254.2

Figure 3 Predicted groundwater levels and groundwater flow pattern after calibration at the confluence of the Motupiko River and the Motueka River.

5. SUMMARY

- The effects of water abstraction from groundwater and surface water is a growing issue for water management in the Upper Motueka River catchment. The purpose of this study is to develop a three-dimensional groundwater flow model that is capable of analysing the effects of groundwater abstraction on stream flow and groundwater levels in order to manage the water resources in the Upper Motueka area sustainably.

- In this study, an adaptive finite-element groundwater modelling system is implemented to simulate the relations and interactions between shallow aquifer and river systems in the Upper Motueka River catchment.

- This report provides results from the development of the model in a steady state condition. The study will continue with the development of the model into a dynamic state for transient and water management simulations.

- The steady-state Upper Motueka groundwater flow model has calibrated using water level recording from the eight groundwater monitoring wells and on the basis of measurement on the basis of river gauging data. The model has been calibrated using visual comparison of the match between predicted and observed values. During calibration the hydraulic conductivity and the in and out transfer coefficients (between river and aquifer) were optimised. The model calibration shows good results in terms of both groundwater levels and river flow loss and gain.

- In this work, it is demonstrated that the Upper Motueka groundwater flow model developed in 3-D adaptive finite-element structure is feasible and can be used as a tool to investigate the effect of the abstraction on the river flow and groundwater levels. The next step, a dynamic Upper Motueka groundwater flow model currently being developed. This dynamic model will provide a better understanding of groundwater flow and its interaction with surface water in the Upper Motueka River catchment, and provide a tool to assess different water allocation management regimes in the Upper Motueka River catchment.

6. RECOMMENDATION

Council receives this report.

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