PATTLE DELAMORE PARTNERS LTD
Level 2, 134 Oxford Terrace
Christchurch Central, Christchurch 8011
PO Box 389, Christchurch 8140, New Zealand

Tel +64 3 345 7100 Fax +64 3 345 7101
Web www.pdp.co.nz
Auckland Tauranga Wellington Christchurch

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memorandum

TO	Jason Augspurger, Tom De Pelsemaeker	FROM	Neil Thomas
	Otago Regional Council	DATE	16 December 2019
RE	Model run to simulate the effect of transferring irrigation race surface water abstractions to groundwater takes in the Wanaka Cardrona Alluvial Aquifer model		

1.0 Introduction

The Wanaka groundwater model was developed previously by PDP to simulate groundwater and surface water interaction within the Wanaka Cardrona Alluvial Gravel Aquifer ('the Wanaka Basin'). The model has been set up to run transiently on weekly stress periods from July 2015 until June 2018 and simulates the Wanaka Basin as a single layer, with streams and rivers simulated using the MODFLOW stream package, which allows losses and gains to occur, and accumulate, along the length of a river. The Cardrona River is simulated from the Mt Barker flow recorder to its confluence with the Clutha River. The calibrated model includes the effects of groundwater and surface water abstractions, as well as the effect of irrigation via the recharge inputs to the model.

The key surface water abstractions simulated in the model include the Farrant Race (99478), the Wanaka Race (98370 and 97199.v1) and the Mt Barker Race (97129). These abstractions are all historic mining permits ('deemed permits') currently used for irrigation and are authorised to abstract large volumes (250 L/s from the Farrant Race, 500 L/s from the Wanaka Race and 138.9 L/s from the Mt Barker Race), although in practice the Mt Barker Race typically abstracts around 40 L/s. No low flow restrictions are set on the consents and the deemed permits will expire in 2021. ORC are currently moving through a process of setting low flow limits for surface water and connected groundwater takes on the Cardrona River, which may affect these takes if they are renewed on expiry.

2.0 Methodology

The three simulated surface water abstractions (i.e. the Farrant Race, Wanaka Race and Mt Barker Race) from the Cardrona River were switched off and in their place six groundwater abstractions were simulated in the model. The volume of water taken by the abstractions was as set in the memo sent from ORC to PDP on 14 November 2019 and represents efficient irrigation for a 1 in 10 year dry season. Table 1 summarises the simulated volumes taken for the irrigation areas on the east and west sides of the Cardrona River. These volumes were spread across the year with a peak in January (Figure 1).

Table 1: Irrigation rates

	Area (hectares)	Maximum monthly demand (mm/month)	Maximum monthly requirements (m^3/month)	Annual demand (mm/yr)	Annual requirements (m^3/yr)
True Right of the Cardrona River					
PAW 45 mm	15	167	25,050	724	108,600
PAW 75 mm	45	146	65,700	669	301,050
PAW 120 mm	284	130	369,200	630	1,789,200
Total	**344**		**459,950**		**2,198,850**
True Left of the Cardrona River					
PAW 75 mm	206	146	300,760	669	1,378,140
PAW 120 mm	98	130	127,400	630	617,400
Total	**304**		**428,160**		**1,995,540**

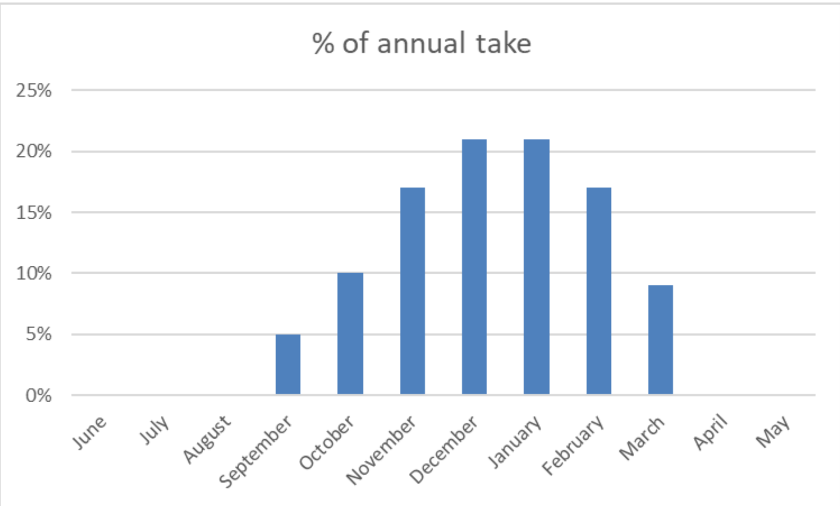

Figure 1: Distribution of simulated irrigation water use through the year

The simulated groundwater abstractions were located close to the irrigation areas and close to roads (to allow access for drill rigs), however we note that these locations do not imply or guarantee that sufficient yield would be available in those locations in reality. Three bores were used to simulate abstraction for irrigation on each of the east and west sides of the Cardrona River (i.e. 6 bores in total) (Figure 2).

Note that the rates in Table 1 were repeated annually throughout the three year model run.

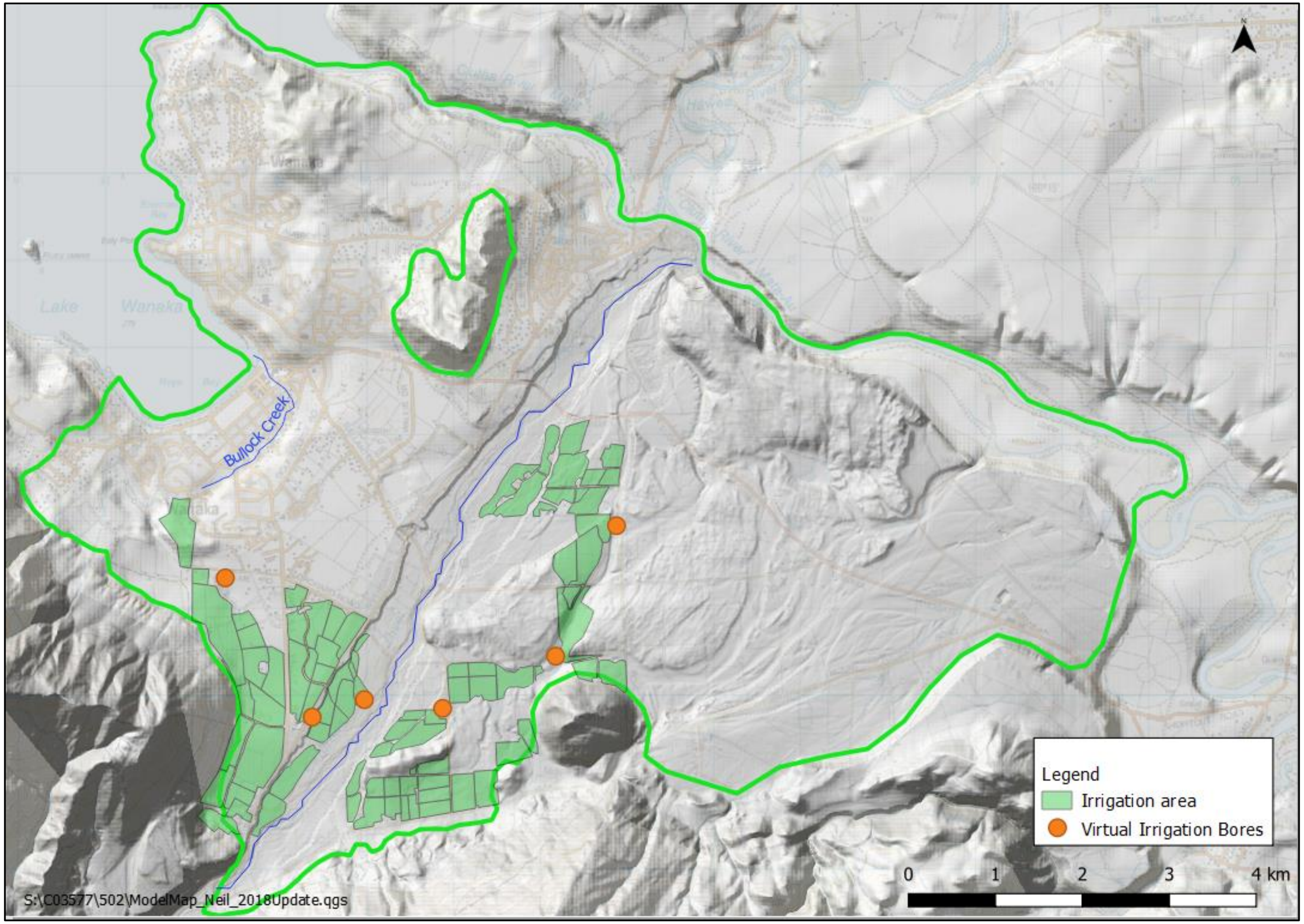

Figure 2: Location of additional irrigation bores

3.0 Results

The results of the model run where the surface water takes were replaced by groundwater takes were compared to the baseline historic model run, where the rates of surface water abstractions were based on measured flows. Note that these measured surface wate take flows were typically larger than the simulated groundwater abstractions. Metered abstraction rates from the Cardrona River can be high under the existing irrigation take consents (up to around 500 L/s), whereas the simulated replacement groundwater takes would be lower, up to a maximum of 328 L/s and on average around 130 L/s.

3.1 Surface water flows

3.1.1 Cardrona at Ballantyne Road

Flows in the Cardrona at Ballantyne Road were predicted to increase because of the reduced abstraction from the river. Figure 3 shows the difference in flows at Ballantyne Road between the baseline scenario (i.e. the calibrated model representing historical abstraction rates) and the groundwater take scenario. At times (for example March 2017), the difference can be in the order of 400 L/s, which is consistent with the upper rates of abstraction via the race intakes. However, it is useful to note that at times, flows at Ballantyne Road still fall to zero, when flows at Mt Barker are naturally low.

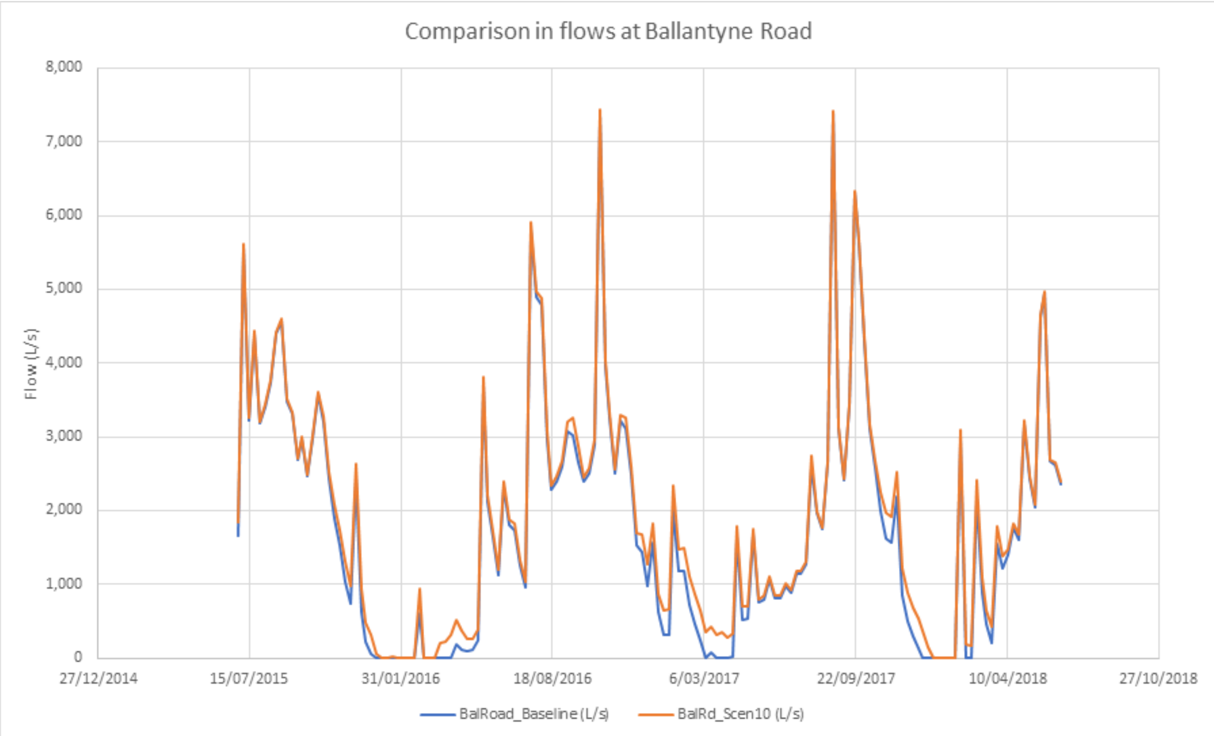

Figure 3: Modelled difference in flows in the Cardrona River at Ballantyne Road

3.1.2 Cardrona at the Clutha Confluence

Modelled changes in flows in the Cardrona River at the Clutha confluence (Figure 4) were variable with both increases and decreases occurring. The impacts on flows are more complex at the Clutha confluence because of losses and gains along the Cardrona River downstream of Ballantyne Road and are also related to the timing of abstraction and flows. On average, the differences are relatively small and are in the order of 50 L/s.

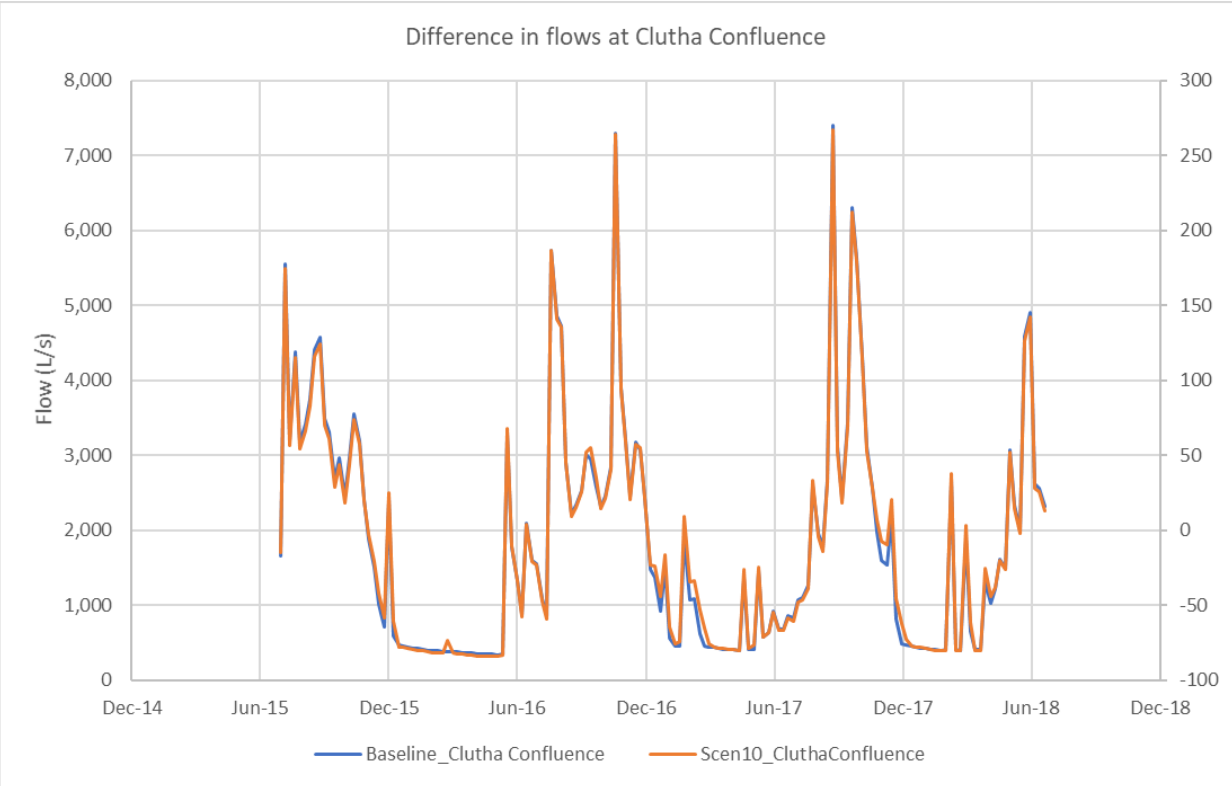

Figure 4: Modelled difference in flows in the Cardrona River at the Clutha conference

3.1.3 Bullock Creek

Modelled flows in Bullock Creek decreased because of the abstraction of groundwater on the true left side of the river for abstraction, which intercepts groundwater that would otherwise flow towards, and discharge into, Bullock Creek. Figure 4 shows the differences in flows. These differences are relatively consistent (despite the seasonal nature of abstraction) and are in the order of 40 L/s. Note that these differences are less than the rate of additional simulated abstraction on the true left of the Cardrona River (63 L/s), which indicates that the increase in abstraction is partly offset by additional seepage from the Cardrona River due to the greater surface water flows without the surface water abstractions and a reduction in discharge to Lake Wanaka and the Clutha River.

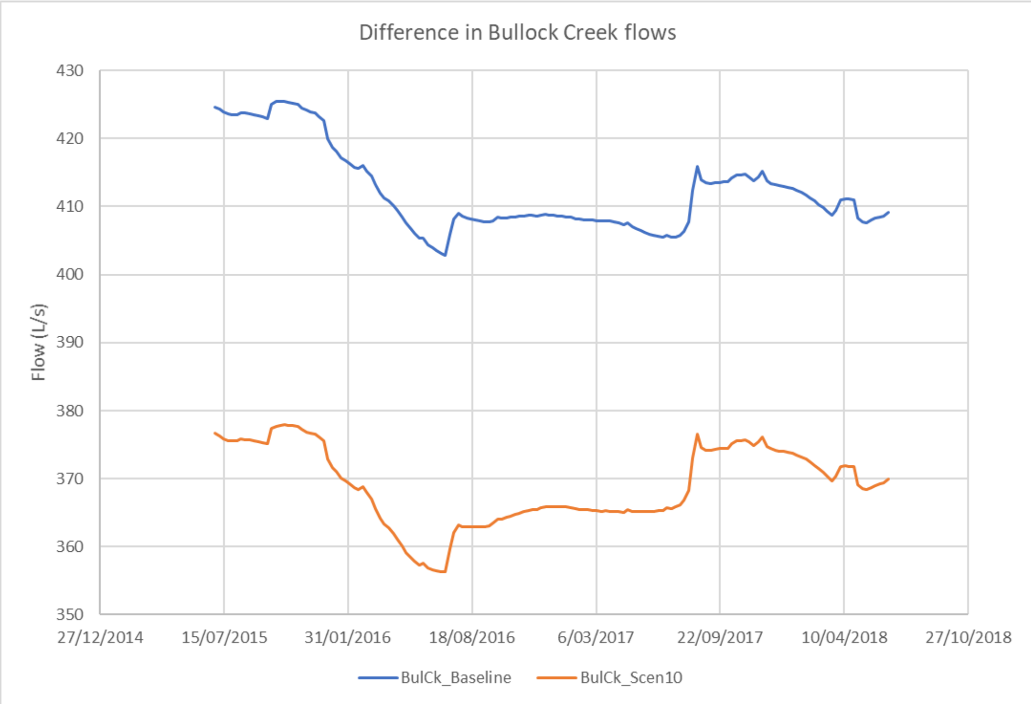

Figure 5: Modelled difference in flows at Bullock Creek

3.2 Groundwater levels

Modelled changes in groundwater levels were consistent with the locations of abstractions, as shown in Figure 6. Greater reductions in groundwater levels occurred on the true right side of the Cardrona River, which reflects the simulated low permeability strata in the area. Note that there is uncertainty in regard to the simulated values of permeability in this area. However, it is possible that groundwater takes on the true right side of the Cardrona River could cause drawdown interference effects with neighbouring bores depending on their final location and yield/drawdown characteristics.

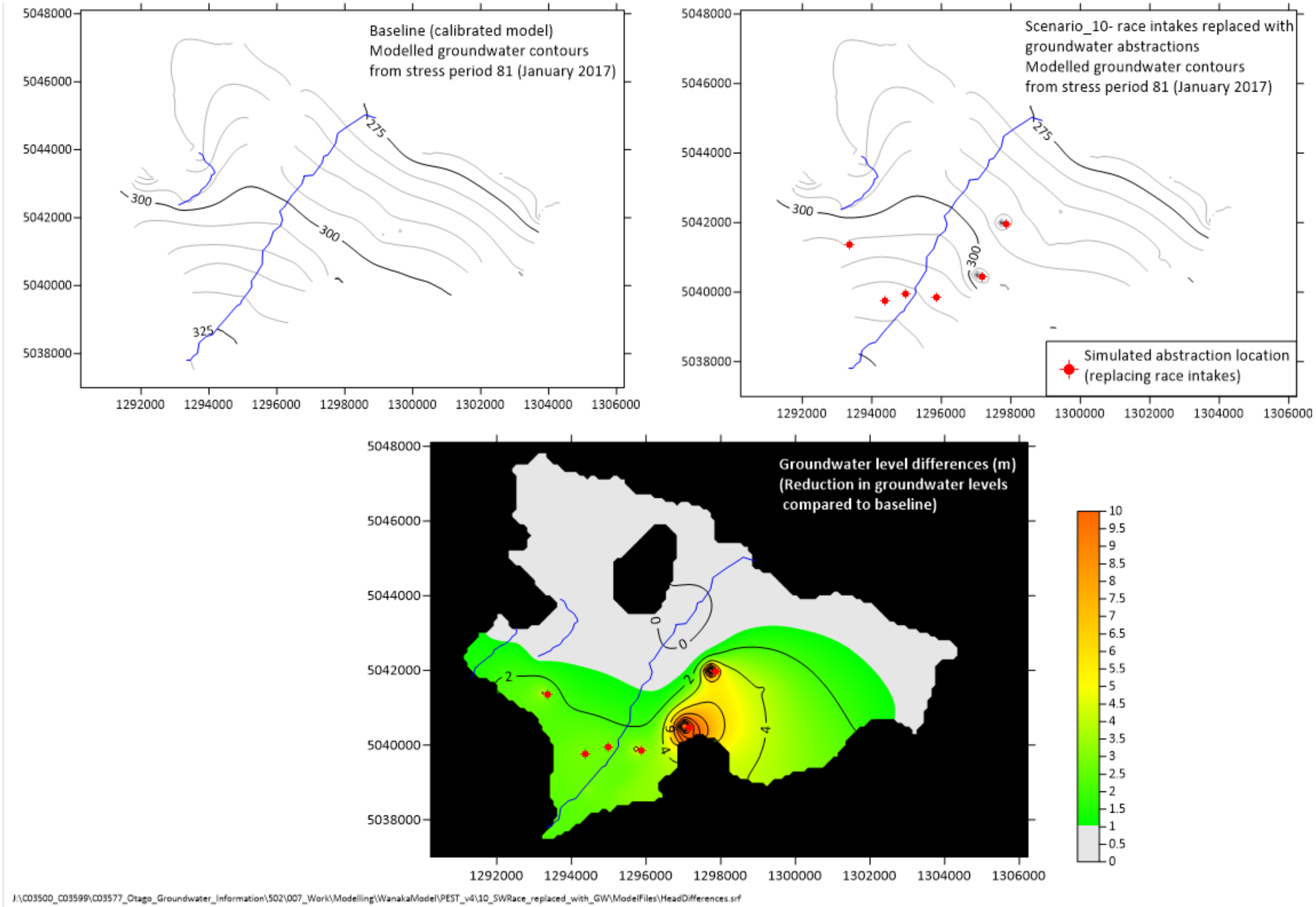

Figure 6: Modelled groundwater level changes

3.3 Model mass balance

In terms of the overall mass balance (Figure 7), the results of the model indicate that stream leakage from the Cardrona River increased which reflects the additional flows in the river due to less abstraction for the races. However, discharges from the model through streams reduced, reflecting the lower flows in Bullock Creek as a result of abstraction and the slight reduction in flows at times in the Cardrona River downstream of State Highway 6. Discharges to the Clutha River and Lake Wanaka also reduced slightly.

Note that there are also some changes to the volume of water that enters the model from groundwater storage, as well as changes to the volume that is removed from the model and enters groundwater storage. This is due to the timing of changes in stream flows (due to removal of the surface water abstractions) and increases in groundwater abstraction (due to the six additional bores), which do not always coincide in time.

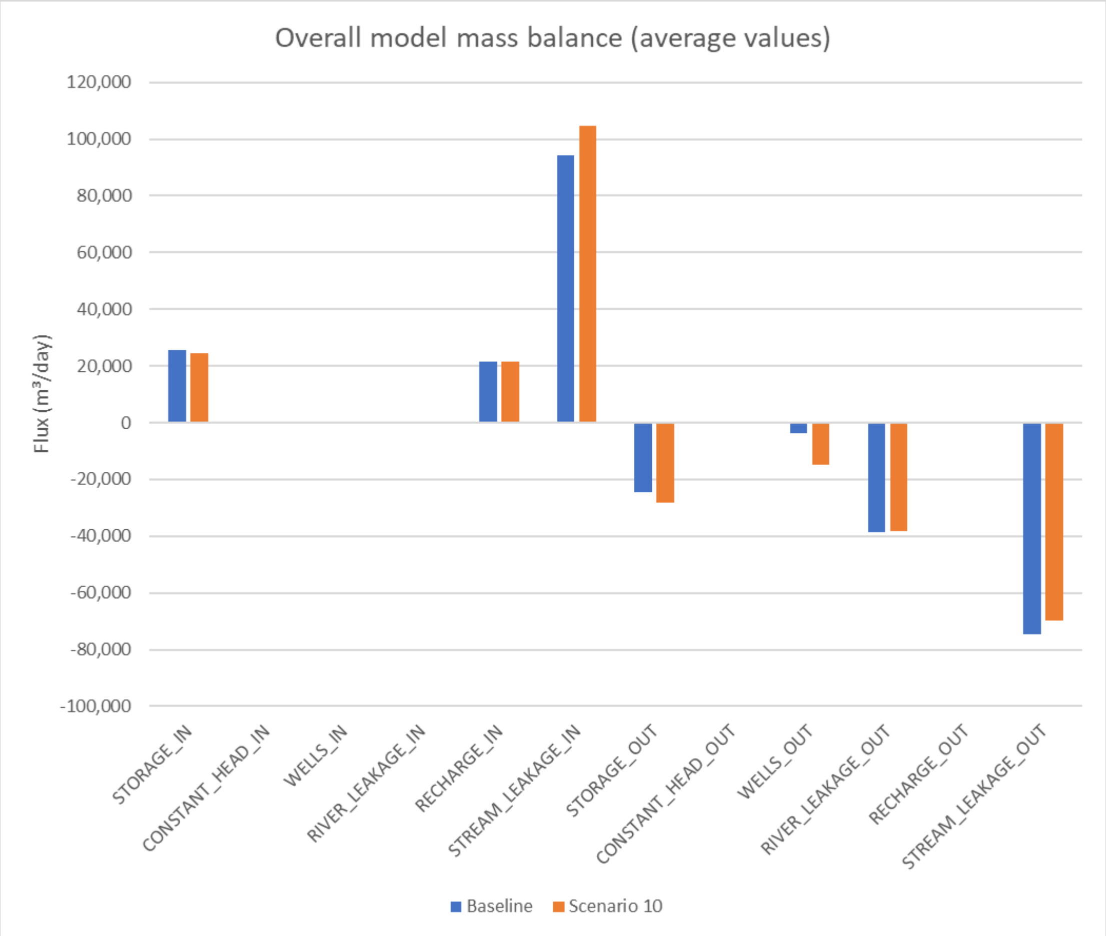

Figure 7: Modelled changes to the average mass balance

4.0 Conclusion

Based on the model, the results of the scenario run where the surface water takes for the irrigation races are replaced with groundwater takes indicate the following potential effects:

- Surface water flows in the Cardrona River at Ballantyne Road are expected to increase particularly at low flows, with potential increases up to 400 L/s at times. However, the Cardrona River at Ballantyne Road will still fall dry at times of low flow;
- Surface water flows in the Cardrona River at the Clutha confluence are expected to show smaller changes;

- Surface water flows in Bullock Creek are expected to decline by approximately 40 L/s;
- The model mass balance indicates that greater seepage from the Cardrona River upstream of Ballantyne Road is expected due to the reduction in surface water takes.
- However, that additional seepage will be partly intercepted by the simulated groundwater abstractions on the true left and right of the Cardrona River. Based on the model average values, the additional seepage may not compensate for the simulated groundwater abstractions and flows in Bullock Creek may reduce.
- We note that the existing irrigation race network may not be fully sealed. Therefore, a shift to groundwater sources may result in less leakage (and therefore recharge) to the groundwater system, which is not accounted for in this scenario run.

It is important to highlight that the abstraction rates simulated in the model run are based on a one in ten-year dry period, repeated through each the three years of the model run. Therefore, the effects represent a 'worst case' scenario and typically, the effects on flows in Bullock Creek would be expected to be smaller. However, we also note that there are uncertainties in the model parameters, which lead to uncertainties in the predictions made in this memo. These are not explored in this memo, but if recommendations are made to decision makers on the basis of these results, some assessment of the uncertainties should be undertaken.

5.0 Limitations

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Prepared by

Neil Thomas
Groundwater Service Leader