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Memo

Date	4 March 2013
To	Phil Towler, EMM
Copy	Trish McDonald, CHC Andrew Krause, CHC
From	Rob Leslie
Ref	2162570C-DMS-WAT-005 RevD
Subject	PB responses to Kalf & Associates Feburary 2013 comments on Groundwater Assessment

Dear Phil

Thank you for providing comments from Dr. Frans Kalf on the updated Groundwater Assessment. The table below summarises the comments and provides our responses. The full comments from Dr. Kalf are attached for reference.

No.	Summarised comment	PB Response
1	Executive Summary. Page xiv. The report mentions "river losses" of 469 Ml/a. Does this include losses also from the creeks (e.g. Sandy and Laheys). (see point 5 below)	"River losses" have been calculated for all rivers in the model. This includes the Talbragar River and tributary creeks.
2	Page xv. When losses from the alluvium are stated is this just Talbragar River alluvium or does include all streams.	Losses are from all alluvium including alluvium associated with tributaries of the Talbragar
3	The Equilibrium level of 373.9 mAHD in 100 years. What are the likely error bars on this value (i.e. the accuracy of this estimate)?	This is reported in Section 8.2.5 of Appendix E (Water Balance and Surface Water Management System) of the Surface Water Assessment – see Figure 1 below this table which is extracted from this section of the Surface Water Assessment. The pit lake remains a net sink feature under the range of stochastic model outcomes (which includes uncertainty in groundwater inflow).
4	Although pressure head profiles were requested the Figures showing model output of total head together with a watertable profile is an acceptable alternative in this case as there is no sub-surface mining that creates an atmospheric void surrounding a mined out zone	Noted. Agreed that total hydraulic head is appropriate for open pit mining.

No.	Summarised comment	PB Response
5	Treatment of creeks and rivers. As stated on Page 18 that Sandy Creek is ephemeral but it is seemingly providing a continuous source of surface water (Appendix H Figure 5.6D - see below)?. This is likely because of the way the Sandy Creek boundary condition has been set up as a constant creek stage ('river package') in the model thereby providing a continuous source of water with the consequent water table drawdown that decreases rapidly towards Sandy creek.? *[other text not reproduced here]*	Comments related to using River cells are noted. The conceptualisation of streams and numerical treatment was discussed at length with our reviewer (Noel Merrick). Early iterations of the model used Drain cells and recharge. However, following initial reviewer comments these were replaced by River cells. The River type boundary was selected with the following reasoning: • Isotopic evidence indicates that groundwater within the alluvium is modern meteoric water, in contrast to the Permian strata which has ancient water (>30 ka) – refer to sections 5.7.1 and 5.7.2.2 in main report. This implies that the streams act as sources of episodic flood recharge even though the hydraulic gradient is towards the creeks during low flow conditions, and that the rate of recharge to the alluvium is potentially much greater than the flux of groundwater discharge from the Permian strata adjacent to the creeks. In this sense the alluvial systems act as weakly connected, rapid through-flow systems overlying a slower moving Permian groundwater system. Drains are therefore not an appropriate boundary condition (as pointed out by our reviewer) and would apply unreasonable conservatism to the model. River cells were used to represent the ongoing recharge due to episodic flooding in creeks over the long term. • Induced vertical fluxes from the alluvium (and river) to the underlying Permian system during mining would be limited by the vertical permeability applied to the alluvium. This mechanism has been quantified by pumping test data. Pumping tests adjacent to Sandy Creek and the Talbragar River were used to estimate the leakage rate between the alluvium and Permian groundwater systems when the latter system was depressurised. Accordingly, a vertical anisotropy (K_h/K_v = 1000) was applied to the alluvium. • The Stream routing package has been rarely used in groundwater modelling of mine impacts (based on a review of 18 recent groundwater assessments), and was not considered practical in this assessment. To implement the stream package realistically requires input from surface water models and also requires additional complex assumptions, which also carry significant uncertainty. In summary the River boundary was considered the best approximation of ongoing stream flood recharge, on balance, given the high surface water runoff component in the creeks and typical 50% to 60% flow. However in response to the reviewers recommendation we have run an additional (highly conservative) model sensitivity scenario whereby the rivers provide no recharge to the aquifer. *The results are presented below.*
6	The same comments apply to the tributary creek channel system that joins Sandy Creek in the region west of PB56 that seems to have locally eliminated drawdown along its course as shown in Figure 6.6.	See previous comment. It is noted that depressurisation of the deeper strata is more widespread.
7	There is no estimate as to the groundwater concentration that would emerge from the backfill and flow into the Sandy Creek alluvium. Figures 7.2 and to a certain extent Figure 7.3 show sub-	The backfill will be more permeable and produce less surface runoff than the pre-existing ground surface, causing significantly higher rates of infiltration and recharge to groundwater in those backfilled areas. Therefore, the assumption is that the flow into the alluvium will be of similar or fresher water quality.

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No.	Summarised comment	PB Response
	surface flow through spoil towards Sandy Creek. Would it be comparable to the salinity currently experienced at depth in the alluvium influence by rock strata?	
8	Page 93 last dot point. It is understood that the 1.5 m/day applied to the spoil was finally applied in the model without the use of TMP1 because this option was inadvertently not implemented? If this is so then delete the last sentence of this dot point.	Note that the TMP feature was re-instated for the final model run, therefore this sentence is valid.
9	Page 94 last dot point. What were the parameters applied for the lake package on the groundwater model?	The lake bed was defined on the basis of the Digital Elevation Model of the final mine landform. Minimum and maximum water levels were based on the lake bed elevation at each cell and the calculated lake equilibrium level. The permeability of the lake bed was set equal to the geometric mean of all intersected geological units.
10	Page 95. Need to indicate how the actual mine inflows tabulated were obtained from the model output. Were these average flows during a stress period; inflows at the end of the stress period; integrated volume divided by the stress period time or some other methodology that was used to obtain the "true" inflow rates from the model output.	Actual mine inflows were calculated by summing the volumes for each time step and dividing by the number of days (integration).

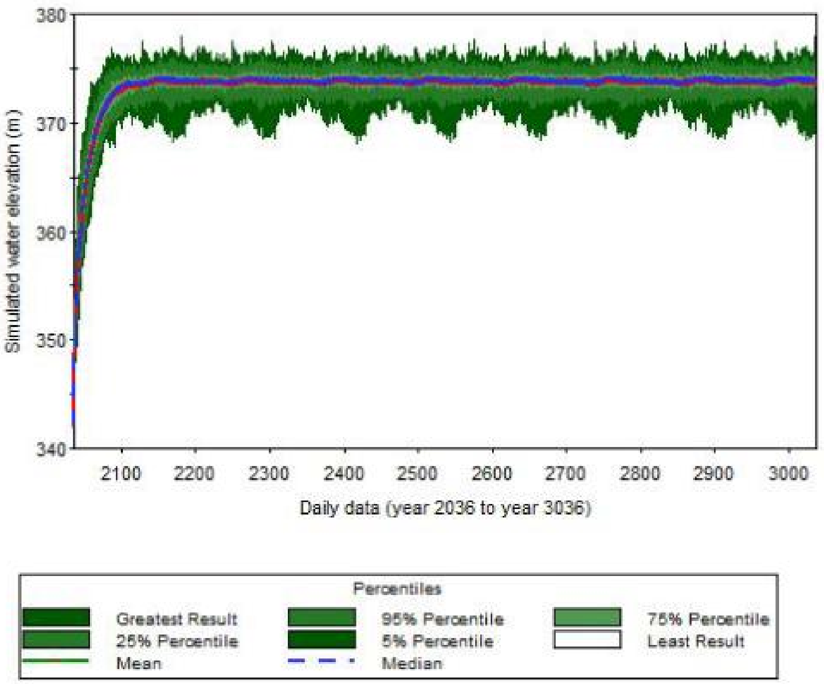

Figure 1 – Final void B water level estimates over 1000 year water balance simulation (from Surface Water Assessment, Appendix E, Section 8.2.5)

Results of the additional model sensitivity run

In response to the recommendations in comment 5 from the external groundwater reviewer, Frans Kalf, the groundwater model was re-run with a more conservative assumption regarding the recharge of groundwater by the creeks.

In the EA groundwater model, streams were assumed to provide on-going recharge to the underlying groundwater systems from episodic flood events. Such recharge is supported by field and isotopic data and would mitigate mine-related drawdown. However, the reviewer has pointed out that in cases where the stream does not flow year-round, recharge from the rivers and streams may be less than that for a perennial system. In order to test the scenario where the creeks and rivers provide no recharge to the groundwater systems, the MODFLOW River head (River stage) was set equal to River bed elevation in the River boundary condition. This forces the river boundary to behave like a drain which allows groundwater discharge when the groundwater gradient is towards the stream, but does not allow recharge to the aquifer when the groundwater level falls below the elevation of the river bed. (This was confirmed by checking that the RIV IN component of the water balance was zero). This approach is considered very conservative and unlikely based on field observations, but serves to illustrate the potential maximum impact under such an assumption.

The results of sensitivity prediction are shown in the table below with respect to predicted drawdown at registered bore sites (the shaded cells in the table indicate which bores experience >2m drawdown). On the assumption that streams and rivers provide no recharge, the model results indicate that a total of 41 bores will exceed 2m drawdown over the mining and post mining period compared to 13 bores identified by the original analysis reported in the Groundwater Assessment (PB, January 2013). Of these 28 additional bores, it is noted that only five bores (highlighted in bold) are not owned by CHC and no bores are known to be used for water-intensive purposes such as crop irrigation. As would be expected, most of the additional drawdown impact under this scenario would occur to the west of Sandy Creek and to the north north-east of the proposed mining area C.

Bore ID	Owner	Bore use	EA Model	Sensitivity Run
PB1	CHC	Stock	0.7142	3.3867
PB10	CHC	Not known	0.1363	3.3147
PB2	CHC	Not known	1.7018	4.9457
PB27	CHC	Stock	1.5095	6.9745
PB28	**Private**	Stock	0.9865	**5.0136**
PB29	CHC	Not in use	1.1386	4.4161
PB30	CHC	Stock	1.1283	4.1242
PB31	CHC	Stock	1.4581	7.5903
PB32	**Private**	Stock	5.0237	9.6773
PB39	CHC	Stock/domestic	30.7951	32.5023
PB42	CHC	During drought	1.6089	7.0528
PB45	CHC	Stock/septic	3.4227	7.5687
PB56	CHC	Not known	2.6326	5.6712
PB61	CHC	Not known	0.9022	4.5108
PB64	CHC	Domestic	0.8898	5.1568
PB65	**Private**	General use	1.3028	**3.9683**
GW001122	CHC	Stock	0.9556	4.8263
GW001140	CHC	Stock	0.68	3.3997
GW001146	CHC	Not known	27.2662	34.6067
GW001794	CHC	Not known	2.1157	3.3712
GW010645	CHC	Stock	1.4892	2.3619
GW011442	CHC	Stock	3.4146	7.3007

Bore ID	Owner	Bore use	EA Model	Sensitivity Run
GW012551	**Private**	Stock	2.4025	3.7944
GW012552	CHC	Stock	1.074	3.063
GW013327	CHC	General use	0.9875	6.9124
GW019643	CHC	Stock	1.6254	4.8028
GW019644	CHC	Stock	1.8514	5.4632
GW023752	CHC	General use	0.9649	3.3548
GW024349	CHC	Stock	0.9082	3.8196
GW024350	CHC	Stock	0.9965	4.0969
GW026780	CHC	General use	0.8571	5.2114
GW027388	**Private**	Stock	0.8489	**4.6194**
GW027389	**Private**	Stock	1.3051	**3.7694**
GW045410	CHC	Stock	0.6526	3.4745
GW051724	CHC	Stock	4.3703	6.6128
GW052777	CHC	Stock	5.5526	7.9907
GW054484	CHC	Stock	1.2208	5.2944
GW058162	**Private**	Stock	0.3779	**2.2633**
GW058583	CHC	Stock	20.8307	27.8449
GW064228	CHC	Stock	3.73	8.5153
GW801735	CHC	Test bore	2.183	5.6829
Bores >2m DD			**13**	**41**
			Additionally impacted bores (no river recharge):	**28**
			Of those, not on CHC land:	**5**

As described in Section 7.5.5 of the environmental assessment, CHC is committed to rectifying significant impacts at private bores at the company's cost.

It should be noted that predicted drawdown will be less than that reported under the sensitivity scenario as it is expected that recharge will occur through the rivers and streams during mining and post-mining recovery.

We trust the above responses are sufficient to answer the reviewer comments.

Yours sincerely

Rob Leslie

Rob Leslie
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Parsons Brinckerhoff