Improved Regulation of Water Supply for the Olympic Dam Mine, South Australia

Gabor Bekesi[1], Murray Tyler[2], Darren Niejalke[2], John Waterhouse[3]

[1]*Australian Water Environments, 1/198 Greenhill Rd, Eastwood, 5006 South Australia, Australia, gaborbekesi@austwaterenv.com.au*
[2]*BHP Billiton, 55 Grenfell Street, Adelaide, 5000 South Australia, Australia, murray.tyler@bhpbilliton.com*
[3]*Golder Associates, 1 Havelock Street, West Perth, Western Australia 6005, Australia, jwaterhouse@golder.com.au*

Abstract Groundwater use from the water supply wellfield in the Great Artesian Basin (GAB) is regulated according to its effect on aquifer pressure, not according to the volume of groundwater taken. Originally a maximum of 5 m pressure drawdown was set at five sites, each approximately 50–60 km from the wellfield. There was initially an unacceptably large uncertainty in drawdown estimation because 'noises' (the effects of antecedent pastoral use and temperature on measured wellhead pressures) were recognised as comparable in magnitude to the 5 m limit. A modified regulatory structure was developed, based on a whole of wellfield approach.

Keywords Artesian pressure, drawdown, Great Artesian Basin, Australia

Introduction

Wellfield B supplies an average of 30 ML/d of groundwater from the Great Artesian Basin (GAB) to the Olympic Dam mine and the town of Roxby Downs (Fig. 1) in South Australia (SA). Water use from Wellfield B was regulated by a drawdown criterion (a maximum of 5 m as pressure drawdown) set at five sites ("assessment sites") to preserve flows at GAB springs and pressure at pastoral wells. This regulation approach had been in place since 1996.

Through analysis of extensive monitoring data collected since 1996, it has become apparent that antecedent pastoral flows and temperature had a larger influence on the measured pressures than originally anticipated (Bekesi *et al.* 2012a). As a result of recent investigations to improve pressure and drawdown calculations by incorporating temperature (Bekesi *et al.* 2012b) the true magnitude of errors/uncertainties became apparent. Disregarding temperature/antecedent flows resulted in signifi-

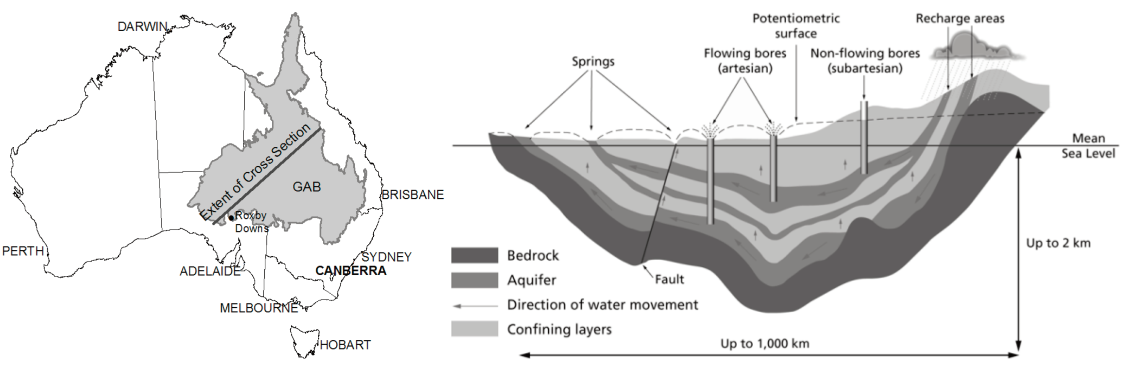

Fig. 1 *The Great Artesian Basin of Australia (cross-section from www.gabcc.org.au).*

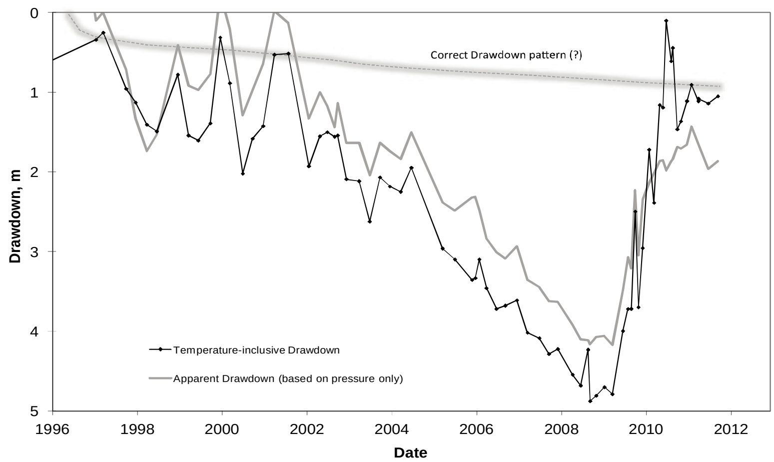

Fig. 2 *Apparent (reported) and correct drawdown in Jackboot Bore, one of the assessment sites (after Bekesi et al. 2012c).*

cant errors in drawdown estimation; at one site drawdown was reported as up to 4 m before being corrected to just over 1 m in 2012 (Fig. 2, after Bekesi *et al.* 2012c). Reported drawdown at another assessment site was up to 4.4 m compared with the current estimate of drawdown of 2.3 m.

The high importance of the wellfield for mining and town water supply, and the magnitude of uncertainties being comparable to the maximum drawdown criterion of 5 m, meant that there was an unacceptably large uncertainty in point drawdown estimation. A new and improved regulatory assessment was required. In particular, the risk of an entire wellfield being non-compliant because of a single incorrectly reported drawdown value exceeding 5 m had to be minimised or eliminated.

Unique Hydrogeological Features of the Great Artesian Basin

Habermehl (1980) and Radke *et al.* (2000) provide comprehensive descriptions of the GAB. The GAB is one of the largest basins (≈ 1.7×10^6 km^2) in the world. In most places, the GAB is the sole source of reliable freshwater for drinking in an arid environment. The main GAB aquifers comprise of sandstones of Jurassic age and up to 2 km in depth (Fig. 1).

Four unique features of the GAB, important for this paper (high temperatures, low storativity, high wellhead pressures and continuously used pastoral wells) are discussed below.

1. Groundwater temperature in the GAB varies between 22 °C in the recharge areas and 100 °C in the discharge areas (Radke *et al.* 2000, Habermehl and Lau 1997; Habermehl and Pestow 2002) and generally increases with increasing depth of burial. Groundwater near Wellfield B (depth ≈ 700 m) has a temperature of 60–80 °C.
2. The GAB aquifer consists of highly confined sandstones and siltstones with a horizontal hydraulic conductivity in the order 1–10 m/d with a very low storativity in the order of 10^{-5}. Because of the highly confined nature of the GAB (low storativity) the assessment sites were located some 50–60 km from Wellfield B (Fig. 3) in an attempt to monitor both the effects of drawdown on pastoral supplies and, to the south of Wellfield B, on GAB springs.
3. Most wells near Wellfield B have high wellhead pressures, approximately +700 kpa (70 m H_2O) above ground level. To measure pressure, most GAB wells are shut in and surface pressure is measured after a predetermined wait/recovery time (Bekesi *et al.* 2012c).

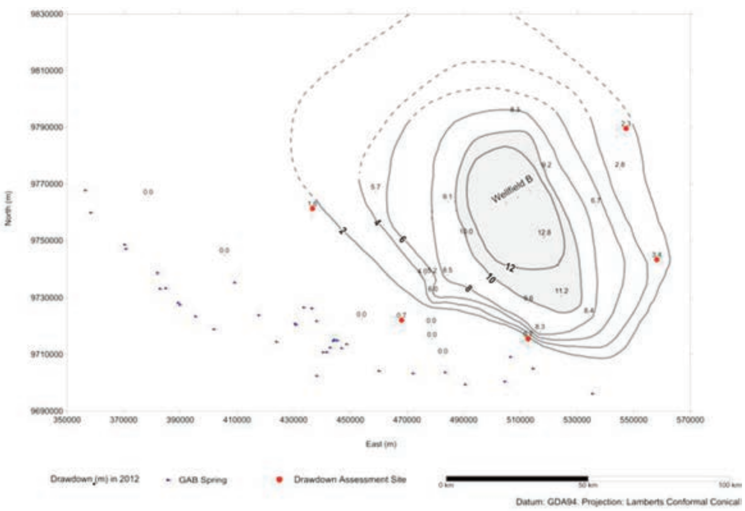

Fig. 3 *Drawdown around Wellfield B in June 2012. Contour interval is 2 m. Shaded region represents drawdown > 10 m with an area of 1930 km². Contours are based on 25 drawdowns calculated as difference between the contemporary wellhead pressure and a reference pressure pre-dating Wellfield B*

4. The GAB is situated beneath arid land, and because of the large area of the pastoral properties, long water supply lines, remoteness of the area, and high drilling costs, some of these pastoral wells are used more or less continuously (Bekesi *et al.* 2012c).

The combination of continuously used wells, high pressures and hot water make flow and pressure measurements and the calculation of drawdown more challenging than in cold aquifers. Pressures measured at the well head often decrease during recovery (Bekesi *et al.* 2013) and the influence of density variations at high temperatures may introduce significant errors. Therefore groundwater temperature has to be incorporated into the drawdown calculations (Bekesi *et al.* 2013).

The Calculation of Drawdown

In 2012, the monitoring network around Wellfield B included both dedicated monitoring sites (28) and pastoral wells (26). Some pastoralist were allowed to tap to monitoring bores and, as a result, only about one-third of the bores were unused in 2012. The monitoring of private wells near Wellfield B serves to provide a large monitoring network and to confirm that artesian pressures are preserved in pastoral wells.

Drawdown at each measuring point has traditionally been calculated as the difference between the contemporary wellhead pressure and an agreed reference pressure (judged to pre-date any effects of Olympic Dam water supply abstractions). Lately, temperature effects have also been incorporated to improve the estimation of drawdown. Despite these improved calculations, drawdown estimation is still subject to an estimated ±1.5 m uncertainty.

Improved temperature-inclusive drawdowns reported in 2012 at the five assessment sites varied between 0.7 and 3.4 m, still comparable to the estimated ±1.5 m uncertainty, presenting a considerable risk for reporting incorrect compliance or false alarms alike. The regulation measured the performance of the entire wellfield with (arguably) too much emphasis on the assessment sites. It was realised that a better way of assessing the broad impact of groundwater abstractions would be to develop a single measure of drawdown. Whilst drawdowns at some points are important, assessment at a few key points does not give a measure of the effects of the entire wellfield.

Negotiations with the Regulator

The high importance of the wellfield for mining and town water supply, and the point-based drawdown approach meant that there was an unacceptably large risk associated with

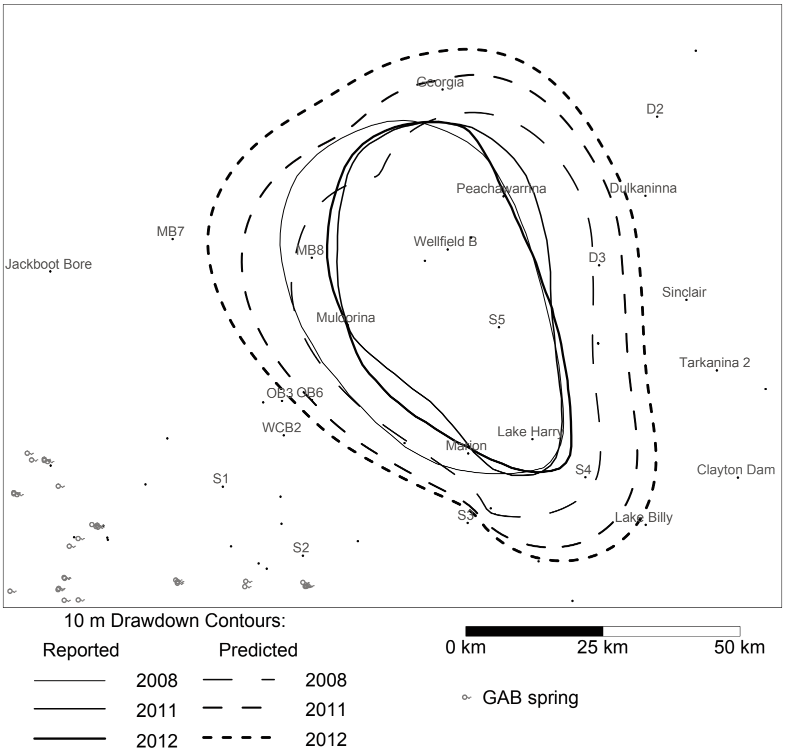

Fig. 4 *Reported (June 2012) and predicted 10 m drawdown contours. Drawdowns are calculated as difference between the contemporary wellhead pressure and a reference pressure pre-dating Wellfield B*

any of the five individual site conditions. Since 2009, BHP Billiton has initiated several reviews of the hydrogeological aspects of wellfield sustainability, monitoring and modeling. As a result, negotiations with the SA regulator commenced in 2010 to review and improve the drawdown criteria for Wellfield B. Several options, ranging from the elimination of some of the assessment sites, to a single drawdown index (weighted average drawdown)representing the entire wellfield, have been investigated. Since 2011/12 investigations focused on deriving a single graphic representation of the interpreted drawdown.

The Area within the 10 m Drawdown Concept

The concept, eventually agreed, is to regulate by the size of the area within the 10 m drawdown contour. That is, drawdowns at individual sites are reported and contoured annually and the area contained inside the 10 m drawdown contour line (where drawdown ≥10 m) is calculated (Fig. 3). Drawdown is calculated as described in page 3, on reference pressures that pre-date Wellfield B.

The choice for the contour value was a compromise between large drawdown (suppressing most of the ±1.5 m errors) and the practicality of constructing a reliable contour line. Fig. 3 indicates that, in 2012, no drawdown was reported > 15 m in observation wells; three reported > 10 m and ten > 8 m. Therefore 10 m was seen as the most sensible value.

A criterion for the area inside the 10 m drawdown contour, *i.e.* 4450 km^2, was calculated from numerical modeling (Fig. 4). For the explicit protection of springs, mostly situated to the south of Wellfield B, individual drawdown criteria were also set at 4 m in two dedicated monitoring bores(S1 and S2 in Fig. 4).

Using the area footprint approach allows focus on resource sustainability that can be monitored by the area of drawdown footprint, contained within the 10 m drawdown contour of Wellfield B. The drawdown cone around Wellfield B is the measure of the depressurisation of the GAB Aquifer. Sustainability, or the availability of water for both current and future users, including the environment, is directly related to the size and pattern of the current drawdown and future rates of recovery of pressures once the mining activity and groundwater production ceases.

Conclusions

The new regulation relies on a simple, graphical and "whole-of-wellfield" measure and minimizes the risk of using incorrect drawdowns at individual sites. Notwithstanding, further opportunities exist to improve drawdown calculations at individual bores regardless of the way compliance criteria are set.

References

Bekesi G, Tyler M, Waterhouse J (2012a) Improved Calculation of Groundwater Heads for Environmental Management in the Great Artesian Basin, Australia. Proceedings, International Mine Water Association (IMWA) 2012. 30 September – 4 October 2012, Bunbury, WA.

Bekesi G, Tyler M, Waterhouse J (2012b) Conclusions From Using an Active Production Well for Mine Drawdown Compliance. Proceedings, International Mine Water Association (IMWA) 2012. 30 September – 4 October 2012, Bunbury, WA.

Bekesi G, Tyler M, Waterhouse J (2012c) Lessons from the Use of an Active Production Well for Compliance Monitoring in the Great Artesian Basin, Australia. Mine Water and the Environment Journal of the International Mine Water Association (IMWA) 31(3):225-232.

Bekesi G, Tyler M, Waterhouse J (2013) Groundwater Head in High Temperature Aquifers. Quarterly Journal of Engineering Geology and Hydrogeology 46:87–94

Habermehl MA (1980) The Great Artesian Basin, Australia. BMR J Aust Geol Geop 5:9–38

Habermehl MA, Lau JE (1997) Hydrogeology of the Great Artesian Basin, Australia. (Map at a scale 1:2,500,000). Australian Geological Survey Organisation, Canberra.

Habermehl MA, Pestow I (2002) Geothermal Resources of The Great Artesian Basin, Australia. GHC Bulletin, 23(2):20-26.

Radke BM, Ferguson J, Creswell RG, Ransley TR, Habermehl MA (2000) Hydrochemistry and Implied Hydrodynamics of the Cadna-Owie-Hooray Aquifer, Great Artesian Basin, Australia. Bureau of Rural Sciences, Canberra.