

Studies on Groundwater Impacts by CSG Productions in Australia Surat Basin

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Abstract: The Surat Groundwater system include shallow, intermediate, coal seam and deep groundwater system. The shallow groundwater resources in Surat basin has been developed over the years for irrigation, stock, domestic and other uses. Extraction water from this aquifer is critical to support the local irrigation. With the large-scale CSG production beginning in the Surat basin, the hydraulic connection between the shallow groundwater and coal seam water become a key problem. This paper first gives an introduction on geology and hydrogeology of the region and then gives a brief view of CSG production affects the groundwater level based on the Condamine interconnectivity test analysis, the monitor results of groundwater level and groundwater level drawdown numerical model predictions. Results show that groundwater levels provide little to no effect relative to CSG production. Further study and simulation work will continue to research CSG and groundwater connections.

1 SURAT BASIN CSG INTRODUCTION

The Surat basin is part of the Cretaceous-Jurassic Great Artesian basin (GAB). The basin overlies the Permo-Triassic Bowen Basin and is a relatively undeformed intra-cratonic basin with overall layer-cake stratigraphy (Exon, 1976). The regional seismic section illustrates that the Surat basin is draped over basement highs and separated by an unconformity from the underlying Permian-Triassic sediments of the Bowen Basin (SRK Consulting 2005). Coals intersected in the Surat Basin are a member of the Walloon Coal Measures (Figure 1). Most CSG blocks are in the eastern margin of the Surat Basin. AA Block is one of CSG blocks in the eastern most of Surat basin. Most groundwater analysis comes from AA CSG blocks.

The Walloon coal measures are Low-rank coal measures with R_0 of 0.6% and are further divided into the Juandah coal measures and the Taroom coal measures. The Walloon coal measures are overlaid

by the Eurombah Formation and Hutton Sandstone and overlaid by the Springbok Sandstone and its equivalents, such as Kumberilla Beds (Figure 2). The complex architecture of Walloon Coal Measures is a result of the highly variable depositional environment. The relatively stable alluvial flood plain allowed river channels to freely migrate and disturb coal swamp development rapidly and laterally (Scott, 2004).

Many LNG projects are being constructed in Australia. Among them, The CSG-LNG projects are located in the east Australia (Figure 3). The gas resources come from the Walloon Coal measures of Surat Basin. This paper provides interconnectivity analysis between the coal seams and the shallow Condamine aquifers, the monitor results of groundwater level and groundwater level drawdown numerical model prediction.

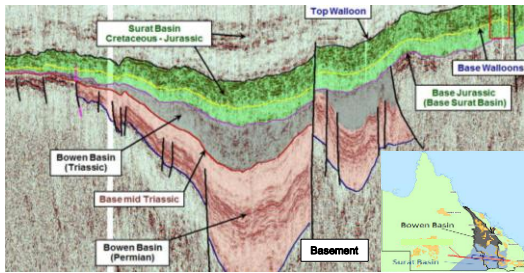


Figure 1: Regional seismic line across the center of the Surat Basin.

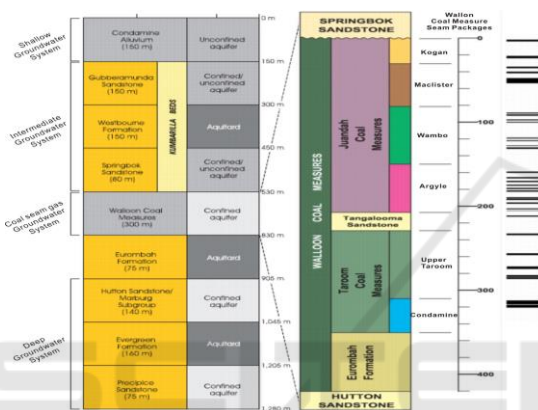


Figure 2: Stratigraphy and groundwater systems in Surat Basin.

2 SURAT BASIN HYDROGEOLOGY REVIEW AND GROUNDWATER IMPACTS ANALYSIS

The Surat Basin is located on the eastern margin of the GAB (Great Artesian Basin), which is Australia’s largest contiguous groundwater resource. The formations are exposed along this eastern recharge zone include the Gubberamunda Sandstone, Hutton Sandstone and Precipice Sandstone, and they are found within the project development area. From the recharge zone, subsurface groundwater flow within the GAB is generally towards the southern, southwestern, western and northern margins of the GAB. In some areas, natural groundwater discharge occurs via flowing artesian springs (Barnett and Muller, 2008).

The aquifers in Surat Basin can be classified as four aquifer units: shallow, intermediate, coal seam and deep groundwater systems according to the stratigraphy features. (Figure 2).

Shallow Groundwater Systems are quaternary unconfined or water layer aquifers. They are named as the Condamine Alluvium aquifers. Condamine Alluvium aquifers generally have some general characteristics that make good resource aquifers, such as high permeability, high hydraulic conductivity, substantial thickness, sandstone-like storage characteristics, consistent characteristics over large distances, and good quality groundwater, but still they have some claystones as heterogeneous layers in (Figure 4). The shallow groundwater system provides the primary source of irrigation water.

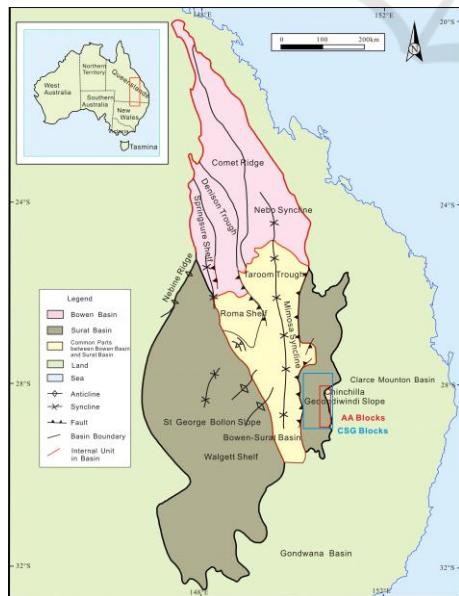


Figure 3: CSG Blocks in Surat Basin.

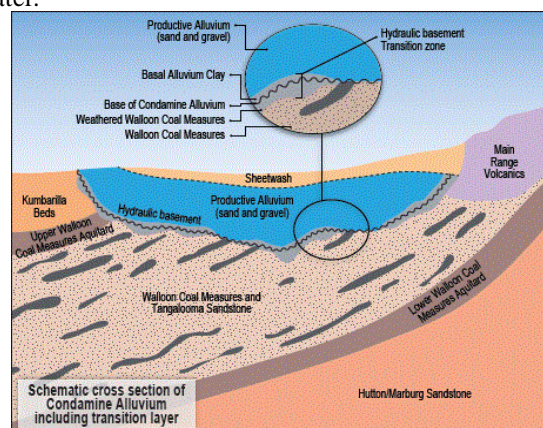


Figure 4: Surat Basin schematic groundwater model.

Intermediate Groundwater Systems include confined aquifers located above the coal seam formations.

Coal Seam Groundwater Systems are confined aquifers associated with coal seam formations. It include Walloon Coal Measures, but are variable and have commonly with low permeability and/or low water quality.

Deep Groundwater Systems: confined porous aquifers located below the Walloon Coal Measures formation. They include the Marburg Formation, Hutton Sandstone and Precipice Sandstone (Arrow Energy 2012; CSIRO 2008; Henning, 2005).

Groundwater movement in the major confined aquifers of the Surat Basin is predominantly horizontal. The lower permeability units between these aquifers (aquitards) restrict vertical interconnection between the groundwater systems. In this situation, there is no impact to groundwater by CSG production; however, vertical inter-aquifer flow may occur in areas where the aquitards are thinner or eroded. In addition, if significant groundwater pressure differences occur across different formations, then inter-aquifer groundwater flow can occur. In these cases, groundwater influence by CSG production should be calculated and taken actions to ensure the safety of irrigation, stock, and domestic uses of groundwater. Three analyses of observing groundwater impacts by Surat CSG production shows in the following sections.

2.1 The Condamine Interconnectivity Analysis

The groundwater resources of the Condamine Alluvium Aquifer been used for irrigation, stock and domestic uses. Communities have expressed concern that groundwater extraction from the CSG wells could lead to reduced groundwater availability from the Condamine Alluvium aquifer. The objective of investigations is to provide scientific evidence about whether CSG development near Condamine Alluvium would have impact on groundwater supplies for irrigation (Scott et al., 2004).

Four underground water-monitoring bores were drilled on two separate intensively farmed properties in the Condamine Alluvium area. Aquifer pumping tests in the bores were undertaken at two locations: 'A' in 2013 and 'B' in 2014, adjacent to the existing irrigation bores.

The analysis on the core porosity, permeability, mineralogy and geophysical logs of groundwater monitoring bores showed the formation layers and the lithology type. Then the density, porosity and permeability of the layers can be determined. The result shows the vertical permeability of "transition zone" of A and B is about 3.5×10^{-6} - 1.0×10^{-6} m/day and 2.0×10^{-7} m/day- 1.6×10^{-4} - 1.6×10^{-4} m/day respectively (Figure 5).

The results from A and B are consistent with the vertical permeability used in the current numerical model and vertical permeability from B indicates the site is less permeable than A. These results verified that there is only a low level of hydraulic connection between the Condamine Alluvium and the underlying Walloon Coal Measures.

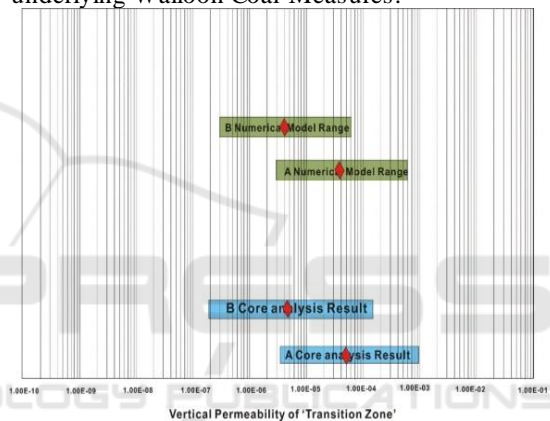


Figure 5: The comparison plot between Model and core analysis.

2.2 Groundwater Level Monitor Analysis

There are many water monitor wells drilled to survey the water level alteration. Since 2009, the potentiometric elevations of 15 wells have been draw down little by little. Figure 6 (different color lines are different coal seams) shows two CSG fields potentiometric elevation drawdown results. D11 and D12 well are from D Field of Block AA, S5 well is from S Field in Block AA. Noticeable potentiometric elevation drawdown (20m-135m) in the different coal seams of Walloon coal measures appears according to Figure 6a and Figure 6b results, which indicate the produced water only come from Walloon confined aquifer, not from the flux between the underlying and overlying aquifers. The Walloon Coal Measures are low permeability sediments and

there are shale zone between different groundwater systems (Schlumberger 2011).

2.3 The Groundwater Level Drawdown Predication Analysis

In order to know the groundwater level alternations, the numerical groundwater model was analyzed to provide estimates of drawdown in response to the abstraction of groundwater associated with CSG activities.

The MODFLOW EVT software packages are used to model the cumulative groundwater case. The cumulative case models all current and proposed water extraction from CSG activities from 1995 onwards.

Total modelled extraction from CSG projects showed in Figure 7. The extraction include CSG water extraction from block AA and other company’s CSG extractions by considering their CSG development plans. The result suggests a cumulative peak extraction of around 550 ML/d in 2015, or around 20 years into the ‘predictive’ simulation, which runs from 1995 onwards (Department of Natural Resource and Mines 2012).

Figure 8 identifies areas where the predicted cumulative maximum impact drawdowns based on the predication simulation result exceed 5 m in each of the affected aquifers. As expected, the impacted area is greatest in the WCM and gradually reduces in the various underlying and overlying aquifers. Predicate result suggest predicted maximum cumulative drawdown impacts of more than 5 m in the Springbok Sandstone, Walloon Coal Measures, Hutton Sandstone, Precipice Sandstone (GHD 2013; Geoscience Australia and Habermehl M.A 2010). The cumulative drawdowns of other aquifers are indistinct. The cumulative model result shows there are no pronounced impacts for the groundwater alteration in Surat Basin by considering all the CSG activities from 1995 onwards.

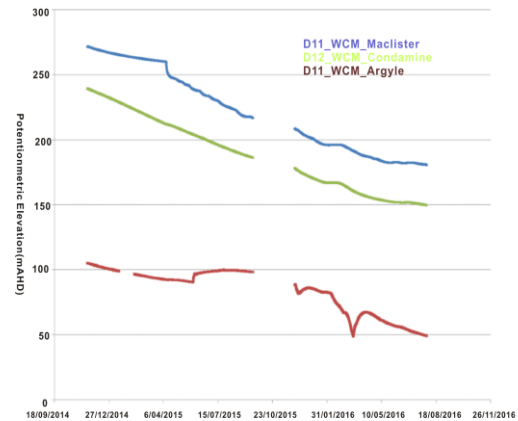


Figure 6a: D Field groundwater monitor map.

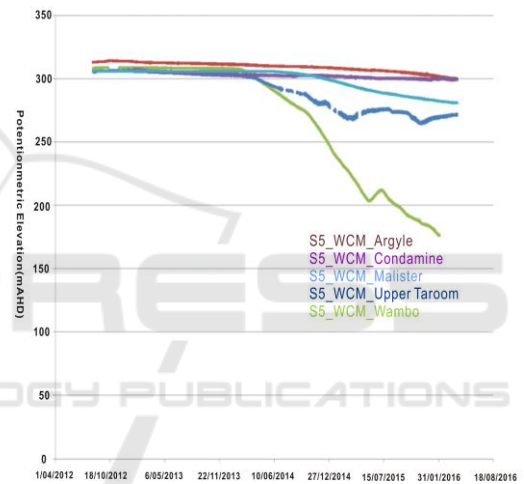


Figure 6b: S Field groundwater monitor map.

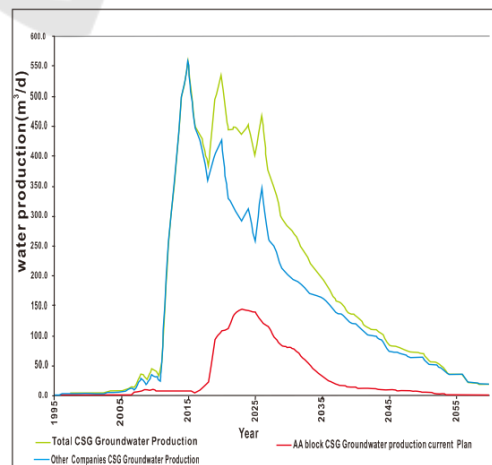


Figure 7: CSG and other extraction in Surat Basin.

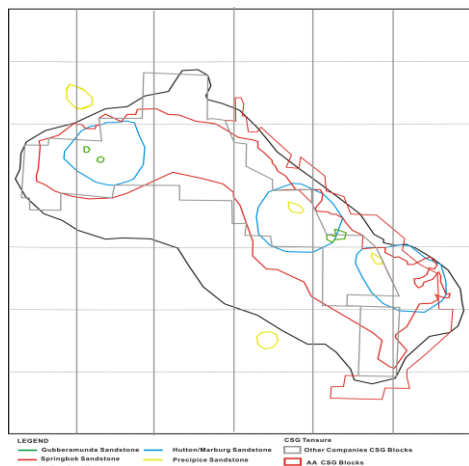


Figure 8: Maximum 5m Drawdown Contours.

3 CONCLUSIONS

There are a low level of hydraulic connection between the Condamine Alluvium and the underlying Walloon Coal Measures according to core analysis and Condamine Interconnectivity study result.

The potentiometric elevations drawdown result from water monitor wells near CSG fields shows the produced water only from Walloon confined aquifer, not from the flux between the underlying and overlying aquifers.

According to predicating result from groundwater model based on CSG and other extraction in Surat basin, there are no pronounced impacts for the groundwater alteration in Surat Basin. Further study and simulation work will go on with the change of CSG and other activities.

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