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NSW Government

Department of Planning & Infrastructure

Dear Sir/Madam,

Reference Number: SSD 13_6038

Title: Santos NSW (Eastern) Pty Ltd, Dewhurst Gas Exploration Pilot Expansion, Environmental Impact Statement (EIS)

I am an Independent Contract Hydrogeologist operating as a sole trader under the name Groundwater Solutions International, NZ. I worked for the formerly named Department of Water Resources, NSW, from 1992 until 1995 as a Project Hydrogeologist and was located in Gunnedah/Sydney. As a result of my work I obtained a good understanding of the hydrogeological processes that occur within, and between, the southern Surat Basin and Gunnedah Basin geological units, having undertaken an intense property-by-property three year study of all bores. Data collected and reviewed included bore and well hydrographic and water quality records; geological records from both the bores, wells and mining exploratory bores; hydrological data from creeks and rivers; and climatic data. I also participated in the mass installation of observation piezometers in the alluvial soils and shallow aquifers of the Liverpool Plains. I ran educational workshops for property owners and government employees working in the area. On occasions since then I have reviewed groundwater impacts of mining operations at the request of community groups. I remain an active interested party with respect to any hydrogeological investigations, and other relevant scientific studies, undertaken in the Namoi Valley Catchment.

I object to the Dewhurst Gas Exploration Pilot Expansion on the grounds it will have a significant impact on Matters of National Environmental Significance (Water Resources).

Introduction

This review has been prepared in response to a document written by CH2M HILL (August 2013). This document, 'Dewhurst Gas Exploration Pilot Expansion EIS, Groundwater Impact Technical Report, Energy NSW Coal Seam Gas Exploration and Appraisal Program (Ref: 474 982/D3/007), was commissioned by Santos NSW (Eastern) Pty Ltd and serves as a supporting document for the Santos' Dewhurst Gas Exploration Pilot Expansion EIS which covers an area defined by Petroleum Exploration Licence (PAL) 2 located in the Pilliga State Forest, Narrabri region.

Background

Santos is submitting an Environmental Impact Statement as part of obtaining approval for their Coal Seam Gas Dewhurst Pilot Expansion, which includes the drilling of two horizontal wells from existing casing within Dewhurst 16H, 17H and 18H to convert each single horizontal to a triple-stacked horizontal well targeting the Bohena, Namoi and Rutley Coal Seams; and the drilling of one new vertical well (Dewhurst 30) and on new triple-stacked horizontal well (Dewhurst 31). This is part of the Santos' three year Pilot Production Well program.

This submission is mostly concerned with the groundwater technical report findings of a cumulative groundwater impact statement, based on numerical groundwater modelling undertaken for the concurrent operation of six pilots within the Energy NSW Coal Seam Gas (CSG) Exploration and Appraisal Program.

Of great concern are the potential impacts of CSG exploration on the groundwater quality and quantity within the Great Artesian Basin (GAB) Pilliga Sandstone aquifer beds and the Quaternary (recent) unconsolidated alluvial aquifers beds. The GAB aquifer beds within PAL 2 provide water for stock and domestic purposes. Of equal concern is that the CSG Program is located within the Pilliga Sandstone recharge beds to the GAB, which are unique to the region. Any activity which intercepts and potentially removes water from the recharge areas, or potentially allows cross contamination of GAB waters with the poor water quality from the coal seams should be scrutinised in light of these potential risks. Any degradation of the GAB beds may have significant consequences to this unique and highly valuable water supply.

Discussion

The purpose of this submission is to outline my concerns that have arisen from the Dewhurst Gas Exploration Pilot Expansion EIS, Groundwater Impact Technical Report (CH2M HILL, August 2013) that require further consideration. My concern is related to Conclusion 2, see below, which has been based on outcomes of the numerical groundwater modelling presented and interpreted in the CH2M HILL 'Groundwater Impact Technical Report'.

'*No aquifer interference to either the alluvial groundwater sources of the Upper and Lower Namoi alluvium (NSW Upper and Lower Namoi groundwater source WSP) or the GAB Surat Pilliga Sandstone (NSW GAB groundwater source WSP) is indicated by the modelling of the six pilot CSG water extraction activities, and hence Dewhurst 13-18H and Dewhurst 26-31 in isolation'.*

I do not believe the current un-calibrated (for Transient conditions); numerical groundwater model can be relied upon to conclude there will be no aquifer interference/drawdown effects in the Pilliga Sandstone and Quaternary Bohena Alluvial aquifer systems. CH2M HILL has not undertaken a sensitivity analysis on the model. It is stated the groundwater model has been 'calibrated' for Steady State conditions with Initial Hydraulic heads (IH) being determined by this initial model and feed into the subsequent Historical Model. The groundwater levels were not measured, they were determined by modelling.

Maximum drawdown calculations depend on:

1. The model being adequately calibrated for transient conditions.
2. The proposed shallow and deep monitoring bores being sensibly located to adequately represent the hydraulic conditions over the program area.
3. Assumed hydraulic conditions at the proposed monitoring locations, given these bores have not been drilled yet so no layer parameters have been collected and input into the model to represent the area. There is no information in the report detailing the monitoring bore total depth; screened intervals; initial groundwater levels; aquifer parameters; etc. It is assumed given no hydrogeological investigations have been undertaken at these sites.
4. The determination of 'generalised' impacts being sufficient enough to make statements such as 'no drawdown' in the shallow aquifers (Pilliga and Alluvial aquifers).

Due to the conclusion drawn from the numerical groundwater model that there will be no drawdown in the shallow aquifers they state that it is 'unnecessary to instigate mitigation measures beyond construction and operational environmental management controls'. What if the model is wrong and there is no plan stating mitigation measures? Who is going to be out there making sure Santos takes the right steps to ensure the shallow aquifers are protected?

However, of most concern is the change in statements made here from those made previously in the EPBC referral, without there being any further data gathering and 'ground truthing' of the numerical model. In the EPBC referral CH2M HILL stated the findings of the cumulative groundwater impact assessment indicated that depressurisation of the target coal seam, as a result of pilot activities, results in a negligible decline in water levels (less than 0.5m) within the Namoi Alluvium and the Pilliga Sandstone groundwater sources. Now they are saying there will be no decline in groundwater levels. Why? What has changed? Where is the new evidence to support this?

Groundwater Modelling

Conceptual Model

The hydrogeological conceptual and numerical groundwater model, presented in the previous Santos' Referral to the Federal Government is still essentially the same. It is still inconsistent with topographic information shown on surface geological maps. Without seeing any geological logs for the pilot bores, the surface geological map suggests the bores should have encountered Keelindi Beds before the Pilliga Sandstone. The Pilliga Sandstone recharge beds outcrop at the surface further to the east of the Program area and they dip to the northwest. The report stated the Pilliga Sandstone was considered to be confined at the Program area, but some of the pilot bores suggest that this can't be the case. They suggest the pilot bores are located directly in the Pilliga Sandstone recharge beds. The cross section indicates the Keelindi Beds outcrop all the way up to the top of the Bohena Creek Catchment. It does not show the Pilliga sandstone exposed in the upper tributaries of the Bohena Creek catchment as the geological map does. Which is correct, the Schematic Cross section or Figure 4-3 Surface Geology from previous Santos' report? This is important as it affects the Conceptual Model on which the Numerical Model is based.

Hence I do not have confidence the numerical model is correctly set up, leading to questionable model outcomes.

Model Code and Layering

1. The Keelindi Beds have not been modeled at all or not as a separate unit.
2. What is Layer 2, if Pilliga Sandstone HSU is assigned to Layer 3? The report states the Pilliga is represented by model Layers 2 and 3, but then later refers to Layer 3 only as representing the Pilliga Sandstone porous aquifer.

3. I don't agree that the Garawilla Volcanics and the Purlawaugh Beds should be modeled as the same layer. The Garawilla Volcanics is a fractured rock aquifer and the thinly bedded silts and clays of the Purlawaugh Beds probably act as an aquitard. Both have very different hydraulic characteristics and different roles to play in the numerical model.
4. The Triassic Digby, Napperby and Deriah Formations should be modeled separately. I would think they would all behave differently if the depressurized Permian target beds compacted over time. Some of these Formations may preferentially fracture along existing weakened planes and should be modeled for this scenario to see how they affect groundwater drawdown in the overlying Jurassic Garrawilla Volcanics, Purlawaugh Formation and Pilliga Sandstone beds.

I have no confidence the numerical model scenarios have been set up realistically.

There is no hydraulic data on the hydrostratigraphic units presented in this report and the report states that there is very little information to base the model and to calibrate it. There is no sensitivity analysis undertaken on the model to see which parameters affect the model.

If models are going to be used to make critically important decisions on whether a sensitive water resource receptor will be affected, then it is important to get appropriate data at the outset. Step drawdown and aquifer recharge tests, long term pump tests, and chemical analyses have not been carried out on bores located within the Pilliga Sandstone aquifer. Critical information could have been collected using observation bores located in the overlying alluvial aquifer system and the Keelindi Beds. The Keelindi Beds protect the underlying Pilliga Sandstone aquifer from the direct infiltration of lower quality groundwater from the overlying Bohena alluvial aquifer.

The same could be done for the underlying Purlawaugh Formation to see if there is any leakage up from the lower quality Garrawilla Volcanic fracture rock aquifer system through the Purlawaugh Beds and into the Pilliga Sandstone aquifer.

The pump tests would help clarify the conceptual hydrogeology of the aquifer, aquitard and aquiclude units.

In addition, it is not shown how the hydrostratigraphic, aquitard and aquiclude units have been characterized in the Numerical Model. For example, have model runs been made for leaky Keelindi aquitard and Purlawaugh Aquiclude? Is the Pilliga Sandstone modelled as a confined aquifer, or have runs also been made for a leaky confined or semi-confined aquifer? If this was done then we could see how sensitive this model is to its inputs.

Initial Conditions and Transient Simulation Protocols

Initial heads (IH) for any of the hydrostratigraphic units are not available for the Program area.

A precursor 'steady-state model' was set up using limited data from the 'shallow Namoi Alluvial aquifers' (which was from a different catchment, not the Bohena Alluvial aquifer and therefore may not really be representative of the conditions at the Bibblewindi site) and 'sparse head data for deeper layers obtained during exploratory drilling'. The groundwater regime and aquifer interactions in the Namoi alluvial aquifer will differ greatly from the Bohena Alluvial aquifer. Despite this, were the measurements from the Namoi alluvial aquifer carried out during the same time as the deep exploratory drilling? That is, were the measurements taken during the same climatic cycle?

The IH have then been used as 'seed heads' for the 'historical model'. As have historical abstractions from the pilot bores between March 2009 and February 2012. The historical model yields 'historical heads' (HH) which are supposed to represent the groundwater condition at the time of the start of the 'predictive model'.

The HH and the planned pilot site water extractions are used in the predictive model to yield 'pilot heads' (PH) representing the groundwater conditions at the end of the extraction phase of the last ten pilot sites.

There have been one Steady State and three Transient models, each relying heavily on the head conditions of the previous model, to produce the drawdown conditions in the Bohena Alluvial unconfined and Pilliga Sandstone semi-confined to confined aquifers. I dispute the validity of the initial heads and do not think in my professional opinion they represent the initial head conditions in the relevant aquifers. With each subsequent model being built the cumulative effect of these uncertain heads only increases my concern that they are not using a valid enough model to make statements that Bohena Alluvial unconfined and Pilliga Sandstone semi-confined to confined aquifers will not be significantly impacted.

The 'recovery model' (third Transient model) was developed to simulate the recovery of groundwater heads over a 1,500 year period. They note they had to use three models to maintain model stability. I would like to know what part of the model was unstable, that is, which part of the model was sensitive to inputs and boundary condition changes? I believe the model was not robust enough and not valid for this water resource assessment. Ground truthing and some real head conditions needed to be input into the model earlier on before producing the predictive model.

No aquifer cross-contamination or leakage of Produced Water to the water resource.

The Coal Seam Gas Well Integrity guidelines are being relied upon by the NSW Government to make sure Santos does not contaminate the water resource. Santos, however, is only required to adequately seal off 'producing aquifers' from each other.

I have reservations about drilling an open hole, with water-based mud, from the Bohena Alluvial aquifer, puncturing through the Keelindi Beds and down through the Pilliga Sandstone aquifer to the Purlawaugh Beds before placing steel casing, back sealing with cement and then drilling through to the lower target formations. There would be a considerable difference in water quality between the Bohena Alluvial aquifer and the Pilliga Sandstone aquifer. I am concerned that if the Keelindi Beds do serve as a protective semi-confining layer then puncturing through without sealing off the alluvial aquifer first could induce unwanted leakage between the Bohena alluvial and Pilliga Sandstone aquifers. The high water quality of the Pilliga Sandstone aquifer may be degraded due to a decrease in groundwater residence time (effectively allowing micro bacteria to enter into the bacteria-free Pilliga Sandstone aquifer).

The report stated the water table in the Bohena Alluvial aquifer is 'perched' on top of the Keelindi Beds and the potentiometric head in the Pilliga Sandstone aquifer is located between 20-30m below ground level. This suggests the Pilliga Sandstone aquifer's potentiometric surface is well below the alluvial aquifer water table and this would set up the likelihood of groundwater leakage down from the alluvial aquifer to the Pilliga Sandstone aquifer if the drilling fluid fails.

Santos may also quite rightly say that the Bohena Alluvial aquifer is not a producing aquifer and therefore does not have to be sealed off according to definitions in Well Integrity guidelines. My issue is the alluvial aquifer might not be a 'producing aquifer' but it is still a lower quality aquifer that will be connected to the Pilliga during drilling activities and therefore poses a risk of leaking lower quality water into the Pilliga Aquifer.

The NSW Government says Santos has to follow these 'robust' guidelines as they have confidence the guidelines will protect the producing aquifers. What the NSW Government don't seem to realise is they are not protecting the Pilliga Sandstone Aquifer because of the definition 'producing aquifer'.

The Groundwater Monitoring Program

Santos has stated they are commencing a bore monitoring drilling program so that an on-going monitoring program can be implemented to provide baseline water level and quality data to validate results of modeling and to provide early warning of any potential impact to water resources within and surrounding the Program area. I am not sure the shallow aquifer monitoring bores (SAMB) are being drilled at the right locations to provide representative hydraulic data over the program area. CH2M HILL has not disclosed any information regarding the total depth of the bores and the screen intervals. They have used assumed hydraulic conditions at the proposed monitoring locations, given these bores have not been drilled yet so no layer parameters could have been collected and input into the model to represent the area. This information is assumed given there has been no hydrogeological investigations undertaken at these monitoring bore sites. Therefore they cannot say the determination of 'generalised' impacts is sufficient enough to make statements such as 'no drawdown' in the shallow aquifers (Pilliga and Alluvial aquifers).

In my opinion the Santos' Dewhurst Gas Exploration Pilot Expansion EIS should include SAMB and DAMB monitoring data and the numerical model ground-truthed **before** the start of the Program in the upper Gunnedah Basin and Surat Basin aquifer, aquitard and aquiclude units. Pump tests could be carried out during drilling to determine critical hydraulic parameters for the shallow aquifers, aquitards and aquicludes. The data could then be fed back into the groundwater model and re-run. A sensitivity analysis would also be undertaken.

I do not think there is sufficient real data input into the numerical model. I do not think the conclusion stating there will be no impact to the Bohena Creek Alluvium and Pilliga Sandstone groundwater sources is appropriate at this stage. Bore monitoring should be carried out and the numerical model run again before approval.

Summary

1. The Conceptual Hydrogeological Model, on which the Numerical Groundwater Model is based, does not appear to have changed. It would therefore be incorrect based on Santos' own data and other published geological maps. The conceptualisation of the hydrostratigraphic beds and how they interact with each other, including the aquitards and aquicludes.

2. The model layers used to build the Groundwater Numerical Model are not representative of the shallow hydrostratigraphy (including the Bohena Alluvium, Keelindi Beds and the Pilliga Sandstone). There appears to be ambiguity regarding what model Layer 2 represents – Pilliga or another layer? The Keelindi Beds, which have an important role to play in the shallow groundwater system, don't appear to have been assigned to a model layer. The Groundwater Numerical Model is based on insufficient hydraulic data; appears to not have a sensitivity analysis carried out and is not calibrated for transient conditions.

3. The absence of any ground truthing of the numerical models' hydraulic parameters, and the process by with the numerical model was developed to ensure model stability, does not give me any confidence in the model outputs.

4. The Coal Seam Gas Well Integrity guidelines are being relied upon by the NSW Government to make sure Santos does not contaminate the water resource. Santos, however, is only required to adequately seal off 'producing aquifers' from each other. The Bohena Alluvial aquifer might not be a 'producing aquifer' but it is still a lower quality aquifer that will be connected directly to the Pilliga during drilling activities. Therefore there is a risk of lower quality water contaminating the Pilliga Sandstone porous aquifer. The CSG Well Integrity guidelines will not protect the Pilliga Sandstone aquifer water resource.

5. The bore monitoring drilling program should be carried out with baseline hydraulic data obtained, as planned by Santos. However, a hydrogeological investigation should be undertaken for the shallow aquifer system before applying for a Pilot Expansion, with the EIS including pump testing and water quality analysis of the Bohena alluvium, Keelindi Beds, Pilliga Sandstone, and Purlawaugh Beds. The data should then be fed back into the numerical groundwater model to ground truth it, a sensitivity analysis carried out and the numerical model being re-run to determine possible drawdown effects.

Yours faithfully

Andrea Broughton

Independent Hydrogeologist

Groundwater Solutions International

This submission has been prepared solely for the purpose of commenting on the Groundwater section of Bibblewindi Multi-lateral Pilot Environmental Impact Statement (EIS), Santos NSW (Eastern) Pty Ltd, Energy NSW Coal Seam Gas Exploration and Appraisal Program Gunnedah Basin and the supporting document 'Appendix 3: Groundwater Impact Technical Report' (CH2M Hill Australia Pty Ltd, 9 July 2013). Neither this report nor its contents may be referred to or quoted in any statement, study, report, application, prospectus, loan, other agreement or document, without the express approval of Andrea Broughton, Groundwater Solutions International.

Disclaimer

The information contained in this desktop review is based on the contents of *Appendix 3: Groundwater Impact Technical Report' (CH2M Hill Australia Pty Ltd, 9 July 2013)* which forms part of *Bibblewindi Multi-lateral Pilot Environmental Impact Statement (EIS), Santos NSW (Eastern) Pty Ltd, Energy NSW Coal Seam Gas Exploration and Appraisal Program Gunnedah Basin*, and my own professional experience. I accept no responsibility for the results of actions taken as a result of information contained herein and any damage or loss, howsoever caused, suffered by any individual or corporation.

The findings and opinions in this report are based on a desk top review undertaken by myself, Andrea Broughton, independent consultant (Contract Hydrogeologist, BSc (Hons), MAppSci Hydrogeology and Groundwater Management) of Groundwater Solutions International.