Development of a Groundwater and Water Supply Management Model for a Coal Bed Methane Project

Przemek Nalecki

Golder Associates Pty Ltd, 611 Coronation Drive, 4066 QLD, Brisbane, Australia,
e-mail: pnalecki@golder.com.au tel: +61 7 3721 5447

Abstract
This paper presents an outline of an operational management model, developed to optimise the cost of coal bed methane (CBM) on-site water management and to assist with future planning of CBM borefield developments. The structure of the model makes it possible to help to optimise the configuration and capacity of a water treatment plant (reverse osmosis), taking into consideration treatment and disposal alternatives and their relative costs. The model can also be applied as a decision support tool, integrating the economic costs of various user-defined water management options and uncertainties in processes, parameters and future events.

Key words: water management, modelling, coal bed methane, CBM

Introduction

The development of coal bed methane (CBM) projects is usually accompanied by the production of large quantities of groundwater. This groundwater is a CBM industry by-product and conventionally is treated as a waste and disposed via evaporation basins. Australia is one of the driest countries on earth and, due to the scarcity of water resources in some areas, the perceived economic and social value of water is continuously increasing. Depending on the quality and quantity of water recovered during CBM operations, there are some substantial environmental and economic benefits from treatment and re-use of the groundwater that would otherwise be discharged to waste.

Coal Seam Gas – What is it?

Coal bed methane (CBM), which is also known as coal seam gas (CSG), occurs naturally within coal deposits. CBM is generated either from a biological process as a result of microbial action or from a thermal process as a result of increasing heat with depth of the coal. CBM is largely composed of the gas methane which is also the principal component of natural gas. Although CSG generally has a very low carbon dioxide content, compared to many natural gas deposits, this is not always the case.
Since CBM travels with groundwater in coal seams, extraction of CBM involves pumping available water from the seam in order to reduce the water pressure that holds gas in the seam. CBM has very low solubility in water and readily separates as pressure decreases, allowing it to be piped out of the well separately from the water. Water moving from the coal seam to the well bore encourages gas migration toward the well (Keith et al. 2003).

The example

As an example the problem is described in which one of the major Australian mining companies is considering a development of new CBM borefield as an addition to the existing borefield. They require a management tool which can be used to manage and forecast water production over time and investigate various options of water disposal. Existing drought, consistently increasing water prices and proximity of the proposed borefield to the extensive farming and irrigation areas made it attractive to look at options involving the treatment and trading of water, instead of disposal via evaporation basins. A flexible model was required to simulate borefield development over time. It was necessary that the model could be easily operated by decision makers to investigate various options of disposal versus treatment or a combination of both, depending on forecasted volumes of water, its quality and the current economical outlook.

Software

GoldSim, a dynamic system modelling package, was used for the water balance modelling. It is a graphical object-oriented modelling environment with an in-built capacity to carry out dynamic probabilistic simulations, which have been used extensively in mine water balance studies in North

and South America, Europe, Africa and Australia. GoldSim is sufficiently flexible to allow efficient revisions in response to the collection and addition of new field data or to any changes in the process water circuits which may occur as a result of future expansion.
GoldSim was initially developed and used internally by Golder Associates in the early 1990s, evolving later into commercial software.

Model implementation

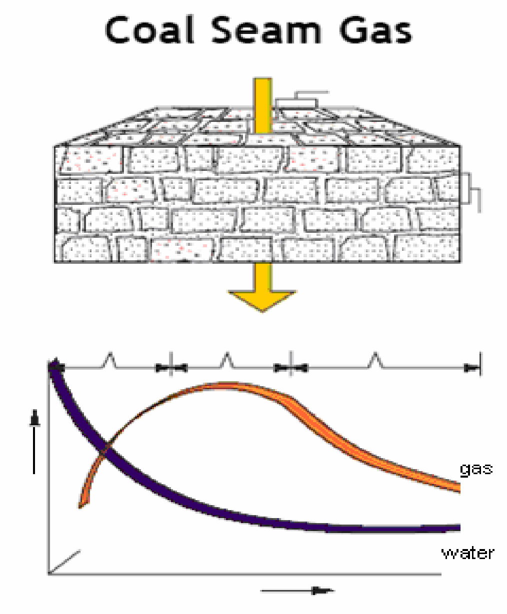
Implementation of the model involved creating a model structure representing the existing logic of water flow within the system, including potential operational alternatives. That involved, among other apects, creating an "open-ended" provision of a borefield in which new additional gas and water production wells could be added at user-specified times. Water production parameters, although well defined, can vary over time and space resulting in various volumes of water produced by gas exploitation wells. Figure 1a shows a typical relationship between gas and water production from a typical well and Figure 1b shows an example of model implemented well production rates. The production curve was modelled as a decay curve with user-defined slope and variability of initial and final production rates, including "production life" of the well. To accommodate uncertainty of the well production variability, uncertain parameters of the well production curve were defined as stochastic parameters with a user-defined distribution. Then, applying Monte Carlo analysis, the parameters were randomly sampled according to their distribution, resulting with a range of possible combinations, which improved reliability of the forecast analysis. Considering the extensive number of wells proposed for the new borefield (in excess of 50 wells – each of the well represented using stochastic distribution of its production parameters) such an approach improved the model forecast capacity, with a provision for the forecast improvement as more data on water production rates and water quality become available during the life of the borefield.
The existing method of saline groundwater disposal involves deposition of pumped water in a number of connected evaporation basins. As expected water production rates are to increase as new wells come on-line, there was a need to accommodate the water surplus. Two options were analysed:

- Option 1 – development of a new evaporation basin the size of which would have to be based on forecasted water production volumes, and
- Option 2 – installation and use of a reverse-osmosis water treatment plant (with its associated infrastructure) which would overtake or work together with the new evaporation basin, and would provide treated water for sale to the irrigation network scheme located nearby.

The analysis of the preferred option involved building of a model which represented both sets of infrastructure options (pond and treatment plant) with a provision for capital (CAPEX) and operational cost (OPEX) estimations during the model simulation.
Implementing a cost tracking routine into the water management model provided an efficient tool that clearly indicated the "real-life" constraints and preferences for the decision makers. It also allowed for optimisation of the process and choice of the optimal option based on the model-simulated financial output. The model helped with estimating the required distribution of expenditure over time, which for many mining operations is a critical issue during the initial period of operation.
An important part of the simulation of the treatment plant operation involved reliability modelling – which represented plant failures, emergency repairs and scheduled maintenance breaks to estimate required size of temporary water storages for pre- and post- treatment which would maintain smooth operation and water delivery (contractual obligations). This part of the process can also have an important impact on the operation and production costs which have to be allocated and built into the plant operational budgets.
Upon completion, the whole model was then subsequently wrapped up into a user-friendly "dashboard" which can be operated from a Windows-like front-end with a capability to input model parameters, run and inspect the model and produce resulting graphs and tables, but specifically not allowing the model itself to be changed. An example of one of model dashboards used for this problem is presented in Figure 3.

Figure 1 *Typical water production curve and an example of its implementation in the model*

1a*



1b

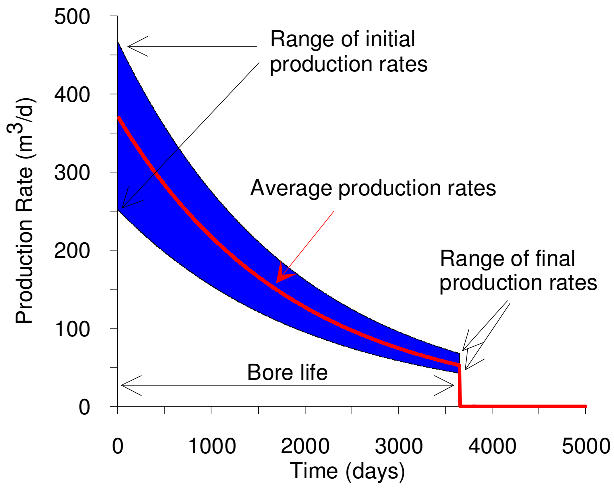
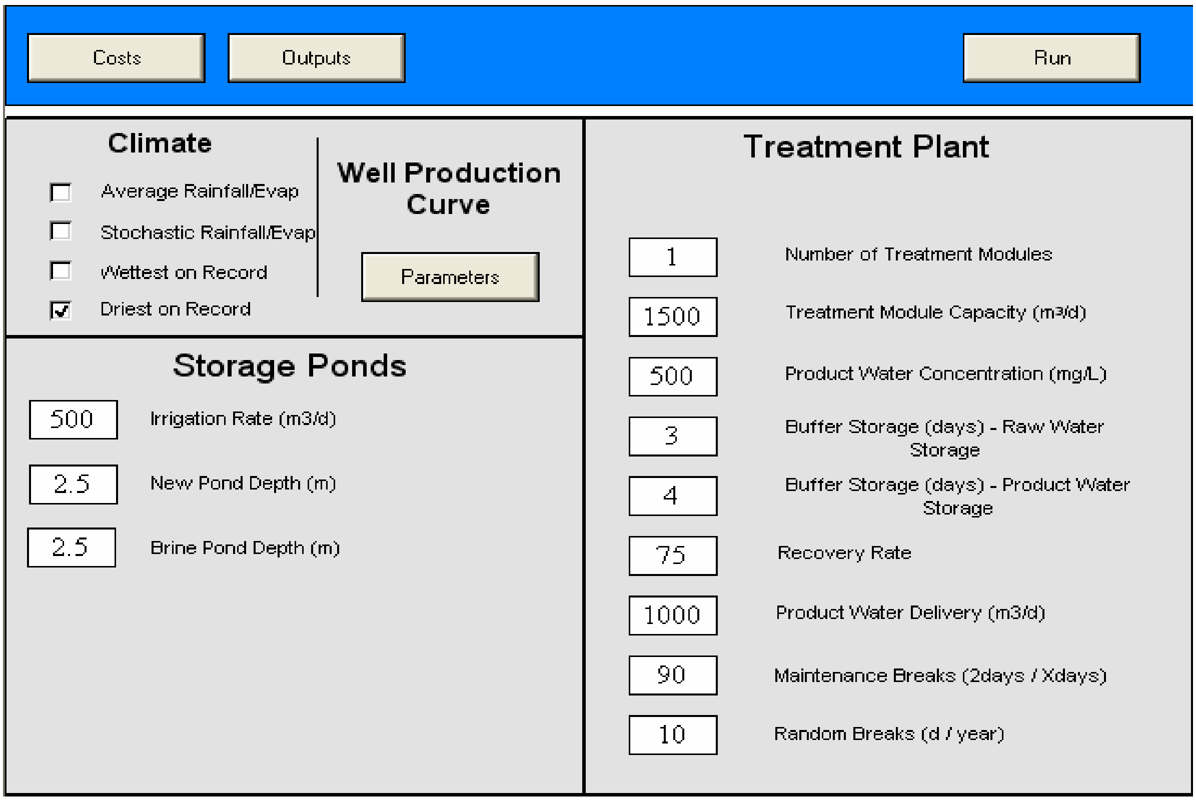


**Figure 1a from Origin Energy (2002) Coal Seam Gas Overview*

Figure 2 *Example of model dashboard*



As can be seen from Figure 2, the user is exposed to a simple and fairly self-explanatory version of the front-end of the model, which makes it easy to drive it or make any required changes to the available model parameters.

Summary

The parts of the developed CSG water management model that are presented above show the real-life application of a flexible, stochastic approach to the optimisation and operation of a water management system that can be planned and analysed in an easy to drive package. The model can be easily operated and used by different levels of the management and decision makers. Due to its flexibility the model can be easily updated as new data become available and this allows for the comparison of different alternatives or composite solutions to the existing problems.

The use of this model resulted in more efficient management and conservation of water, which otherwise would be treated as waste. It is believed that the approach presented here created an effective tool to provide a way in which alternative designs, plans and policies can not only be evaluated and compared but also defended and explained to various stakeholders in easy and highly graphical way.

References

GoldSim Technology Group (2007) GoldSim User's Guide

Keith K., Bauder J., Wheaton J. (2003) Coal Bed Methane (CBM) Frequently Asked Questions. Internet publication

Origin Energy (2002) Coal Seam Gas Overview