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# WATER INFLOW ISSUES ABOVE LONGWALL PANELS

Winton Gale<sup>1</sup>

**ABSTRACT:** The aim of this paper is to discuss the issues which relate to surface water inflow through the fractured overburden above longwall panels. The information used is a combination of field experience and computer modeling. Computer models used in this study simulate the fracture process in the geological units throughout the overburden. Analysis of the mining induced fracture patterns and *in situ* joint patterns allows an estimation of the hydraulic conductivity within the overburden. The cubic flow relationship has been used in examples presented.

## INTRODUCTION

The occurrence of water inflow into longwall panels has been recognised and studied over a long period of time. Records of the inflow events and water make into mines allows a review and comparison methods of prediction.

Much of the published recorded information of water inflow has come from judicial inquiries and previous ACARP studies. Particularly useful information has been obtained from studies conducted in the Bowen Basin (Klenowski, 2000). Recent developments in computer modelling have allowed simulation of rock fracture, caving and stress redistribution about longwall panels with increasing confidence (Gale, Mark and Chen, 2004; Gale, 2004 and Gale, 1998). The models are being assessed against field monitoring and have significantly increased the understanding of caving related fractures and resultant hydraulic conductivity within the overburden.

The aim of this paper is to present an overview of the factors which relate to water inflow and those which may mitigate the impact of the fracture zones, which are created by longwall extraction. Published data and insights obtained from computer models are discussed.

## FIELD EXPERIENCE OF WATER INFLOW

Experience of water inflow into mines has been reviewed in terms of the relationship between panel geometries and associated water inflow. The data collated is associated with ACARP Project (C13011).

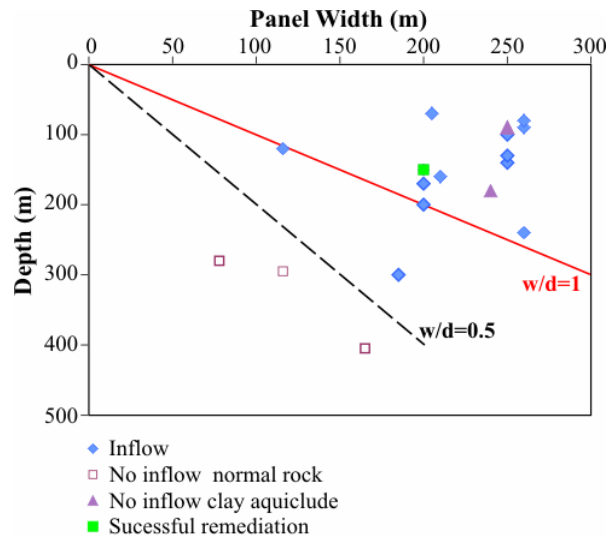
The data is categorised in terms of confirmed inflow and no flow. The sites having flow may be based on actual inflow experience or piezometer monitoring data of the site which indicates the height at which inflow would occur. Sub-sets of the data have been collated for sites at which remedial repair has been conducted to provide a water resistant seal against future inflow. The term connection implies that surface water can enter the mine. It does not imply an inundation or direct connection via a single fracture.

The results of the study are summarised in Figure 1, for which the data is presented relative to depth and panel width. The results show that for situations of normal rock head, without significant aquacludes, panels with a width to depth ratio greater than one typically show confirmed connection. One site shows connection with a width to depth ratio of approximately 0.75. Panels with a width to depth ratio of less than 0.4 show no connection. The sites categorised as having aquacludes are those which have significant clay layers (i.e. 4 m+) between the aquifer and the normal rock section or have low permeability aqueous deposited silt layers above the normal rock section.

Examples of sites for which the existence of significant clay layers have controlled the inflow of water for geometries having width to depth ratios greater than one include Crinum Mine and is inferred for Gordonstone (Kestrel) Mine. These sites have significant sections of clay rich layers which are sufficiently compliant and have low permeability to maintain an effective seal between the water source and the fracture zone. These are relatively unique in the overall database.

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**Fig 1: Water inflow experience with longwall panels.**

Similarly, sites at Oaky Creek for which inflow was noted were subsequently repaired by ripping and compacting the surface to perform as a low permeability membrane (generally  $1e-8$  m/s or less) above the fractured rock section.

The sites at Crinum, Gordonstone and Oaky Creek (repaired surface) are consistent with the concept of having a low permeability section which is able to control the flow between the water source and the mining induced fracture zone.

There are instances of ash dams for which limited flow occurs or which remain intact above extraction panels. The permeability of sub aqueous deposits within ash dams are typically low ( $1e-9$  m/s or less) whereas the permeability of the overburden below the dam may be several orders of magnitude higher. Mannering Creek ash dam is one instance which was undermined by Wyee State Mine (Longwall 4) without major issue. It is not conclusive (to the author) as to whether it was breached and subsequently healed. This instance is viewed as an extension of the aquaclude scenario for which the compliance of the low permeability silt/clay lining is sufficient to survive the strains imposed by mining, or can subsequently “heal” the initial cracking. Mining under Lake Macquarie (Wyee longwall panels) has occurred without significant impact, however these occurrences are considered to fall within the aquaclude category rather than be part of the “normal rock section” data set. It is considered that the base of the lake is composed fine unconsolidated silts which have very low permeability characteristics.

Mining has occurred under the Pacific Ocean at Burwood Mine, however the mine geometry had a width to depth ratio less than 0.3.

Overall, it appears that for a “normal rock section” (without aquaccludes), longwall panels with a width to depth ratio above one have a high probability of connection and inflow. Panels with a width to depth ratio less than approximately 0.4 have not exhibited any connection. Panels of width to depth of approximately 0.75 have exhibited connection. Unfortunately the data set is not sufficient to define the transition point in more detail.

### COMPUTER MODELLING INSIGHTS

Computer modelling of overburden caving and its comparison to typical subsidence characteristics has been undertaken as part of the project. The results of this, in relation to the height of cracking and induced vertical conductivity, have been compared to the results presented above. This has involved taking a number of Hunter Valley geological sections and modelling the effect of different size longwall panels. In this way the height of cracking and the subsidence created can be compared to the regional subsidence experience and the potential for

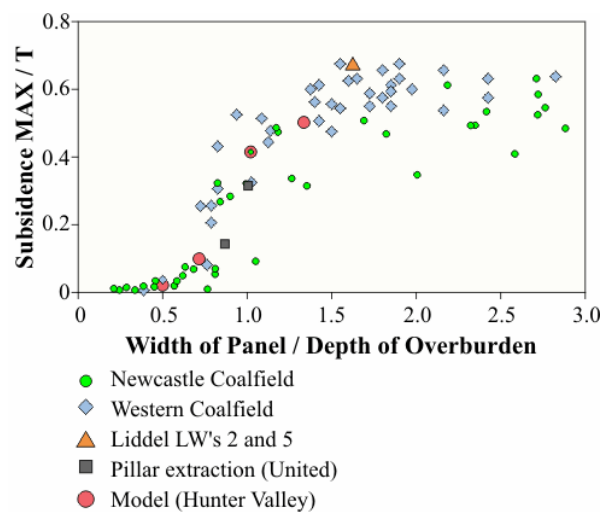
inflow at different width of panel to depth of mining can be compared to the results presented in Figure 1. The depth of mining in the modelled data set ranged from 150 to 300 m.

The stress field is based on regional estimates and the overburden conductivity is based on regional data (Gale, 2004).

The model used is based on FLAC 4 code, and has coupled mechanical and fluid interaction, such that the water pressure and flow is modelled together with mechanical ground movements.

The subsidence obtained from the models is presented in Figure 2 together with the regional subsidence information of the published Newcastle and Western Coalfield. This data is presented in terms of percent maximum subsidence relative to width/depth of the panel. The modelled results are consistent with the regional data and confirm the models' ability to:

- i. simulate the overburden deformation characteristics in a suitable manner; and
- ii. simulate the goaf loading and compaction characteristics.



**Fig 2: Regional subsidence data for Hunter and Western Coalfields.** NOTE: Local data and modelled data included.

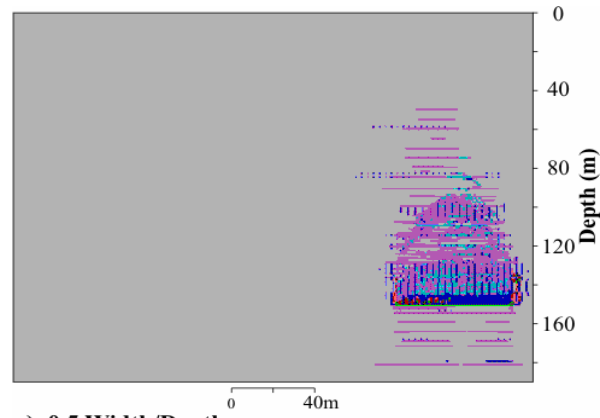
#### OVERBURDEN CRACKING RELATIVE TO PANEL WIDTH

The mode and extent of cracking within the overburden for panels of 0.5, 0.75 and 1 x depth are presented in Figure 3. This plot shows the overburden section together with the fracture distribution relating to each panel width. The results show that cracking connects to the surface for panels of 1.0 x depth. The 0.5 depth panel shows no connection and the 0.75 depth panel shows no connection but does display additional cracking between the main cracking zone and the surface. The 0.75 depth panel is considered to represent a transitional case.

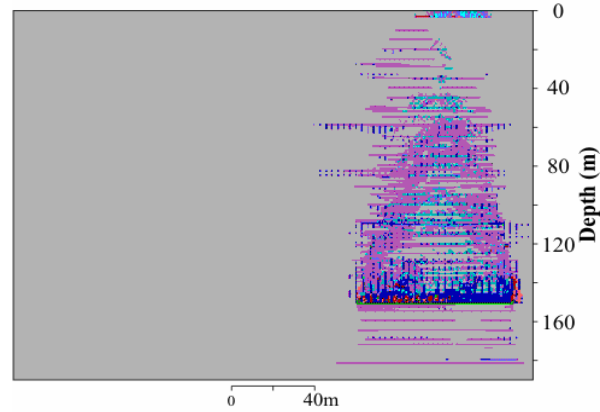
The height of cracking relative to panel width is presented in Figure 4 and indicates that the height of cracking is the range of 1-1.2 times the panel width. Experience at other sites indicates that this range may extend depending on the geological characteristics.

#### INTERPRETATION IN RELATION TO INFLOW

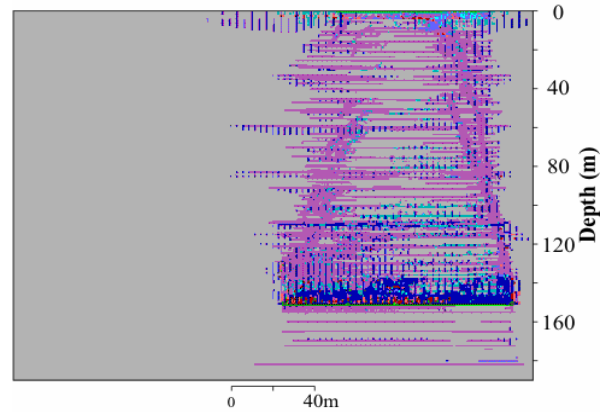
The fracture networks created in the overburden will create a conductive network within the "Permian" rock (fractured rock above the extraction panel). However, it is important to assess the effect of recent sediments or soils on the surface when assessing the overall impact of the fracture networks created in terms of the inflow characteristics from surface or near surface sources.



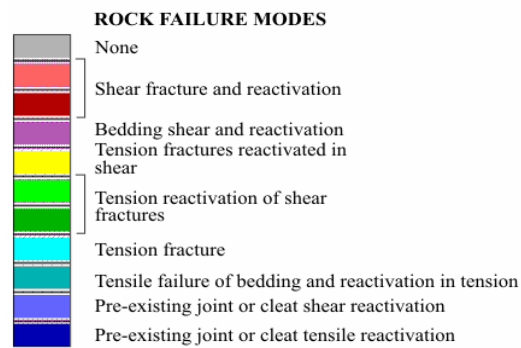
a) 0.5 Width/Depth



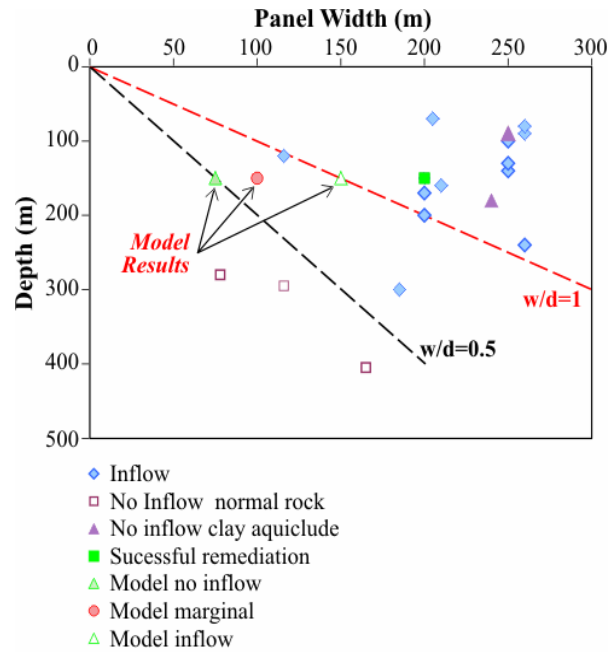
b) 0.75 Width/Depth



c) 1.0 Width/Depth



**Fig 3: Height and mode of rock fracture for various panel widths.**



**Fig 4: Water inflow experience with longwall panels.** NOTE: Modelled data included.

If soft low conductivity clay like materials exist then they may act as aquacludes or else significantly restrict the inflow rate from water sources. Experience to date indicates that the material properties of aquiclude would need to be similar or softer than wet clay. Example of this could relate to situations where subsidence fractures have been remediated by the placement of clay or silty clay layers. Aqueous silt layers may also provide a similar function under ash dams and lakes. The existence of unfractured clay beneath water bearing basalt units at Crinum would also fall into this category. Alternatively, a 10 mm crack through the surface cover can allow significant inflow. Therefore, in order to assess the inflow rates, characterisation of the surface materials and their conductivity is required. The impact of mining induced strain and resultant change in conductivity of those materials is required to assess the way in which water is transmitted into the "Permian" fracture system.

The impact on the integrity of surface aquifers with also require an assessment of the flow and recharge capability of the aquifer in relation to the flow capacity of the "Permian" fracture system above the extraction panel.

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