Surface Impacts of Dewatering Old Colliery Workings

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ABSTRACT

Underground mining in the West Moreton coal field started in the 1870's. Subsidence related to coal mining activities is an ongoing problem facing planners and developers in the Ipswich area in South Eastern Queensland. The history of coal mining in the area over the last 110 years has left the legacy of periodic surface instability in several areas.

In general, modern engineering analysis with current mining methods combine to create predicatable analysis of surface stability and movement. Where old workings using several variations of the bord and pillar system are affected by current activity, the predictibility of the surface movement is greatly reduced. Geological complexities further complicate the analysis.

Mining and the related dewatering affects the stresses on pillars in old workings. This is caused by reducing buoyancy effects caused by changes in the water levels in old workings.

Of particular relevance is the depth of workings and strength of the coal and overburden. The type of subsidence affecting the surface can range from localised pillar failure, to roof failure and potholing and the likelihood of the particular form of subsidence can be assessed from studying the workings in relation to the stratigraphy and structure of the coal measure formations.

INTRODUCTION

Two cases are considered. Firstly, in the North Ipswich area, a widespread creep has occurred and the conditions for future mining prohibit dewatering of old workings. In the second area, Dinmore, an assessment of pillar stress changes due to dewatering from on adjacent open cut was undertaken. Because of uncertainty in relation to pillar dimensions and the competence of interseam strata, monitoring is being undertaken. The location of the sites is shown in Figure 1.

On one side of the area, a large open-cut mine is operating to a depth of 100 meters. As this mining operation progresses towards a highway, industrial sites and a residential estate, the old workings were dewatered by 44m.

GEOLOGY

The stratigraphic section in the Ipswich coal field is shown in Table 1. The Brassall Sub-group divided by Mengel and Carr, (1976) into two parts - the Blackstone and Tivoli Formation.

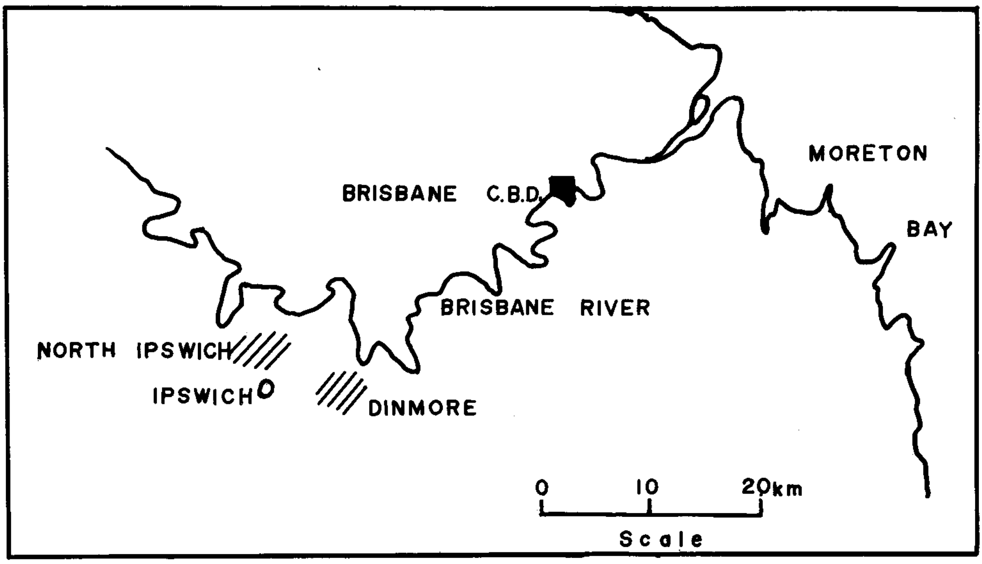

FIGURE I LOCATION PLAN

TABLE 1

Age	Group	Sub-group	Formation	Thickness
TERTIARY			RACEVIEW FORMATION	
JURASSIC			MARBURG FORMATION	
JURASSIC / LATE TRAISSIC	BUNDAMBA GROUP	WOOGAROO SUB-GROUP	RIPLEY ROAD SANDSTONE	365m
			RACEVIEW FORMATION	120m
			ABERDARE CONGLOMERATE	30m
	unconformity			
LATE TRAISSIC	IPSWICH COAL MEASURES	BRASSALL SUB-GROUP	BLACKSTONE FORMATION	240m
			TIVOLI FORMATION	480m
		KHOLO SUB-GROUP	CRIBB CONGLOMERATE	
			HECTOR TUFF	
			COLLEGES CONGLOMERATE	
			MOUNT CROSBY FORMATION	360m
			WEIR BASALT	
			BLACKWALL BRECCIA	
	unconformity			
?CARBONIFEROUS	NERANLEIGH - FERNVALE BEDS			

IPSWICH COAL-FIELD - STRATIGRAPHIC SUCCESSION
(after Mengel and Carr)

The coal measures are made up of some 1080m of freshwater shales, sandstones, and coal seams with tuff, conglomerate, and breccia in the basal units (Mengel and Carr, 1976).

The Tivoli Formation is some 480m thick and is made up of sandstones, siltstones, shales and mudstones, with a number of coal seams. The sandstones are lenticular and are massive, lithic, coarse-grained and commonly pebbly. Because of this lenticularity, the thickness of strata between coal seams varies greatly.

The upper 320m are made up of alternating beds of shales or mudstones and sandstones. These beds contain all the productive coal seams of the North Ipswich district. The main seams, in descending order, are the Garden, Tantivy, Fiery, Waterstown, coal above the Tivoli, Tivoli, Eclipse, and Benley seams. Of these, the Eclipse seam has been the most persistent and economically important. This formation outcrops in the North Ipswich Area. The typical seam thicknesses and inter-seam sediment thicknesses are shown in Figure 2.

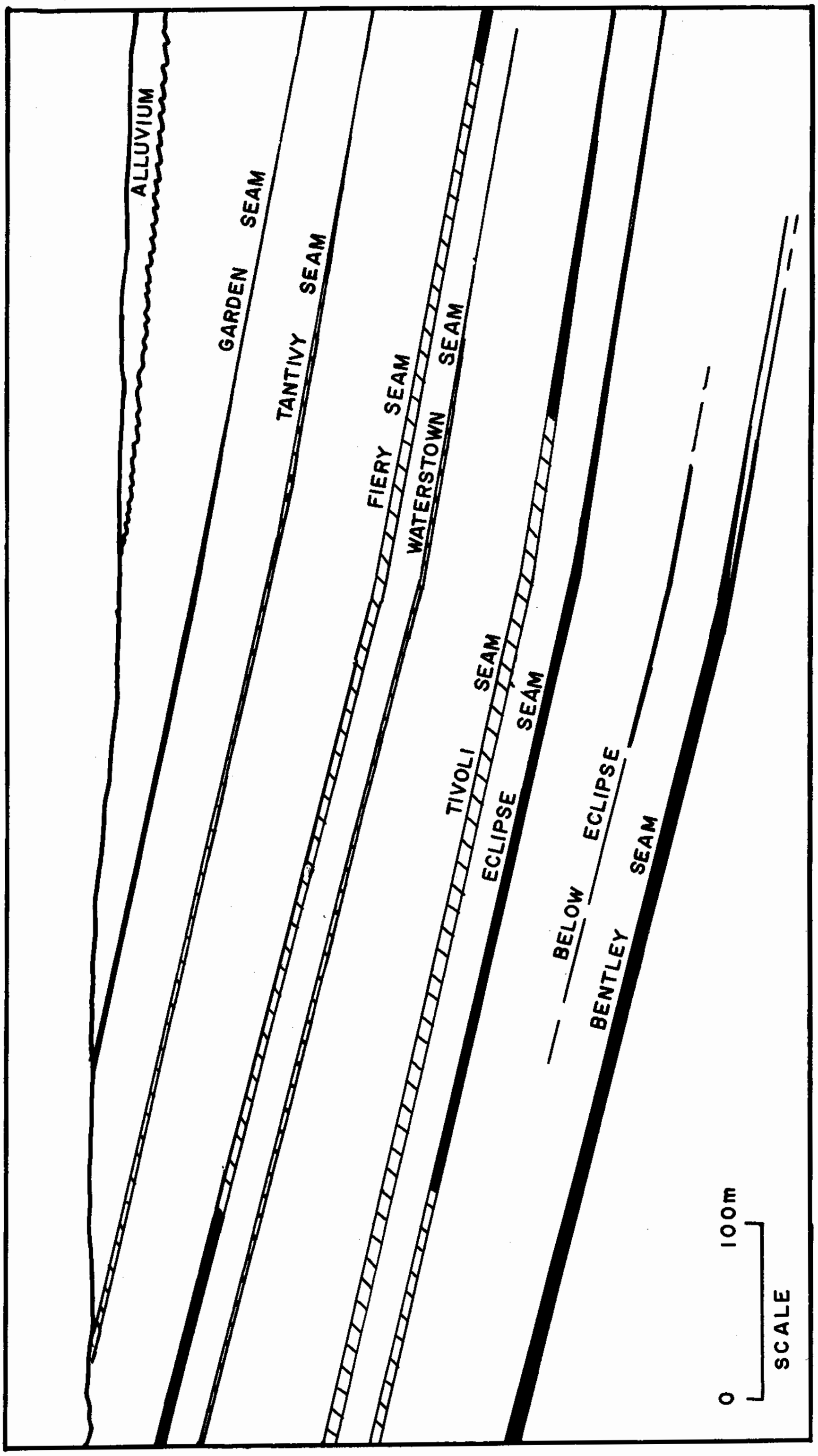

FIGURE 2 GEOLOGICAL CROSS SECTION NORTH IPSWICH

The uppermost formation, the Blackstone Formation, lies conformably on the Tivoli Formation and crops out on the limbs of the Bundamba Anticline.

In the Dinmore area, the surface outcrops to the north-west consist of clays of the Tertiary Raceview formation. These unconformable overlie the Blackstone Stage of the Ipswich Coal measures. In descending order the following coal seams are found - Bluff, Top Coal, Four Foot, Bergin, Striped Bacon and Rob Roy Seam The typical seam thicknesses and inter-seam sediment thicknesses are shown in Figure 3.

There is considerable structural disturbance in the form of faulting in this area. The seams generally dip to the south at approximately 8^{o} - 14^{o}. In the south lies the New Chum fault with a throw of up to 30m. It is a low angle reverse fault. Some 4 or 5 medium to small faults lie to the north of this fault. In the northern part of the area all seams have been eroded away, and Tertiary claystones have been deposited.

Figure 4 shows the outline underground workings with structural contours (Surface R.L. - 2000m) of the top of the Bergins seam.

An underpass lies within 50m of the surface expression of the New Chum Fault.

HISTORY OF MINING

Mining Methods

Most of the mining in the study areas was done by bord and pillar methods. From the start of mining in the late 1860's to the end of the 19th century, welsh bords were operated in workings down to 100 meters. The main access addits were driven down the dip of the seam and other developments followed close to the strike to facilitate hand pushing of wagons. Pillars were rarely surveyed in and the plans of these old workings were rarely made.

In the first half of the 20th century, bord and pillar workings developed using explosives with either hand or mechanical loading.

After the second world war, the introduction of mechanical loaders, shuttle cars and conveyors progressed rapidly. Coal was broken by cutting, drilling and blasting. In the late 1950's, continuous miners were introduced and a more methodical approach to pillar design was adopted.

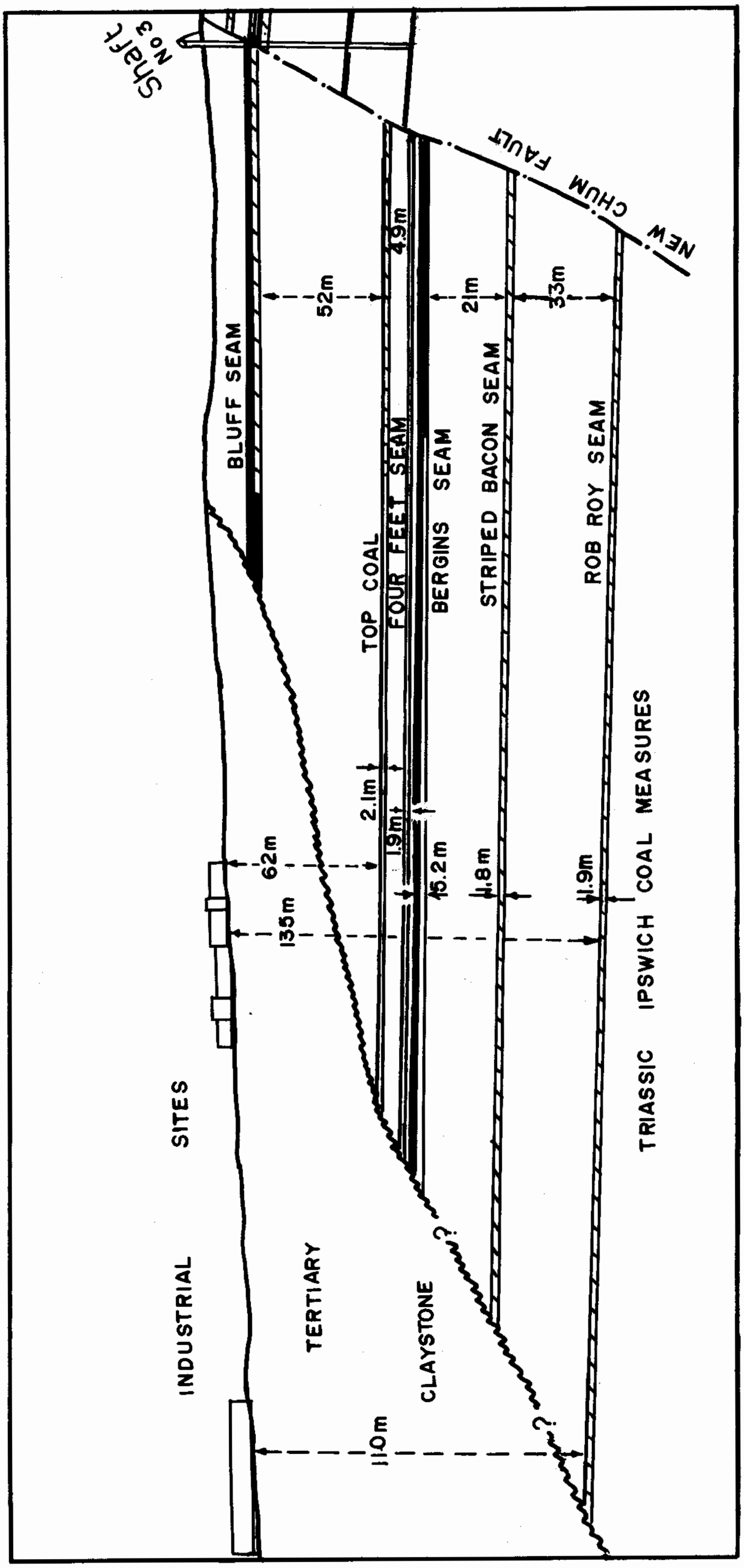

FIGURE 3 GEOLOGICAL CROSS SECTION DINMORE

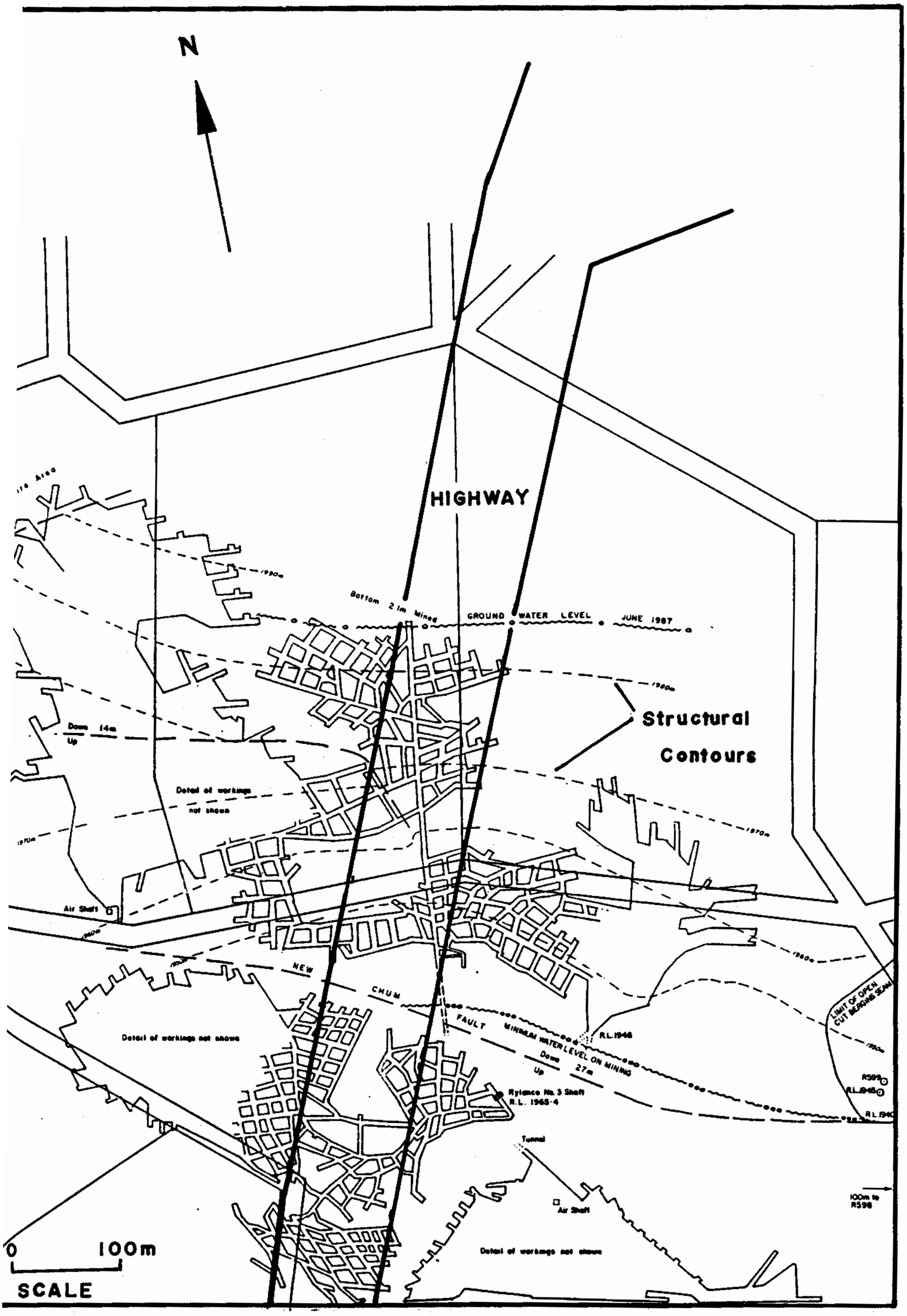

FIGURE 4 BERGINS SEAM WORKINGS

While pillar extraction was not generally undertaken, pillars were regularly split such that there long term stability was marginal in some areas.

North Ipswich

The first recorded mine workings were in the 1850's, soon after the settlement of the Brisbane - Ipswich area. Mines were established in the Ipswich area in the mid 1860's in the Tivoli and Garden Seams.

Progressively all the other seams were developed by several operators in the same area.

Dinmore

Extensive workings were developed in the Top Coal seam, Four foot seam, Bergins seam, Striped Bacon seam and the Rob Roy seam. Only limited workings exist in the overlying Bluff seam.

Workings in the Top Coal Seam were 2m high and at a depth of approximately 62m. The Four Foot seam lies 4.6m below the Top Coal and is worked in a 1.4m section. This was the first seam worked from 1890 to 1910 and the welsh bord method was used. The 5.2m Bergins seam lies 0.46 m below the Four Foot seam. the bottom 2m was generally worked between 1925 and 1938. The pattern of workings suggest that the close proximity of these three seams and lack of a regular mining layout caused undesirable stress interactions.

The Striped Bacon seam is 1.8m thick and lies 21m below the Bergins seam at a depth of approximately 100m. This seam was worked between 1945 and 1959. The deepest seam worked was the Rob Roy seam. This seam is 1.9m thick and lies 33.5m below the Striped Bacon seam at a depth of 135m to 150m. Mining in this seam was undertaken from 1955 to 1963 under the site.

Reports of the Queensland Geological Survey indicate that there are no mining reserves below the Rob Roy seam although several thin seams are evident.

At present, an open cut coal mine operates a 100m deep open cut mine some 500m east of the highway. The company is planning to mine coal reserves to 100m depth, some 200m east of the highway. The operation has partially drained the extensive old workings. While the old workings range from 25 to 100 years in age, and some may have caved if they are unstable, the dewatering will change the stresses on pillars. There is a small possibility that this may activate pillar or septum failures in these old workings and cause further subsidence.

Opencut Mining

Opencut mining is being undertaken on a 260ha site on the eastern side of the study area. The area was partially mined by the underground bord and pillar method up to the early 1960's. Since then opencut mining has replaced underground methods.

The open cut operations in the north-west portion of the Colliery will extract the Top Coal, Four Feet seam and Bergins seam to a depth of 100 meters up against the New Chum fault. The mining in this sector is planned to be completed by late 1990.

In excavating this pit, the water level has been reduced from RL 1984 (mine datum) to RL 1940m. This lowering of the water level will undoubtedly lower the water level in the adjacent interconnected workings which extend under the industrial site, highway and a residential estate.

After mining is complete the pit will be backfilled and the water levels will rise. The company is currently planning the rehabilitation of the site to optimize land use of their site after mining.

MONITORING PROGRAMME

A first stage monitoring programme has been conducted by the Main Roads Department along the highway.

As a result of the preliminary assessment and some visible settlement over a 5 meter strip of pavement survey pins were installed at the locations requested and fortnightly level surveys were undertaken by the Main Roads Department from April 1987.

The surveys on the area from Chainage 31300 to 31520 are not over mine workings, but considerable settlement (40mm) has occurred in a narrow band. This zone lies over a former carriageway. The movement in pavement is interpreted as differential compaction due to variations in laying the fill and road base over this area.

The road at one point is in a cutting with no very shallow underlying mine openings. Pins at this point show excellent stability which indicates that pillars in the lower dewatered workings are stable.

The road between Chainage 32160 and 32195 overlies split pillars in the Bluff Seam. There is significant and continuous subsidence at 5m/month in this area. It is unlikely that these workings were previously flooded.

ANALYSIS OF PILLAR STRESS AND SURFACE STABILITY

After the study by Salamon and Munroe (1967) in South Africa and that of Maconochie and Colwell on pillar stability in the West Moreton Coalfield (unpublished report for CSIRO) pillar stress and strength are estimated as follows:-

1. Pillar Stress (MPa) = $\dfrac{qd}{1-ER}$

   where: q = stress increase per meter depth
   = 0.025MPa/m
   d = depth (m)
   ER = Extraction Ratio

2. Pillar Strength (MPa) = $5.6 \dfrac{W^{0.46}}{h^{0.66}}$

   where: W = width of pillars (m) and
   h = working height (m)

The estimate of pillar stress is modified by the bouyancy effect of water in flooded mine workings. In submerged workings the stress increase per meter depth is 0.015 MPa/m as compared with 0.025MPa/m for drained workings. Thus, in calculating the stress on pillar in flooded workings, the stress components for dry and submerged depths are calculated separately.

APPLICATION

To translate these principals to a practical terms two cases are considered:- firstly that of possible dewatering of old workings in North Ipswich; and secondly, that of dewatering caused by the open cut mining operations in the eastern portion of the workings at Dinmore.

In the case of the North Ipswich area, the workings are adjacent to the Bremer River. The water level in the old workings is assumed to be at sea level -0.0 Datum. Stress increases in the Tantivy, Fiery, Waterstown and Tivoli seams are estimated and shown in Table 2.

TABLE 2

Seam	Tantivy	Fiery	Waterstown	Tivoli
Maximum Depth (m)	110	170	195	250
Working Height (m)	2.7	1.3	1.1	1.5
Pillar Width (m)	10	17	16	11
Pillar Strength (MPa)	8.4	17.3	18.8	16.9
Pillar Stress (Mpa)				
Undrained	4.4	5.0	5.9	5.6
Drained	6.6	7.7	9.2	8.9
Stress Increase (%)	50	54	56	59

ESTIMATED EFFECTS OF OLD WORKINGS IN NORTH IPSWICH WERE DRAINED

In the second case, monitoring by Aberdare Collieries has indicated that the water level is currently RL1985 in the old workings. This is approximately 15m below seam level. Seepage through seams and faults into nearby open cut operations is keeping the water level from rising to a few meters above sea-level.

As the open-cut develops through the old workings the level of the pit floor will reduce to RL 1940 where the Bergins seam is to be mined up to the New Chum Fault. This will cause dewatering of workings in the Top Coal, Four Feet Seam, Bergins and Striped Bacon seams under the industrial site and the highway. The waterlevel in the Rob Roy seam will be greatly reduced. The changes in the stress conditions under the industrial site and highway are estimated as shown in Table 3.

TABLE 3

Seam	Bluff	Top Coal	Four Feet	Bergins	Striped Bacon	Rob Roy
Maximum Depth (m)	25	62	68	73	96	135
Working Height (m)	3.0	2.1	1.9	3.0	1.8	1.9
Pillar Width (m)	12	8.0	7.0	12.0	12.0	14.0
Pillar Strength (MPa)	8.5	8.9	11.0	8.5	11.9	12.3
Pillar Stress						
Before Draining	1.4	3.5	3.8	3.2	4.4	4.7
After Draining	1.4	3.9	4.3	3.7	5.3	5.4
Stress Increase (%)	0	11	12	16	16	15

CONCLUSIONS

The bouyancy effect of water has a significant effect on pillar stress in flooded colliery workings. The stress changes due to reducing the water level can be estimated.

Subject to the assumptions in the calculation of pillar strength, changes in the factor of safety due to dewatering can be estimated.

The case studies examined indicate that dewatering old workings in the North Ipswich area would have a detrimental impact on pillar stability. The workings by the open cut mine will cause significant lowering of the water table but the previous pillar strength is hopefully sufficient to preserve pillar stability and hence is likely to have little effect on the pillar stability under the industrial site and the highway. This conclusion is subject to the assumptions that the old plans are reliable and that pillar stress inter-actions do not cause failure of the interseam strata.

REFERENCES

Mengel D.C. and Carr A.F. 1974. Ipswich Coalfield G.S.Q. Report 94.

Salamon M.D.G. and Munroe A.H. 1967. A Study of the Strength of Coal Pillars, Journal of the South African Institute of Mining and Metallurgy, September 1967.