Management of aquifer depressurization system in Hazelwood mine, Latrobe Valley, Australia.

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The Hazelwood Mine is an open cut coal mine, and to maintain the Mine stability while mining is in progress it is required to carry out depressurisation of two major aquifer systems- Morwell formation aquifer system (M1) and Traralgon formation aquifer system(M2). A monitoring of ground water pressures within the Mine and its periphery is carried out to control ground water extraction against stability of the Mine floor and the Mine batters. In the assessment and management of the environmental impacts due to groundwater extraction from these two major aquifer systems regional groundwater monitoring, ground modelling and reporting has been undertaken. In addition land level monitoring is carried out every 5 years to estimate land subsidence due to groundwater extraction. The data is used to calibrate subsidence models for the prediction of land subsidence due to future mining operation. The paper gives insight of aquifer depressurising method used, and the monitoring system adopted to stabilise the mine for coal winning process.

Keywords: aquifer; depressurization system; stability; operation; maintenance

1. Introduction

International Power owns one of the largest brown Coal open pit Mines in Australia, situated in Latrobe Valley, Victoria, Australia (Figure 1). Annually the Mine produces approximately 19 Million Tonnes of Brown Coal for its 1600MW coal fired Power Station. Approximately 4 Million Cubic Metres of overburden is removed per year which includes dredger and Truck and Shovel operation in Coal winning process. Thickness of overburden in the present field (West Field) varies between 10 to 14 metres above the Coal seam. Overburden dumping is carried out in the old part of the Mine using a stacker and a dedicated conveyor system.

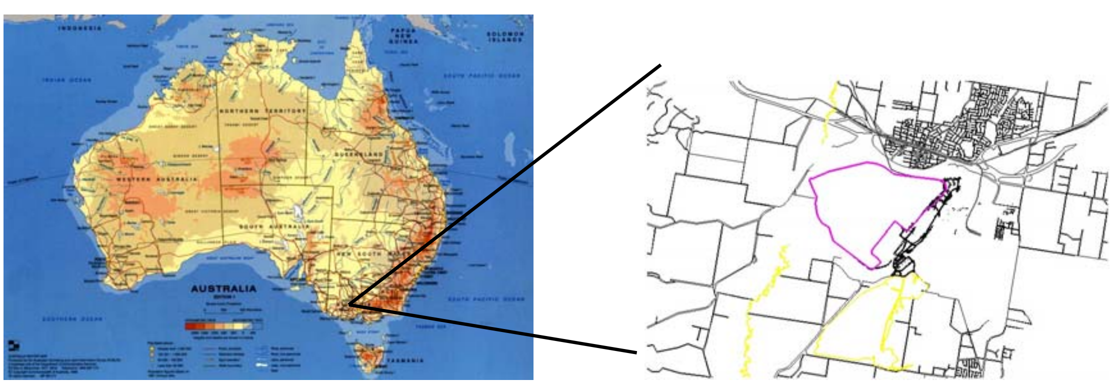

Figure 1: Location of Hazelwood Mine

2. Background

Aquifer depressurisation in Latrobe Valley Coal Mines is a well established practice. It is required for safe mining operations in winning brown coal for coal fired power stations. Hazelwood Mine commenced operation in 1950s and aquifer depressurisation begun in 1960s. The aquifer depressurisation has become significant around 1970s. Figure 2 shows the aquifer depressurisation history of Hazelwood Mine (formerly Morwell Mine).

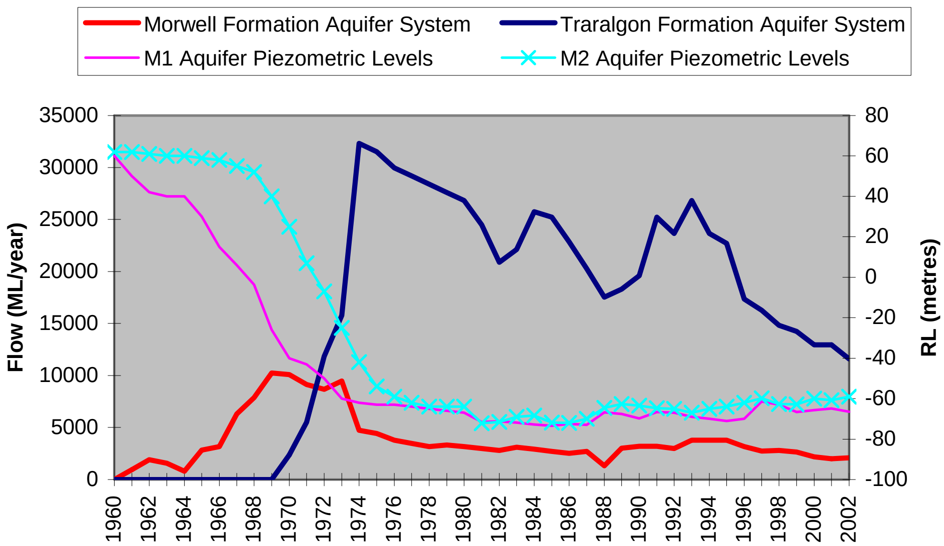

Figure 2: Hazelwood Mine
Groundwater Extraction & Aquifer Drawdown

The effects of aquifer depressurisation (extraction of groundwater which decreases aquifer pressures) extend for many kilometres from the Mine and cause major impacts on aquifer piezometric levels, water temperature and land subsidence.

There are two major aquifer systems underlying the Coal seams. They are known as M1 (Morwell Formation Aquifer System) and M2 (Traralgon Formation Aquifer System). The M1 aquifer system is situated just below M1 coal seam whereas M2 aquifer system is situated 65 metres below the bottom of M1 coal seam (Figure 3). Both these aquifers are required depressurisation to maintain aquifer pressures below target aquifer pressures for safe and consistence coal mining operation.

3. Aquifer Depressurisation

3.1 Reasons for groundwater extraction

Withdrawal of groundwater from M1 (Morwell Formation Aquifer System) and M2 aquifers (Traralgon Formation Aquifer System) associated with Tertiary sediments in the Morwell area is essential to allow coal winning to proceed to depth. Water pressures in coal joints must be lowered to maintain stable Mine batters during the mining, whilst the pressures in deep aquifers must be lowered to avoid floor heave inflows to the Mine and instability of permanent mine batters as the open cut develops in size and depth. There is an ongoing need to depressurise the aquifers in Hazelwood Mine.

3.1.1 Requirements for stability. To prevent catastrophic floor heave, it is required to maintain the water pressure levels in the aquifers below the Target pressure levels. The Target Aquifer Pressure level is established by calculating the weight of the overlying materials against aquifer pressure including a factor of safety. The equilibrium pressure is that pressure which just balances the weight of the overlying sediments and aquifer pressures. Consequently, as the depth of the open cut is increased, the weight of overlying sediments is reduced, and the required amount of aquifer depressurisation is increased to achieve balance. It is assumed that the weight of the overlying sediments of clay and coal provide the reactive force required for stability as shown in Figure 4. The shear strength of the material separating the aquifer and open cut base cannot be relied upon for assistance because of the large floor area and the presence of near vertical joints that penetrate the full thickness of coal seams.

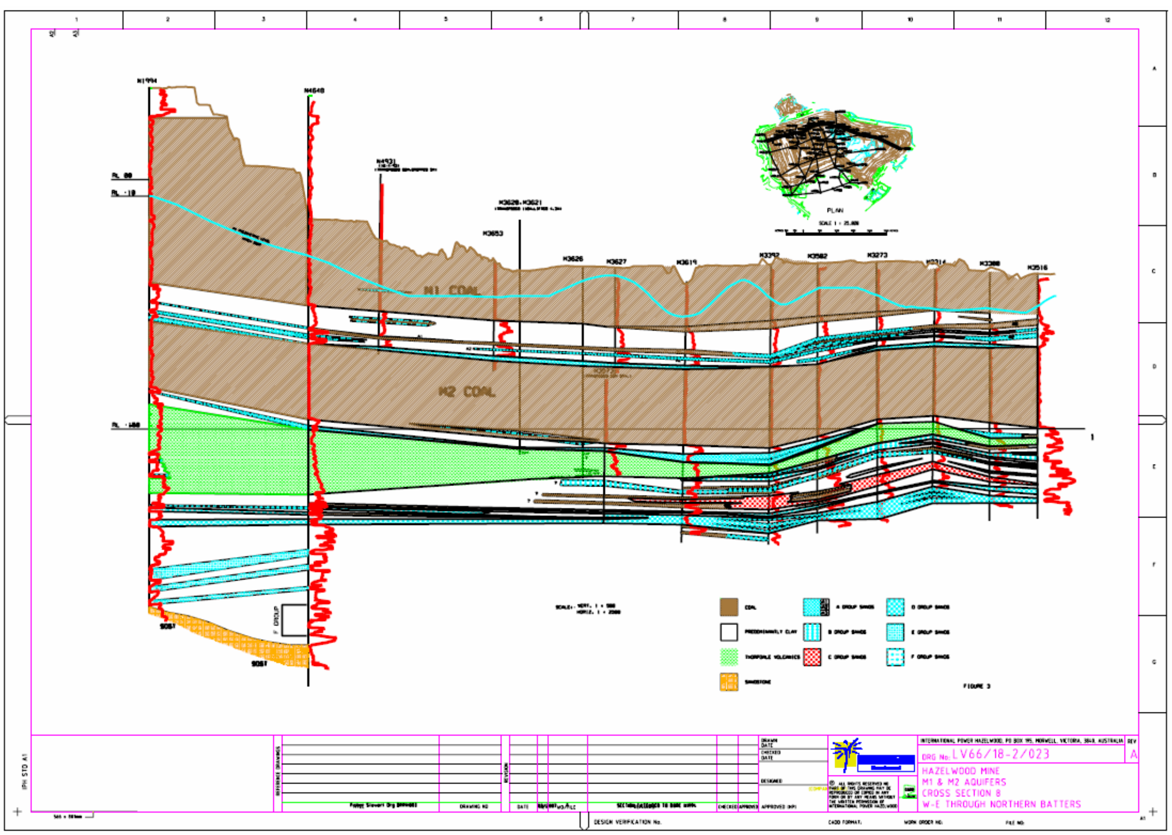

Figure 3 - Hazelwood Mine M1 & M2 Aquifers Cross section

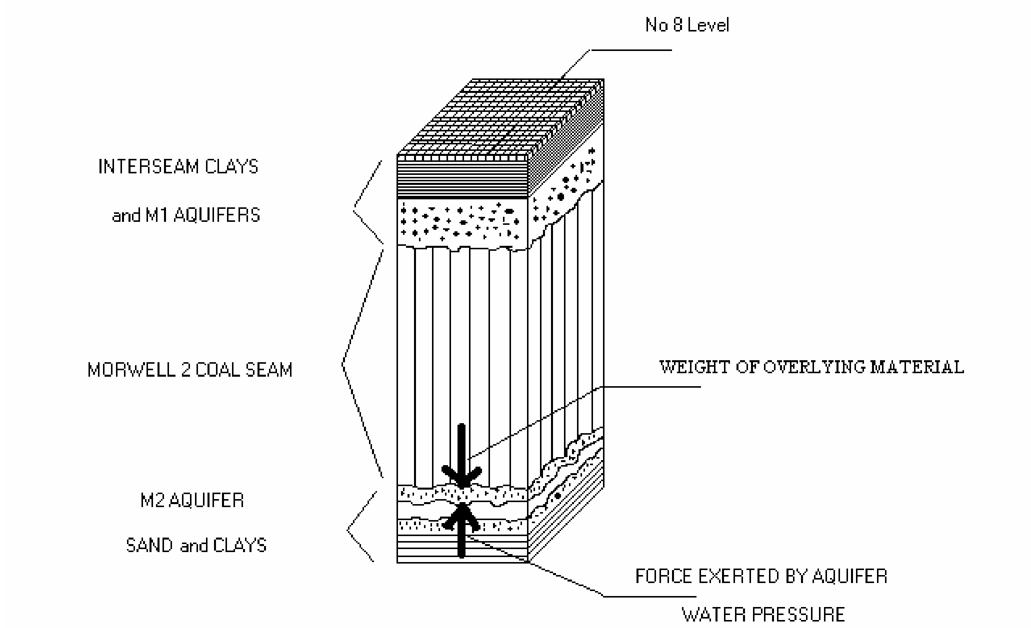

Figure 4 - Equilibrium Forces

To maintain stability, it is required that the artesian pressure at every location be lower than the corresponding equilibrium pressure. The critical location is where the weight of the overlying sediments is a minimum (deepest part of open cut) and aquifer depressurisation should be centred on that location to minimise pumping.

3.1.2 Effect of overburden dumping in the pit over weight balance. Overburden dumping in the northeast corner of the pit (Internal Overburden dump) commenced in 1998. As a result, weight over the M1 and M2 aquifers has been considerably increased overtime. This has increased the Target level and as a consequence reduced groundwater extractions from this part of the Mine.

3.1.3 Risk-based approach to setting of required aquifer pressure levels (target level). Risk based approach involves weighing the cost of meeting various design criteria against the likelihood and consequence of failure if these criteria are not met. Required aquifer pressure for safe mining without risking mine floor failure is defined as Target Aquifer Pressure Level (Target Level). The Target aquifer pressures level is determined including a factor of safety value. This value is selected to allow for the potential failure in the mechanical and electrical components in the depressurisation system. In the most critical area of the mine (current operation face, toe of northern batters and southern batters), the FOS (factor of safety) for M1 aquifer is 1.5 and for M2 aquifer it is 1.2. Table 1 gives the current FOS for the mine.

Table 1. CURRENT FACTOR OF SAFETY FOR THE MINE

Area	Status	M1 Aquifer	M2 Aquifer
Operation face, northern batters	Most critical	1.5	1.2
Base of the mine, western batters, southern batters	Critical	1.4	1.15
Eastern batters, Internal dump	Less Critical	1.3	1.1
Outside the mine	None critical	1.2	1.05

3.2 Groundwater extraction license

All drilling activities associated with groundwater investigation, extraction and monitoring have been carried out to date in accordance with Clause 106 of the SECV Act (1958). With the introduction of the Water Act (1989), provision was made for the establishment of groundwater management plans to ensure that the groundwater resource was managed in an equitable manner. It also required that consideration be given to environmental concerns when licenses were issued. The current groundwater license No.2007403 is valid until 2025. Licensed groundwater extraction volumes for Hazelwood are 3312 ML and 18,924 ML per year for the M1 and M2 aquifers respectively. Under the groundwater licence agreement International Power Hazelwood is obliged to carry out the following;

- Annual regional groundwater monitoring and reporting
- Preparation of five year groundwater management plan
- Participating in regional groundwater committee
- Maintain annual groundwater extraction volume less than the licensed volume

4. Groundwater management strategy

Morwell Formation Aquifer (M1) and Traralgon Formation Aquifer (M2) systems are found beneath the floor of Hazelwood Mine and its periphery. The aquifers need to be depressurised to ensure safe mining operations, in particular, mine floor and batter stability. The M1 aquifer system lies between M1 and M2 coal seams and M2 aquifer system occurs below M2 coal seam and above the Mesozoic basement. For the purpose of managing aquifer pressures, the base of the Mine has been subdivided into 7 Sectors (Figure 5). For each Sector an aquifer pressure Target Level has been established. Aquifers are depressurised to maintain safe aquifer pressures below Target levels.

4.1 Morwell formation aquifer system (M1 aquifer)

The Morwell Formation (M 1) aquifer system (Figure 3) comprises four sand layers interbedded with stiff Silty Clay and thin brown Coal seams. These numerous sand aquifers have varying thickness and textures. The thickness of sand layers varies from 0.5 m to 10m in places. Stratigraphically M1A0 (0.1 to 1.0m thick) is the uppermost sand layer in the

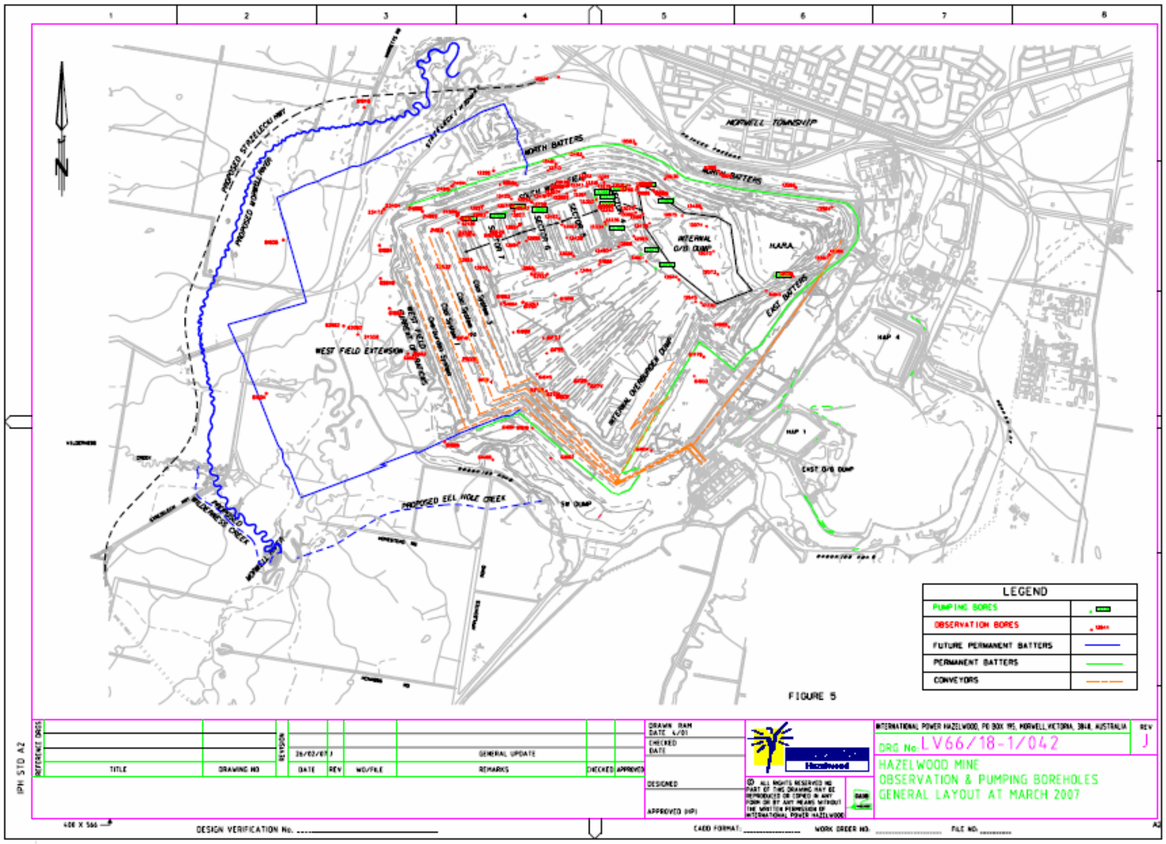

Figure 5 - Hazelwood Mine Sectors Location plan for Aquifer System

M1 aquifer system and the lowest is M1A3 (2 to 10m thick). The three upper sand layers are patchy and often not continuous, whereas the lowest sand layer (M1A3) is continuous and prominent. It spreads throughout the current Hazelwood Mine area as a sheet and also extends to the West Field. The aquifer is recharged by the Morwell River upstream of Hazelwood Mine area (local experience). Transmissivity varies from 100 - 300 m2/day and the storage coefficient is 1.2 x 10-4. At the moment aquifer depressurisation has been carried out only for M1A2 and M1A3 sand aquifers and need to continue depressurisation in West Field too. The other two sand layers (patchy sand layers with fine silty sands, very low transmissivity) are not considered to have any potential impact on current mining operations.

4.2 Traralgon formation aquifer system (M2 aquifer)

Traralgon Formation Aquifer System (M2) comprises (Figure 3) numerous sand layers, in which the thickness of sand varies form 0.5 m to 20 metres. These sand aquifers are interbeded with impervious stiff clay layers and have varying thickness and textures. They often split into several sub layers within the aquifer, for example the M2D sand layer generally has three splits such as M2D1, M2D2, and M2D3 which are interbeded with stiff silty clay layers. Similarly the rest of the sand layers also have many splits. Occurrence of aquifer sand splits beneath the Mine is not unique. Stratigraphically M2A (0.5 to 4m thick) is the uppermost sand layer in the M2 aquifer system and the lowest is M2G (2 to 6m thick). M2D sand aquifer shows the highest Transmissivity (1500 m2/day) and storage coefficient (7 x 10-4). M2B and M2C aquifers show generally low permeability and low aquifer pressures. M2A sand aquifer (which is found just below M2 coal seam) has moderate pressures but its aquifer properties are similar to M1A3 aquifer sands. 2E, 2F and 2G sand aquifers have low permeability and generally contain undifferentiated sediments. At the moment, aquifer Depressurisation has only been carried out for M2D sand aquifer. Other M2 sand aquifers are not considered a risk to the current mining operations.

5. Operation & maintenance of aquifer depressurisation system

The section covers M1 and M2 pump bores operational and maintenance issues, construction of new bores, observation bore maintenance & rehabilitation, and then expands into bore decommissioning and steel borehole casing removal activities in the current mining field (West Field).

5.1 M1 & M2 aquifer pump bores

There are eight M1 pump bores existing in the M1 aquifer depressurisation system of which six are operational and two are spare bores whereas there are five M2 pump bores existing in the M2 aquifer depressurisation system of which four are operational pump bores and one spare bore. Details of these bores and their maintenance issues are discussed below.

5.1.1 Operation. The status of M1 & M2 aquifer operational and spare pump bores is shown in following Table 2.

Table 2: M1 and M2 Operational and Spare Pump Boreholes in Hazelwood Mine.

Bore No.	Status	Aquifer	Yield, l/s	Description
M3396	Operational	M1	10	Groyne 5 North, 1A3 sand pump bore
M3455	Operational	M1	30	Sector 2 North, 1A3 sand pump bore
M3548	Spare	M1	6	Sector 4 North, 1A3 sand pump bore
M3684	Spare	M1	7	Sector 6 North, 1A3 sand pump bore
M3705	Operational	M1	6	Sector 7 North, 1A3 sand pump bore
M3708	Operational	M1	10	Sector 6 North, 1A2 & 1A3 sand pump bore, capable of pumping 20 l/s
H1885	Operational	M1	10	Sector 7 North, 1A3 sand pump bore
H1902	Operational	M1	10	Sector 4 North, 1A2 & 1A3 sand pump bore
M3274	Operational	M2	100	Sector3 South, 2D sand pump bore, capable of pumping 100 l/s, flow metered
M3284	Failed during	M2	100	Sector 3 North, 2D sand pump bore, capable of

	review period			pumping 80 l/s
M3333	Operational	M2	100	Groyne 5 North, 2D sand pump bore, capable of pumping 100 l/s
M3392	Failed during review period	M2	80	Sector 5 North, 2D sand pump bore, currently not in operation
M3395	Operational	M2	100	Groyne 5 South, 2D sand pump bore
M3452	Spare	M2	50	Sector 2 South, 2D sand spare pump bore
M3461	Operational	M2	100	Groyne 5 North, 2D sand pump bore

5.1.2 Maintenance. Maintenance of the aquifer depressurisation system includes the following.

- Pump Borehole rehabilitation
- Repairing pump bores
- Repairing pumps
- Repairing flow meters and head works
- Repairing pipelines
- Repairing Electrical systems
- Order spare parts and accessories
- Pump Removal and installations

5.1.3 New & spare pump bores. Time to time new pump bores are added to the system depending on the new depressurisation requirements in relations to mine development. In addition to new pump bores failed pump bores are replaced with replacement pump bores.

5.1.4 Operational & maintenance issues. Depressurisation system operation & maintenance is carried out by two parties in the Mine. The Mine Engineering section is responsible for planning & purchasing issues and the Mine Service Group is responsible for implementation of planning done by the Mine Engineering. Delays in pump installation, setting up electrical cubicles, pump replacements, purchases, ordering spare parts, construction of bore head works, and power supply etc reduces the efficiency of the M1 & M2 depressurisation system. Since operational Aquifer pressures were maintained at higher levels to reduce groundwater extraction, the risk of floor and batter instability has been increased. Therefore as general rule, the Mine must have a capability of replacing a bore pump within a day and replacing a pump bore within two months. Mine Services Group has taken prompt actions to carry out aquifer depressurisation system maintenance activities during the review period

6. Impacts of groundwater extraction

Depressurisation of M1 (MFAS) and M2 (TFAS) aquifers has resulted in declining aquifer levels within the Latrobe Valley groundwater systems. Operation and management of the aquifer depressurisation system are carried out under a Ground Water Extraction License No. 2007403 (Water Act, 1989) At the commencement of aquifer depressurisation in early 1960’s M1 and M2 aquifer piezometric levels were within 10 metres of ground level

around the Mined area and depressurisation has resulted in drawdown in excess of 10 metres, 5 to 10 km from the Mine.
Currently groundwater extraction from Hazelwood Mine is maintained around 13 Gigalitres, in comparison with the past ground water extractions (22 GL). The current rate is 9 GL less than the past extraction rates.

The impacts of groundwater extraction due to expansion of Hazelwood Mine towards the West has been studied using two modelling packages develop by the State Electricity Commission of Victoria (SECV), Australia. The regional groundwater modelling work was initiated by the SECV in 1980 using the AFPM model. Later in 1984 a COMPAC model was developed (SECV) especially to predict regional subsidence. The AFPM (Aquifer Flow in Porous Media) groundwater model predicts regional aquifer drawdown and the COMPAC subsidence model had been used to predict regional land subsidence resulting from the regional drawdown. Two models were last run in the year 2000 during the five year regional reporting (Geo-Eng report 1000/8505/99). For the present study, groundwater modelling (AFPM) and Subsidence modelling (COMPAC) were carried out by Golder Associates Pty Ltd and GHD Pty Ltd., respectively.

6.1 Regional effects

The AFPM model predicted regional groundwater potentiometric contours for the year 2030 for Morwell Formation Aquifer System (MFAS) and Traralgon Formation Aquifer System (TFAS)... There are consequences of groundwater extraction from the Hazelwood West Field from 2000 to 2030 if Loy Yang mine's groundwater extraction rate is kept at constant (groundwater extraction rate as at the year 2000). When actual groundwater levels of MFAS and TFAS as at the year 2000 (regional groundwater monitoring data - 2000 regional report No. 1000/8505/99) are compared with predicted levels at the year 2030, it was found that a drawdown of 5 and 2.5 metres could occur at Rosedale in the MFAS and TFAS respectively. Compared to the past aquifer piezometric level (1982 to 2000) depletion in MFAS (drawdown of 4.3 metres) and TFAS MFAS (drawdown of 9.3 metres), predicted aquifer piezometric level depletion during the next 30 years is half.

6.2 Subsidence prediction around hazelwood mine

The revised computer modelling of time-dependent ground subsidence due to the 30 year predicted groundwater withdrawal plan in Hazelwood Mine has been undertaken.

6.2.1 Results of compac modelling. Results of COMPAC modelling (report MD03/) and actual land level surveys done (report 1000/8505/99 - 1999) for the area are shown in Figures 6 & 7.

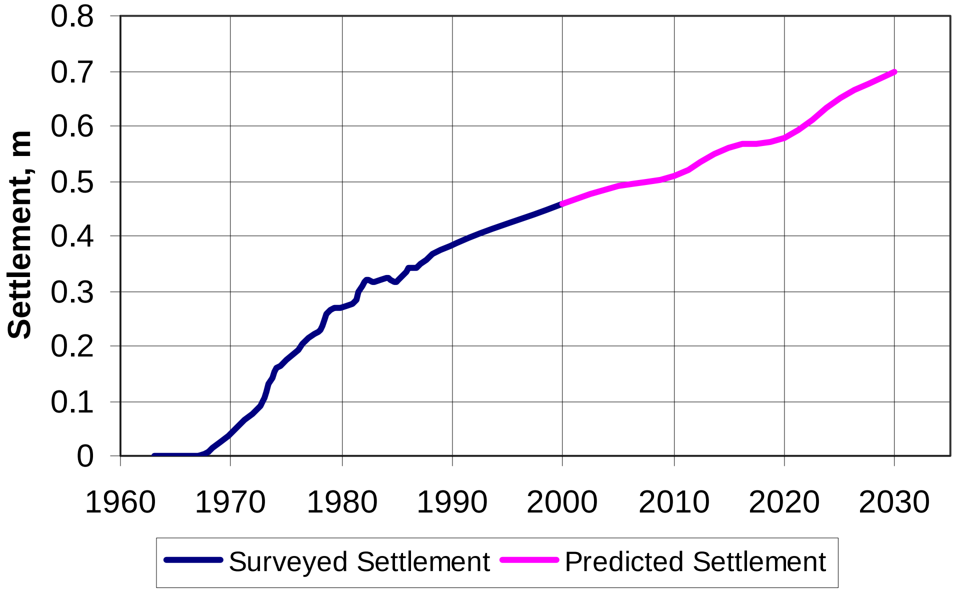

Figure 6 Actual and predicted settlement in west of the Mine.

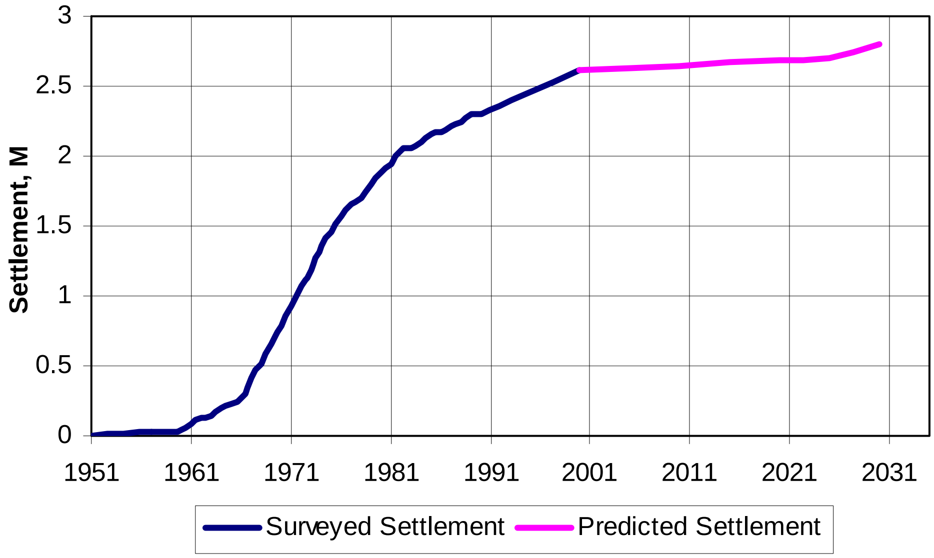

Figure 7: Actual and predicted settlement in North of the Mine.

These figures indicate that total actual settlement from 1960 to the year 2000 was 2.6 metres north of the Mine (Morwell town) and approximately 0.45 metres west of the Mine (Driffield) and the COMPAC model predicted settlement from 2000 to 2030 will be 0.18 at north of the Mine (Morwell town) and 0.25 metres in west of the Mine (Driffield).

7. The groundwater management practice

The groundwater management practice discussed in this section describes the present practice as well as the groundwater management plan for the next 30 years. It is an expansion of the current practices to the extent of the Mine's life.

7.1 Groundwater level monitoring

Systematic observations of aquifer piezometric levels and the review of aquifer flows is the key to proper management of the aquifer depressurisation system.

7.1.1 Hazelwood mine's groundwater observation bore network. Existing M1 and M2 groundwater observation bore networks will be expanded to incorporate more aquifer observation points when the Mine is progressed into the West Field. These bores monitor aquifer pressures in the overburden to the basement rocks.

In addition, stability observation bores will be installed along the rim of the Mine to obtain water pressures in coal and overburden to evaluate permanent batter stability. Bores are drilled in the rim of the pit and outside the Mine to evaluate groundwater pressure levels due to groundwater extraction in close vicinity of the Mine.

7.1.2 Regional observation bores. International Power - Hazelwood is actively participating in the Regional Groundwater Committee by providing adequate funding for regional works. This comprises regional bore monitoring, rehabilitation & maintenance of regional bore network, replacement or decommission of regional observation bores, groundwater and subsidence modelling and the preparation of annual and five year Regional Groundwater review reports.

7.2 Groundwater Flow Monitoring

7.2.1 Aquifer flow monitoring. Electromagnetic flow meters are installed in the discharge lines of all high flow pump bores (M2 pump bores). Flows are also measured manually, where no flow meters are attached to the bore. For example, M1 pump bore low flows are estimated using an in-house developed calibrated stick and plumber arrangement (non-chucker). Flow meters are also installed in strategic locations along the collection system. Pump operating times are measured from the pump hour meter located in each pump cubical. From these individual bore flows are calculated monthly. Similar or advanced aquifer flow measurement systems will be employed in the West Field.

7.3 Frequency of monitoring pressure and flows

All the groundwater observation bores in the Mine are monitored in weekly, monthly and quarterly intervals. The bores at the base of the Mine, between the base and the grass level, and periphery of the Mine are monitored in weekly, monthly and quarterly intervals respectively. All the pump bore flows are monitored on a weekly basis and pump hour meters are read on a monthly basis. In addition to groundwater bores, batter stability bores are monitored in quarterly intervals. These practices will be reviewed from time to time for improvement and quality assurance purposes during the next 30 years.

7.4 Maintaining groundwater databases & models

7.4.1 Groundwater databases. Groundwater flow and aquifer pressures are validated and logged into a groundwater database. The groundwater database is built using the Microsoft Access database engine. Weekly, monthly and quarterly data collected are taken out of the database for aquifer pressure modelling at the end of every month or when necessary. There is a plan to build an oracle based interactive database to store borehole, stability and aquifer pressure data for the West Field.

7.4.2 Aquifer Models. Aquifer pressure distribution across the Mine is modelled using Vulcan Mine planning software at the end of every month. Aquifer pressures are compared against the Target levels set out using the weight balance concept (see Section 3.1). If the aquifer pressures are above or at the Target level in a particular area of the Mine then the flow from pump bores will be increased to stabilise the Mine floor. If the difference between aquifer pressure levels and Target levels are higher then pumping from the area will be reduced.

7.5 Analysis of pressure and flows

The analysis of the aquifer pressure data from within the Mine, involves comparing the aquifer pressure to the aquifer equilibrium level or designated Target level. The aquifer equilibrium level is the pressure at which the overlying weight of strata is balanced by the aquifer pressure, and is maintained at or below the Target level to ensure safe working conditions for the Mine plant and personnel. Isopachs of actual and required aquifer pressures provide means of minimising extractions while maintaining the safe aquifer pressures.

Existing Target levels are reviewed annually and new Target levels are established to incorporate the progress of mining. Groundwater modelling is carried out using new Target levels to determine the additional groundwater extraction needs. These practices will be carried out for next the 30 years to predict aquifer extraction needs in the West Field.

7.6 Planning of new pump bores

Results of groundwater modelling are used to determine the number of pump bores that need to be drilled and their tentative locations. The locations, aquifer morphology and characteristics are combined to locate new pump bore locations. Before the construction of a new pump bore is carried out, a pilot bore is sunk at the selected location to verify aquifer thickness, sorting, gradation, texture of sands etc. Sometimes a pump test is carried out to determine aquifer properties and the yield before construction commences. If the location does not meet the set criteria that pump bore requires, then construction of pump bore is abandoned and the bore is converted into an observation bore.

7.7 Land subsidence monitoring

Surface movement in a Mining environment is attributed to a number of factors such as;

- Horizontal relative movement which is caused by the release of horizontal stresses due to the removal of coal, overburden and also the excessive hydrostatic pressure in coal joint systems within coal Batters.
- Vertical movement (up or down) is potentially due to the displacement of one block of coal relative to another block along coal joints, tilting of coal batters (due to excessive water pressure in coal joints), and as part of the vertical stress relief (heave). Vertical settlements are primarily due to consolidation settlements caused by the release of coal water pressure and also depressurisation of underlying aquifers.
- Subsurface movement is caused by the stress relief on the underlying M1 clay layer as well as the dynamic force generated by the fluctuating water pressures in M1 Aquifer below M1 clay seam.

Monitoring of land subsidence is achieved by periodically recording the relative level of survey pins located within the Mine, the immediate vicinity and throughout the Latrobe Valley.

7.7.1 Frequency of monitoring. The schedule for the survey of the pin line network in Hazelwood Mine is assessed in the review period in an effort to focus on the key areas of the Mine. These include the western batters and northern batters.

Five year bench mark levelling surveys are carried out around Hazelwood, Yallourn and Loy Yang mines and all major townships in the Latrobe Valley and this will be continued for next 30 years.

7.7.2 Analysis of Subsidence. Changes in the rate of subsidence are analysed using vector and contour plots for both horizontal and vertical movements. On a regional basis, subsidence predictions are made using a finite element modelling program COMPAC. The actual values are compared to the predicted values following completion of the five year surveys. The COMPAC program models various sites around the mines and throughout the region and are remodelled with up to date predictions of groundwater pressures obtained from the regional groundwater modelling.

7.8 Reporting

The following regular reporting of groundwater extraction and environmental monitoring is provided both internally in the Mine and externally to pertinent government bodies.

7.8.1 Aquifer depressurization monthly reporting. A report is prepared on a monthly basis which details the status of groundwater extraction in the Mine. This report is provided to the Environmental Review Committee. Major items reported monthly are:

- Aquifer pressures in and around the Mine for each aquifer,

- Pressure isopachs comparing aquifer pressures with Target levels,
- Aquifer yield for each major aquifer,
- Summary of significant activities that took place during the period, e.g. new pump or bore installation, bore rehabilitation etc, and
- Recommendation for priority works to be undertaken in succeeding months in order to maintain the aquifer depressurisation management system.

7.8.2 Aquifer depressurization annual review. Annual Review collates and summarises the information in the monthly report including

- aquifer pressure levels and the fluctuation of each aquifer during the 12 month period,
- total aquifer flow (yield) for each aquifer,
- movement in the centre of pumping,
- establishment of new Target levels,
- general status of pumping bores, observation bores and related infrastructure issues,
- new observation bores and pump bores,
- decommissioning of abandoned bores,
- steel bore casing removal in the Coal operation faces,
- Program of works and work scopes for planned mining developments for the following year and budget estimation for the program.

In addition the review discusses longer term trends including changes to the regional impacts of aquifer depressurisation at Hazelwood. This report is provided to the Environmental Review Committee.

7.8.3 Bore information. The Borehole Database Committee comprises membership from Geological survey, Victoria, Hazelwood, Yallourn and Loy Yang mines. It maintains a total record of all drilling and bore installations in the Latrobe Valley. This data is stored in a computer database "borehole database" and maintained and managed by the above body. All bores drilled in Hazelwood Mine and its periphery will be recorded in the Latrobe Valley Borehole Database.

7.8.4 Regional groundwater committee annual review. An annual review of groundwater management activities is prepared for Southern Rural Water. This report includes the following;

- A review of total yield and average piezometric levels at each mine for each major aquifer in comparison with the predicted values,
- Comments on any significant variance to yield or piezometric levels,
- Provision of an updated list, locations and flows of pumping bores,
- Drilling logs of completed bores.

7.8.5 Regional groundwater and land level monitoring five year review. Under the terms of the groundwater extraction licence, Hazelwood Mine (together with the other two mines) is obliged to participate in the Regional Groundwater Committee and produce a five year review of the impacts of aquifer depressurisation on the regional aquifers. The report includes the following;

- Overview of regional hydrogeology
- Groundwater extraction during the five year period compared with licence extractions
- Regional groundwater levels
- Regional groundwater modelling to predict future aquifer levels
- Regional groundwater level depletion and comparison of actual and predicted depletion
- Results of regional land survey
- Land subsidence
- Land subsidence predictive modelling to predict future subsidence
- Comparison of modelled and actual subsidence
- Aquifer monitoring network and other infrastructure related issues.

7.8.6 Five year review of Hazelwood Mine's groundwater management plan. It is intended to review this groundwater management plan every five years or whenever pertinent change occurs in government policy which may impact groundwater extraction activities. This review will examine the extraction rate, piezometric levels and ground settlement which have occurred over the preceding five years compared to the predicted values. It will examine other issues such as the temperature, pH, TDS as necessary. It will also make prediction for the five years in relation to key parameters.

8. Conclusions

- Effective and Efficient management of aquifer depressurisation system could help reduce environmental impacts due to groundwater extraction for coal winning process.
- Further effective depressurisation maintains Mine stability for safe mining operation.
- Aquifer level depletion cannot be avoided; however effective management of aquifer depressurisation could slow down the aquifer level depletion. The current rate of depletion a kilometre away from the Mine is 2.6 metres per year for M1 aquifer and 50 mm per year for M2 aquifer.
- Land subsidence can be maintained at a lower rate and total subsidence predicted closer to north of the Mine where Morwell township is located will be 0.2 metres by the end of 2030. Rate of subsidence from 2000 to 2030 is 6.7 mm/year.

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