COLLIERY CLOSURES IN THE MIDLANDS

A Review of the Potential Impact of Colliery Closures on the Water Environment in the Midlands

NRA

National Rivers Authority

INTRODUCTION

This document presents an overview of the potential impact of the recent colliery closure programme on the water environment in the Midlands. Concerns that there will be imminent and severe pollution of our rivers, fuelled by publicity on the issue in other parts of the country, are not well founded. However, studies by the NRA have identified potential problems for the future. We cannot be complacent and must gather better data now and over the next few years in order to predict and quantify any environmental impacts and plan remedial measures where these are shown to be necessary. This report only addresses environmental issues arising from deep mines and does not deal with open cast mining.

BACKGROUND

Coal has been mined in Britain for centuries, possibly since Roman times, but it was only during the Industrial Revolution that coal production started to increase dramatically, becoming a major industry from the mid 19th Century onwards. Since the 1960s the industry has declined substantially such that only a relatively few mines remain open. The long-term future of these is by no means certain, following the privatisation of both the coal and electrical supply industries.

Early mines exploited coal at shallow depths and utilised drainage tunnels to keep the workings dry. The development of the steam engine enabled larger volumes of water to be pumped giving access to deeper coal seams. Further sophistication in mining techniques and advances in geological knowledge led to the exploitation of the concealed coalfields beneath younger non-coal bearing rocks. Modern coal mining can work seams at depths of over 1000 metres and many kilometres from their outcrop at surface where the early miners first worked.

The progressive working and reworking of coal seams has frequently led to the deliberate and complex interlinking of coal workings within a coalfield. This facilitates access, ventilation and coal clearance but it also provides ready pathways for water. It is often necessary therefore to maintain a network of pumping stations, using old shafts or boreholes in otherwise abandoned areas of the coalfield, in order to protect hydraulically connected collieries from flooding. Minewater is pumped to the surface and often mixed with process water, from coal washing and site drainage, before being discharged into nearby watercourses.

Water within the mine workings comes from two main sources; water entrapped within the sediments that formed the rock strata when they were originally formed 300 million years ago, known as connate water, and water which has its origin as rainfall and has infiltrated from the surface through the overlying rock.

The volume of connate waters present within the coal seams and the surrounding strata is usually not great. In comparison, water which infiltrates from the surface can, depending on the geological conditions, give rise to significant quantities for disposal. This can be an important factor on the exposed coalfields and is the reason why there is significant environmental concern in coalfields in other regions such as Durham and South Wales. However, where coalfields are confined beneath younger rocks infiltration is much less. Hence the time scales for the flooding of mines in these situations are much longer.

MINING HISTORY IN THE MIDLANDS

As a cradle of the industrial revolution and a centre for the iron and steel industry, coal mining has always been important in the Midlands. Exposed coalfields in the West Midlands, Forest of Dean, Coalbrookdale, Cheadle and other places were abandoned for deep mining many years ago, although the exploitation of shallow seams by opencast methods still continues. Coalfields where mining is actively taking place or has only recently ceased are North Staffordshire; Cannock/South Staffordshire; Warwickshire; South Derbyshire/Leicestershire; South Yorkshire/Derbyshire/Nottinghamshire and the Vale of Belvoir. These are shown on Fig 1.

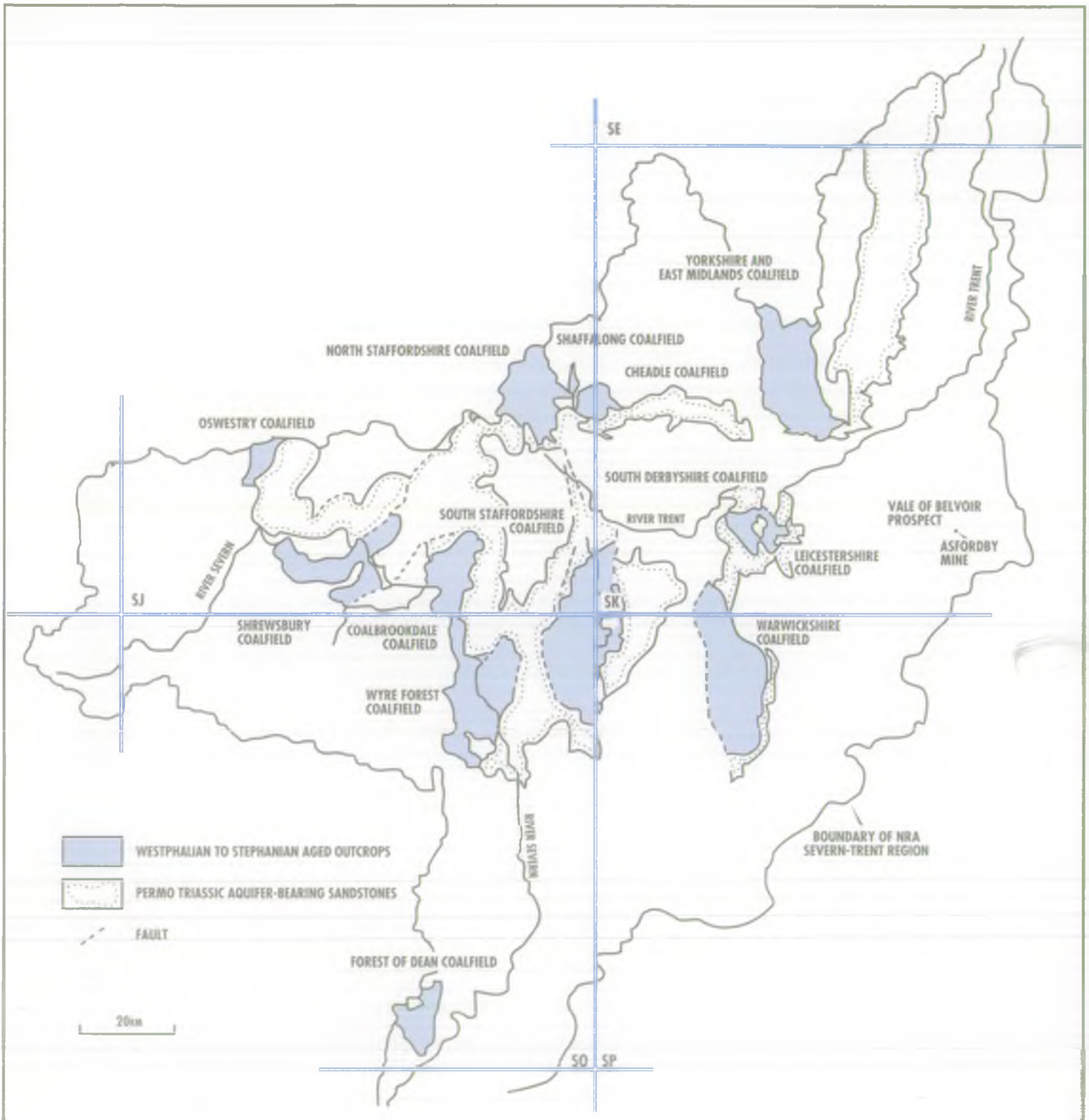


Fig 1. Location Plan showing coalfields in NRA Severn-Trent Region

MINING METHODS

Throughout the history of coal mining, various mining methods have evolved. These different methods have a bearing on water storage and flow within old workings.

The earliest workings exploited seams exposed at or near the surface. They seldom reached depths greater than 10 metres, and were worked by means of bell pits. Although these are now mostly completely infilled with collapsed material, the permanently disturbed ground may allow increased recharge to deeper workings. In the 16th and 17th centuries the pillar and stall method was introduced whereby more extensive working of the coal seams was aided by leaving pillars of coal in place to support the roof during working. When abandoning a mine the pillars were frequently extracted resulting in the collapse of the roof and subsidence in the overlying rocks.

Longwall mining techniques were introduced in the early 20th Century and through various refinements continue to be employed today. Essentially a rectangular panel of coal is extracted, with modern mining techniques these panels may be 200-250m wide and perhaps several thousand metres long in favourable geological conditions. The wide part (the face) advances as the coal is cut and the roof is allowed to collapse behind it. Access to the face is kept open by means of roadways on either side which are permanently supported. (Fig 2.)

The areas of collapse (known as goaf) represent potential pathways of increased transmissivity for groundwater. However, the extent and nature of this will be uncertain because of the variable nature of the rock lithology and other factors. After abandonment some roadways will remain open. These will provide extremely high hydraulic conductivity pathways for minewater movement, effectively acting as large pipes.

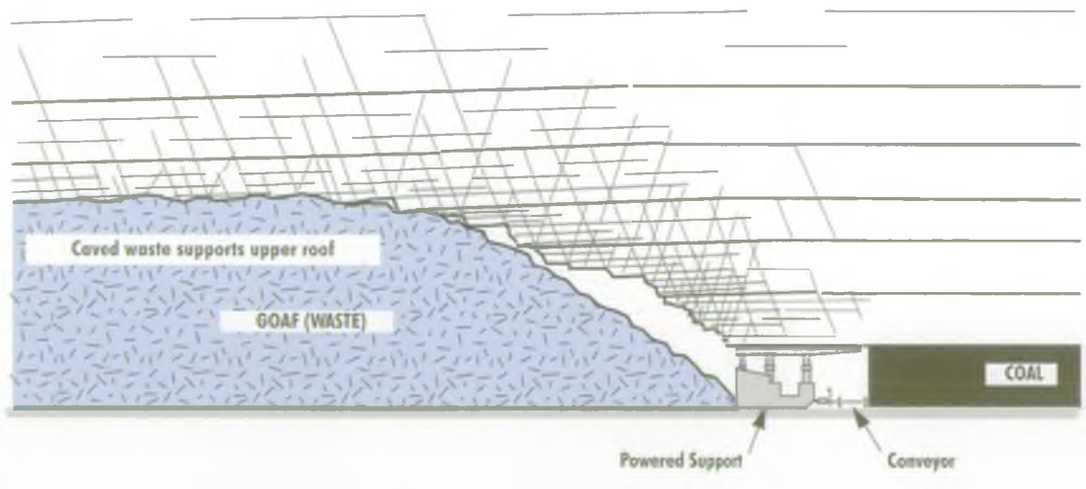


Fig. 2. Idealised Cross-Section Through a Longwall Face

THE NATURE OF THE PROBLEM

Present Day

Connate water from the Coal Measures is often rich in the minerals which were present in the seas when the coal was formed. In the Midlands, chloride concentrations in some waters can exceed those found in sea water today. In working collieries this saline water is pumped to the surface where after mixing with colliery process water, it is discharged to watercourses. Salinity levels in these watercourses can therefore be unnaturally high. In some places, for example in Nottinghamshire and Cannock Chase, the hydraulic connection between surface water and groundwater has led to the saline water re-infiltrating and contaminating the shallower groundwater used for public supply. This occurs particularly where groundwater levels are generally depressed in an area by pumping and where water supply boreholes are sited next to watercourses.

The salinity can also be detrimental to some crops (eg. potatoes) when the water is abstracted by farmers and used for spray irrigation.

When Mines are Abandoned

The mining process exposes sulphide minerals in the various shafts, audits and roadways. These are present naturally in association with the coal and the surrounding strata. Iron pyrites (fools gold) is the commonest of these. During working, these minerals come into contact with air and oxidise to form acidic solutions of iron. These in turn react with other minerals to form secondary iron minerals which are deposited along the preferential flow pathways which develop in a working mine. After a mine is abandoned and pumping ceases the water table will rise through the workings. The water is usually low in dissolved oxygen and under these reducing conditions the secondary iron minerals can be redissolved. In other situations where the rising minewater is aerated, perhaps because there are rapid pathways from the surface, the oxidation of pyrites will continue. However, in this latter situation the water will not be particularly saline because of its origin. In both cases the minewater becomes rich in dissolved iron and if it reaches the surface an ochrous discharge results. In very acidic minewaters aluminum dissolution can also be a problem.

THE SCALE OF THE PROBLEM

The abandonment of mining will have varying effect on the surface environment. In some places the rate at which the mine fills will be sufficiently fast that the volume of discharge at the surface could have a significant and detrimental impact on the receiving watercourse. In others the rate will be so slow that the effects will be insignificant and very long-term. Much depends on a number of complex and interlinked issues. These include:

- the origin of the water which fills the mine;
- the rate of recharge;
- the physical characteristics of the underground workings;
- the chemical reactions which take place and
- the characteristics of the receiving watercourse.

Many of these factors will be not known with any precision. Prediction of the impact is therefore difficult. However, within the Midlands the volume of minewater that is pumped from most mines is relatively small.

WHAT HAPPENS WHEN MINES CLOSE

Mining areas can be described using the concept of "ponds" or "buckets". Each pond is a self-contained area of mining activity. When mining stops and the pumps are turned off the minewater will rise until the water escapes into another pond with which there is subsurface interconnection. The concept is shown in Fig 3. Eventually the water may reach the surface via old shafts, horizontal tunnels (adits), the activation of natural springs or by general seepage into the bed of a watercourse. How quickly each pond fills depends upon the factors described above.

Eventually all the voids in the mined area become full and the water level stabilises at a position dictated by the point at which it can escape to the surface. This is when the ochrous discharges may be observed. These discharges have a major impact on the aquatic habitat by affecting stream chemistry and by blinding the stream bed with iron rich precipitate.

The closure of mines can also have an impact on the flows in the surface watercourses into which they formerly discharged their minewater and process water. Although there are benefits following closure, in that the salinity of streams and rivers can be reduced, the loss of flow in some areas could be a handicap to other river uses and users. This is particularly the case where baseflows are low due to the loss of a substantial natural groundwater contribution caused by high rates of groundwater abstraction for water supply. A reduction in flow may lead to the loss of dilution water for sewage works discharges, which may in turn lead to the need for more restrictive discharge consents to preserve the river water quality. Reduced flows will also restrict the ability of farmers to abstract surface water in summer for spray irrigation since they are often prohibited under the terms of their licences to take water below certain flow thresholds.

THE LEGAL POSITION

Discharges from abandoned mines have been exempted under previous pollution control legislation. The Environment Act 1995 addresses the issue but continues the exemption for mines abandoned before 1999. After this date it will be possible to require mine operators to undertake remedial schemes to mitigate pollution. Where there is significant pollution occurring the Environment Agency will be able to take preventative action using powers under S.161 of the Water Resources Act 1991, but at its own expense. There is also the potential for civil action to be taken by seeking an injunction against a mine operator to prevent the cessation of pumping.

Stream contaminated with ochrous discharge from abandoned mineworkings.

THE REGIONAL SITUATION

In the **North Staffordshire Coalfield** there remain six working collieries, although three others have been closed in the last three years. Only two collieries (Silverdale & Hem Heath) extract coal from deep workings and the closure of either would potentially threaten a number of surface watercourses in the area.

The **South Staffordshire Coalfield.** Mining in the southern part of this coalfield ended with the closure of Baggeridge Colliery in 1967 but continued in the Cannock Chase section until 1994 with the closure of Littleton Colliery. The Cannock Chase coalfield is complex, comprising seven small ponds with uncertain linkages. A preliminary study for the NRA of the impact of Littleton Colliery closure identified a potential medium term risk to surface water features but also the need for a much more detailed study.

The **Warwickshire Coalfield** continues to be mined with two active collieries (Daw Mill and Coventry). It comprises four ponds, two are still being pumped whilst there has been no mining in another for over thirty years. No adverse effects have been observed. Monitoring of rise rates within the fourth will be needed to assess the risks.

The **Leicestershire and South Derbyshire Coalfield** is centred around Ashby de la Zouch but is separated into two distinct hydraulic units. The last Colliery closed in 1991 but no impact on surface water has occurred. The minewater in the Leicestershire Coalfield is not so poor in quality as elsewhere and Whitwick and Ellistown Colliery discharges were once used for drinking supply.

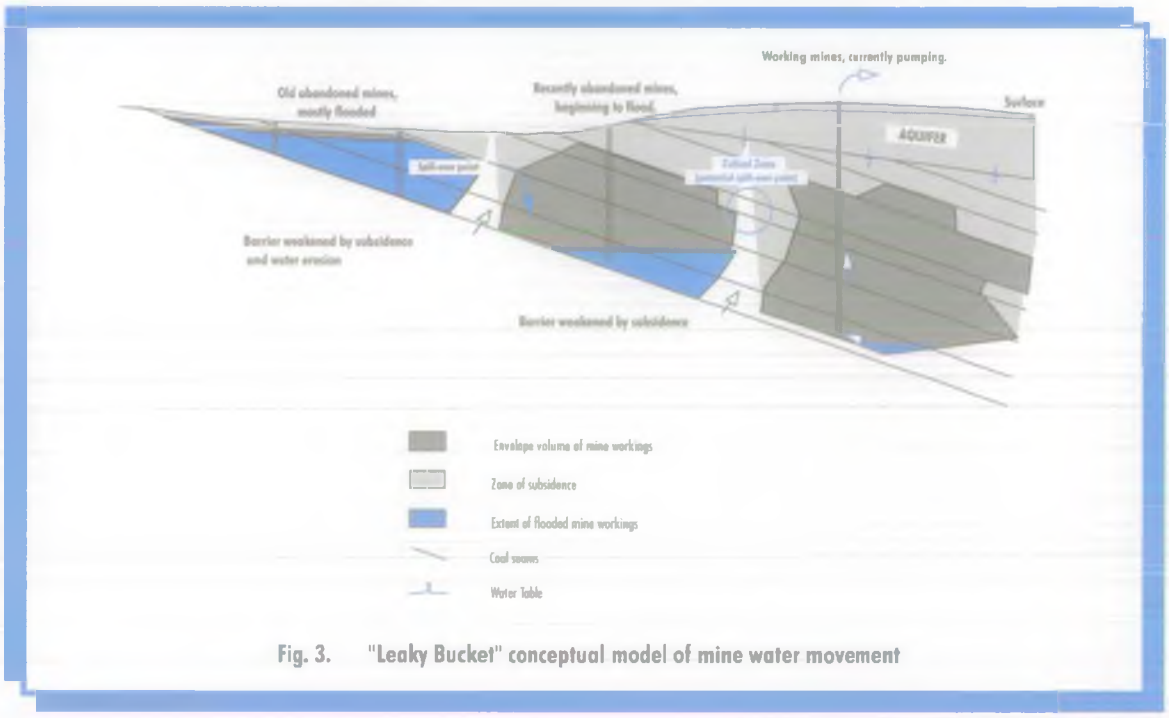
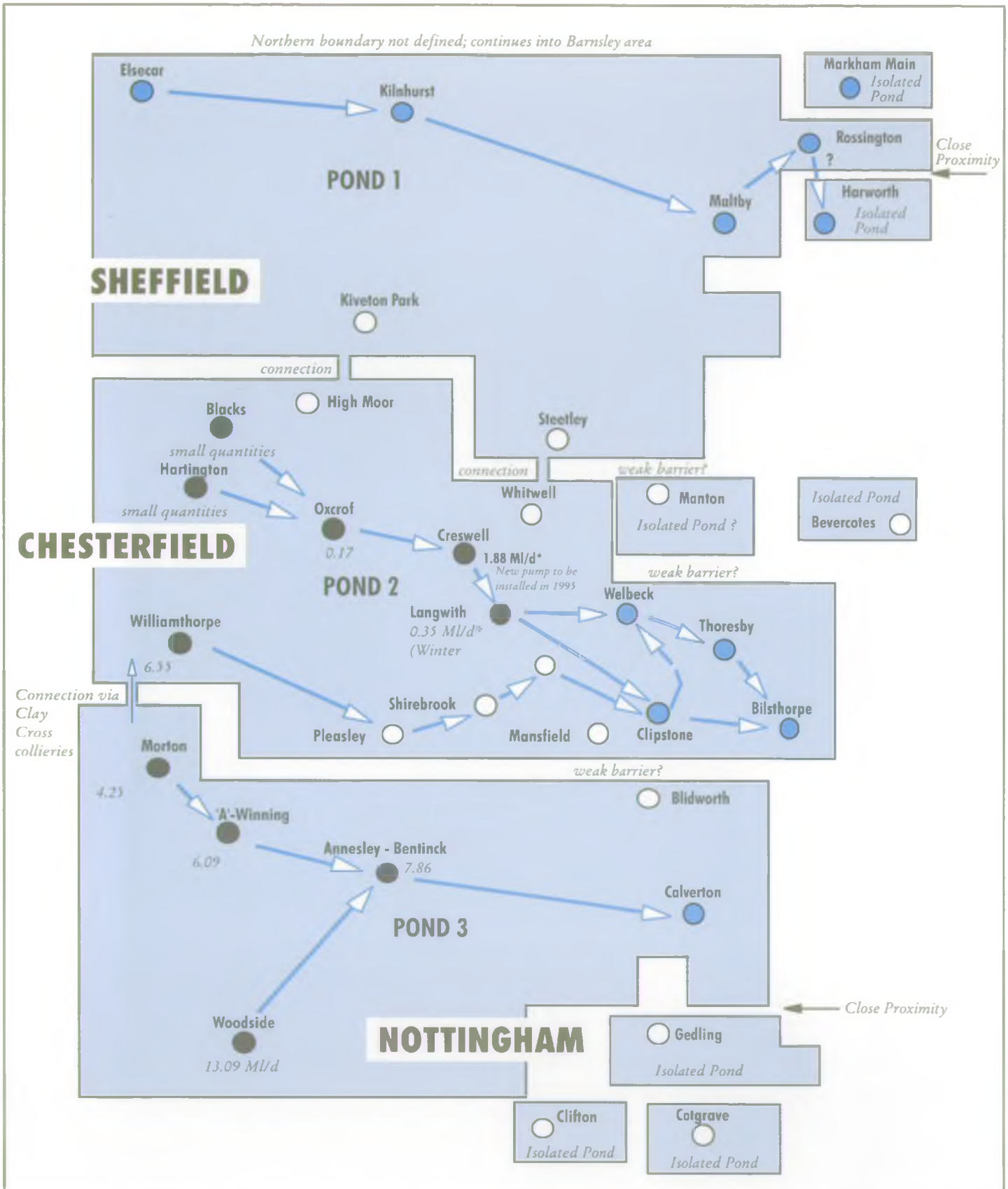


Fig. 3. "Leaky Bucket" conceptual model of mine water movement



Pumping Stations with average pump rate for 1994. (for 1991 where shown *)

Working Collieries

Closed Collieries (selected)

Schematic water flow if up-dip pump ceases operation

South Yorkshire / Derbyshire / Nottinghamshire Coalfield
Schematic Pumping Arrangements
(as at February 1995)

Fig. 4.

The **South Yorkshire/Derbyshire/Nottinghamshire Coalfield** is both the largest and the most complex within the Region. Mining has moved progressively eastwards, following the coal seams deeper as they dip beneath the Permo-Triassic rocks. (Fig 4). It extends north outside the Trent catchment and there are significant minewater movements across the catchment boundaries.

Many of the working pits are now located on the Triassic sandstones, the major aquifer for the Region. Their minewater discharges are made into streams which cross the sandstone so that in places where the water seeps down through the bed of the watercourse the salinity of the groundwater can be increased.

Since the minewater discharges also help to support baseflows in the Rivers Poulter, Maun, Meden, Ryton and Torne and dilute sewage effluent discharges, colliery closure and cessation of pumping could have a significant impact on some stretches.

The complex interlinking of collieries and the need to protect the working easterly collieries which are down the stratigraphic gradient, has meant that pumping has continued in parts of the coalfield. The closure of some collieries in this coalfield has therefore not led to any problems of rising minewater. If all collieries closed and pumping ceased completely then minewater would eventually build up and emerge in the surface water system. The River Erewash and possibly the River Leen are potential recipient watercourses.

Because of the higher ground in the west of the coalfield it is also a possibility that if the abandoned workings became completely flooded minewater could infiltrate strata overlying the Coal Measures further to the east. However, it is considered that the risk of water supplies being affected is extremely low because of the low permeability nature of the intervening strata.

WHAT IS BEING DONE

The NRA has regular discussions with the Coal Authority and their predecessors at both national and at regional level and has agreed a Memorandum of Understanding with the Coal Authority on environmental aspects of new closures. A Memorandum of Understanding also exists between the NRA and the Coal Operators over the need to give warning of mine abandonment and pumping cessation. Studies have been commissioned and undertaken by the NRA over the effects of stopping pumping at Littleton Colliery (South Staffordshire Coalfield) and Annesley Colliery (Nottinghamshire Coalfield), the latter being undertaken in association with British Coal. In addition an overview study has been carried out for the Severn-Trent Region of the NRA by the British Geological Survey. Elsewhere in the NRA, studies have been undertaken on different coalfields (for example Durham, South Wales and South Yorkshire) to provide further useful insights into a complex problem. A national research project is underway which will provide improved methods of predicting groundwater rise rates better as the abandoned workings fill.

All the studies demonstrate the lack of data which handicaps our understanding of the hydraulics of abandoned mines and therefore limits our predictive capabilities.
In particular the lack of good historical information on the amount of minewater pumped has pointed the need for better record keeping in future. The other area where difficulties arise is in predicting the rate of rise of minewater in flooded workings. Although computer modelling will help in this, good monitoring data is vital to validate the model results. Hence we are working with the coal industry to ensure that access is maintained to abandoned workings through existing shafts or boreholes so that rise rates can be measured.

ACTION PLAN

The future steps for the NRA and the successor Environment Agency are:

- Continue close and regular liaison with the Coal Authority and coal operators over mining operation plans.

- Investigate, by means of more detailed local studies, those areas of potential risk identified in preliminary studies where minewaters could emerge at the surface. This is most pressing for those coalfields where pumping has ceased completely.

- Instigate monitoring schemes for groundwater levels, groundwater quality and discharge rates, if necessary installing purpose drilled monitoring boreholes where no facility exists.

- Estimate potential impact having established likely discharge points and flow rates. Undertake modelling to help predict timescales and impacts using collected data.

- Determine action needed to avoid problems and liaise with land owners, mine operators and local authorities over solutions. Such action might involve the continuation of pumping and/or diversion of underground flows by sealing strategic pathways through the workings. In many situations minimal action will be required because of the small scale impact predicted. The long term goal must be to seek sustainable solutions which minimise or avoids the need for continued pumping but this may not always be possible in the short to medium term.

It is important that the potential impact and timescale over which any effect may be seen is thoroughly understood before any precipitate action is taken. In most places the potential will be insignificant but in others it may well necessitate positive action. Detailed understanding is the key to solving problems and the NRA will initiate studies to provide the information we need to form judgements. Even though problems may not be imminent the need to acquire reliable data is urgent. These new studies, like those done to date, will be carried out in liaison with the coal industry wherever possible.

This report has been prepared by the National Rivers Authority, Severn-Trent Region. It is based upon studies done for and with the NRA by the British Geological Survey, Wardel Armstrong Ltd and British Coal. The collaboration of the Coal Industry is acknowledged.

NRA

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THE ENVIRONMENT AGENCY

In April 1996 the NRA will merge with Her Majesty's Inspectorate of Pollution and the Waste Regulation Authorities to form the Environment Agency.

This new body will be responsible for the protection of water, air and waste and will continue to prevent and control pollution.

NRA

Severn-Trent Region

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