The Environment Agency's approach to mining pollution

Hugh Potter, Brian Bone, Joanne Forster, Phil Chatfield and Graham Tate.

Environment Agency, Olton Court, 10 Warwick Road, Olton, Solihull, B92 7HX.

ABSTRACT

The legacy of mining in the UK could be a significant barrier to achieving Water Framework Directive goals since mine waters are the major cause of pollution in many catchments. The scale of coal mine discharges to rivers is generally understood, and the Agency is working with the Coal Authority to remediate the highest priority discharges. No equivalent framework exists for metal mines outside Wales.

New European legislation will affect existing remediation schemes, and also provide a significant new driver for managing mining pollution. Research in a number of catchments demonstrates the significant contribution from point and diffuse mining sources to metal loading. Investigation of metal transport through catchments and consequent impacts on water quality and ecology will inform decisions on measures needed to comply with the WFD.

A strategic approach to dealing with mining pollution will be focused around the new *Environment Agency Research Fellowship for Mine Waters and Wastes* at the University of Newcastle. The overall science priority is understanding the hydrogeochemical processes associated with mining pollution to inform decision-making for sustainable management of mining wastes and mine-impacted catchments. Research will investigate innovative remediation of coal and metal mine discharges, and examine minewater rebound and catchment-scale impacts.

This paper will discuss the changing legislative regime, outline the Agency's strategic approach to research, and present a case study to illustrate the challenges in remediating sites affected by mining activities.

1 INTRODUCTION

The legacy of coal and metal mining in the UK could be a significant barrier to achieving Water Framework Directive goals since mine waters are the major cause of pollution in many catchments, especially in Wales (Mullinger 2004), and the north and west of England. No comprehensive study of the length of rivers impacted by mining has been undertaken, however the National Rivers Authority estimated more than 400km affected by coal mines, and 200km by metal mines (NRA 1994). Mining pollution has had a generally low profile within the Environment Agency, apart from when specific events have raised interest, for example:

- release of acidic minewater from the abandoned tin/zinc mine at Wheal Jane (Cornwall) in 1992, resulting in a highly visible plume of acidic, metal-laden water in the Carnon River;
- significant concerns over risks to human health and livestock, for example at various spoil sites in mid-Wales, and Shropshire; and
- minewater rebound following the closure of Whittle Colliery (Northumberland) in 1997 which threatened the River Coquet unless dewatering was undertaken.

The main environmental concerns are metal-contaminated water from the rebound of formerly depressed groundwater and leaching from spoil heaps, and the residual spoil and other solid wastes from the extraction and smelting processes. The areal and temporal (many centuries) extent of mining activities means that in addition to point sources of pollution (e.g. discharges from discrete adits), there are also more diffuse discharges that may affect entire catchments (e.g. River Ystwyth, Wales; Mullinger 2004). The Agency's approach has tended to be highly reactive utilising "end-of-pipe" treatment only when polluting discharges appear at the surface (e.g. Wheal Jane). Although, by working with the Coal Authority, this operationally driven approach has so far been relatively successful in coping with problems at individual sites (Tate 2002), at least in the short term, it has not tackled the problem at source, i.e. before the pollution reaches the river or the related ecosystem. The Water Framework Directive will require a different approach whereby more diffuse pollutant sources must be addressed, for example ancient spoil heaps that are dispersed across a catchment, to protect aquatic ecosystems.

The last 10 - 15 years has seen a move toward research and installation of passive treatment systems for mine waters, utilising natural attenuation processes and natural energy sources in constructed systems to remove metal contaminants from, and adjust the pH of, discharged mine water

(Younger et al. 2002). Such passive methods range from traditional aerobic wetlands to combined aerobic/anaerobic systems with multiple components. Passive systems tend to have a high capital cost, but are designed to be low (not no!) maintenance. Despite the large number of passive systems now in operation in North America and Europe, there is often a poor understanding of the natural processes involved in treating mine water. The current multidisciplinary research being carried out to understand these processes more fully (e.g. Hallberg and Johnson 2002) should be encouraged and extended, and ultimately lead to the design of more efficient passive systems that perhaps will require less land. An example of the latter is the development of permeable reactive barrier technologies (Environment Agency 2002) and their application to mine water treatment (e.g. Amos and Younger 2003). Other important, and little addressed, issues for passive treatment systems include the disposal of sediment, the potential need for decommissioning and the long-term fate of contaminants with particular regard to their potential to be re-released into the aquatic environment.

Managing mine waters and wastes therefore requires a thorough understanding of hydrogeology, hydrology, geochemistry, microbiology, civil engineering, and not least, mining practices. Moreover it should be noted that mining remediation schemes offer the opportunity to involve, and engage, the local community and so break down the traditional split between "technical experts" and "the public". Successful engagement with the local community can be critical to successful remediation since many schemes will require regular maintenance, and the avoidance of vandalism, over several decades before the remedial objectives are achieved (e.g. Quaking Houses, Durham – Younger et al. 1997; Johnston 2004). In addition, the impact of remedial measures designed to improve water quality must be carefully balanced with protection of unusual metal-tolerant species, and the need to protect historic structures of archaeological significance.

2 POLICY AND REGULATION

As the following items are under continual discussion and negotiation, the Agency's views are likely to change. These comments are therefore provisional and do not form the Agency's definitive view.

2.1 Water Framework Directive (2000/60/EC)

The Water Framework Directive (WFD) is the most significant piece of European water legislation to be produced for over twenty years. It will rationalise existing water legislation and introduce an holistic integrated approach to water management in Europe based on the concept of river basin planning.

The major aims of the Directive are:

- to prevent further deterioration and protect and enhance the status of aquatic ecosystems and associated wetlands;
- to promote the sustainable consumption of water;
- to reduce pollution of waters from priority substances;
- to prevent the deterioration in the status and to progressively reduce pollution of groundwaters; and
- to contribute to mitigating the effects of floods and droughts.

The overall requirement of the WFD is to achieve "good ecological and good chemical status" by 2015 unless there are grounds for derogation. A case for a derogation can be made on the basis of the technical infeasibility or disproportionate cost of measures required to bring water bodies to good status. Derogations can enable extended deadlines or lower objectives. There is also a general "no deterioration" provision to prevent deterioration in status. These will require the management of the quality, quantity and structure of aquatic environments. The Directive also requires the reduction and ultimate elimination of priority hazardous substances and the reduction of priority substances to below set quality standards. Following transposition into UK legislation, the Agency will be the sole competent authority charged with implementation of the WFD in England and Wales.

2.1.1 River Basin Characterisation

A key aspect of the WFD is the identification of River Basin Districts (RBD) to which all surface and groundwater bodies will be assigned. For each RBD the Water Framework Directive requires:

- an analysis of its characteristics;
- a review of the impact of human activity on the status of the water bodies; and
- an economic analysis of water use.

By December 2004 each RBD must be characterised to describe the current and predicted future state of aquatic environments, to highlight the pressures and impacts on water bodies, and to inform:

- the setting of appropriate environmental objectives;
- the targeting of monitoring efforts towards those water bodies at greatest risk of failing to meet their stated objectives; and
- the establishment of programmes of measures to ensure water bodies reach the environmental objectives.

The initial characterisation exercise is currently being undertaken by the Agency to identify water bodies potentially at risk of failing to meet environment objectives as a result of a variety of activities and pollutants. Impacts from coal and metalliferous mining activities are being assessed using existing water quality databases, and information on mine locations. Preliminary results indicate that mining activities may be one of the most significant barriers to achieving the WFD objectives. It is expected that draft results from the initial characterisation will be published in September 2004.

The process of refining the initial characterisation and undertaking "further characterisation" will continue up to and beyond the delivery of the first River Basin Management Plans in December 2009. Dealing with diffuse historical mining pollution is expected to pose a considerable challenge.

2.2 Proposed Mining Waste Directive (2003/0107 COD)

In June 2003, the European Commission presented a proposal for a Directive on the management of waste from the extractive industries (referred to as the Mining Waste Directive (MWD) in this paper). The Mining Waste Directive seeks to improve the management of mining wastes by setting minimum requirements and specifically addressing the environmental and human health risks that may arise from the extraction, treatment and disposal of such waste.

The proposed MWD is being negotiated in the European Commission via the co-decision procedure. The first reading took place in the European Parliament on 31st March 2004 and preparation is continuing via the European Council Working Group for the first reading in the European Council. The Council is unlikely to complete the first reading during the Irish presidency and will therefore seek a political debate in council by June 2004. The following Dutch presidency is keen to continue the momentum of negotiations that the Irish started.

It should be noted that the original proposal referred to the management of waste and the waste facilities of operational sites only, but the amendments agreed in the first Parliamentary reading has extended the

Directive to the management of the extractive process and closed mining sites. It will need to be seen if these amendments are accepted in the European Council.

The Office of the Deputy Prime Minister (ODPM) is leading for the UK on the preparatory work, whilst the Department for the Environment, Food and Rural Affairs (Defra) has overall responsibility. The Agency is assisting ODPM and Defra in developing the UK position for these negotiations. Given the fluid nature of the negotiations, this paper is based on the position in early May 2004 which is likely to have changed by the date of the IMWA conference.

Although the Agency welcomes the objectives of the MWD, it has a number of concerns over the current proposal and the amendments proposed by the Environment Committee and voted for in the European Parliament. The Agency intends to continue to support ODPM and Defra to ensure these concerns are addressed and incorporated into the UK position for negotiation in Council and Parliament. Specific concerns include:

- many aspects of the proposal attempt to reproduce provisions of extant Directives, especially the WFD. The relationship between the MWD and other environmental legislation therefore requires careful clarification.
- the requirement for an inventory of closed sites. This would be an onerous task for the UK as it could potentially include very old mines (Roman sites etc). The current proposals for such an inventory are not based on risk, appear to partially reproduce elements of the Water Framework Directive, and may therefore undermine that Directive.
- whether the excavation void will attract the full requirements of the MWD.
- the lack of a time limit for on-site storage of mineral waste meaning the full requirements of the Directive apply to stored material.
- the scope of the MWD, for example the impact of the 'Avesta Polarit Chrome' European Court of Justice ruling. This relates to the backfilling of the excavation void by certain materials which may, as a result of the ruling, fall out of the requirements of the Waste Framework Directive and the MWD although such material can potentially be polluting, and therefore may be subject to the Groundwater Directive.

ODPM has instigated discussions on transposing the Directive into UK legislation, and at present the Competent Authorities who will be responsible for implementing the MWD are the Mineral Planning Authorities, and the Health and Safety Executive. The impact of the MWD on the Agency's regulatory activities remains to be determined. It is

possible that the Pollution Prevention and Control (PPC) regime, used in the UK for permitting landfills and other industrial facilities may be applied to mining activities in future, not least since the MWD was developed to complement the Waste Framework Directive (which PPC implements in part), however this has yet to be decided.

2.3 Spoil disposal and the Groundwater Regulations, 1998

In March 2001, guidance on the Groundwater Regulations was issued by the UK Government (DETR 2001). Paragraphs 75 and 76 addressed the disposal of spoil, and discharges from abandoned mines. The Agency's Head Office Groundwater Quality and Protection teams are currently developing guidance on the use of the Groundwater Regulations to authorise the disposal of mining spoil containing List I and II substances. Similar guidance for Scotland has recently been published by the Scottish Environment Protection Agency (Younger & Sapsford, 2004) The Agency has already authorised two colliery spoil disposals with further applications expected. In conjunction with this work, the Agency's charging scheme for such solid disposals is being reviewed to produce an application and subsistence charge based on volume and risk.

2.4 National Mining Group

Working with the Coal Authority at a national level has enabled prioritisation for remediation of discharges from coal mines to be agreed (Tate 2002). However it is only relatively recently that a national approach has been taken to coal mining at an operational level, whilst work on a national strategy for metal mines in England has only recently begun (following the strategy for Wales published in 2002). The Agency has now formalised the structure of its National Mining Group with representatives from Head Office Policy, Process and Science working with operational staff to ensure national consistency. The focus remains on coal mining since this group was created in response to the Memorandum of Understanding signed with the Coal Authority, however efforts are being made to widen the scope to address impacts from metal mining. This group will help the Agency respond to the challenges posed by the Water Framework Directive and potentially the Mining Waste Directive, and encourage the efficient exchange of information across the country.

The Coal Authority's investment programme has resulted in a growing number of schemes using wetlands to treat coal mine discharges with significant improvements in surface water quality as a result. Whilst the

impact of rising groundwater in coal mines is being carefully monitored in order to predict breakout of mine water at the surface and to protect groundwater in overlying aquifers (e.g. Permo-Triassic Sandstone, Magnesian Limestone), a full understanding of the risks from minewater rebound remains elusive. The Agency is working with the Coal Authority to develop a prioritisation scheme for rebound into overlying aquifers which draws on the existing system for discharges to surface waters.

2.5 Landfill Directive (1999/31/EC)

The implementation of the Landfill Directive will severely limit the disposal of sludges to landfill since low density sludges (often as low as 5% weight/weight solids) may be classed as liquid wastes, and the availability of landfill for hazardous wastes (e.g. due to heavy metal concentrations) will be severely restricted. Furthermore, excavating abandoned mine spoil for disposal to landfill as part of remediation schemes will become increasingly expensive if the waste is classed as hazardous.

3 MINING POLLUTION SCIENCE STRATEGY

Following the creation of the Agency's Science Group in October 2003, a greater emphasis has been placed on an integrated strategic approach to many key science challenges such as mining pollution, considering contaminant fluxes across different media, and at both the catchment and local scales.

To facilitate development of a science-based strategy for mining pollution and support research to underpin the Agency's current and future regulatory responsibilities, the *Environment Agency Research Fellowship for Mine Waters and Wastes* has been created in collaboration with the University of Newcastle. Dr. Adam Jarvis has been appointed to provide the focus for the Agency's research into mining pollution for the next three years, particularly to develop understanding of the hydrological and biogeochemical processes associated with minewater rebound and mine spoil weathering/leaching, place these within the context of diffuse pollution management strategies at both local and catchment scales, and promote the sustainable management of mining wastes and waters.

One of the main goals of this strategic science programme will be to increase the transfer of knowledge on mining pollution between academia, practitioners, the Coal Authority, and industry within the UK. This will be

achieved by participating in existing research activities, directly funding new research, and collaborating with other funding bodies.

As the Agency prepares to implement the WFD, the need for an improved scientific understanding of mining pollution is imperative. Diffuse pollution requires creative regulation and innovative approaches to remediation due to the difficulties associated with treatment at source. The role of the Science Group is to ensure the Agency's regulatory and policy approach is scientifically-based, and to facilitate the transfer of knowledge from academia and other external initiatives into the Agency, for example, the guidelines for catchment scale management of mining impacts recently produced by the European Commission 5th Framework ERMITE project (Younger & Wolkersdorfer 2004).

4 GREENSIDE MINE CASE STUDY: REGULATION OF INVESTIGATION AND REMEDIATION

Greenside Mine is located within the Lake District National Park, NW England (Figure 1). It covers some 60 hectares of an upland area exposed to heavy rainfall (around 2.5 metres/year) in a steep-sided valley 5km upstream of Ullswater Lake. The mine site is located within an Area of Outstanding Natural Beauty and is a Scheduled Ancient Monument. Ullswater Lake is a Site of Special Scientific Interest, a protected ecosystem notified under the Wildlife and Countryside Act 1981.

Mining for lead commenced in the late 17th century and from 1860, ore crushing, processing and smelting activities were located above the confluence of two streams (Tyler 1998). Tailings from the mill were originally discharged directly to the streams until around 1940, when the complaints of residents living downstream led to the construction of two tailings dams in 1940 and 1952. These dams were abandoned in 1962 and a number of attempts were made to stabilise them by revegetation. A flank of the younger of the two dams collapsed during a period of heavy rainfall in winter 1989, and released metal contaminated tailings into the adjacent stream that discharges into Ullswater Lake. This event left a scar that is open to further erosion and greater instability (Figure 1).

Fig. 1. *Location map for Greenside Mine, and view east towards Ullswater showing collapsed tailings dam and erosion of spoil heaps*

The mine buildings were constructed on terraces built on scree and retained by a number of walls (Figure 2). The North West Regional Development Agency has provided funding to the Lake District National Park Authority (LDNPA) to repair and rebuild the retaining walls to protect public safety. Environmental risks are equally important and the Agency is working in partnership with LDNPA to investigate, and where necessary remediate, potential sources of pollution.

Both diffuse and point source discharges from the mine site are known or inferred including:

- minewater discharge from the Lucy level;
- piped discharges from the tailings dams;
- leaching from mining spoil;
- seepage from the tailings dams into the scree;
- release of contaminated leachate and tailings from erosion of the dams; and
- secondary sources from contaminated sediments.

Investigations carried out by the Agency (and its predecessor bodies) have revealed elevated levels of arsenic, cadmium, copper, lead, zinc and barium in the soils and tailing dams at Greenside Mine. The dams were constructed using the "upstream" method and comprise an outer embankment slope of loose to medium dense sand and an inner core of variably laminated, very soft, sandy silts and clays. The perched leachate in both dams results in contaminated discharges to surface waters and reduces the stability of the dams.

Fig. 2. *Complex retaining walls at Greenside Mine, and collapsed tailings dam*

Reports commissioned by the Agency in the late 1990s raised concerns

about the consequences of the continued accumulation of contaminated sediment in deeps within Ullswater Lake (IFE 1999; EA undated). Ullswater does not have uniform bathymetry but is divided into three basins, or deeps, to a depth of around 60 metres below the lake's surface. Filamentous blue-green algae dominate in Ullswater during late summer blooms, and these are known to rapidly sink when conditions are unfavourable for growth. Intense deoxygenation of the deep water in the lake basin is caused by bacterial degradation of the algae. As a result, the lowering of redox potential in sediments has the potential to remobilise heavy metal contaminants. Excessive loading of metals and increased eutrophication of the lake could exacerbate the detrimental impact on

water quality and affect the population of a protected fish species, the Schelly, which occupies the deeps during warm weather. The change in water chemistry could also impact on a drinking water supply, recreational use of the lake and salmon fisheries. The Agency's approach to deal with this issue has involved a campaign to lower the nutrient loading, and remediation of the collapsed tailings dam to decrease the contaminated sediment load reaching the lake.

The tailings dam could potentially have been inspected and determined as contaminated land under Part IIA of the Environmental Protection Act 1990 (contaminated land legislation implemented in England and Wales in April 2000). However, as the tailings dam was in an unstable condition it was decided to expedite works using powers under section 161 of the Water Resources Act 1991 (WRA). Funding for urgent remediation works was therefore secured by the Agency to prevent pollution of controlled waters from uncontrolled collapse of the tailings dam releasing contaminated sediment to Glenridding Beck and Ullswater Lake.

Remedial works were planned to commence during summer 2001, but the outbreak of Foot and Mouth disease restricted all access to the site. Remedial works were delayed until May 2002 and completed by September 2002. The remediation has two overall objectives:

1) to reduce existing contamination of surface waters; and
2) to prevent further collapse and erosion of the tailings dam that could endanger life and property and cause widespread water pollution.

A number of options for remediation of the tailings dam were considered before agreeing a design comprising:

- construction of French and surface water drains upslope of the dam to intercept run-off and shallow groundwater ingress from the scree;
- construct retaining wall sections and cut-and-fill to reduce the slope of the dam, fill the failure void, and engineer a backfall from the crest to the drain to encourage run-off;
- a capping system on the top of the dam comprising a soil cover;
- revegetation; and
- repair of the under-cut revetments along Swart Beck.

During investigation of the tailings dam a number of contaminated discharges were observed from both dams and from the mine drainage level. Stream sampling also confirmed Environmental Quality Standards for lead and zinc were exceeded upstream of the tailings dams and mine discharge, and indicate that there may be significant additional sources of contamination in the upper catchment. Following on from the urgent

remedial works there is now a need to investigate the stability of the older tailings dam and assess other potential sources in terms of contaminant concentration and loading to Swart and Glenridding becks.

Under the current regulatory regime, any polluting discharges from the tailings dams or waste rock would be dealt with under Part IIA if "significant pollutant linkages" can be demonstrated. Any mitigation of impacts from the minewater discharge (Lucy level) would have to be addressed under different legislation (s161 of the WRA) and would have to be balanced against the impact of discharges from diffuse sources. Funding would also need to be sourced for long-term monitoring and maintenance of the tailing dams, including surface water and French drains, to manage both public safety and environmental risks. The mine is currently being inspected by the local authority to determine whether all or part of the site can be determined as statutory contaminated land.

The Water Framework Directive requires member states to "protect and enhance the status of aquatic ecosystems"; for mine-impacted catchments this objective would be best served by taking an integrated approach to the assessment, monitoring and remediation of the mine site and catchment impacted by all point and diffuse sources of pollution. When orphan sites are causing catchment-scale impacts, there may be a case for de-coupling the funding for investigation and remediation from the legislative drivers (e.g. Part IIA) to encourage effective management of complex abandoned mine sites.

5 CONCLUSION

The legacy of mining in the UK could be a significant barrier to achieving Water Framework Directive goals since mine waters are the major cause of pollution in many catchments. The Agency is working with government to influence and improve the proposed Mining Waste Directive. These new Directives, and implementation of existing legislation, pose challenges for the remediation of mining pollution but also offer opportunities to improve awareness of the impact of minewaters and wastes and therefore obtain real improvements to the aquatic environment.

The Environment Agency has created a three year *Research Fellowship for Mine Waters and Wastes* in collaboration with the University of Newcastle which will form the focus for a new strategic approach to mining pollution by implementing a nationally co-ordinated science and research programme. This will benefit the Agency and the UK by developing understanding of the hydrological and geochemical processes

associated with minewater rebound and mine spoil weathering/leaching, place these within the context of diffuse pollution at both local and catchment scales, and promote the sustainable management of mining wastes.

A case study (Greenside Mine, Lake District) is presented to illustrate the difficulties of using existing legislation to deal with diffuse and point sources of pollution typified by historic mining activities. Mechanisms for funding the remediation of orphan sites need to be reviewed if the more integrated approach required for the Water Framework Directive is to be successful.

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7 DISCLAIMER

The views expressed in this paper are not necessarily those of the Environment Agency. Its officers, servants or agents accept no liability whatsoever for any loss or damage arising from the interpretation or use of the information, or reliance upon views contained herein.

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