Institution: Newcastle University

Unit of Assessment: UoA14 Civil and Construction Engineering

Title of case study:

Best policy, scientific practice and engineering solutions for mining-polluted river systems

1. Summary of the impact

Research into the characteristics and remediation of mining pollution has had sustained and significant impacts (2008 - 2013) on environmental policy and practice at regional, national and international scales. Impacts, all with documentary evidence, include:

- Defining locations for engineering interventions to manage pollution in the economically important River Tyne and its estuary (**S1**).
- Triggering, and supporting delivery of, multi-million pound government investment in remediation of mining pollution nationally (**S2, S3, S4**).
- Determining design of the first large-scale 'passive' metal mine drainage treatment system ever built in the UK (**S3, S5**).
- Ensuring European mining pollution issues are properly addressed in production of definitive international guidelines on mining pollution management (**S6**).
- Shaping of public policy and practice for management of water in mining regions of Peru and Honduras via international advisory roles (**S7, S8**).

2. Underpinning research

Key research insights relating to impact:

Establishing metal sources and flux in mining-polluted catchments under varying hydrological conditions: A key research achievement of the Newcastle University (NU) team (previously referred to as the HERO Group) relates to the sources, significance and fate of metal contaminants from, and within, mining catchments (2004 – present; **G3**, **G5**, **G7**). Carefully designed experiments comprising simultaneous river flow and quality measurements, with equivalent measurements of polluting discharges, illustrated the importance of diffuse sources of mining-related pollution and also the substantial metal fluxes to freshwaters occurring during periods of high flow (e.g. **O1**). Impacts are in Section 4(B). More detailed research on metal fluxes in the River Tyne catchment (**G5**) revealed the critical role of abandoned mine pollution in determining metal levels in estuarine sediments, with implications for estuary dredging operations specifically, and catchment management more generally (2009 - 2011). Sensitivities surrounding the economic implications of the findings mean that this research is commercial-in-confidence. Impacts are in Section 4(A).

Quantifying the scale and impacts of mine water pollution: The first ever assessment of the scale and impacts of abandoned base metal mines on freshwater systems of England and Wales was undertaken by the NU team (2007 - 2009; **G3**), developing an impact assessment methodology founded primarily on hydrochemical data and hosted on a GIS (**O2**). This was successfully applied across the nation (2009 - 2010) to highlight key regions affected by mining-related pollution, and continues to be used by the Environment Agency (EA) (Section 4(B)). Careful interrogation of the data revealed the very substantial scale of abandoned mining pollution in England and Wales for the first time: the problem affects 7-8% of all waters in England and Wales, and it is responsible for at least 50% of all the metals in our freshwaters (**O3**).

Developing novel passive treatment systems for metal-polluted waters: The NU team's development of sustainable ('passive') mine water treatment systems initially investigated coal mine water treatment (e.g. **G1**), but more recently the main contaminants in abandoned base metal mine drainage have been the focus (**O4, G6, G7**). The research focused on enhancing rates of bacterial sulphate reduction in compost bioreactors in particular, and demonstrated the potential for successful treatment in much smaller systems than previously thought possible. Impacts are in Section 4(C).

Policy and management research in catchments impacted by mining: Starting from experiences in the UK, the NU team worked with the European Commission services and WWF policy unit at the interface between the Water Framework Directive (WFD) and Directive on Mining Waste (2001 – 2004; **G2**), producing the first published guidelines on management of catchments with mining (**O5**), and experiencing first-hand European policy-making. In 2005 - 2010 the group continued this line of research in European projects (e.g. **G4**) with groups in Peru, Chile and Bolivia. These projects also involved the production of general guidelines in Spanish (UNESCO) and specific policy guidelines for the research catchments (**S8**). Key aspects of this research were published in **O6**. Impacts are in Section 4(E). Impacts from coupling of policy and technical insights are in Section 4(D).

Names of key researchers and positions held:

Dr Jaime Amezaga: RA, 1999 – 2002, SRA, 2002 – 2007, Senior Lecturer, 2007 on
Dr Adam Jarvis: Environment Agency Research Fellow, 2004 – 2007; Senior Lecturer, 2007 – 2013; Reader, 2013 on
Professor Paul Younger: Reader, 1999 - 2001, Professor, 2001 – 2012
Dr Catherine Gandy: RA, 2002 on; Dr Will Mayes: RA, 2003 – 2009; Dr Tobias Rötting: RA, 2007 - 2010

3. References to the research

Key outputs (*Note: Key publications are O3, O4 and O6*):

[O1]Gozzard E, Mayes WM, Potter HAB, Jarvis AP (2011) Seasonal and spatial variation of diffuse (non-point) source zinc pollution in a historically metal mined river catchment, UK. Environ. Pollut., 159, 3113-3122.
[O2] Mayes WM, Johnston D, Potter HAB, Jarvis AP (2009) A national strategy for identification, prioritisation and management of pollution from abandoned non-coal mine sites in England and Wales. I. Methodology development and initial results. Sci. Total Environ., 407(21), 5435-5447.
[O3] Mayes WM, Potter HAB, Jarvis AP (2010) Inventory of aquatic contaminant flux arising from historical metal mining in England and Wales. Sci. Total Environ., 408, 3576-3583. (*Quantifies, for the first time, impacts and extent of metal mine pollution nationally)*
[O4] Mayes WM, Davis J, Silva V, Jarvis AP (2011) Treatment of zinc-rich acid mine water in low residence time bioreactors incorporating waste shells and methanol dosing. J. Hazard. Mater., 193, 279-287. (*Demonstrates scientific principles of novel passive treatment prior to scale-up)*
[O5] ERMITE Consortium (2004) Mining impacts on freshwater environments. In: Mine Water Environ., 23 (Supplement 1), S2-S80.
[O6] Amezaga JM, Rötting TS, Younger PL, Nairn RW, Noles A-J, Oyarzún R, Quintanilla J (2011) A rich vein? Mining and the pursuit of sustainability. Environ. Sci. Technol., 45, 21-26. (*Illustrates underlying principles of best international environmental policy and practice)*

Key research grants (PI in parentheses):

[G1] EC FP5, 2000-03, PIRAMID: Passive In-situ remediation of acidic mine / industrial drainage, €1.5M (Younger)
[G2] EC FP5, 2001-04, ERMITE: Environmental Regulation of Mine waters in the European Union, €1M (Amezaga)
[G3] Defra / Environment Agency, 2007 – 09, Identification and prioritisation of abandoned non-coal mine pollution (NoCAM), £200K (Jarvis)
[G4] EC FP6, 2007-10, CAMINAR: Catchment management and Mining Impacts in Arid and Semi-arid South America), €1.8M (Amezaga).
[G5] Port of Tyne Authority / Environment Agency / Newcastle City Council / ONE North East / North Tyneside Council, 2009-11, River Tyne sediment study, £220K (Jarvis)
[G6] EA/Defra, 2009-12, Mitigation of pollution from abandoned metal mines, £267K (Jarvis)
[G7] Coal Authority, 2012-13, Non-coal mine water pollution programme, £278K (Jarvis)

4. Details of the impact

Research into the characteristics and remediation of mining pollution has had sustained and significant impacts on policy and practice at regional, national and international scales. Examples of impacts within the period 01/08 – 07/13, all with documentary evidence, include:

(A) Regional impact on the economy and environment

On research undertaken by the Newcastle University team on the River Tyne the Minister for the North East of England at the time of the impact, commented that (**S1**):

> "*… our hopes for the regeneration of industrial Tyneside, and the thousands of jobs that already rely on that regeneration, are underpinned by the work you have undertaken"*

This impact arose from applying research findings (e.g. **O1**) on metal fluxes under varying hydrological conditions (2010 - 2012), and demonstrated that metal pollutants in estuarine sediments of the River Tyne are associated with abandoned mines 60 km upstream, not contemporary industry located on the banks of the estuary. This has critically shaped plans for engineering interventions to address the problems (**S1**).

(B) National impact on policy makers and the environment

NU research (**O2**, **O3**) demonstrated that 8% of all waterbodies in England and Wales fail to meet EU WFD objectives due to pollution from abandoned mines (**S2**). This directly informed Defra's decision to release £10.5M of funding to the EA (**S3**) in 2011, specifically to monitor pollution effectively and construct new treatment systems. NU has had a major impact in both areas of work, as detailed below. Abandoned metal mines are explicitly mentioned (page 37) in HM Government's White Paper on water (December 2011) as a result of the NU team's quantification of the problems, and data from the team's research is used in the White paper (**S4**). In allocating these funds to specific activities the Deputy Chief Scientific Adviser at Defra stated (**S3**):

> *"..in utilising £1.2 million of this funding (during 2012 – 2013) the Environment Agency has directly adopted the monitoring practices recommended by the Newcastle University team..*"

and, in relation to the first large-scale passive mine water treatment system to be built, that

> "*funded from Defra's £10.5 million investment, via the Coal Authority, the treatment process and system size were directly determined by the Newcastle team …*"

These are clear statements of the impact of the team's research from 2009, in influencing government policy and investment in environmental problems, on the environment regulator's practices in addressing this form of pollution, and on the engineering solutions adopted for treating mine water pollution (more details below).

(C) National impact on practitioners and the environment

The UK Coal Authority (CA) engaged the NU team (2011) to lead on the design of the first ever large-scale passive metal mine water treatment system in the UK, a £1M system that commenced construction in September 2013. The Director of Operations at the Coal Authority acknowledges that (**S5**):

> "*The overall treatment process, including treatment unit type and size, was determined by Newcastle University following research and development by the research team between 2009 and 2012 …"*

This will be the blueprint for schemes in the coming decades (**S5**). The treatment system is a *directly* scaled up version of the bioreactors developed through research (**G6**, **G7**, **O4**), thus clearly linking the research and impact.

The EA is undertaking nationwide investigations (from 2012) of mining-polluted river catchments, at a cost of £1.2M (**S3**). The catchments were selected directly from NU research (**G3**, **O2**). The EA has modified its approach to monitoring based on the NU team's recommendations in light of its research on diffuse pollution (**O1**, **S3**). Recognising the importance of the work, both EA and CA engaged the NU team to deliver training courses (2010 – 2011) on mining pollution to 75 of their organisations' staff i.e. virtually all of their staff involved in mining pollution. The CA has commented on these training courses that *"… no other organisation has provided more technical training to our staff … than the Newcastle University team"* (**S5**).

(D) International impact on practitioners

Internationally, the Global Acid Rock Drainage (GARD) Guide was an initiative of the world's major mining houses. The GARD Guide is the first comprehensive international guidance document on mining pollution management. A web-based document (http://www.gardguide.com), as at 04/2013 the GARD Guide had been accessed by 161,000 users, 176,000 by 06/2013 (**S6**), 193,000 by 08/2013, and 206,000 by 10/2013. Two members of the NU team sat on the committees that shaped both the structure and content of the Guide (2008 – 2009), and so the team is indirectly having a continuing impact on the practice of thousands of professionals worldwide.

That NU was the only organisation in the world to be represented twice on these committees (http://www.inap.com.au/committees.htm) is recognition by the international mining community of the impact of the team's applied research, and a reflection of the team's unique understanding of both technical and policy issues related to mining pollution in Europe (**S6**). The multinational mining company Rio Tinto stated that (**S6**):

> "*…there is no question that the Newcastle University team has had a worldwide impact on the practice of professionals in the mining sector dealing with mine water pollution*"

The clear influence of the NU team is further made plain in Section 1, Chapter 1 of the GARD Guide: *"The target audience is adapted from a model developed by the PIRAMID Consortium (2003)"*; a reference to the major output, authored by the NU team, of an EC project led by NU (http://www.imwa.info/piramid/files/PIRAMIDGuidelinesv10.pdf; **G1**). The GARD Guide also references the team's policy work, such as **G2** (**O5**).

(E) International impacts on public policy and services

Underpinned by research in Europe and the Americas (**G2**, **G4**, **O6**), NU's work in the Arequipa region of Peru had impacts on public policy and services; the team led the formation of an official advisory group which wrote guidelines on river basin management in mining areas for the Arequipa region, with involvement from all key stakeholders (**S8**).

Because of this expertise the NU team has been engaged by the Catholic Agency for Overseas Development (CAFOD) Andean Programme (2012 – 2013) to provide policy advice and support to local authorities and civil society in one of the highest profile mining conflicts in Peru (Tintaya mine, Espinar), and were officially accepted by the environmental working group set up by the Prime Minister's Office (**S7**), with participation of three Ministries, to resolve these issues (**S7**). Consequently the team has had direct impact on the establishment of long-term monitoring programmes, definition of regional policies overseas, and the practices of NGOs, as recognised by CAFOD, that comments (**S7**):

> "*Working with Newcastle University has opened a series of different options and strategies for changing government policy and practice which had previously been closed to NGOs*"

5. Sources to corroborate the impact

[S1] Testimonial from former Minister for the North East of England
[S2] see http://www.environment-agency.gov.uk/business/topics/pollution/36564.aspx
[S3] Testimonial from Deputy Chief Scientific Adviser, Defra
[S4] HM Government's White Paper on Water (Dec 2011), Figure iv, page 30, and page 37 (http://www.official-documents.gov.uk/document/cm82/8230/8230.pdf)
[S5] Testimonial from Director of Operations, Coal Authority.
[S6] Testimonial from Global Practice Leader, Energy, Environment and Climate Change, Rio Tinto
[S7] Testimonial from Head of Latin America & Caribbean, Catholic Agency for Overseas Development (CAFOD)
[S8] Jiménez P, Amezaga J, Rötting T, Guzmán E (2010) El Río Chili: Cuenca Árida con presencia minera. Universidad Nacional de San Agustin. ISBN: 978-612-45662-1-9.