Low maintenance options and challenges for the collection and interception of mine drainage

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Introduction

- Vast majority of mining operations in UK now abandoned
- Legacy of abandoned deep coal and metal mines and waste rock piles
- Liabilities typically absent, particularly for mines closed prior to 1st January 2000 (legal loophole which made it very difficult to prosecute former mine owners before this date)
- UK Coal Authority has remit to address environmental problems from deep coal mines of former nationalised coal mining industry
- No such body for abandoned metal mines or for waste rock piles, and therefore remediation initiatives tend to be piecemeal

Collection of mine drainage

Typically in the UK decisions on how to intercept / collect drainage have been driven by:

1)Prevention of groundwater rebound due to uncertainty of consequences / how to deal with the consequences:

→ *PUMPING WITHOUT TREATMENT*

2)Prevention of pollution of overlying aquifer by rising mine waters:

→ *PUMPING WITH TREATMENT*

3)Ensuring mine drainage emerges at surface in a location suitable for treatment / prevention of pollution of surface waters by uncontrolled discharges:

→ *PUMPING WITH TREATMENT*

4)Requirement for minimal capital and revenue costs for treatment of long-running uncontrolled surface discharges

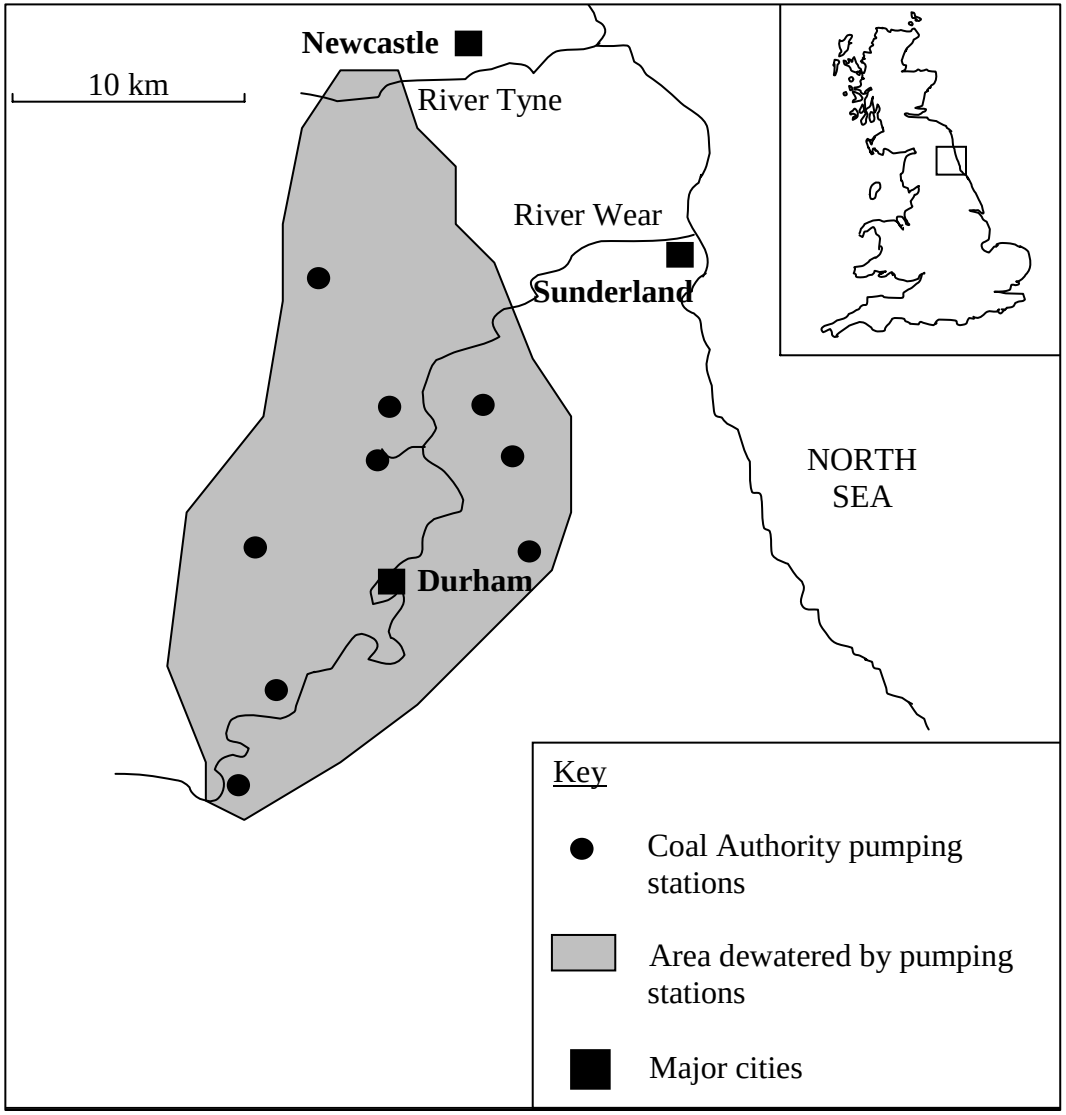
→ *GRAVITY DRAINAGE WITH TREATMENT*

Regional dewatering

Kimblesworth mine water pumping station, one of a number installed to prevent mine water rebound across the former coalfield of eastern County Durham.

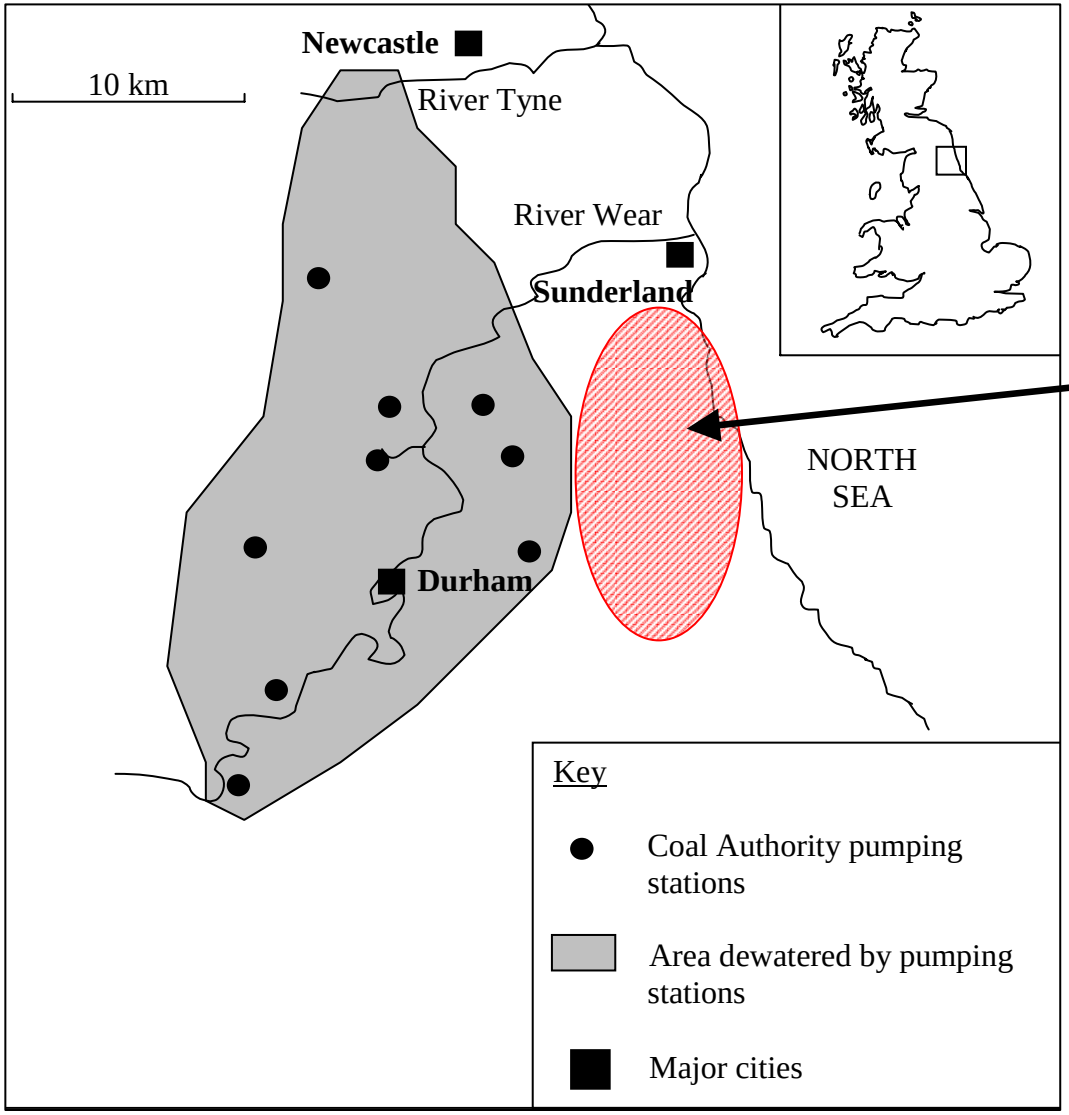
Approx. 10 ML/d of marginally contaminated water (~ 3 mg/L Fe)

Regional dewatering



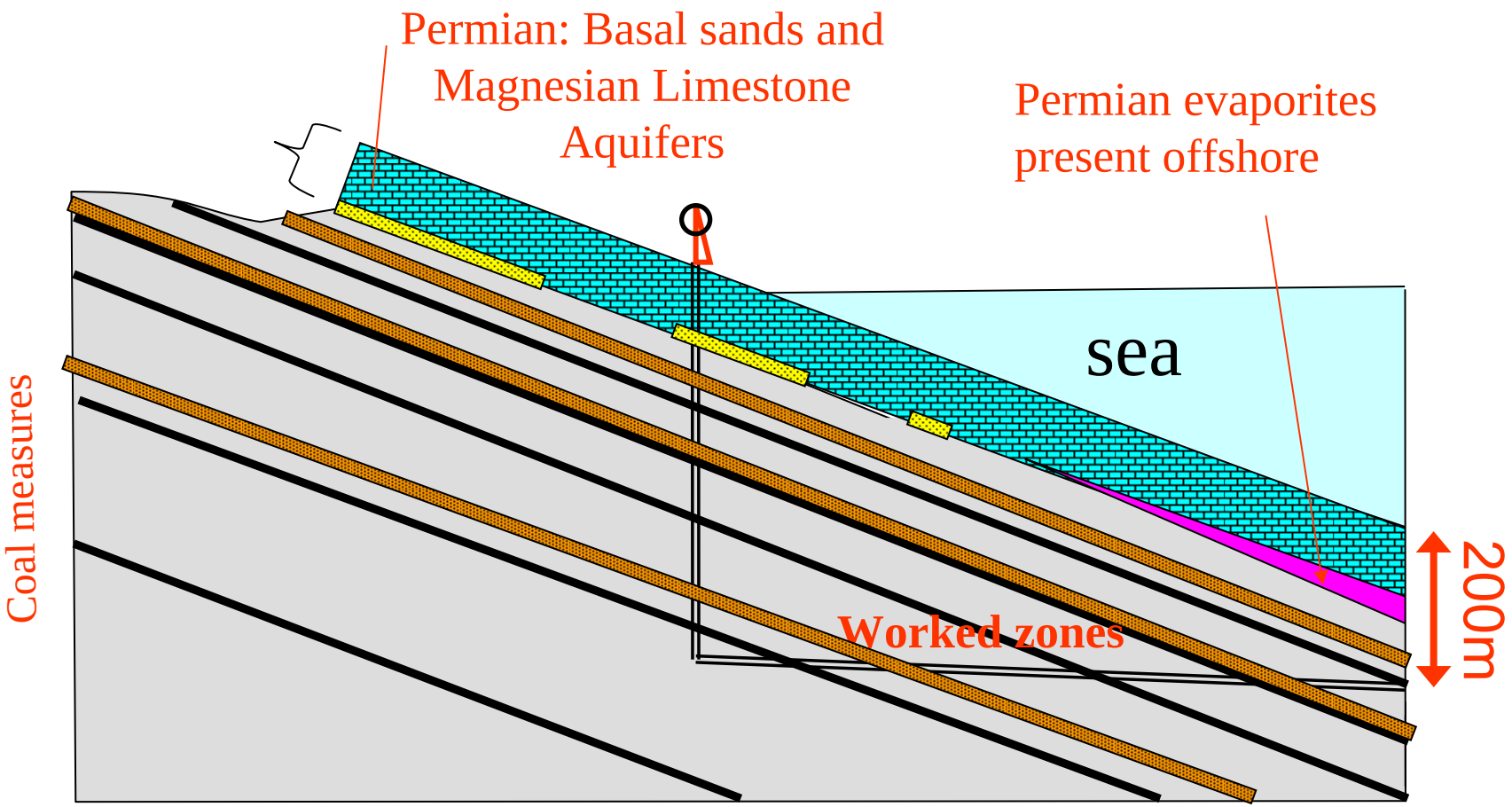
- Regional dewatering of coalfield originally comprised 9 pumping stations
- ~100 ML/d dewatered, at a cost of ~£1 million / annum
- Gradual reduction in number of stations and volume pumped, allowing controlled mine water rebound

Aquifer protection



- The last mines closed in County Durham were in the east of the region, beyond influence of regional dewatering
- Therefore rebound occurred, threatening overlying magnesian limestone aquifer, a major source of potable water

Aquifer protection



Aquifer protection

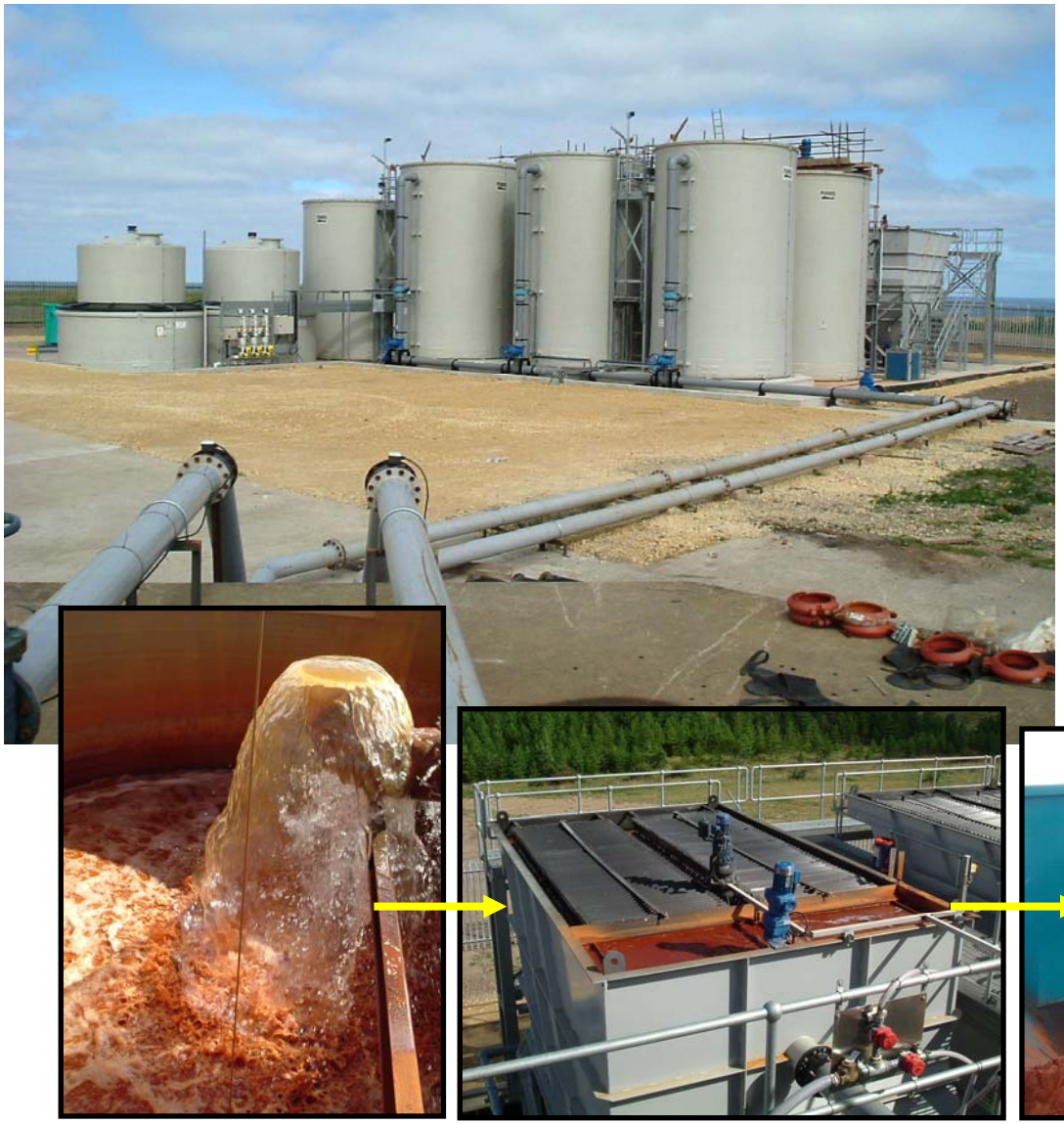
Real threat to water supplies in this case was salinity of mine water, due to dissolution of evaporites offshore

TDS of mine water = ~100,000 mg/L

cf. sea water = ~35,000 mg/L

Fe *ca.* 100 mg/L

Aquifer protection



- The UK Coal Authority's Unipure plant at Horden, County Durham. A multi-million pound pump-and-treat scheme to protect the magnesian limestone aquifer
- Objective is to remove iron, with disposal of treated water to sea due to elevated chloride

Pump-and-treat

- The majority of the UK Coal Authority schemes (of which there are ~50 in total) comprise pumping to surface followed by gravity drainage through passive treatment units (aeration cascades, settlement lagoons and wetlands)

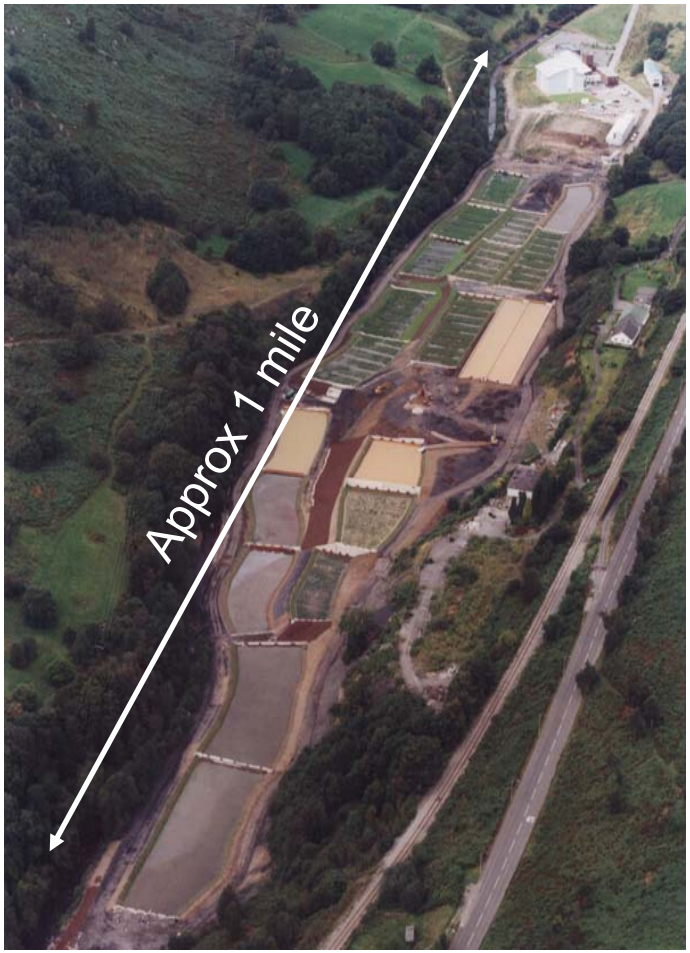
- Reasons for pumping:
  - uncertain location of uncontrolled discharge if mine water rebound allowed to occur
  - generate hydraulic head
  - space restrictions necessitates inlet to treatment system at particular point
  - controllable flow-rate, with option for 'down-time' because of storage capacity in mine workings

- Despite additional costs of pumping, gravity-drainage treatment through passive units tends actually to be the exception rather than rule in the UK

Pump-and-treat

Coal Authority's Whittle scheme. Mine water is pumped from a shaft to the aeration cascade at the top of a steep-sided valley, such that mine water can then drain through a settlement lagoon and series of terraced wetlands down the valley side.

Pump-and-treat



Coal Authority's Taff Merthyr scheme, south Wales. The largest mine water treatment system in the UK, only possible due to availability of large tract of land in valley bottom

Gravity drainage with treatment

- Not actually that many examples of this in the UK

- In the UK, discharges amenable to gravity drainage and treatment tend to be:
  - comparatively low volume (5-10 L/s)
  - discharges with land available at a lower elevation
  - long-running, uncontrolled discharges
  - discharges outside the remit of the Coal Authority
  - discharges which have attracted complaints from local residents / community groups

- As it turns out systems are typically both full-scale and also experimental to a degree, often treating acidic waste rock drainage

Gravity drainage with treatment

Quaking Houses compost wetland

- A small compost wetland (horse manure, municipal waste compost) treating acidic, iron and aluminium rich, waste rock drainage
- A charitably funded project, designed by Newcastle University in liaison with the local community environmental group, which had raised the profile of the problem with the regulator
- Discharge arises as a pipe outfall from the base of the waste rock pile of a former coal mine
- Originally constructed in 1997 for approximately £50 000.

Gravity drainage with treatment

Quaking Houses compost wetland

Gravity drainage with treatment

Quaking Houses compost wetland

- Hydraulic head generated by blocking culvert and therefore raising water level
- Overflow facility since pipe also receives surface drainage, and therefore variable flow

Gravity drainage with treatment

Quaking Houses compost wetland

Gravity drainage with treatment

By 2006, wetland inundated due to accumulation of dead plant material – clear maintenance issue

Therefore totally renovated in late 2006, at a cost of approx. £100 000.

Gravity drainage with treatment

Bowden Close Reducing and Alkalinity Producing System

- Generally a preferred option where hydraulic head permits (more required than for compost wetland), due to smaller area footprint requirement

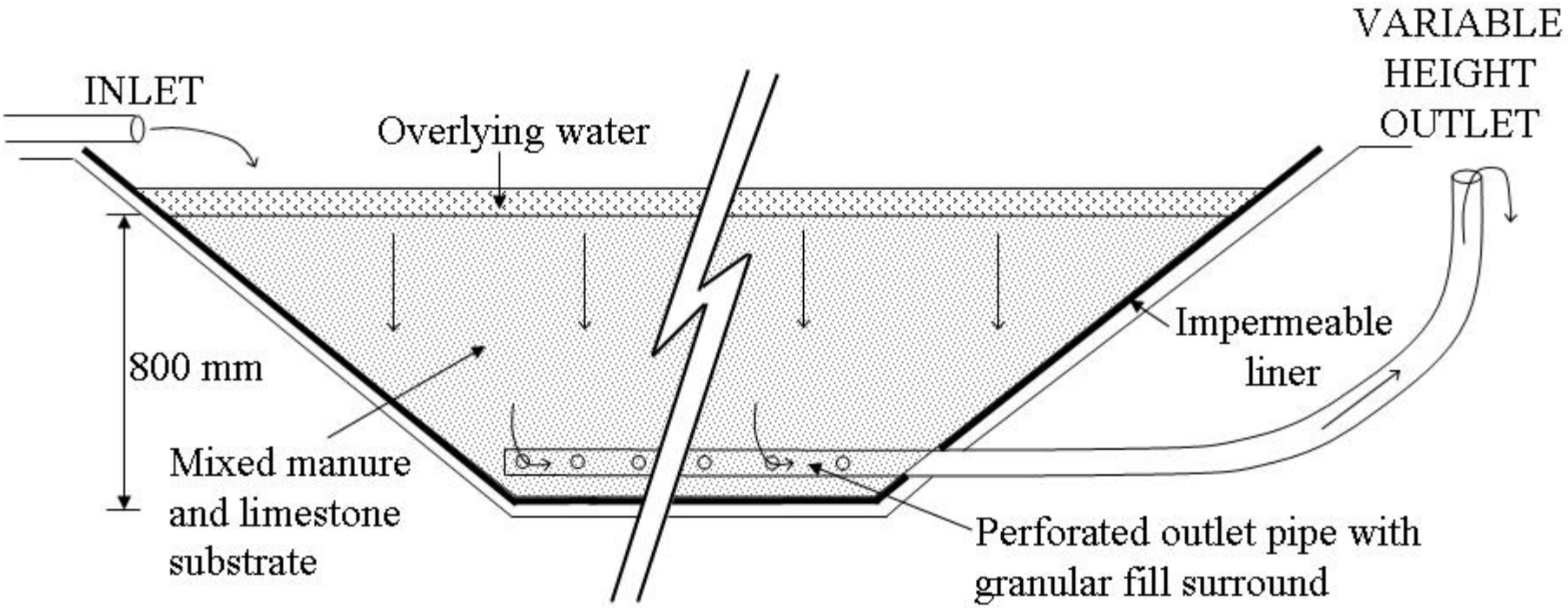
- Bowden Close system was second RAPS in UK, and first to function as designed in the medium- to long-term

- At *ca.* £200 000, higher cost than Quaking Houses system, due to greater earth-moving, concrete structures (manhole chambers etc) and pipe work.

- Intercepts (by gravity) 3 separate drainage features, from both underground workings and waste rock

Gravity drainage with treatment

Bowden Close Reducing and Alkalinity Producing System



Conceptual illustration of
RAPS operation

Gravity drainage with treatment

Construction (above) and completion (right) of Bowden Close RAPS system

Gravity drainage with treatment

Shilbottle Permeable Reactive Barrier (PRB)

- Diffuse drainage through a coal waste rock pile in the shallow subsurface, entering a stream running parallel to the waste rock

- Highly acidic (pH < 3) and metal-rich (500 – 1000 mg/L Fe; 200 mg/L Al and Mn), with flow-rate up to 10 L/s

- Intercepted with 100 m long, 2 m deep and 3 m wide trench at toe of waste rock pile, backfilled with compost limestone mix

- Followed by settlement lagoons and (pre-existing) wetland to remove metals (the space for which was made available by permanently diverting course of stream)

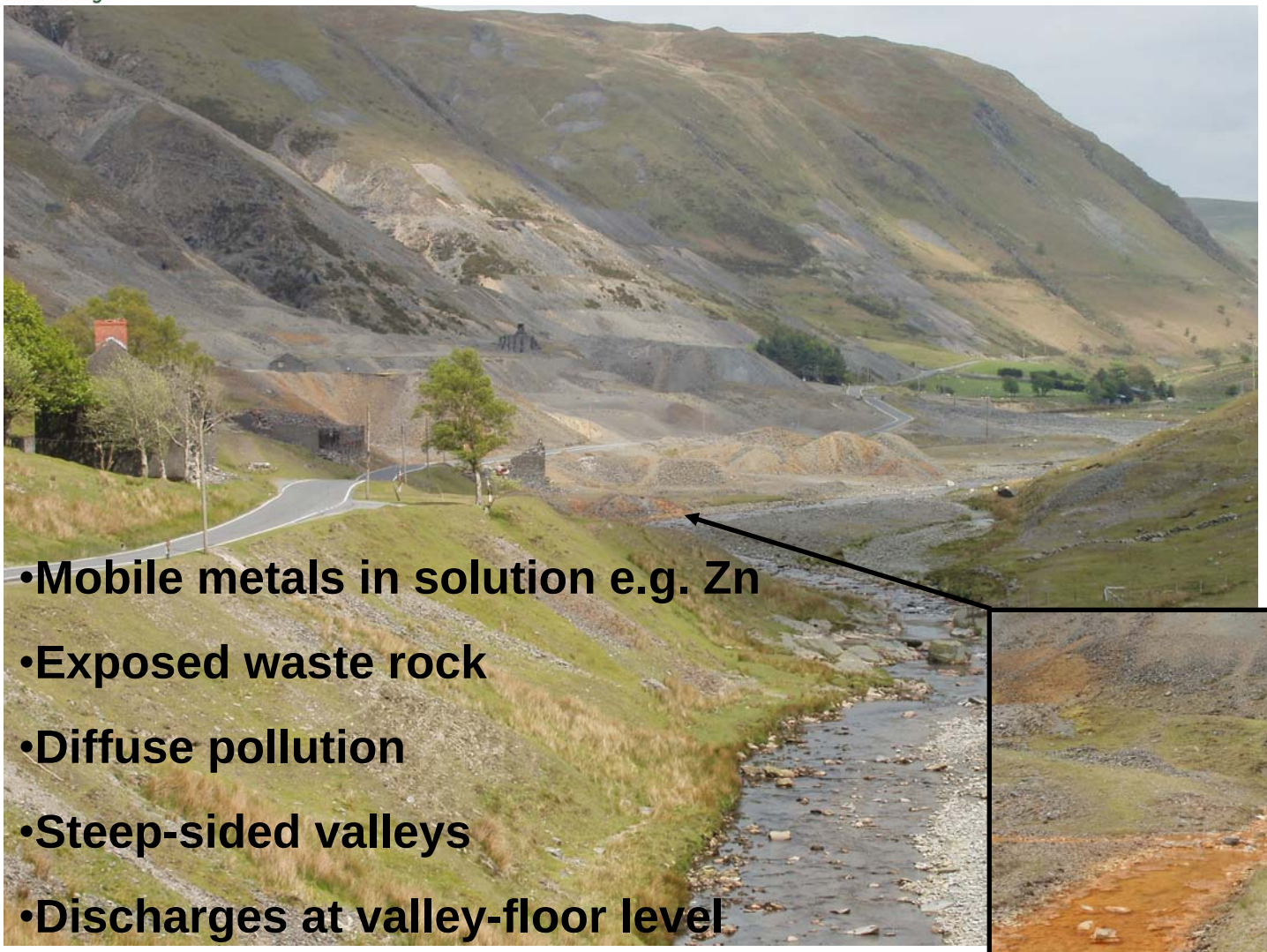
Gravity drainage with treatment

Shilbottle PRB

Backfilling trench with reactive compost / limestone PRB media (piezometers in foreground)

Gravity drainage with treatment

Challenges



- Mobile metals in solution e.g. Zn
- Exposed waste rock
- Diffuse pollution
- Steep-sided valleys
- Discharges at valley-floor level

Challenges

- Mobile metals such as zinc, proving difficult to remove on a consistent basis by truly passive means
- Diffuse pollution: shown to be a major contributor to the total mass of contaminant metals in some river basins – a real headache for collection / interception of mine drainage
- In the UK, no single body responsible for addressing metal mine water pollution
- Contrasting / conflicting priorities

Challenges

Water quality

Archaeology

Local interest

Priority??

Conservation

Health & Safety

Conclusions

- For a variety of reasons, the majority of current mine water treatment systems in the UK comprise pumping to a treatment system, or even pumping to avoid treatment

- Under favourable conditions of topography, land area availability, and mine water flow-rate and water chemistry, truly passive systems (i.e. no energy or chemical inputs during operation) can be effective if appropriately designed

- In the UK, future challenges are likely to be principally focused on addressing collection and treatment of abandoned metal mine water discharges

Finally … thanks for listening!