The importance of point and diffuse pollution in developing management strategies for long-abandoned deep coal and metal mines in the UK

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Background

- In Europe, the Water Framework Directive (2000/60/EC) (WFD) is the most important legislative instrument relating to the water environment ever introduced.
- The WFD necessitates surface and ground waters to be of ‘good chemical and ecological status’ by 2015.
- Assessment is based on river catchments.
- In seeking to achieve this, the first step of the regulators in the UK has been to conduct a pressure and impact assessment exercise.
- In addition to looking specifically at phosphorus, nitrogen, pesticides etc, mine waters have been assessed.

Table 1. Summary statistics of the England & Wales Environment Agency's draft pressure assessment for mine waters.

Risk of failing WFD objectives	Rivers		Groundwaters	
	No. of waterbodies	River length (km)	No. of waterbodies	Area of waterbodies (km^2)
At risk[1]	139	1822	10	9060
Probably at risk[2]	87	1714	16	9251
Probably not at risk[3]	512	6709	93	56062

1. At risk - At risk of not achieving WFD objectives by 2015 (high certainty)
2. Probably at risk - Probably at risk of not achieving WFD objectives, but further information is required to make sure (lower certainty)
3. Probably not at risk of not achieving WFD objectives, but further information is required to make sure (lower certainty)

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Background

- In former mining districts of the UK, WFD objectives are unlikely to be met due to mine water pollution.
- For the last 12 years the UK Coal Authority has undertaken a rolling programme of treatment initiatives for abandoned coal mine waters (approximately 40 treatment systems to date).
- However, these systems only address point sources of mine water pollution.
- Preliminary assessments have suggested that diffuse mine water pollution might be a serious problem, and an impediment to meeting WFD targets.

Introduction

- The objective of current work at Newcastle is to quantify the extent and nature of diffuse mine water pollution, with a view to developing monitoring and management strategies for such pollution problems.

- The focus of the studies has been two river basins in the North east of England:

  - The River Gaunless catchment, an area of former deep coal mining

  - The River Allen catchment, an area of historic deep mining for lead and zinc

- The purpose of the talk is to illustrate the results and implications of these complimentary studies.

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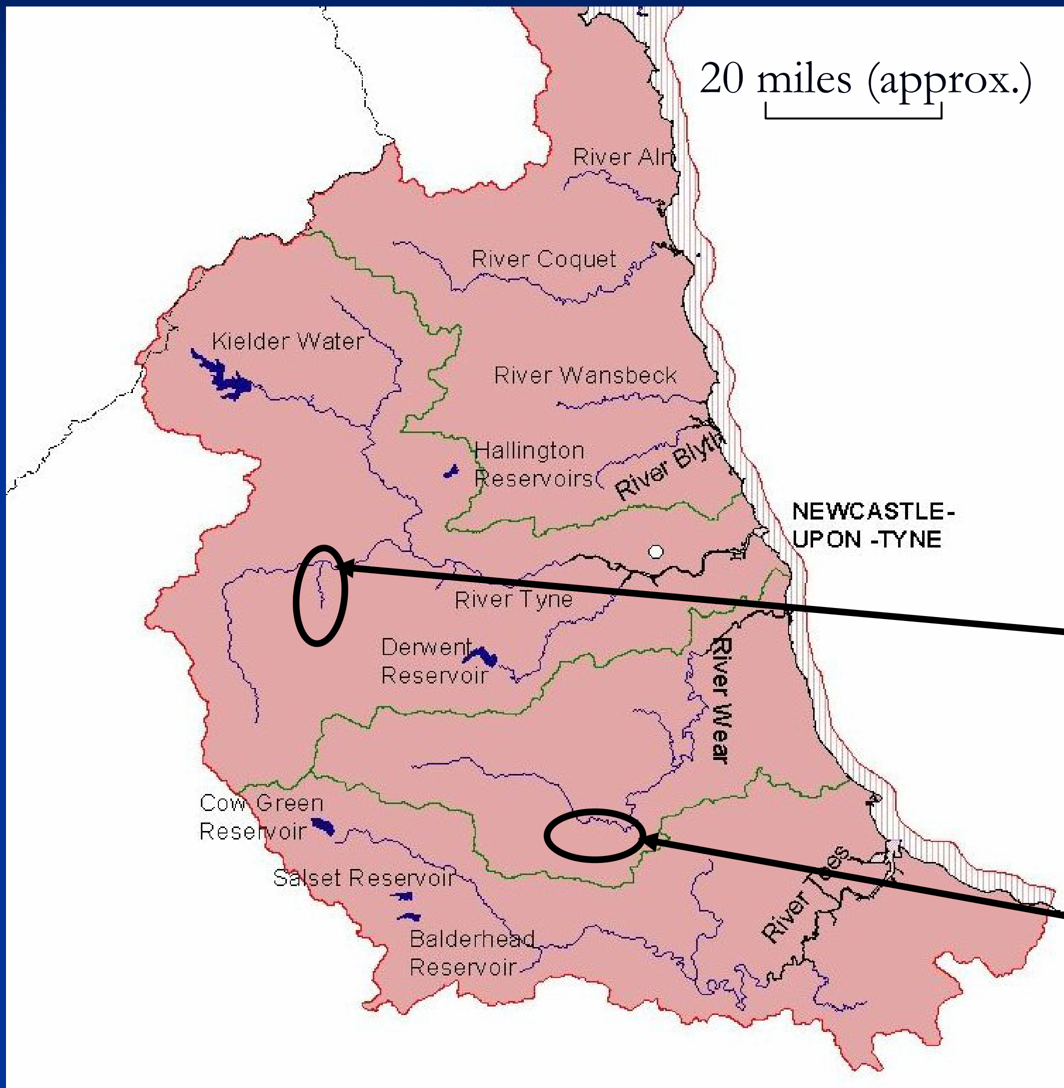
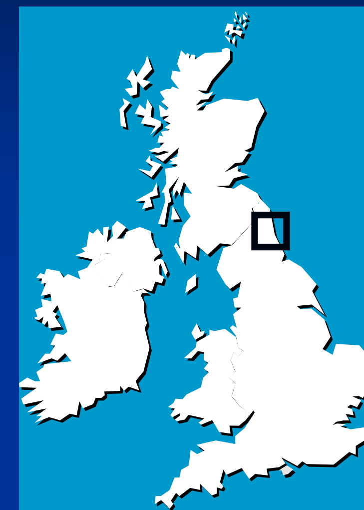
Study sites





River Allen catchment

River Gaunless catchment

Study sites

- River Gaunless is a major tributary of the River Wear, in the southern portion of the Durham Coalfield
- The 93 km^2 catchment is entirely underlain by Coal Measures and heavily mined for >150 years prior to 1976
- Phases of abandonment in 1920s and 1960s; final cessation of pumping to affect catchment was in 1975, and most recent new discharges commenced flowing in 1981
- River Gaunless receives several point discharges from numerous abandoned mines
- Total Fe concentrations instream rarely <0.5mg/L and large reaches of catchment perennially ochre-stained

Study sites

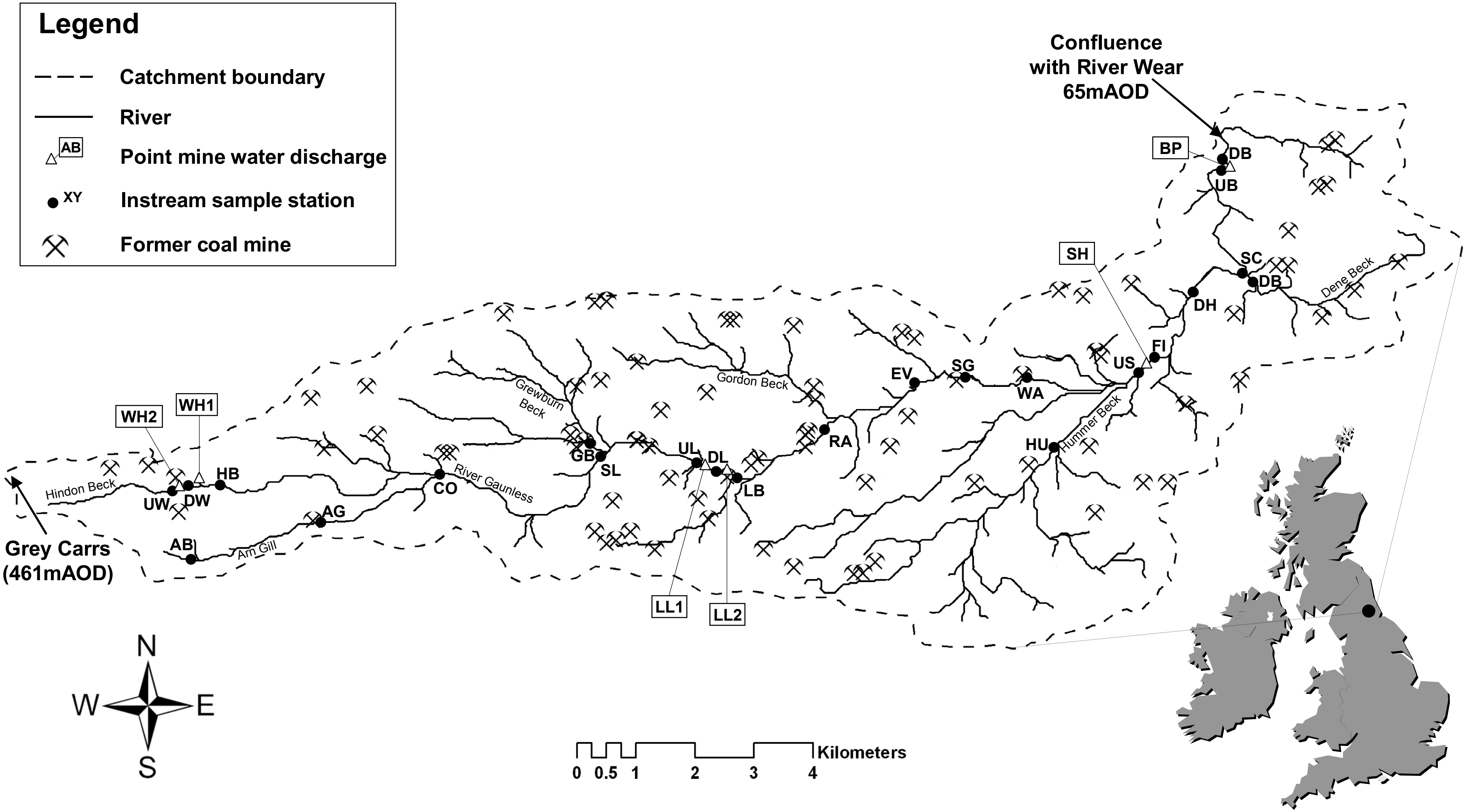
- The River Allen is a 190 km^2 catchment, and a major tributary of the River Tyne
- It was mined for lead and zinc from 17th century until 1970s
- Underlain by Carboniferous limestone
- Hydrology and hydrochemistry of the river is deeply influenced by mining history
- Both the River East and West Allen receive point sources of mine water pollution, the principal contaminant being zinc

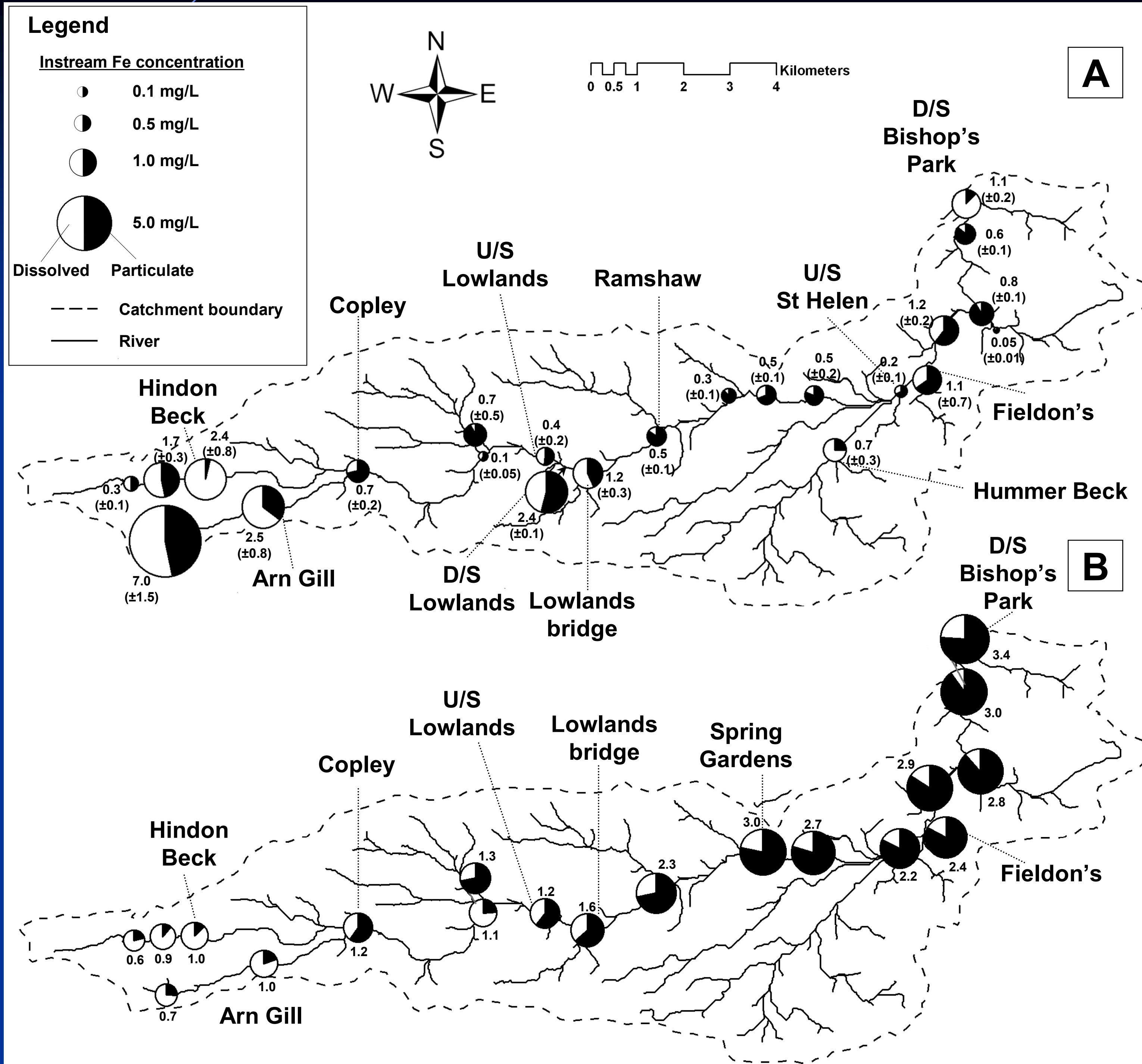
Methodology

- Reconnaissance sampling
- Synchronous monitoring of contaminant <u>loads</u> at instream sample stations and point mine water sources
- Selected sampling and analysis of river sediments
- Offers insight to specific locations and mechanisms of diffuse input to channel in addition to instream attenuation processes

Point mine water discharge at Bishop's Park, River Gaunless

River Gaunless





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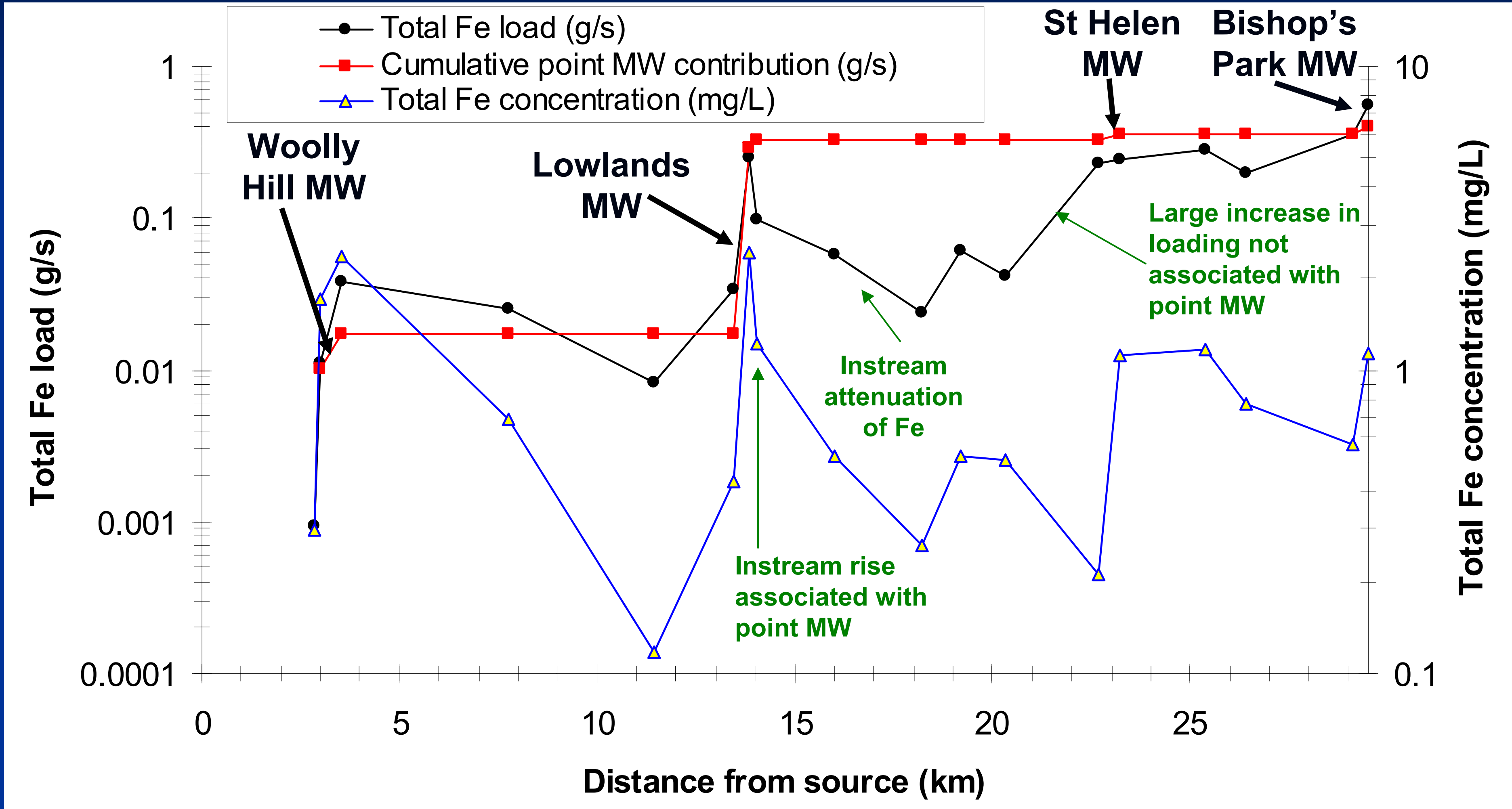
Low Flow

High Flow

River Gaunless: Low flow Fe loadings



Mean low flow (<Q70) instream Fe loadings and concentrations alongside point MW contribution

River Gaunless: Low flow Fe loadings

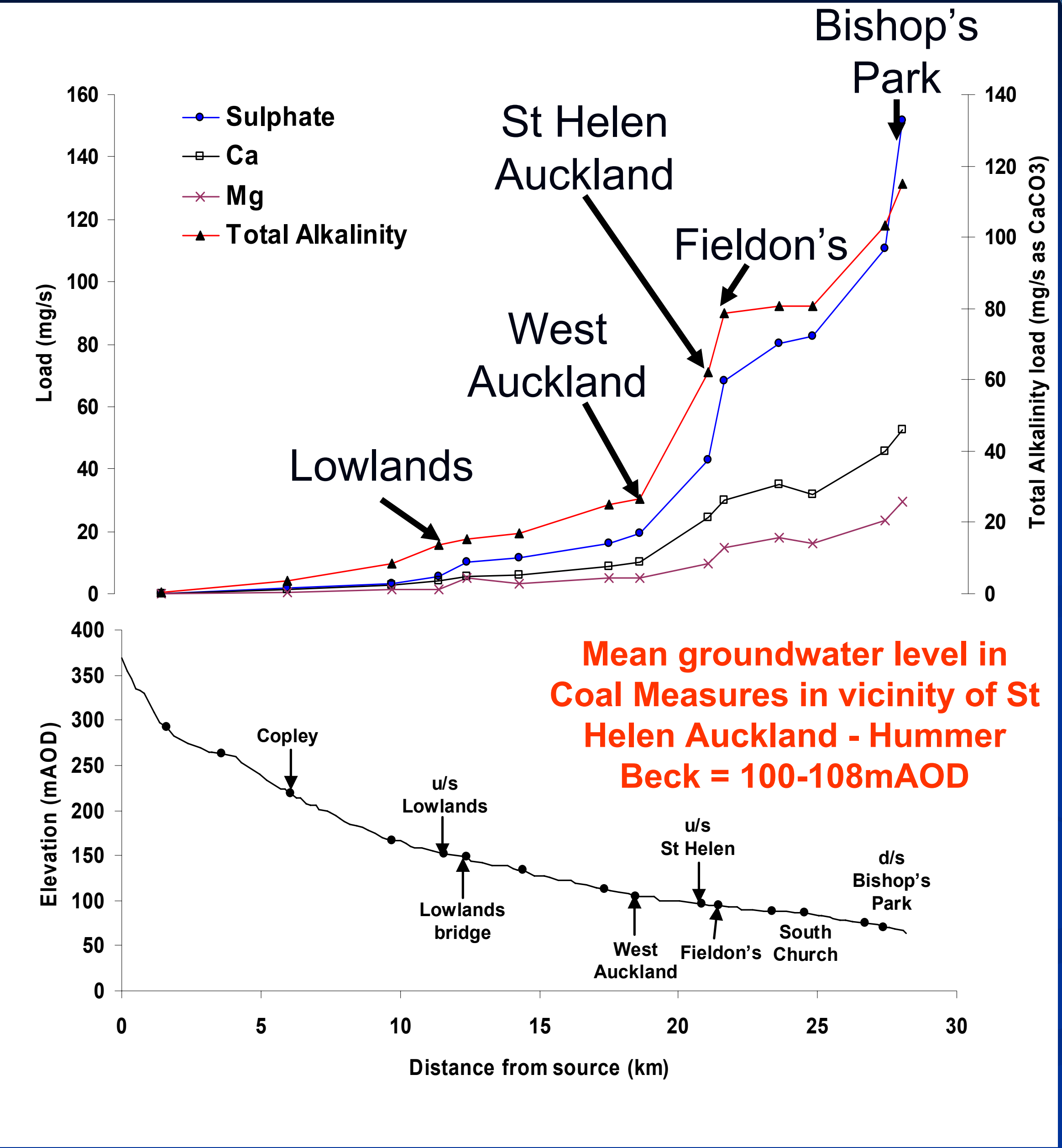
Low Flow

•Point discharges of mine water account for >60% of the in-stream loading in the upper catchment

•Lowlands mine water accounts for >100% of the in-stream rise in Fe i.e. immediate loss of Fe as ochre on stream bed

•Direct groundwater input in the lower catchment appears to be significant

River Gaunless Groundwater input



Low flow loadings of chemical species indicative of groundwater sources

Longitudinal profile of Gaunless riverbed

River Gaunless Groundwater input

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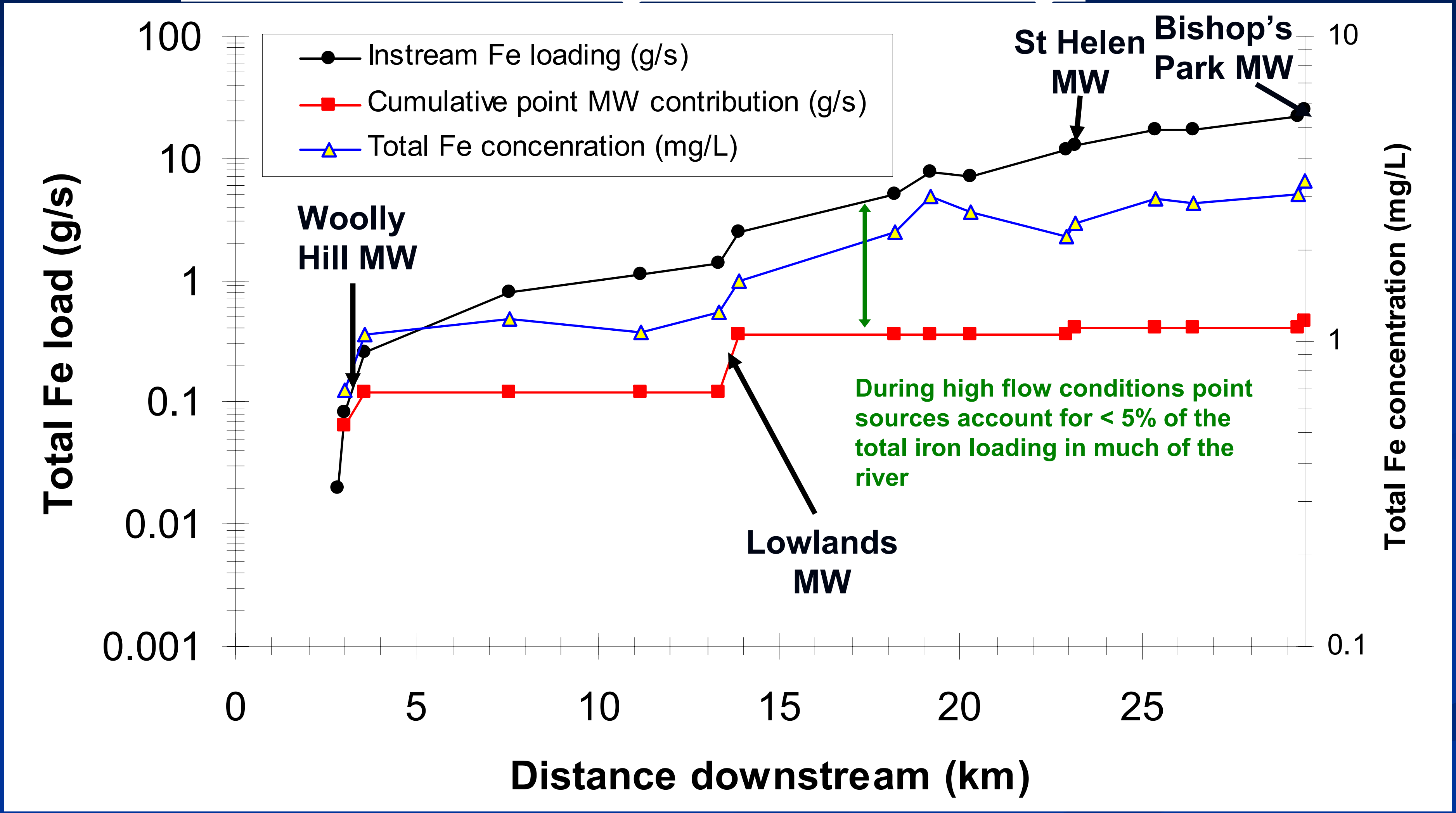
The lower reaches of the River Gaunless

River Gaunless: High flow Fe loadings

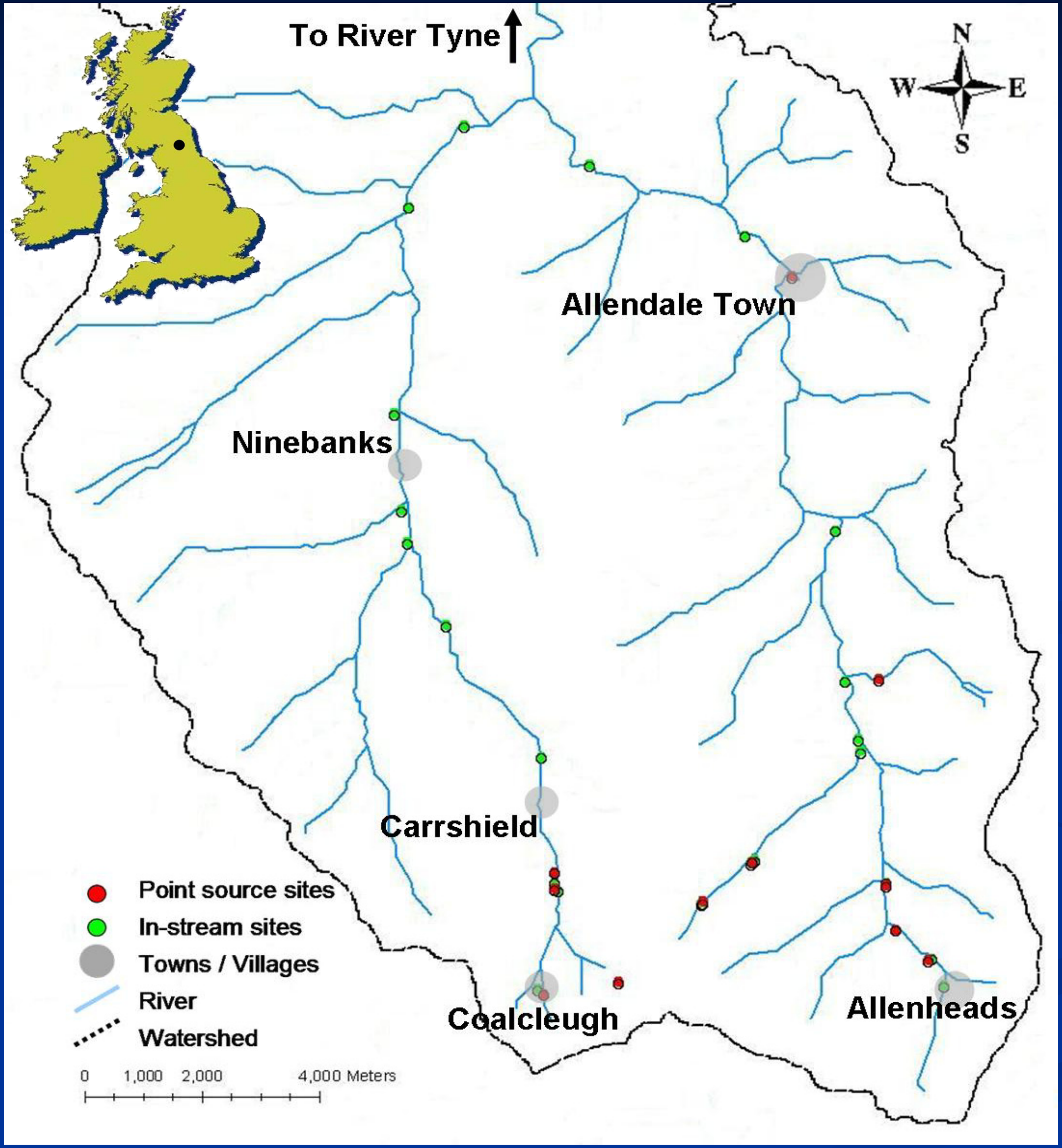


High flow (~Q10) instream Fe loadings and concentrations alongside point MW contribution

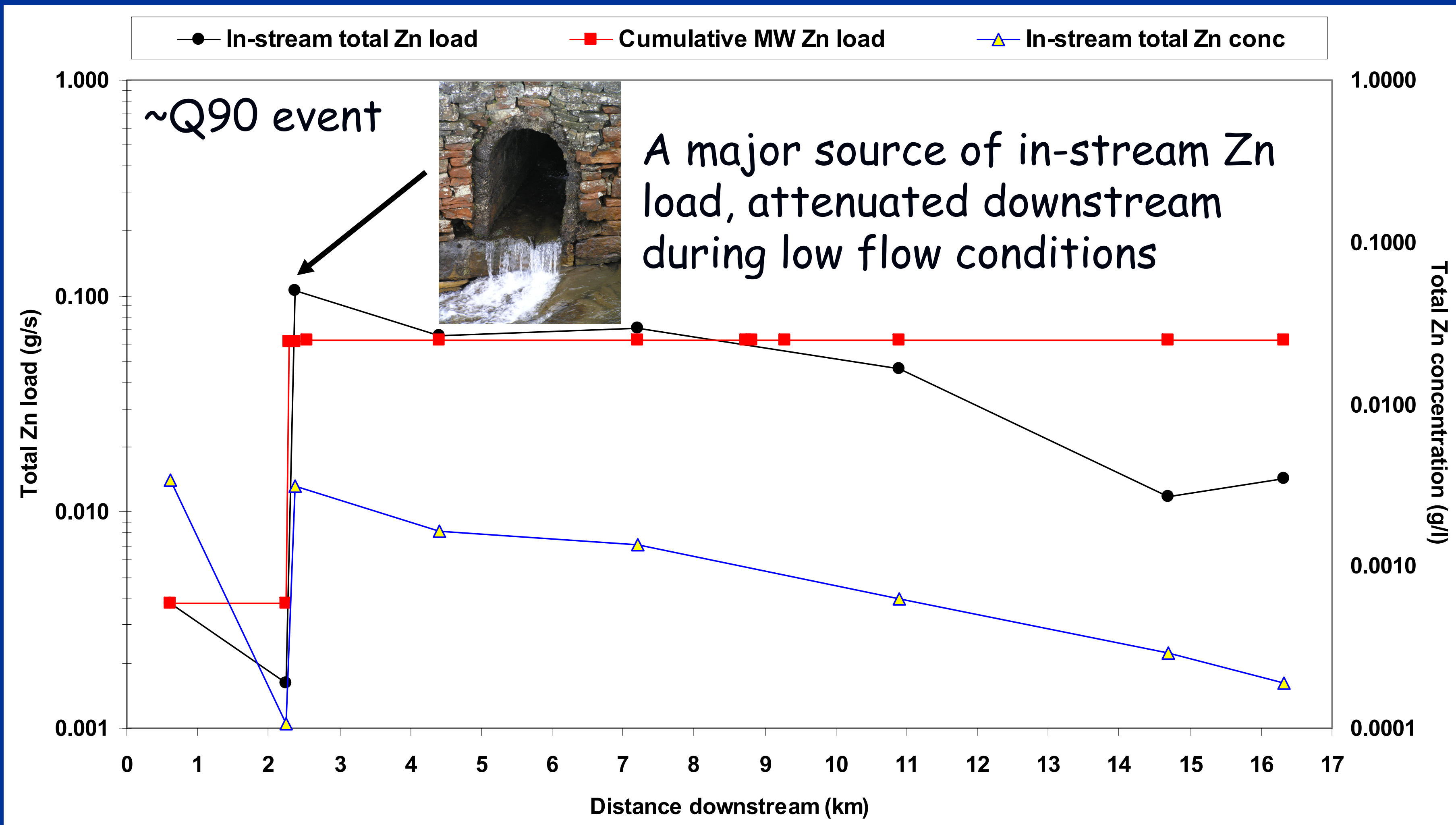
River Gaunless: High flow Fe loadings

- Consistent ↑ in Fe concentration (and therefore large ↑ in loading) downstream
- Point sources account for <5% in-stream Fe
- Principal sources:
  - Spoil heap runoff
  - Re-mobilised Fe from stream bed (particularly from reaches downstream of point mine waters)
  - Non-mining related terrestrial sources (e.g. peat erosion, runoff from Fe-rich strata)
  - Highways runoff (sodium hexacyanoferrate used as anti-caking agent in deicing salts) in lower catchment
- Future event-based sampling

The River Allen catchment



River West Allen: Low flow Zn loadings



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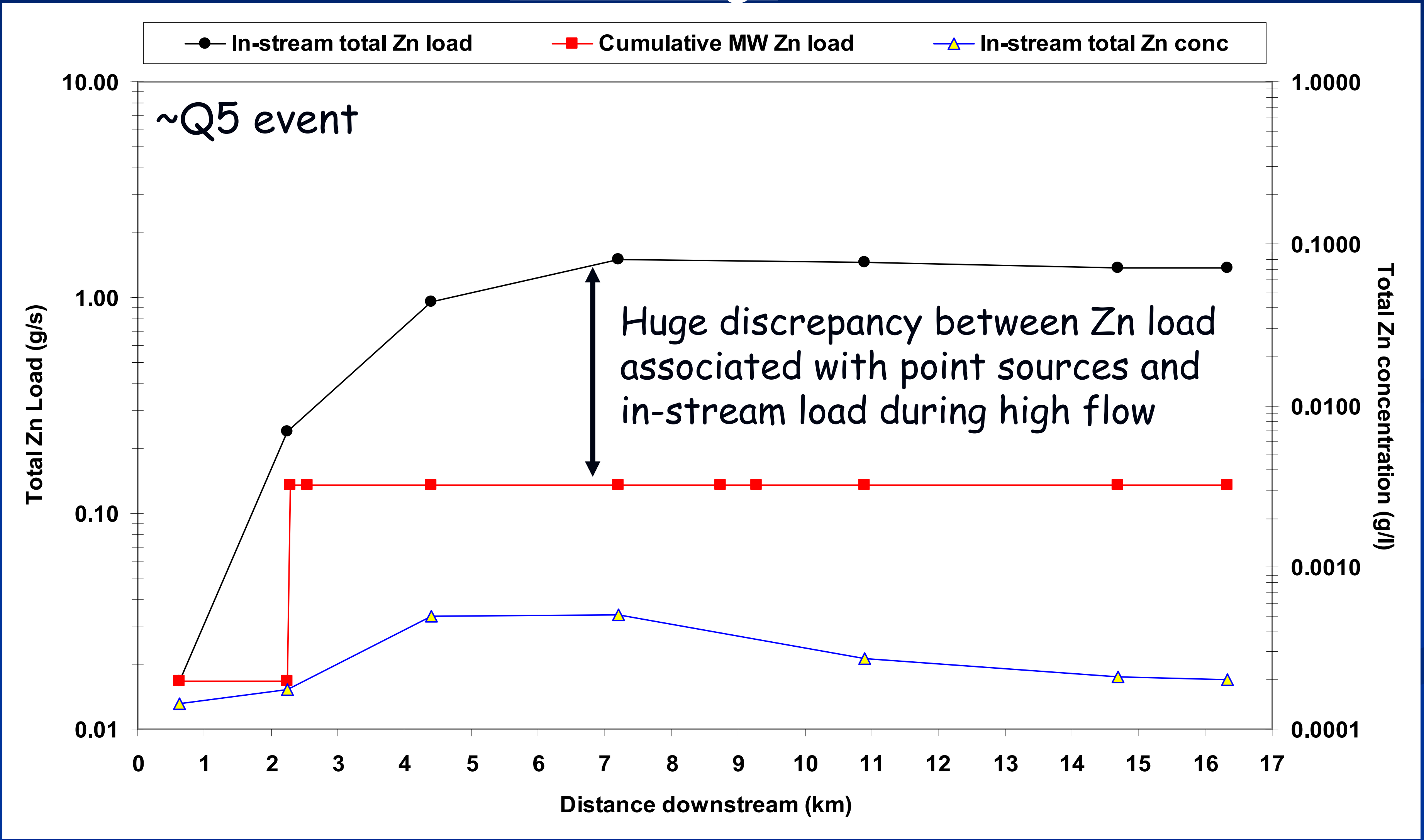
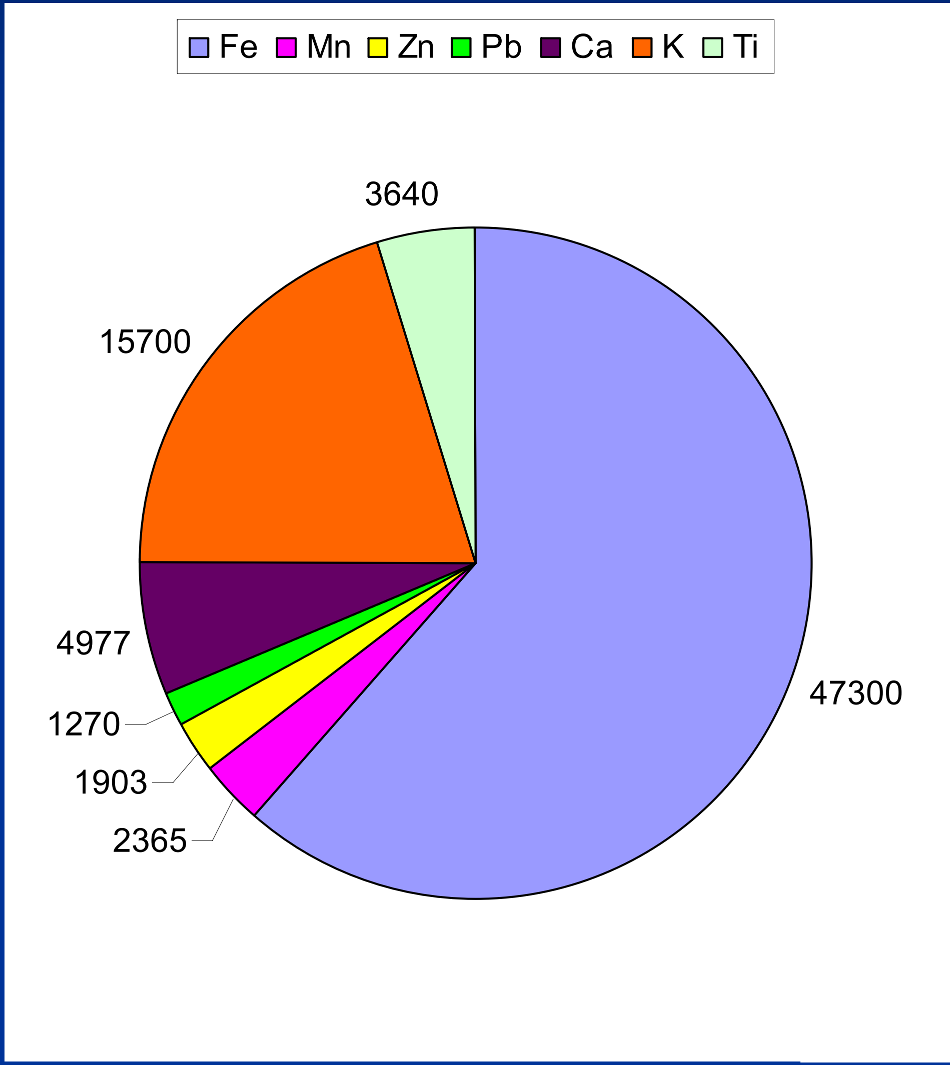
River West Allen: High flow Zn loadings



River West Allen: High flow Zn loadings

- 90% total Zn load attributed to diffuse sources
- Site 20 still major input – accounts for 61% increase in total Zn load in-stream
- Zn increase d/s of point sources due to sediment re-suspension / remobilisation and spoil heap run-off?

River West Allen: sediment XRF



- No set sediment quality guidelines in UK
- TEL guidelines from Canada
  - Zn: 123 mg/kg
  - Pb: 35 mg/kg
- Zn exceeds by factor of 15
- Pb exceeds by factor of 35
- Ongoing Tessier extractions indicating Zn concentrations much higher than these at certain locations

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Conclusions and ongoing work

- Both studies highlight the dynamic importance of diffuse sources under different flow conditions
- High flows exacerbate diffuse inputs
- Low flow diffuse inputs potentially more important for quality purposes
- Clear issues for WFD compliance in terms of cost-effective monitoring and management for diffuse pollution from former deep mining districts
- Wider remediation issues and technology gap needs addressing

Conclusions and ongoing work

Ongoing research in the Gaunless and Allen:

- Continued sampling under varying flow conditions

- Event-based sampling

- Sediment analysis

- Geochemical modelling / laboratory experimentation to determine likelihood of remobilisation of metals from previously deposited sediment

- Zn removal trials

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