Canal & River Trust

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Analysis of Heavy Metals in Canal Sediments to Gain a Better Insight into Current and Future Canal Management Strategies

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Canal and Waterway Management

- Historical industrial route
  - Coal, glass and metal-working
  - ≈257km of waterways during peak operation
- Leisure Route
- Maintenance includes
  - ≈160km open to navigation
  - Depth maintenance
  - Towpath clearing
  - Refuse collection
- Connected to national canal systems at a number of intersections

Canals and waterways maintained by Canal & River Trust (previously British Waterways)

Canal Maintenance

- Depth maintenance
  - 25 year plan in urban canals
  - 40 year plan in rural canals
  - 8 year survey period
  - Dredging as required at confluences, inlets

- Removal carried out in stages
  - Canal sediment modelling/hydrographic surveys
  - Sectional dredging
  - Sediment disposal via incineration/landfill

Background, Aim and Objectives

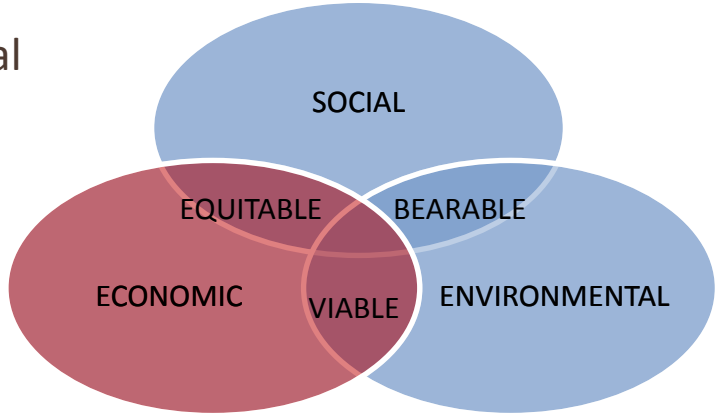
- Dredging expenses in 2014 totalled £4.4m

- Canal & River Trust intend to invest £8-10M a year for the next decade on canal maintenance

- Canal & River Trust identified current disposal methods as an area for improvement by
  - Recovering and recycling contaminants present in the sediments
  - Reducing the volume of waste sent to landfill

Background, Aim and Objectives

- Aim to improve maintenance sustainability by developing a better understanding of canal sediment contamination
- Objectives of the project were to:
  - Identify constituent compounds/elements in canal sediments that require remediation or are recoverable based of value of recycling
  - Evaluate processes that may allow efficient recovery of target constituents
  - Investigate economic feasibility of potential scale up options
  - Measuring sediment accretion to enhance dredging plans



Elements of Interest

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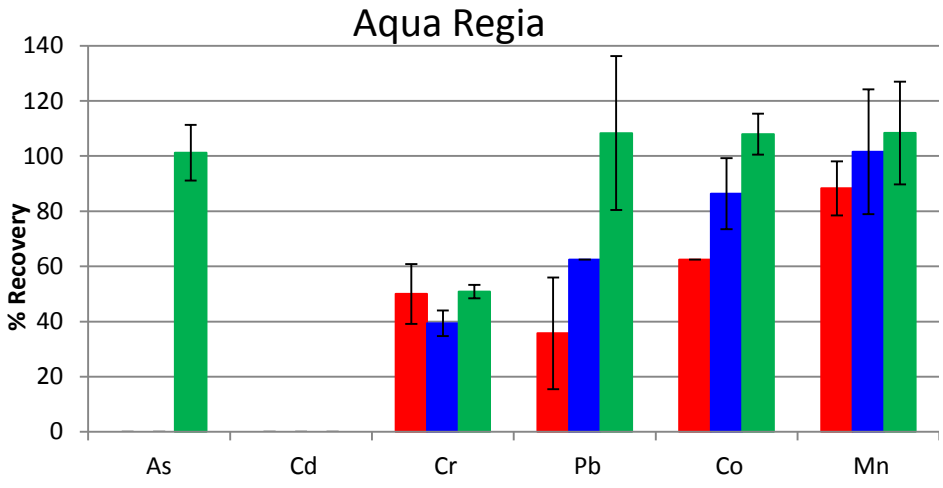
Target Element	Landfill Limit /mg kg^{-1}	Leach limit /mg l^{-1}	EQS /µg l^{-1}
As	0.4	0.3	10
Cd	0.6	0.3	5
Cr	4	2.5	50
Pb	5	3	50

- 32 elements targeted
  - 6 heavy metals shown
  - Environmental Regulations
  - Economic Potential
- Legislation Directives
  - 2006/11/EC-Dangerous substances in the aquatic environment
  - 1999/31/EC; 2003/33/EC -Landfill

Target Element	Historical Applications	Current Applications
Co	Ceramic and Glass Pigment	Temperature/Corrosion resistant alloys, nanotechnology and chemical industries. 30,680 USD/t. source LME
Mn	Ceramic and Glass Pigment, Steel Production	Steel and alloy production. Year end value-2,350 USD/t. source ICE

Metals Recovery Method



•Total Digest significant higher recovery

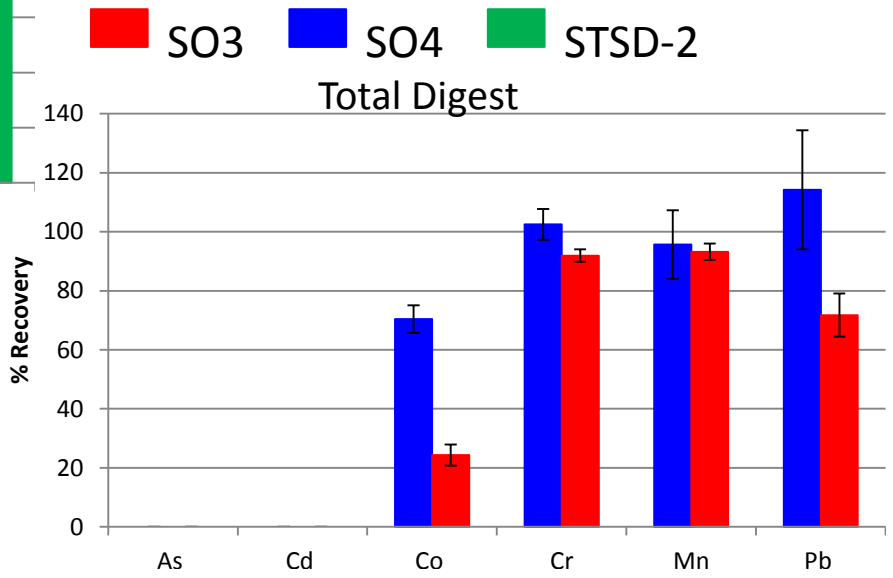
•Aqua Regia (AR) digest used on canal sediment samples

Error bars represent 2 std deviations

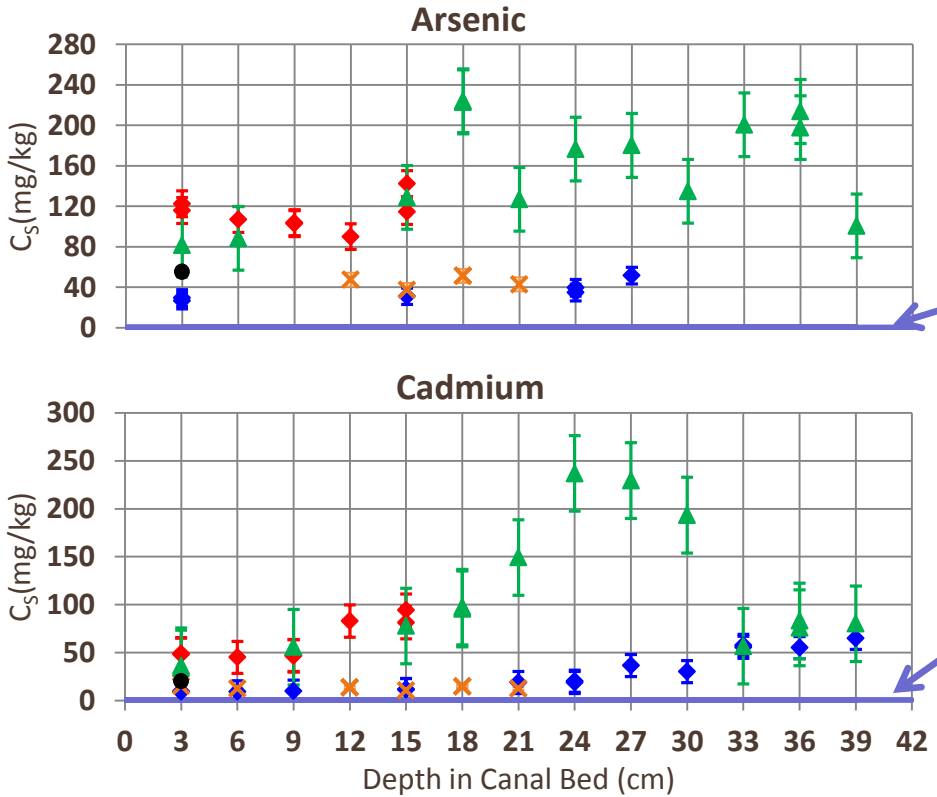
CERTIFIED REFERENCE MATERIALS (CRM)

•SO3/SO4 sediments certified from 40 separate labs

•STSD-2 provisional values



Metal Concentration and distribution

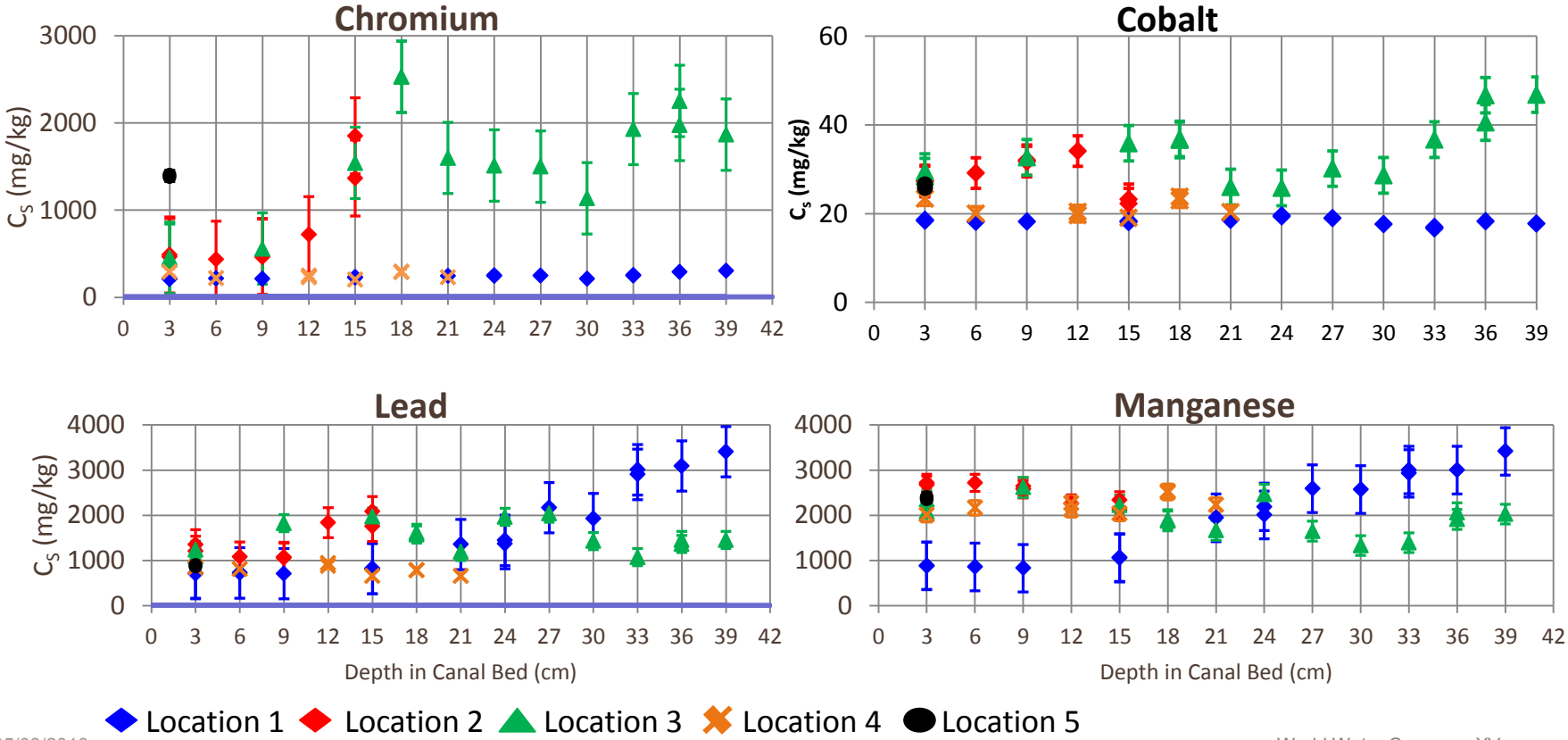


Target Element	As	Cd
Landfill Limit /mg kg^{-1}	0.4	0.6
Leaching limit /mg l^{-1}	0.3	0.3
EQS /µg l^{-1}	10	5

Location 1 Location 2 Location 3
Location 4 Location 5

Error bar represent 95% confidence intervals for each location

Metal Concentration and distribution



Management Strategies

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Areas for improvement

- **Recovering and recycling contaminants present in the sediments**
- **Reducing the volume of waste sent to landfill**

Drivers behind improvement

- Environmental and economic considerations for current practice versus potential management practice
- Concentration of analytes in the sediment may at a level requiring disposal to hazardous landfill (sustainability issues)
- Current practice of blending requires analytical service costs and availability of uncontaminated material (sustainability issues)
- Economics also extend to associated transport and disposal* costs.

*dredging activities are exempt form landfill taxes

Management Strategies

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- Improved knowledge on distribution and concentration of heavy metals targeted management/treatment of sediment

- Targeted treatment
  - Less inert material for blending
  - Carry out targeted remediation allowing recovery of materials

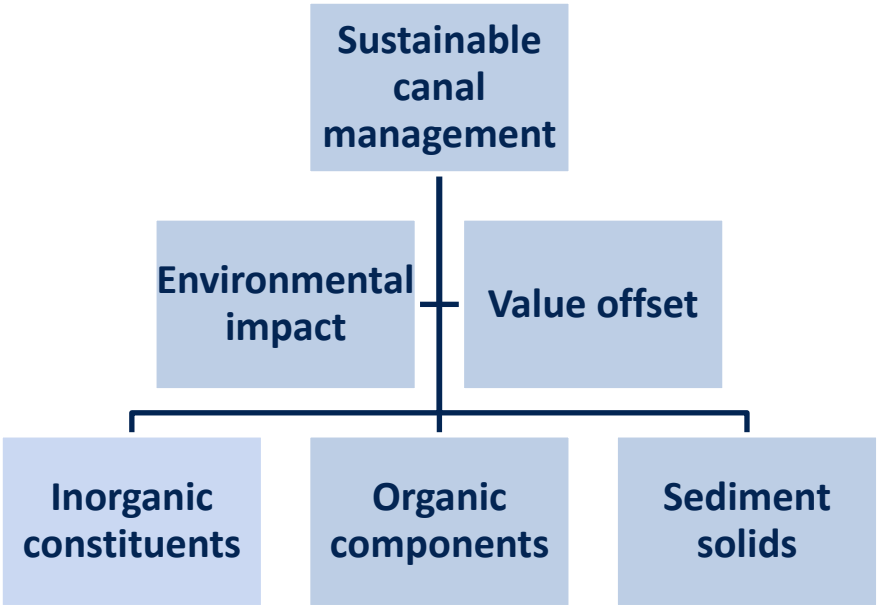
- Recovery of materials
  - Metals and inorganic constituents
  - Sediment

- Any recovery method must be economically and environmentally viable

Heavy Metal	Lowest mean concentration /mg kg^{-1}	Landfill limit /mg kg^{-1}
As	34.1 ± 8.1 location 1	0.4
Cd	20.0 ± 1.4 location 5	0.6
Cr	241.7 ± 15.7 location 1	4
Pb	790.7 ± 80.9 location 4	5

Summary

- Comprehensive sampling-Depth and Location
- Constituent concentration depth, location and element specific
  - Aqua Rega digest does not provide absolute recovery data
- Depth and location data allows the possibility of targeted remediation
- Recovery of constituents and sediment material
- More work needed in inorganic and organic constituent identification



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Questions-Aqua Regia/Total Digest