British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

GRoundwater And Soil Pollutants (GRASP)

A screening tool applying soil geochemical data to assess threats to groundwater

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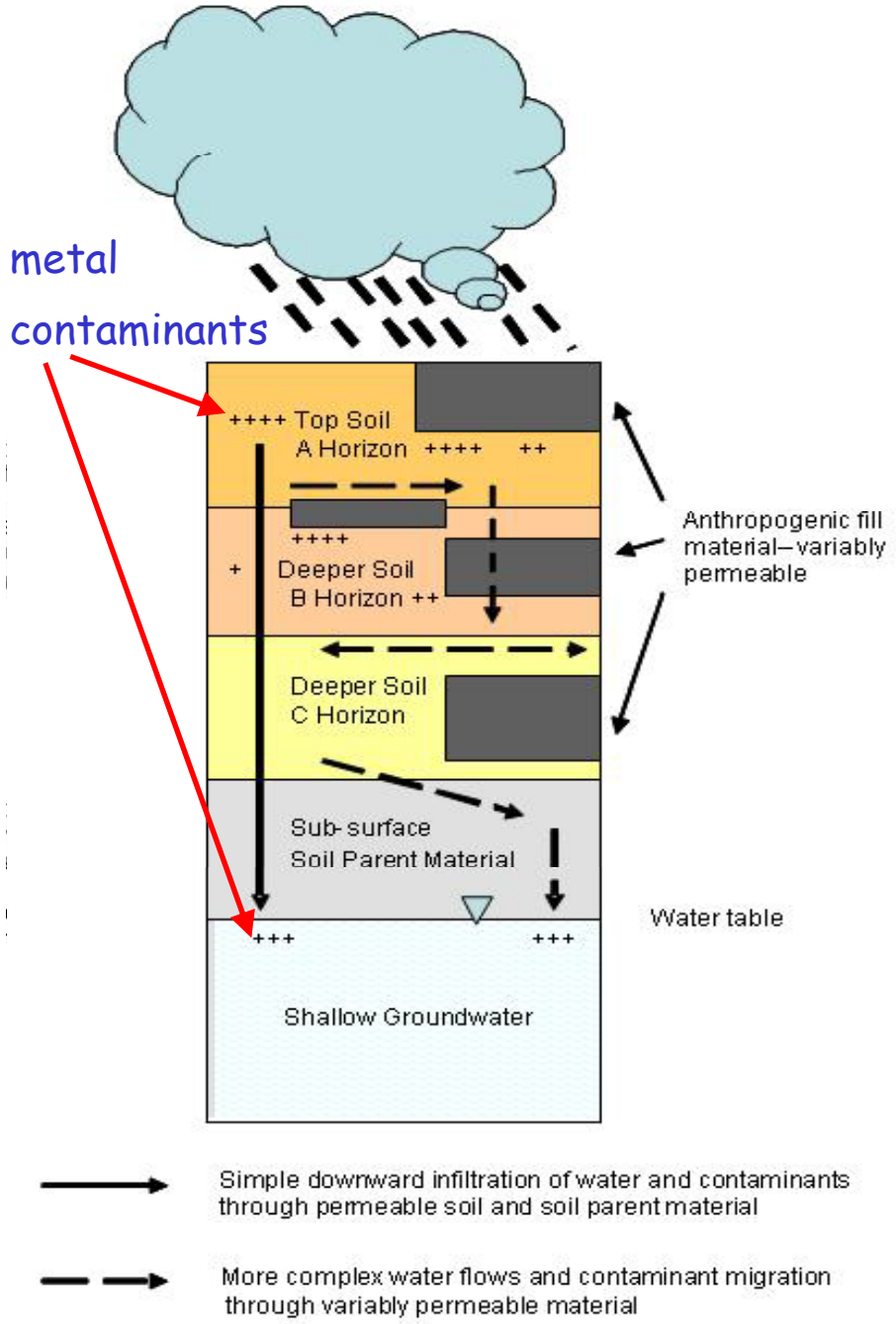
British Geological Survey

EGU 22 April 2009

SSS32: Pedogeochemical mapping of potentially toxic elements



GRASP:

Predicting threats to shallow groundwater quality from the downward leaching of soil metal contaminants

Glasgow, UK

- Scotland's largest city
- Post-**industrial**
- Urban regeneration
- Main **stakeholders**: Glasgow City Council, Scottish Environment Protection Agency

Why GRASP? Why Glasgow?

- **City-wide** scale
- **First-pass** screening: highlights **greater** or **lesser** threat
- Basis is a **soil leaching model**: BS-ISO 15175 (2004)
- New high quality **geochemical soil survey data** available
- Groundwater is **pathway** for contaminants
- **Water Framework Directive / Groundwater Directive**: protect **whole-water system** and **ecological status**.

BGS Clyde Urban Super Project (CUSP)

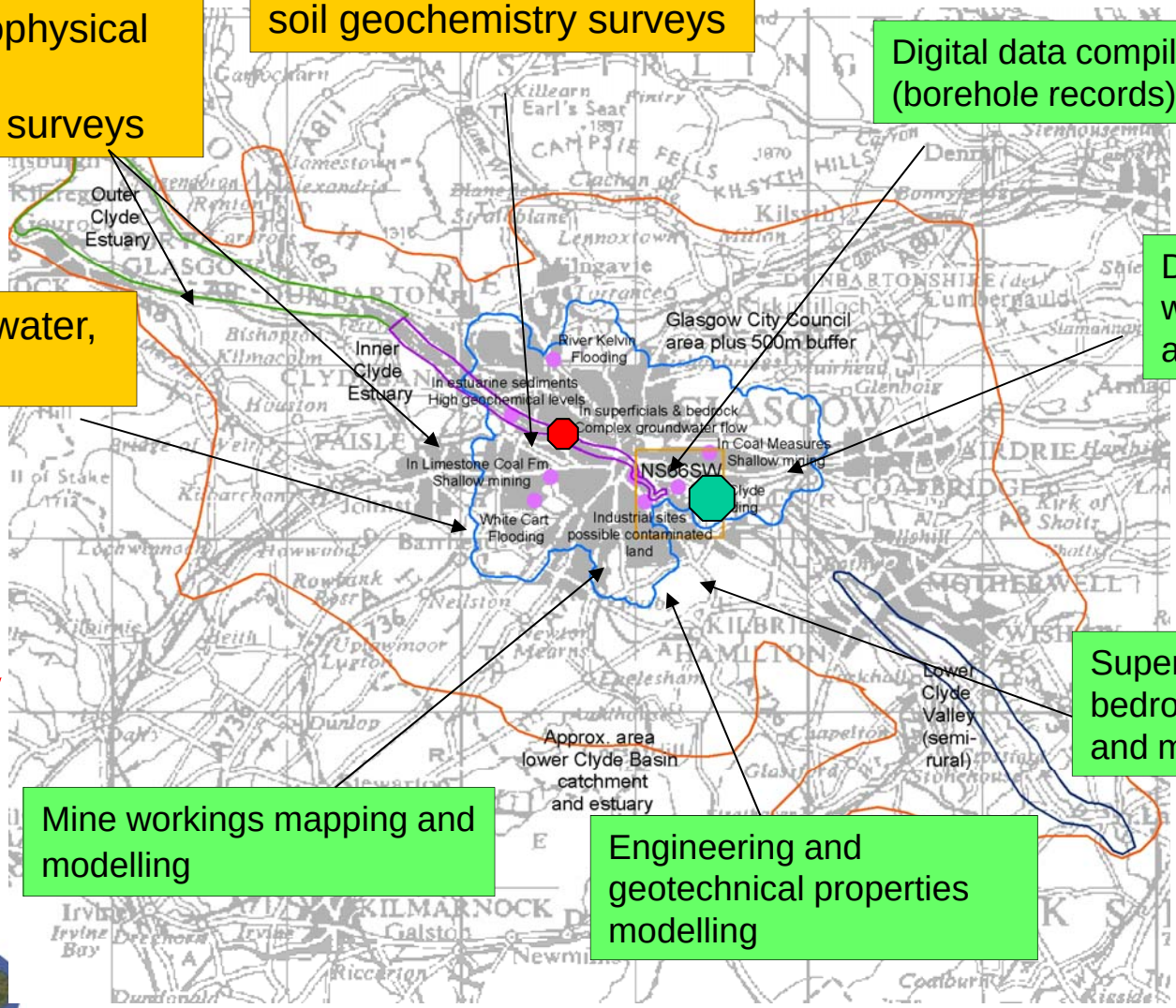
Estuarine geophysical and sediment geochemistry surveys

Onshore sediment and soil geochemistry surveys

Digital data compilation (borehole records).

Groundwater, **GRASP**

Data exchange with local authorities



Superficial and bedrock 3-D modelling and map update

Mine workings mapping and modelling

Engineering and geotechnical properties modelling

GRASP Methodology

Step 1: Attenuation properties of unsaturated soil & Quaternary deposits

Step 2: Climatic water balance

Step 3: Depth to groundwater

BS-ISO soil leaching model **validated for 10 metals**

Step 4: Measured metal concentrations in soil for each of 10 metals

Step 5: Combined GRASP prioritisation assessment for all 10 metals

GRASP additional factors

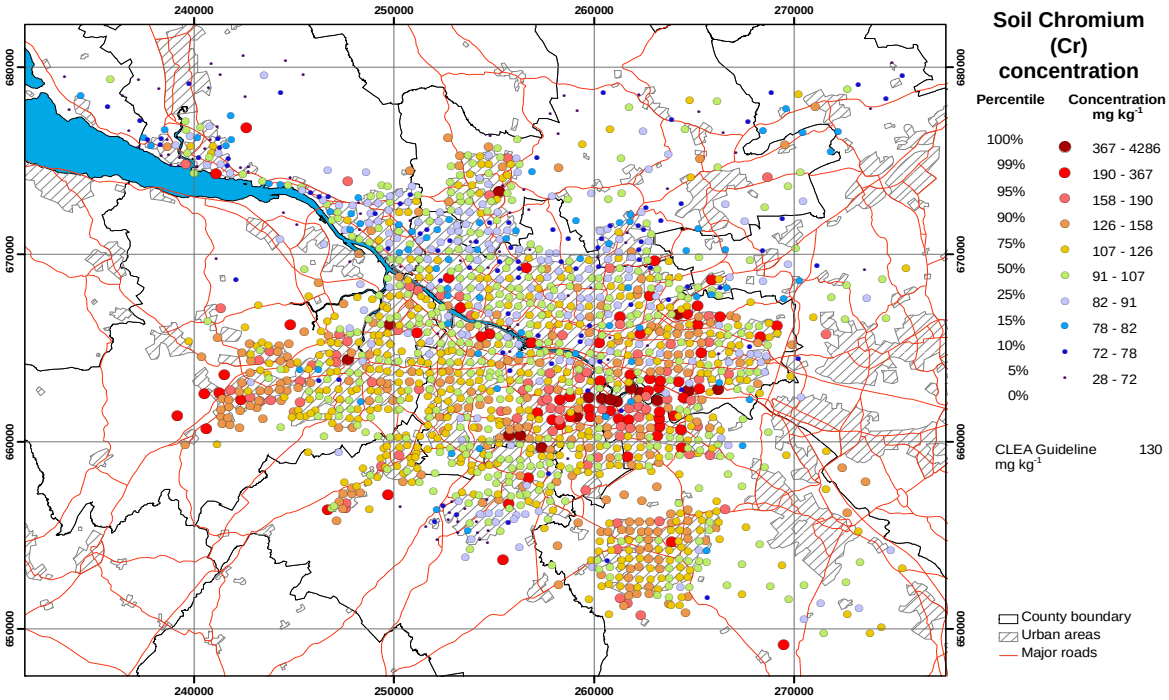
Al
As
Cd
Cr
Cu
Fe
Mn
Ni
Pb
Zn

Input data (i): Geochemical Soil Survey

(BGS Geochemical Baseline Survey of the Environment: G-BASE)

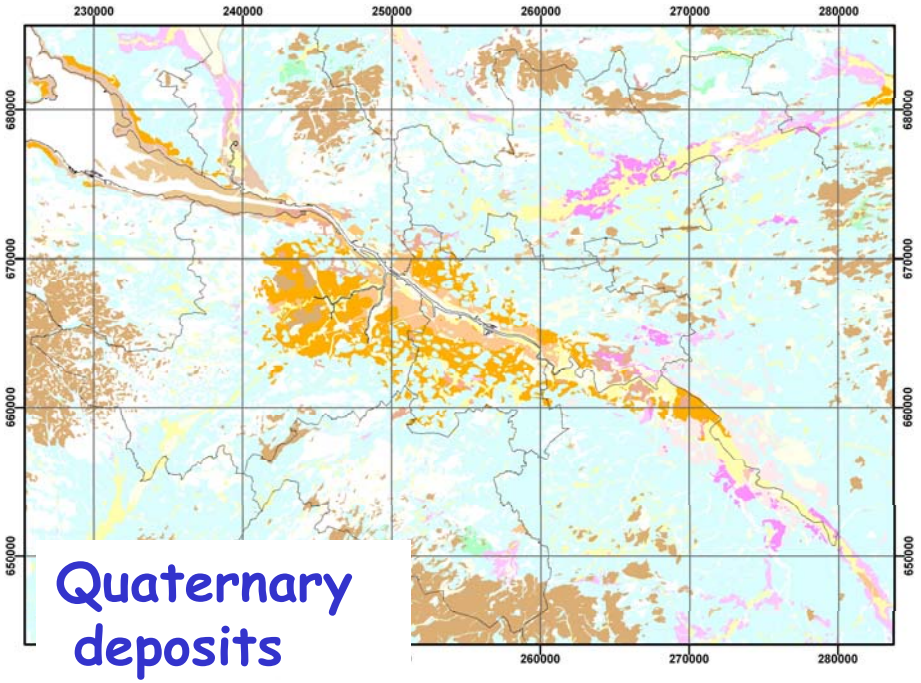
- Soil chemistry at **0.2 m** and **0.5 m** depths for **1622** sites.

- Total concentrations of 46 **elements**; **pH**; **Loss On Ignition**; **soil texture**; and **colour**.

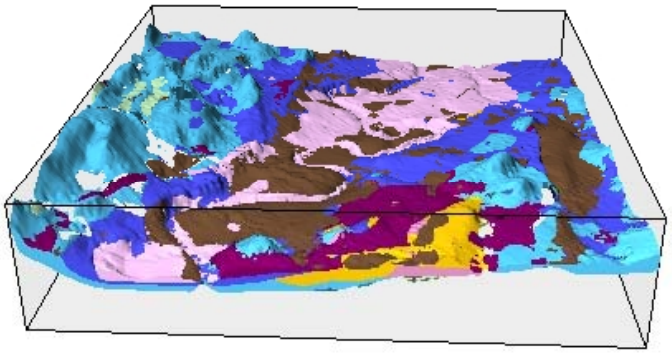


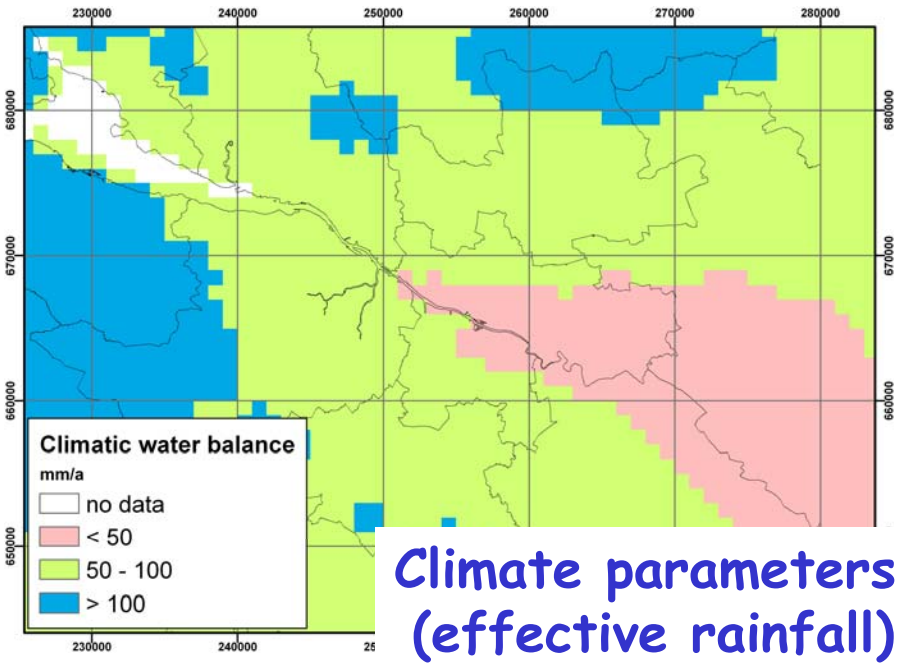
E.g. of geochemical map of Cr in soils

Input data (ii)

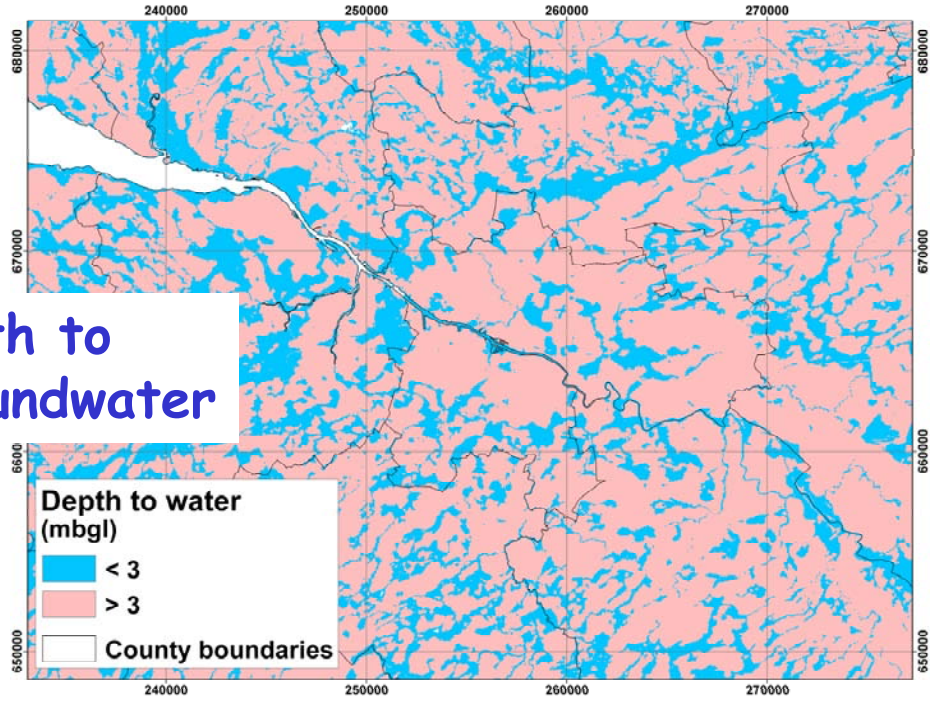


Quaternary deposits





Climate parameters (effective rainfall)



Depth to groundwater

Steps 1 - 3: BS-ISO 15175:2004

top soil → pH + organic carbon + clay + sesqui-oxides

+

sub soil + Quaternary → unsaturated → organic carbon + clay

+

effective rainfall

+

depth to groundwater

Metal	Relative Binding Force b_{ij} for given pH-range									
	2.5 to 2.7	> 2.7 to 3.2	> 3.2 to 3.7	> 3.7 to 4.2	> 4.2 to 4.7	> 4.7 to 5.2	> 5.2 to 5.7	> 5.7 to 6.2	> 6.2 to 6.7	> 6.7 to 8.0
Cd	0.0	0.5	1.0	1.5	2.0	2.5	3.5	4.0	4.5	5.0
Mn	0.0	1.0	1.5	2.0	2.5	3.0	4.0	4.5	5.0	5.0
Ni	0.0	1.0	1.5	2.0	2.5	3.0	4.0	4.5	5.0	5.0
Co	0.0	1.0	1.5	2.0	2.5	3.0	4.0	4.5	5.0	5.0
Zn	0.0	1.0	1.5	2.0	2.5	3.0	4.0	4.5	5.0	5.0
Al	1.0	1.5	2.0	3.0	3.5	4.5	5.0	5.0	5.0	5.0
Cu	1.0	1.5	2.0	3.0	3.5	4.5	5.0	5.0	5.0	5.0
Cr(III)	1.0	1.5	2.0	3.0	3.5					
Pb	1.0	2.0	3.0	4.0	5.0					
Hg	1.0	2.0	3.0	4.0	5.0					
Fe(III)	1.5	2.5	3.5	5.0	5.0					

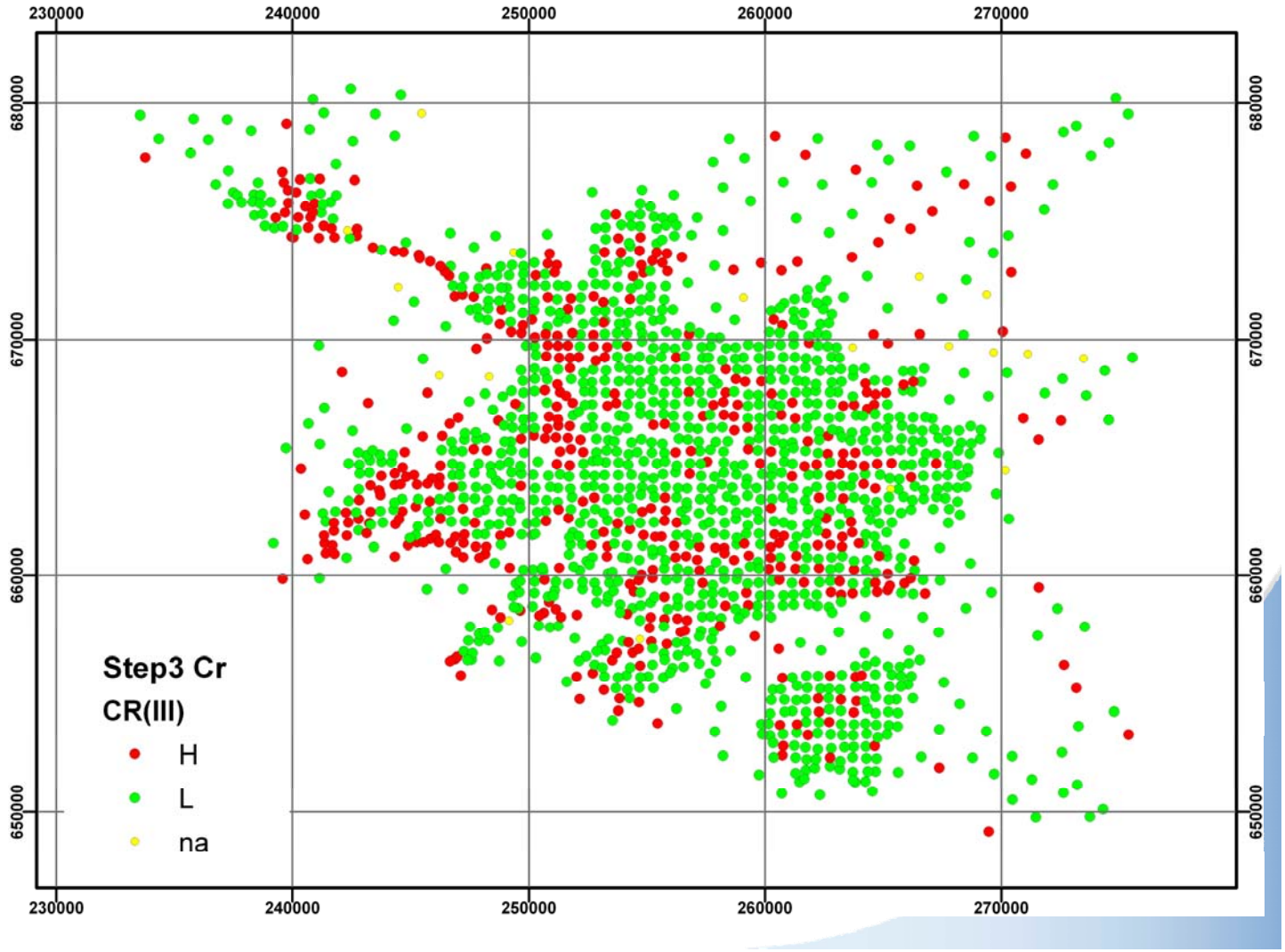
E.g. of look-up table for pH

Al As Cd Cr Cu Fe Mn Ni Pb Zn

End Step 3: Leaching Potential Maps

For 10 metals, e.g.:

Cr leaching potential map



Step 4: Incorporating soil metal concentrations

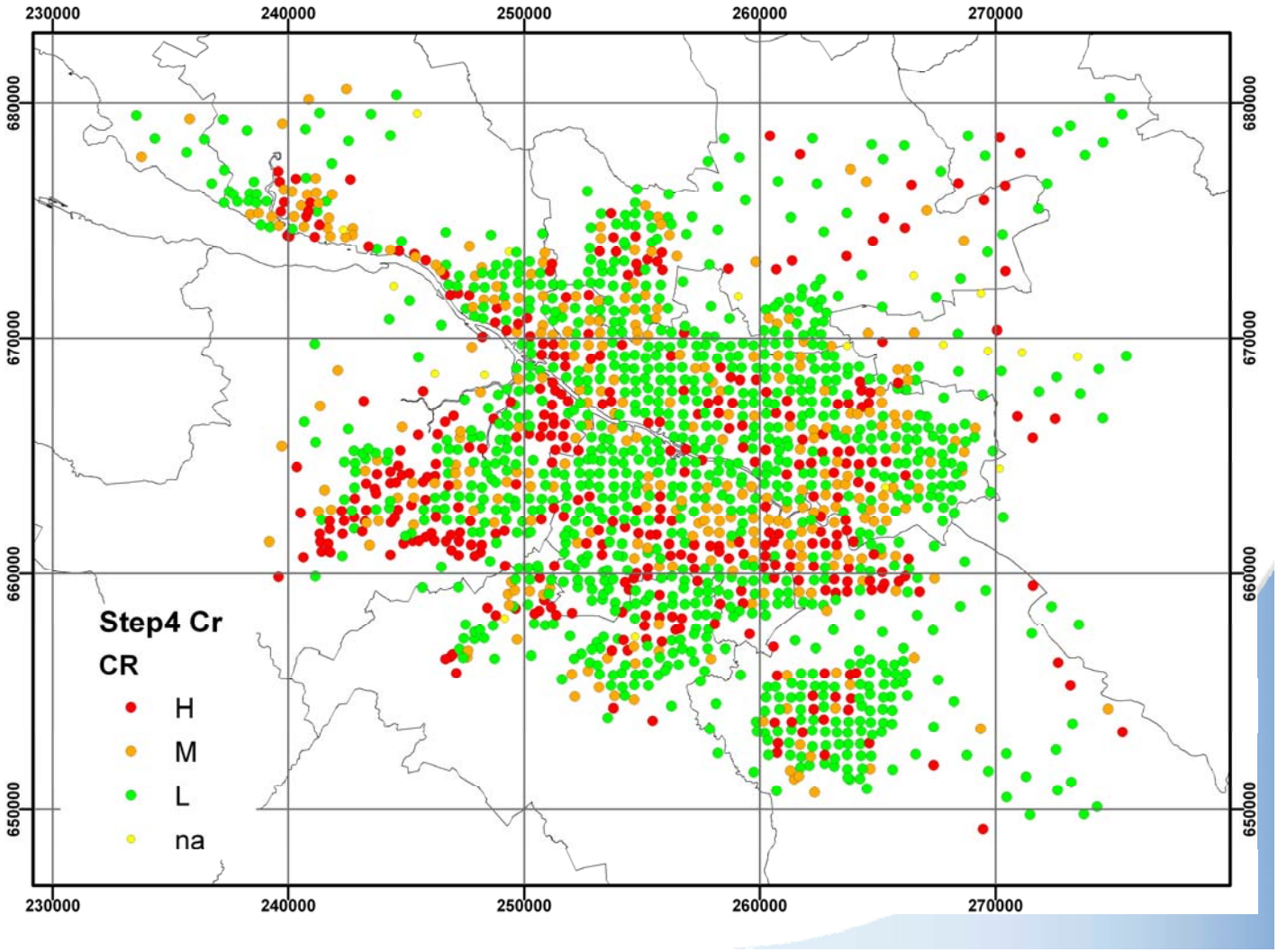
Combination matrix

		G-BASE Metal Concentration Category (percentiles)		
		0–25% (L)	25–90% (M)	90–100% (H)
GRASP Metal Leaching Potential Category (Step 3)	H	M	H	H
	M	M	M	M
	L	L	L	M

End Step 4: Prioritisation Ranking Maps

For 10 metals, e.g.:

Cr prioritisation ranking map

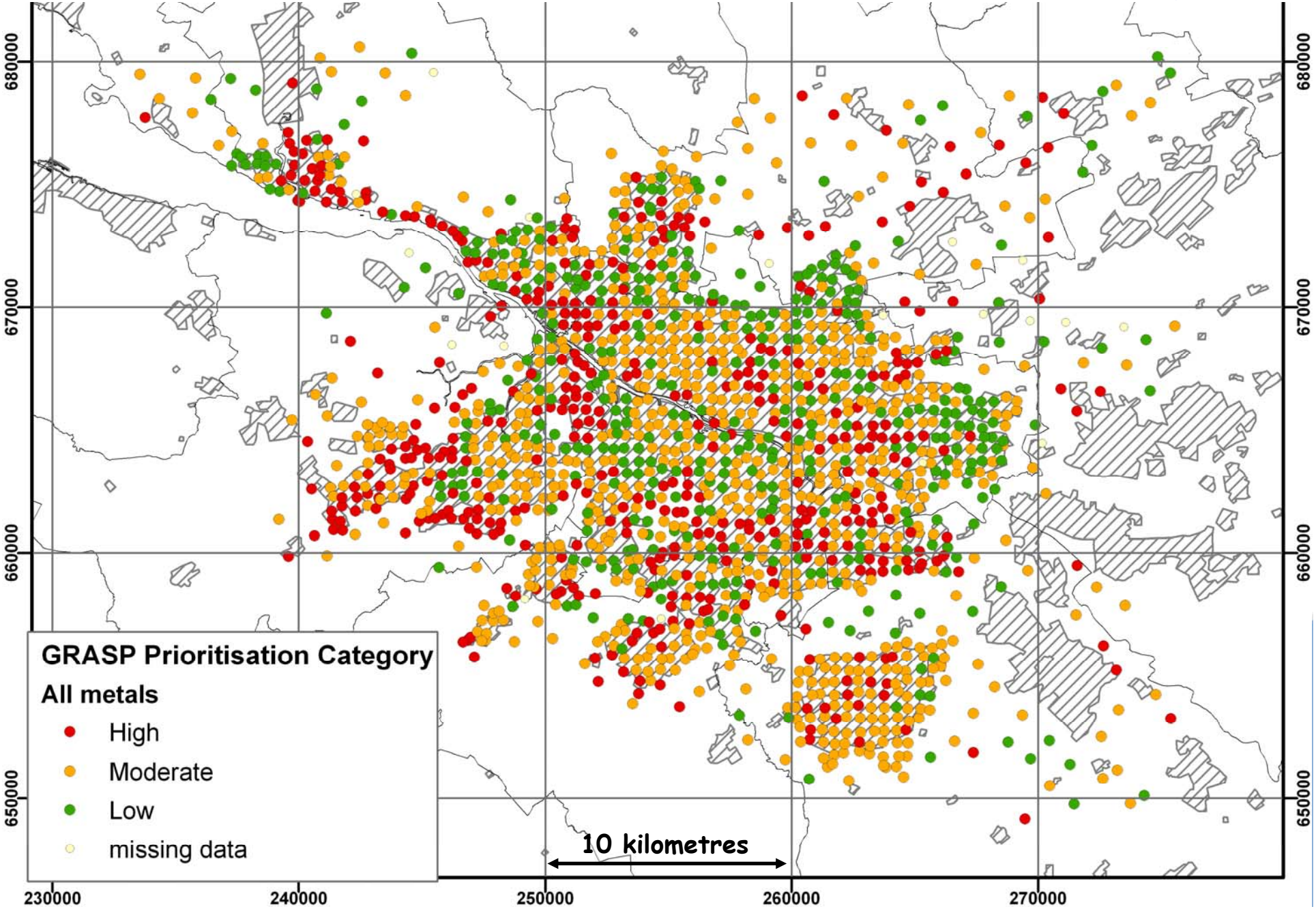


Step 5: Combined prioritisation ranking

Precautionary: combined prioritisation category is determined by the highest ranking for any metal at that site

Individual Metal Rankings (Step 4)	Combined GRASP Priority Category (Step 5)
All 10 are Low	Low
One or more is Moderate; the rest are Low	Moderate
One or more is High; the rest are Low or Moderate	High

End Step 5: GRASP Prioritisation Map



Interpreting GRASP outputs

- GRASP highlights **key areas at greatest threat** of metals leaching to shallow groundwater
- Main control on the location of these **high priority** sites is **depth to groundwater**
- **Metal concentrations** have a big influence on the location of **moderate priority** sites, but not on high priority sites
- Many highlighted areas coincide with known **industrial areas**

Future developments

- Collect new **groundwater level** data
- Refine how GRASP combines **leaching potential** with **metal concentrations**
- Collect new **groundwater quality** data for **validation**
- Apply to different issues: e.g. **Sustainable Urban Drainage Systems**

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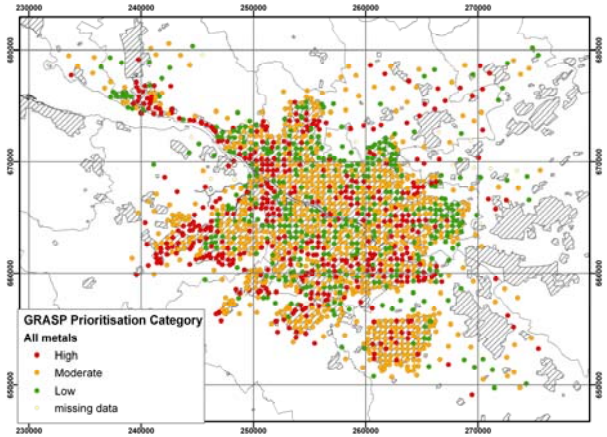

Thankyou

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