Queen's University Belfast

TELLUS

The Geochemistry of Soils in Greater Belfast

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SPACE

Oct 07

Building Sustainable Prosperity

Department of Enterprise, Trade and Investment

Geological Survey of Northern Ireland

I was born in Belfast between the mountain and the gantries

To the hooting of lost sirens and the clang of trams:

Thence to Smoky Carrick in County Antrim…….

The brook ran yellow from the factory stinking of chlorine,

Louis MacNeice

'Carrickfergus' ***1937***

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Introduction

Geochemistry & Environmental Concerns

Inorganic Sampling

Organic Sampling

Geochemistry & Environmental Concerns

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Why sample in Urban Areas?

Determination of soil quality (EU soil thematic strategy)

Determination of Potentially Hazardous Substances

History of urbanisation – poor historical waste management practices

Use Data to develop conceptual models & preliminary risk assessments

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Using the TELLUS data

Tellus data is of use in urban areas to produce preliminary risk assessments and to help build conceptual models

Tellus data will not define urban land as contaminated or not contaminated

Definition of Contaminated land

Environmental Protection Act, Part IIa (1990) / The Waste and Contaminated Land (Northern Ireland) Order 1997
Contaminated land is defined as: "any land which appears …to be in such a condition by reason of substances in, on or under the land that: Significant harm is being caused or there is a significant possibility of such harm being caused or Pollution of controlled water is being or likely to be caused" *Harm is defined as:* "harm to the health of living organisms, or other interference with the ecological systems of which they form a part, and in the case of man, harm to his property"

Pollutant linkage model

Quantification of the pollutant linkage model allows the derivation of *assessment criteria*

Soil Guideline Values (SGVs)

- Assessment Criteria applied to ‘Generic’ Scenarios
- Derived using exposure models
- Often more detailed quantitative values for site specific cases
- Conceptual and exposure models must be modified for site specific cases

Inorganic Sampling Locations

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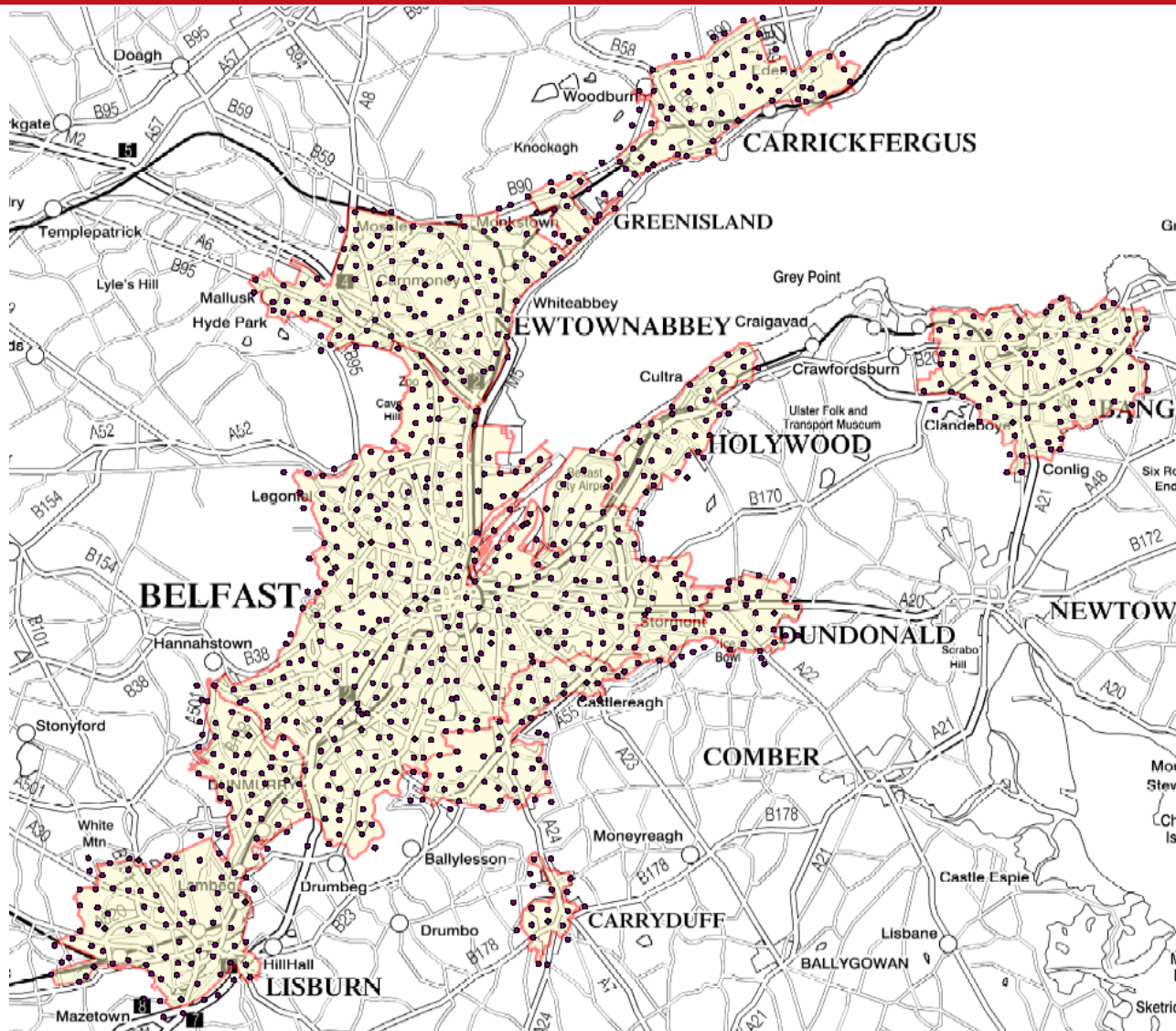
Inorganic sampling at 4 sites per km^2

GBASE protocols used



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Sampling locations

Urban areas (including brownfield sites) are often built on ‘Made ground’ or ‘Fill’

This is often reworked natural ground or material brought in from elsewhere

It is highly heterogeneous in nature - The data can’t be easily extrapolated. Other BGS surveys have produced variograms that often don’t have spatial connectivity over the sampling grid

Metals (median concentrations) in selected cities

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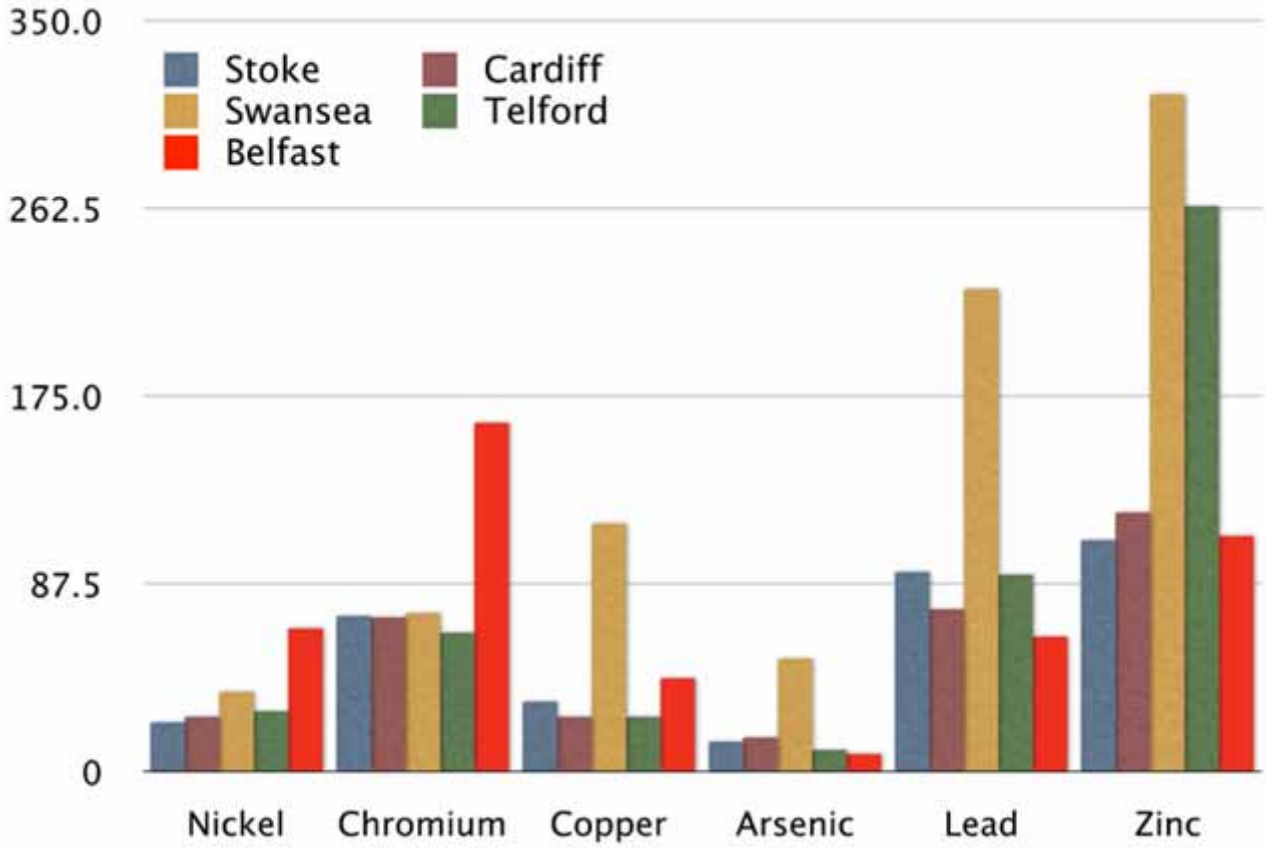

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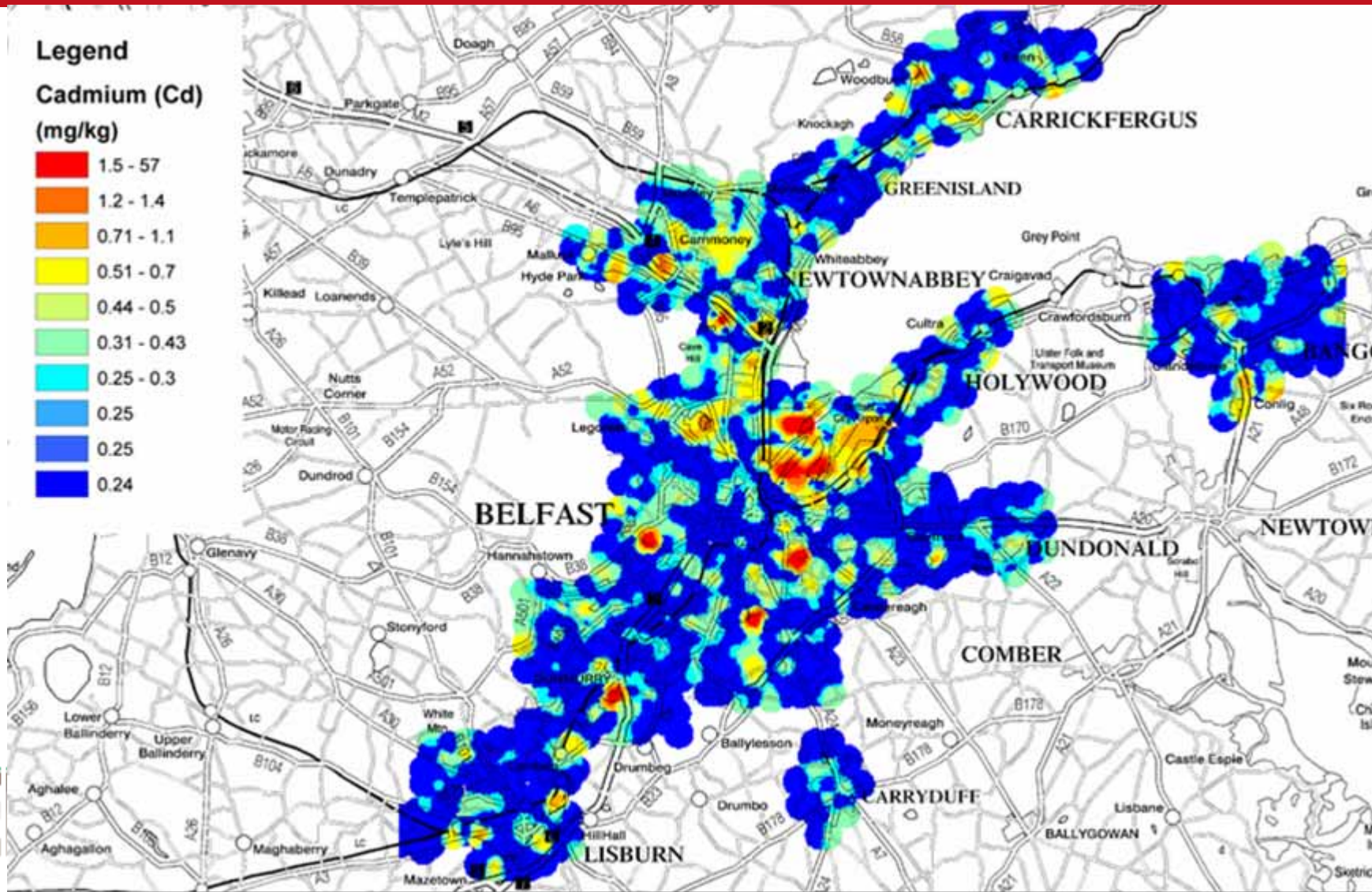
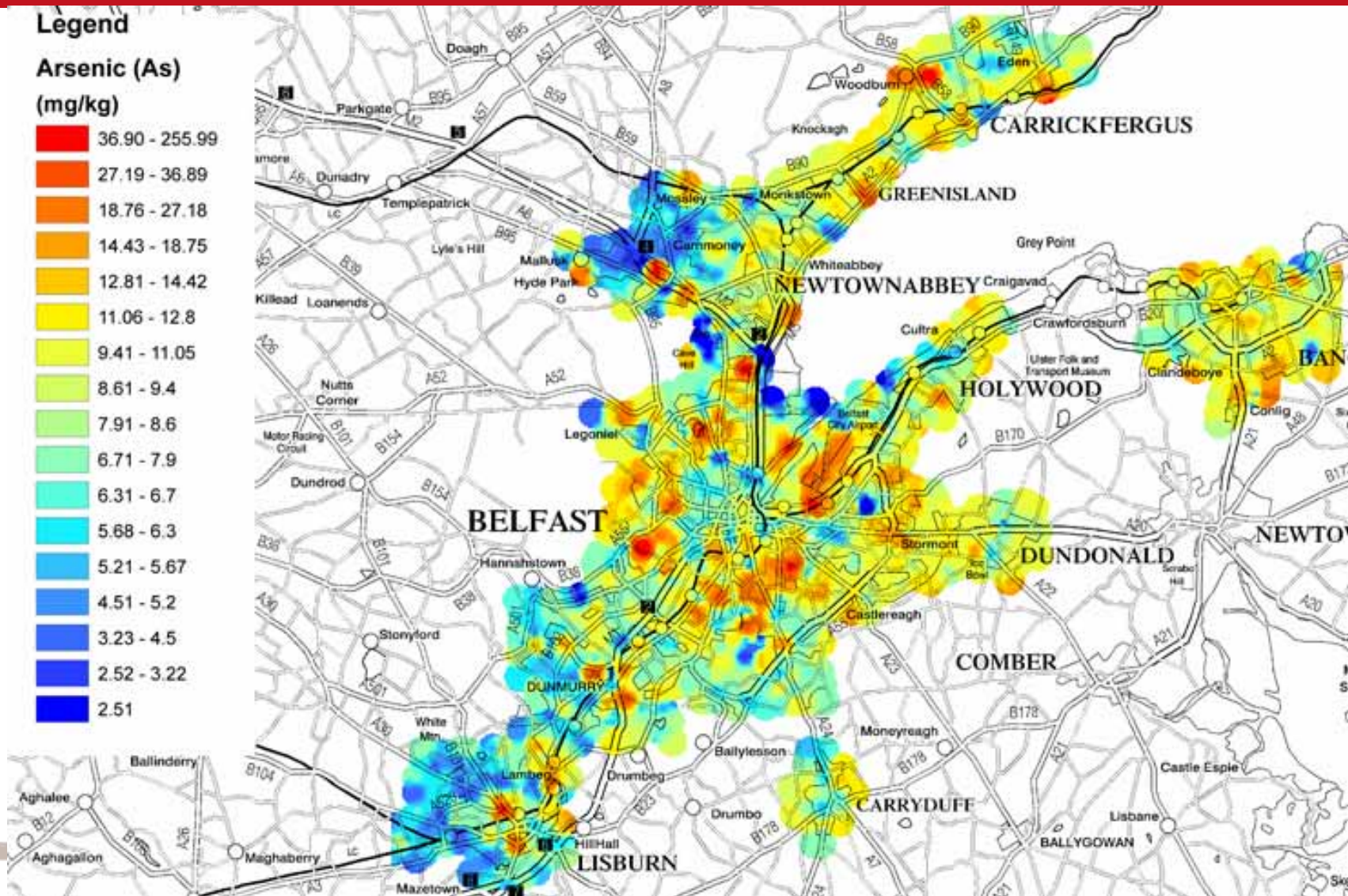
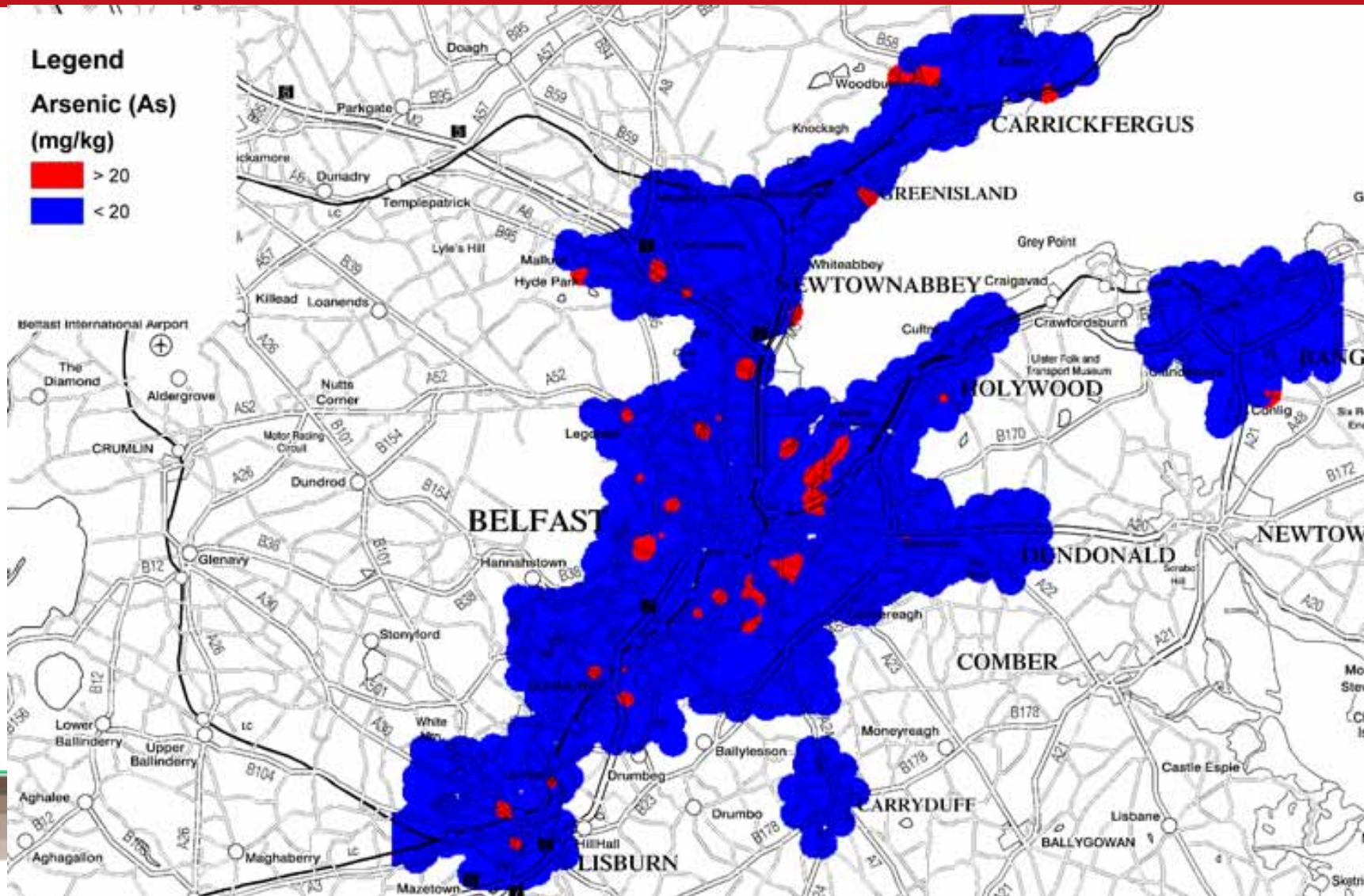
Cadmium


Legend
Cadmium (Cd)
(mg/kg)
1.5 - 57
1.2 - 1.4
0.71 - 1.1
0.51 - 0.7
0.44 - 0.5
0.31 - 0.43
0.25 - 0.3
0.25
0.25
0.24
BELFAST
CARRICKFERGUS
GREENISLAND
NEWTOWNABBEY
HOLYWOOD
DUNDONALD
COMBER
LISBURN
CARRYDUFF
BALLYGOWAN
Doagh
Parkgate
Dunadry
Templepatrick
Killead
Loanends
Nutts Corner
Dundrod
Glenavy
Hannahstown
Stoneyford
Lower Ballinderry
Upper Ballinderry
Aghalee
Aghagallon
Maghaberry
Mazetown
Knockagh
Cairnmoney
Whiteabbey
Craigavad
Grey Point
Crawfordsburn
Cultra
Conlig
Ballylesson
Drumbeg
Drumbo
Moneyreagh
Castle Espie
Lisbane

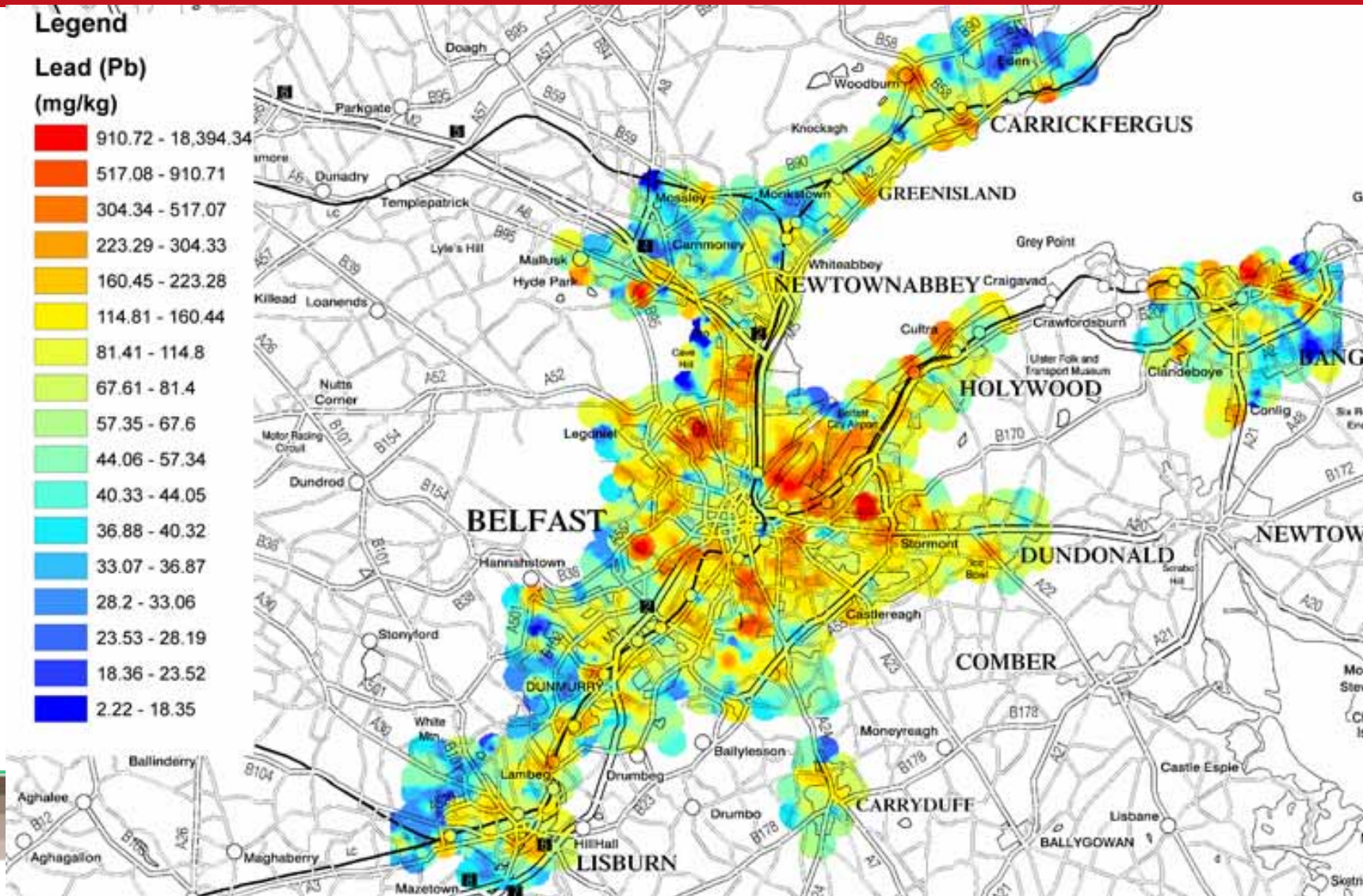
Arsenic


Legend
Arsenic (As)
(mg/kg)
36.90 - 255.99
27.19 - 36.89
18.76 - 27.18
14.43 - 18.75
12.81 - 14.42
11.06 - 12.8
9.41 - 11.05
8.61 - 9.4
7.91 - 8.6
6.71 - 7.9
6.31 - 6.7
5.68 - 6.3
5.21 - 5.67
4.51 - 5.2
3.23 - 4.5
2.52 - 3.22
2.51
BELFAST
NEWTOWNABBEY
CARRICKFERGUS
GREENISLAND
HOLYWOOD
DUNDONALD
COMBER
CARRYDUFF
LISBURN
BALLYGOWAN
Doagh
Parkgate
Dunadry
Templepatrick
Killead
Loanends
Nutts Corner
Dundrod
Stoneyford
DUNMURRY
Hannahstown
Legoniel
Cavehill
Cammoney
Mossley
Monkstown
Whiteabbey
Hyde Park
Lyle's Hill
Knockagh
Woodburn
Eden
Grey Point
Craigavad
Crawfordsburn
Cultra
Ulster Folk and Transport Museum
Clandeboye
Conlig
Belfast City Airport
Stormont
Scrabo Hill
Castlereagh
Moneyreagh
Ballylesson
Drumbeg
Drumbo
Lambeg
HillHall
Castle Espie
Lisbane
Ballinderry
Aghalee
Aghagallon
Maghaberry
Mazetown
White Mtn
Motor Racing Circuit

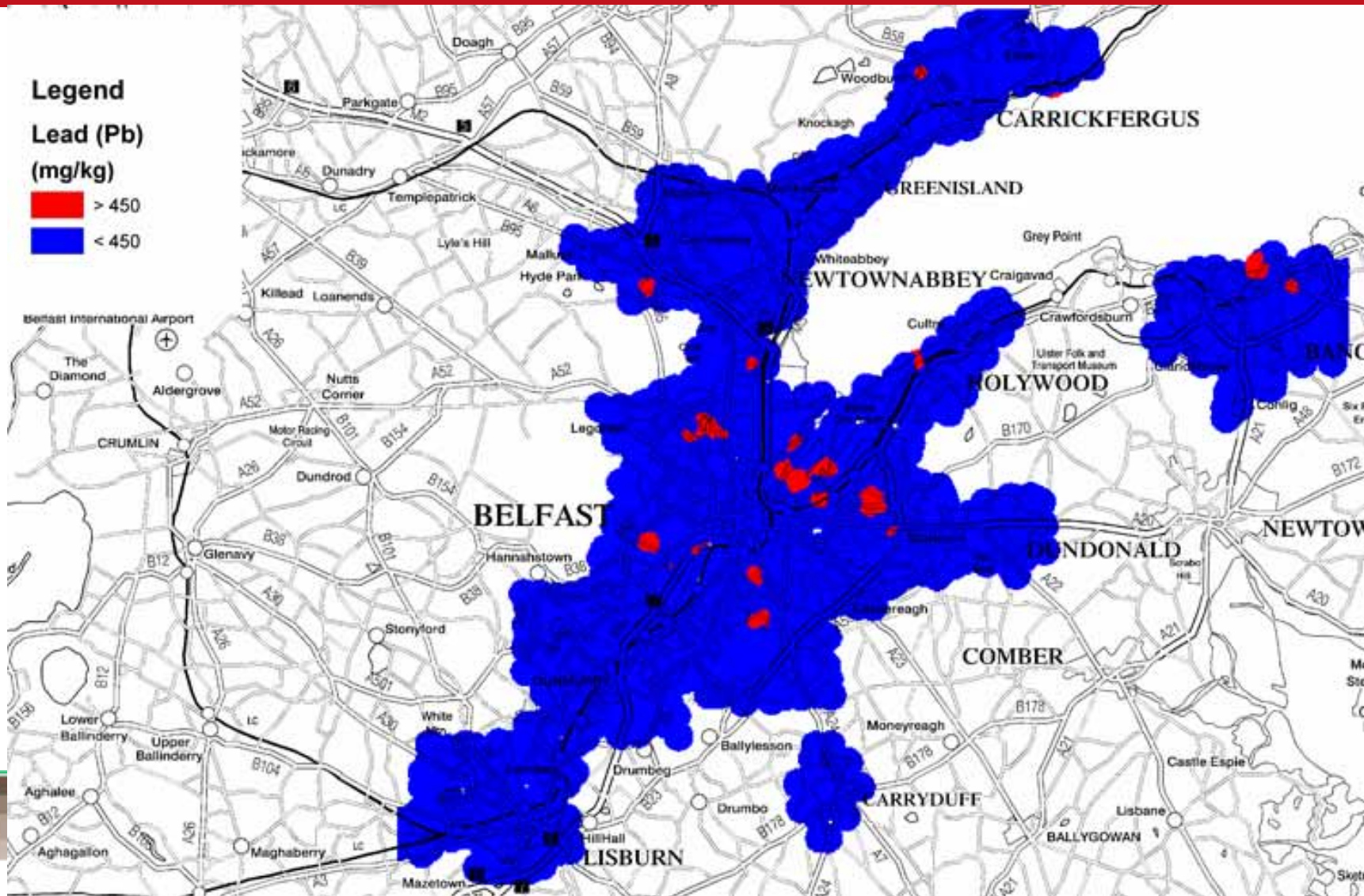
Arsenic


Legend
Arsenic (As)
(mg/kg)
> 20
< 20
Doagh
Parkgate
Dunadry
Templepatrick
Killead
Loanends
Belfast International Airport
The Diamond
Aldergrove
Nutts Corner
CRUMLIN
Motor Racing Circuit
Dundrod
Glenavy
Hannahstown
BELFAST
Stoneyford
Lower Ballinderry
Upper Ballinderry
Aghalee
Aghagallon
Maghaberry
Mazetown
LISBURN
White
Drumbeg
Drumbo
Ballylesson
Moneyreagh
CARRYDUFF
BALLYGOWAN
Lisbane
Castle Espie
COMBER
NEWTOWNABBEY
Whiteabbey
Grey Point
Craigavad
Crawfordsburn
HOLYWOOD
CARRICKFERGUS
Knockagh
Lyle's Hill
Hyde Park
Ulster Folk and Transport Museum

Lead


Legend
Lead (Pb)
(mg/kg)
910.72 - 18,394.34
517.08 - 910.71
304.34 - 517.07
223.29 - 304.33
160.45 - 223.28
114.81 - 160.44
81.41 - 114.8
67.61 - 81.4
57.35 - 67.6
44.06 - 57.34
40.33 - 44.05
36.88 - 40.32
33.07 - 36.87
28.2 - 33.06
23.53 - 28.19
18.36 - 23.52
2.22 - 18.35
CARRICKFERGUS
GREENISLAND
NEWTOWNABBEY
HOLYWOOD
BELFAST
DUNDONALD
COMBER
CARRYDUFF
LISBURN
BALLYGOWAN
Doagh
Parkgate
Woodburn
Knockagh
Dunadry
Templepatrick
Mossley
Monkstown
Carnmoney
Whiteabbey
Grey Point
Craigavad
Mallusk
Hyde Park
Killead
Loanends
Lyle's Hill
Cultra
Crawfordsburn
Clandeboye
Nutts Corner
Motor Racing Circuit
Dundrod
Legoniel
Belfast City Airport
Stormont
Hannahstown
Castlereagh
Stonyford
DUNMURRY
White Mn
Ballylesson
Moneyreagh
Castle Espie
Ballinderry
Aghalee
Aghagallon
Maghaberry
Lambeg
Drumbeg
Drumbo
HillHall
Lisbane
Mazetown

Lead


Legend
Lead (Pb)
(mg/kg)
> 450
< 450
Doagh
Parkgate
Dunadry
Templepatrick
Killead
Loanends
Belfast International Airport
The Diamond
Aldergrove
Nutts Corner
CRUMLIN
Motor Racing Circuit
Dundrod
Glenavy
Stoneyford
Lower Ballinderry
Upper Ballinderry
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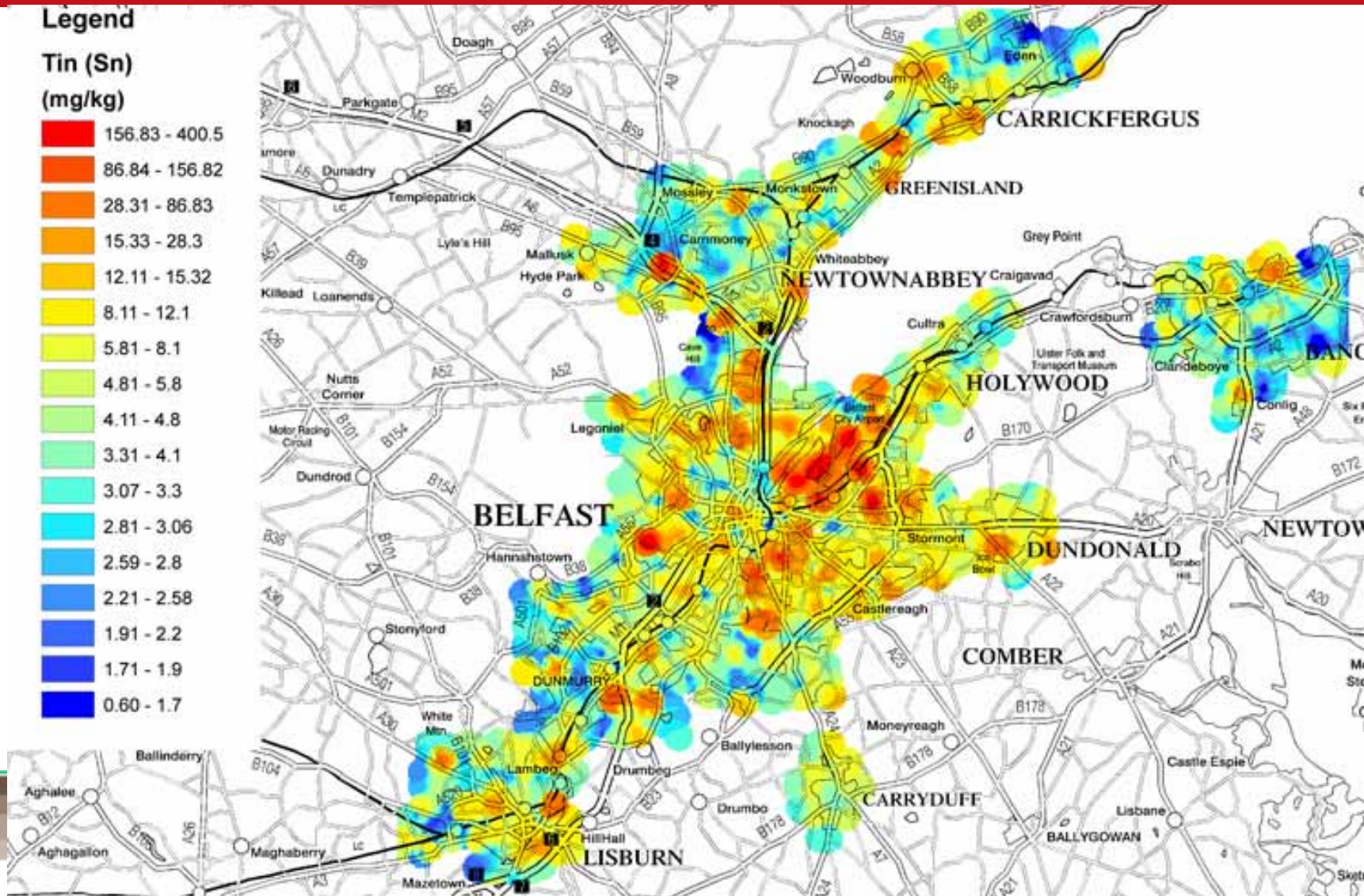
HillHall
LISBURN
Mazetown

Tin


Legend
Tin (Sn)
(mg/kg)
156.83 - 400.5
86.84 - 156.82
28.31 - 86.83
15.33 - 28.3
12.11 - 15.32
8.11 - 12.1
5.81 - 8.1
4.81 - 5.8
4.11 - 4.8
3.31 - 4.1
3.07 - 3.3
2.81 - 3.06
2.59 - 2.8
2.21 - 2.58
1.91 - 2.2
1.71 - 1.9
0.60 - 1.7
CARRICKFERGUS
GREENISLAND
NEWTOWNABBEY
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BELFAST
DUNDONALD
COMBER
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Doagh
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Dunadry
Templepatrick
Woodburn
Knockagh
Mossley
Monkstown
Carnmoney
Whiteabbey
Grey Point
Craigavad
Crawfordsburn
Cultra
Clandeboye
Malusk
Hyde Park
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Castlereagh
Stonyford
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Lambeg
HillHall
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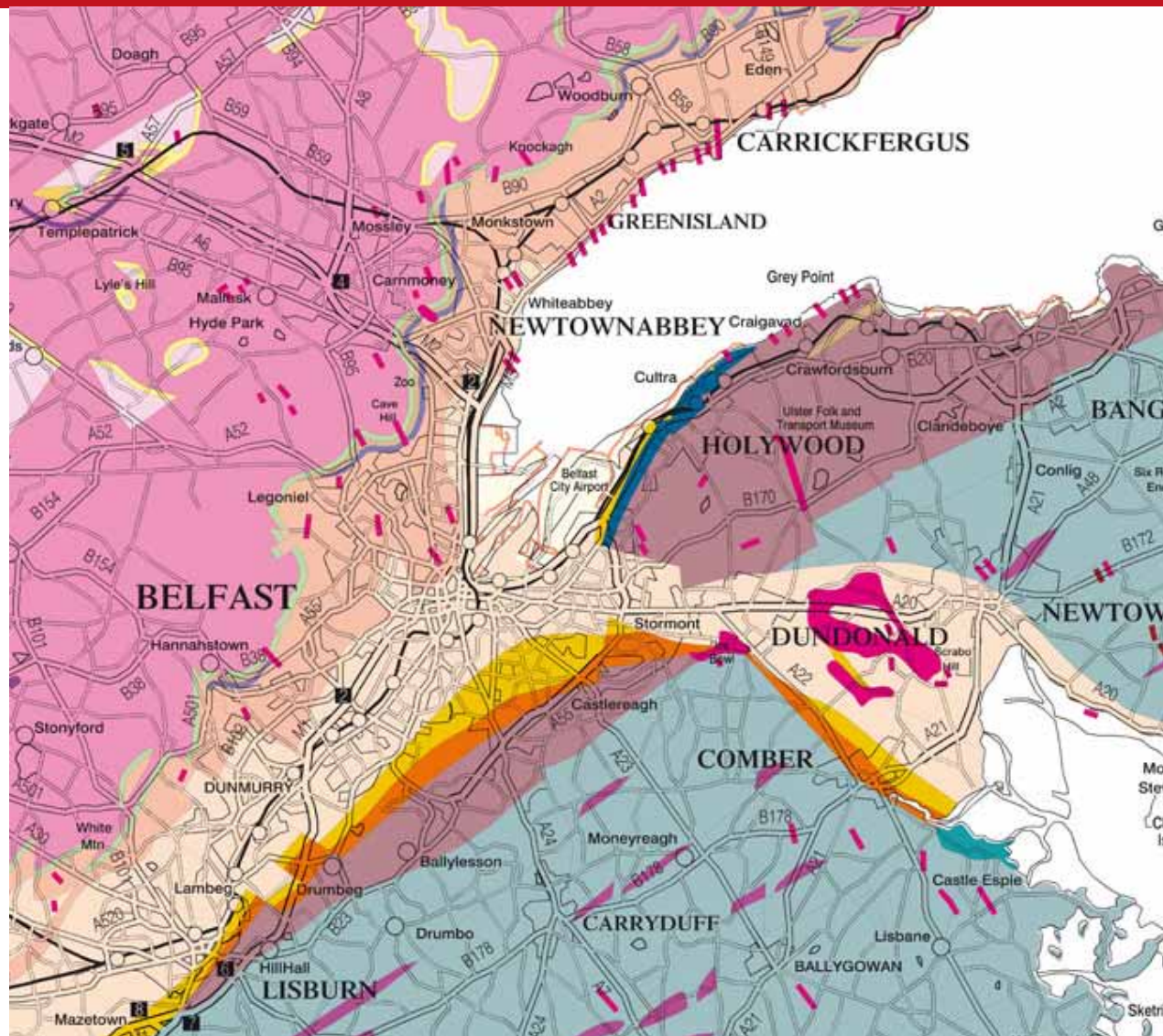
Ballinderry
Aghalee
Aghagallon
Maghaberry
Mazetown
Ulster Folk and Transport Museum
Motor Racing Circuit
Belfast City Airport

Underlying Geology

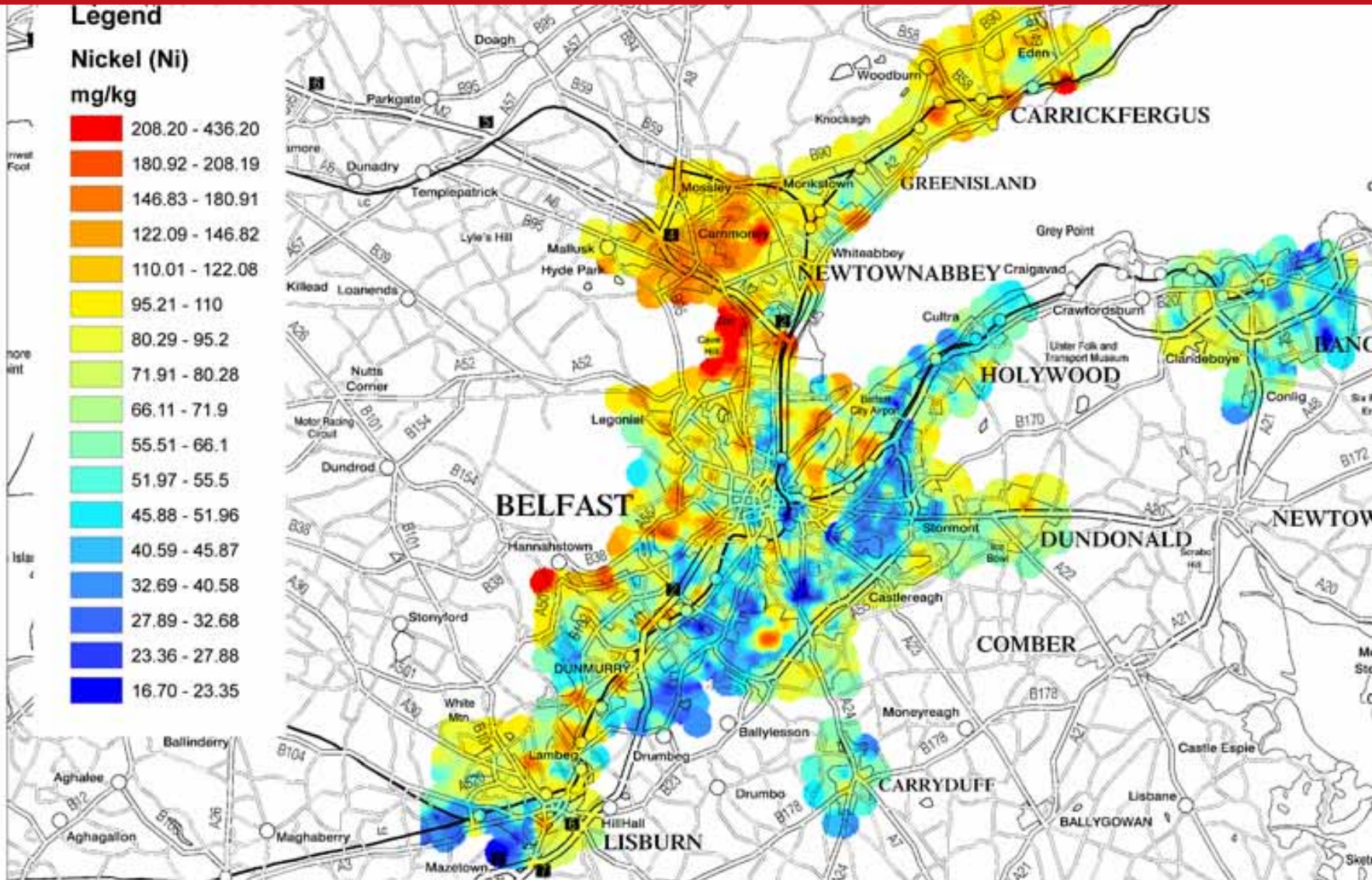
Pink = Palaeogene (Basalts)

Beige = Triassic (Sandstone & Mudstones)

Grey = Silurian (Shales)



Nickel


Legend
Nickel (Ni)
mg/kg
208.20 - 436.20
180.92 - 208.19
146.83 - 180.91
122.09 - 146.82
110.01 - 122.08
95.21 - 110
80.29 - 95.2
71.91 - 80.28
66.11 - 71.9
55.51 - 66.1
51.97 - 55.5
45.88 - 51.96
40.59 - 45.87
32.69 - 40.58
27.89 - 32.68
23.36 - 27.88
16.70 - 23.35
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GREENISLAND
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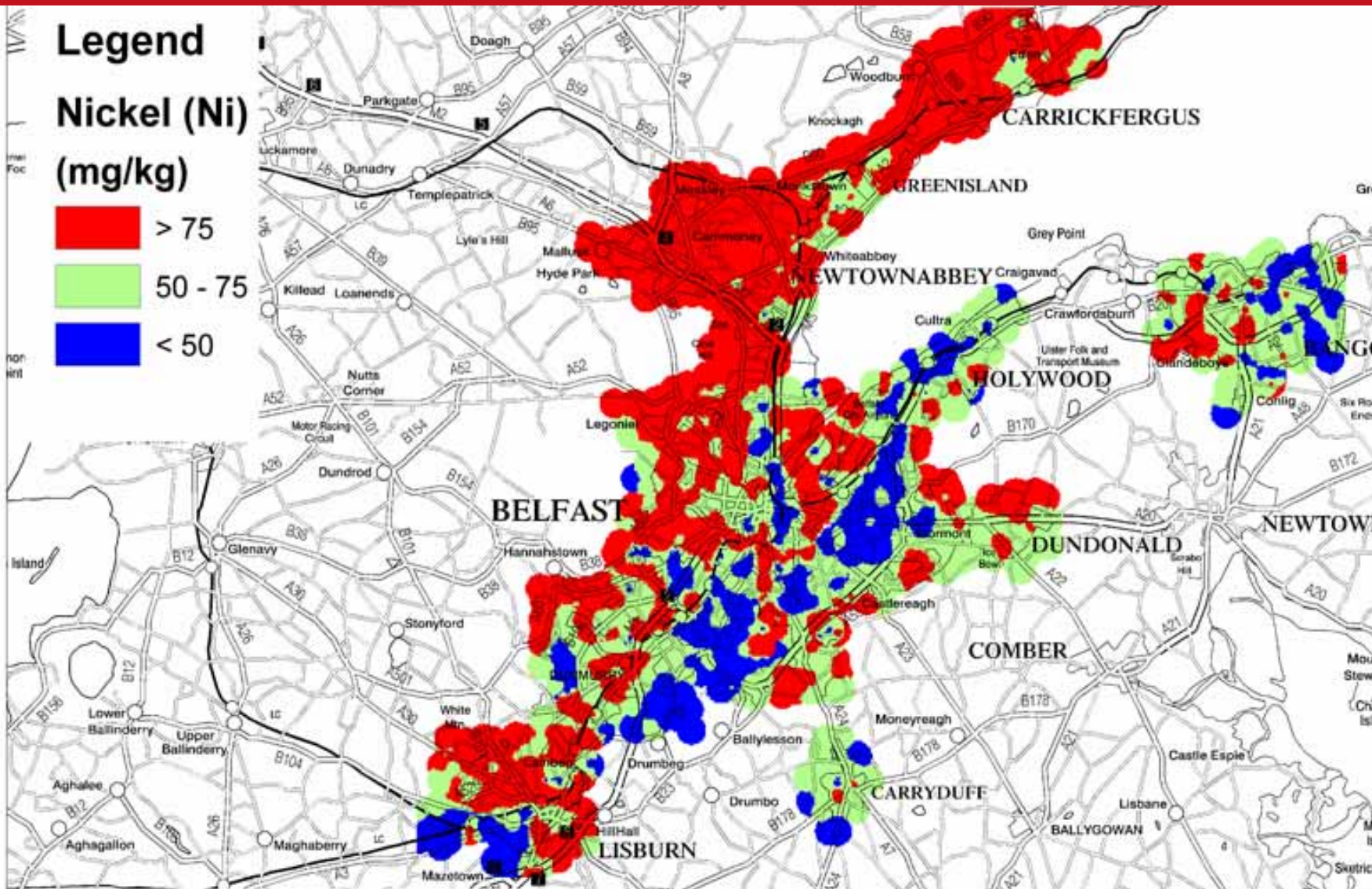
Aghalee
Aghagallon
Maghaberry
Mazetown

Nickel


Legend
Nickel (Ni)
(mg/kg)
> 75
50 - 75
< 50
CARRICKFERGUS
GREENISLAND
NEWTOWNABBEY
HOLYWOOD
BELFAST
DUNDONALD
COMBER
CARRYDUFF
LISBURN
BALLYGOWAN
Doagh
Parkgate
Dunadry
Templepatrick
Killead
Loanends
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Dundrod
Glenavy
Stonyford
Lower Ballinderry
Upper Ballinderry
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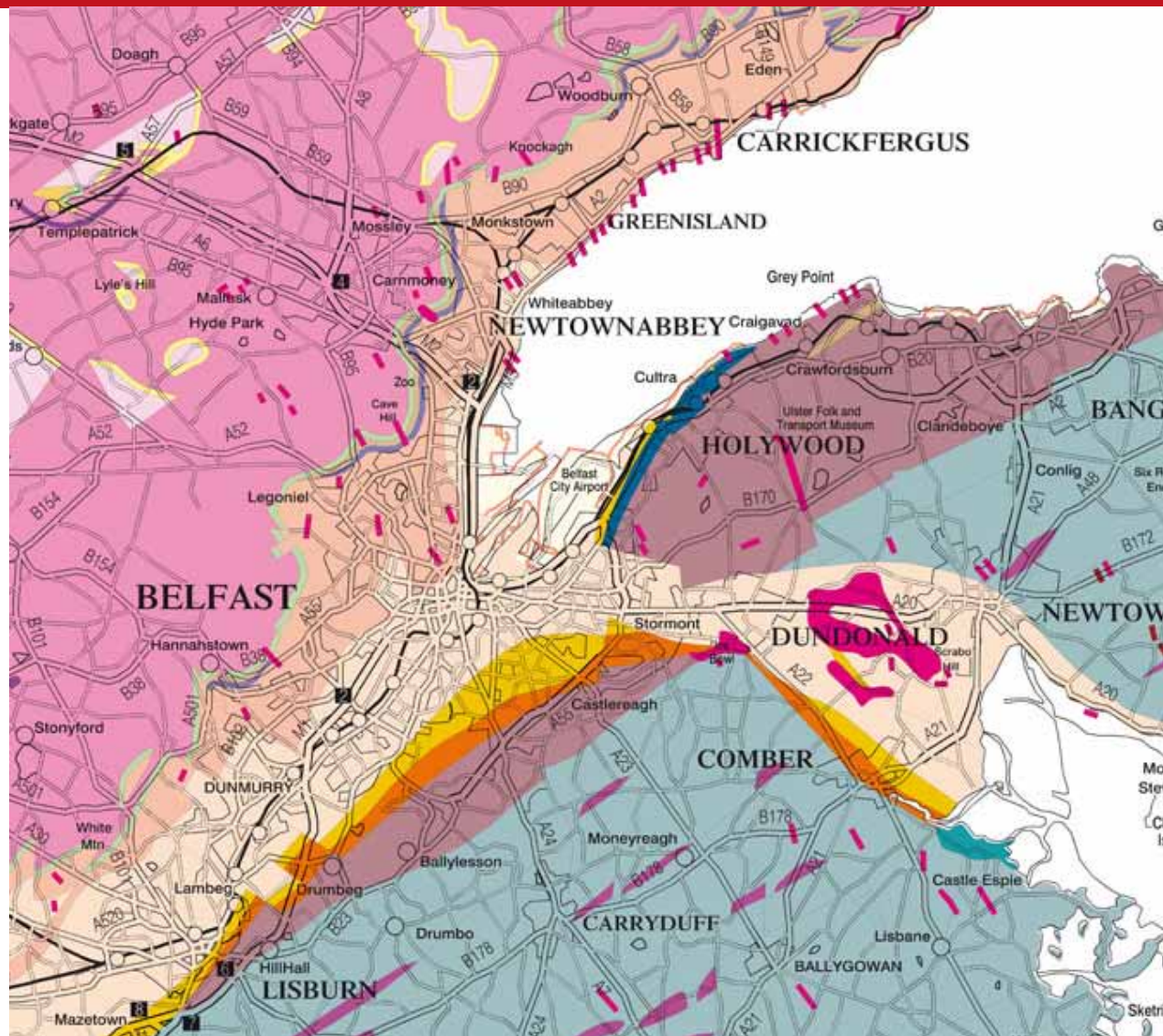
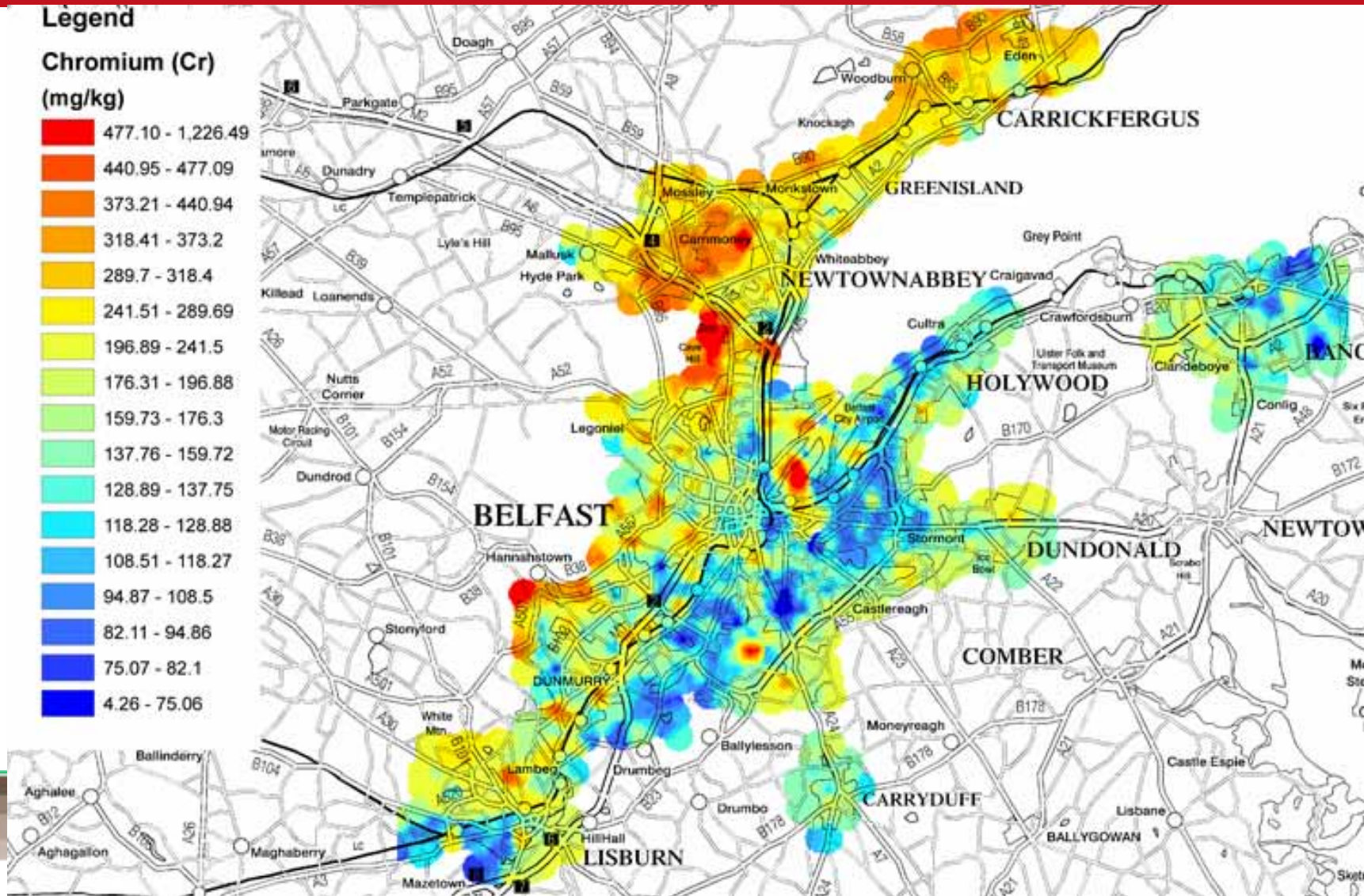


Chromium


Legend
Chromium (Cr)
(mg/kg)
477.10 - 1,226.49
440.95 - 477.09
373.21 - 440.94
318.41 - 373.2
289.7 - 318.4
241.51 - 289.69
196.89 - 241.5
176.31 - 196.88
159.73 - 176.3
137.76 - 159.72
128.89 - 137.75
118.28 - 128.88
108.51 - 118.27
94.87 - 108.5
82.11 - 94.86
75.07 - 82.1
4.26 - 75.06
BELFAST
NEWTOWNABBEY
CARRICKFERGUS
GREENISLAND
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COMBER
CARRYDUFF
BALLYGOWAN
LISBURN
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Cavehill
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Crawfordsburn
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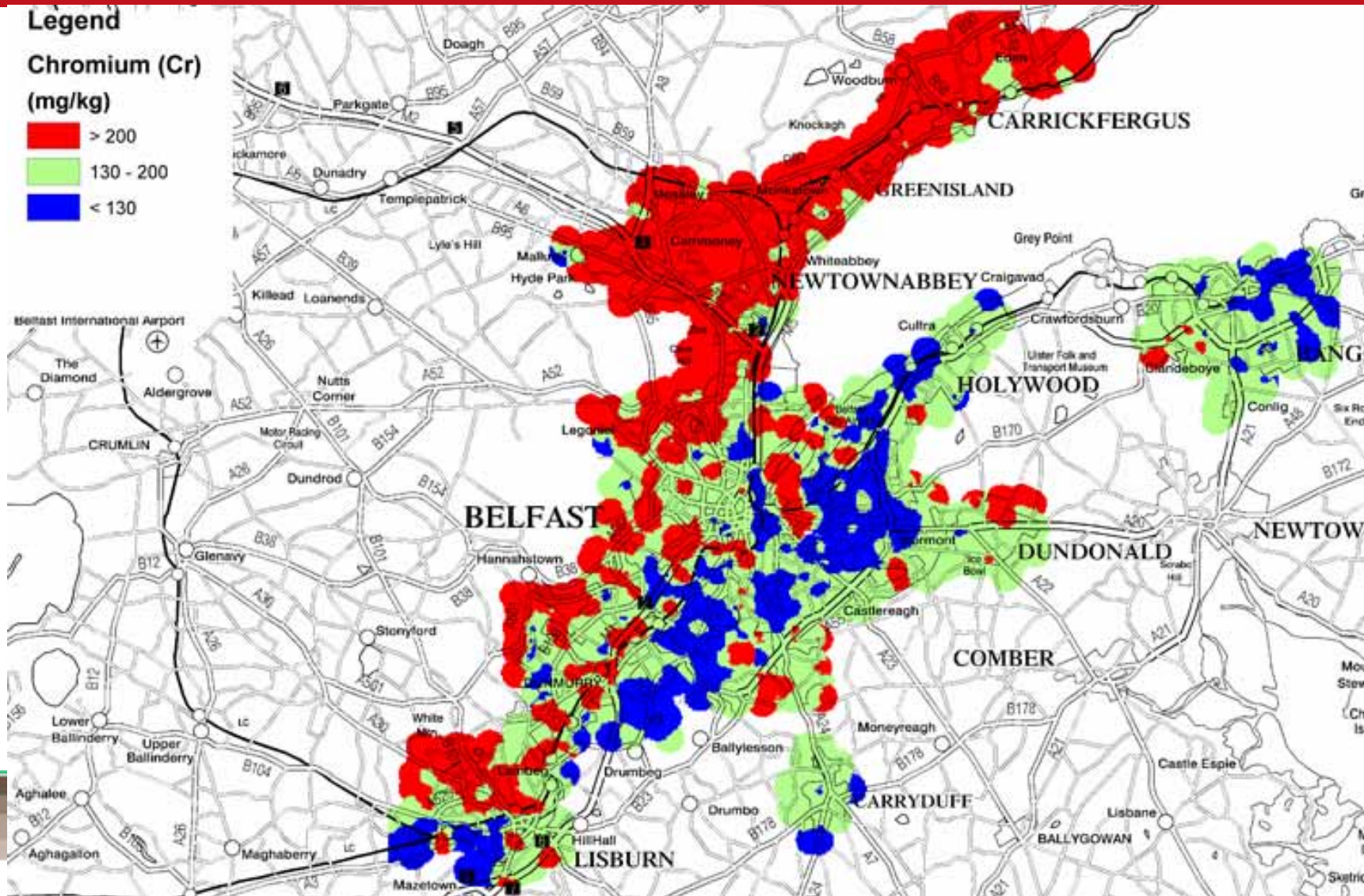
Clandeboye
Ulster Folk and Transport Museum
Nutts Corner
Killead
Loanends
Lyle's Hill
Malluska
Hyde Park
Legoniel
Dundrod
Motor Racing Circuit
Hannahstown
Stormont
Castlereagh
Stoneyford
DUNMURRY
White Mtn
Lambeg
Drumbeg
Ballylesson
Moneyreagh
Castle Espie
Drumbo
Lisbane
HillHall
Mazetown
Ballinderry
Aghalee
Aghagallon
Maghaberry
Conlig

Chromium


Legend
Chromium (Cr)
(mg/kg)
> 200
130 - 200
< 130
Doagh
Parkgate
Dunadry
Templepatrick
Killead
Loanends
Lyle's Hill
Malone
Hyde Park
Cavehill
Whiteabbey
NEWTOWNABBEY
Craigavad
Grey Point
Woodburn
Knockagh
CARRICKFERGUS
GREENISLAND
Cultra
Crawfordsburn
Ulster Folk and Transport Museum
Bangor
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Conlig
Belfast International Airport
The Diamond
Aldergrove
Nutts Corner
CRUMLIN
Motor Racing Circuit
Dundrod
Legacurry
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Hannahstown
Stormont
DUNDONALD
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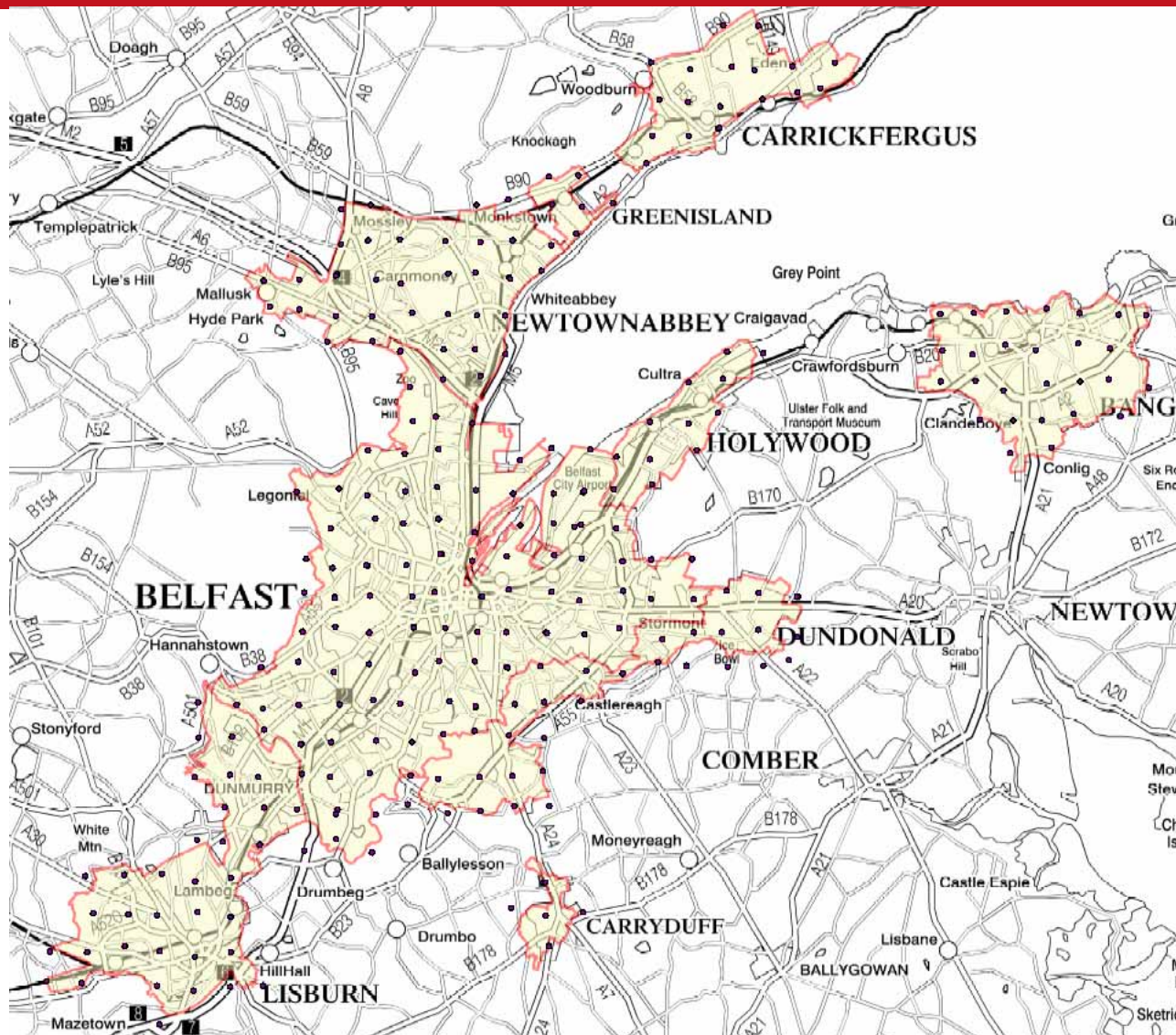
Stoneyford
COMBER
Lower Ballinderry
Upper Ballinderry
White Mtn
Moneyreagh
Ballylesson
Drumbeg
Castle Espie
Aghalee
Aghagallon
Maghaberry
Drumbo
CARRYDUFF
Lisbane
BALLYGOWAN
HillHall
LISBURN
Mazetown

Organic Sampling Locations

Organic sampling at 1 site per km^2

GBASE protocols used



Poly Aromatic Hydrocarbons - PAHs

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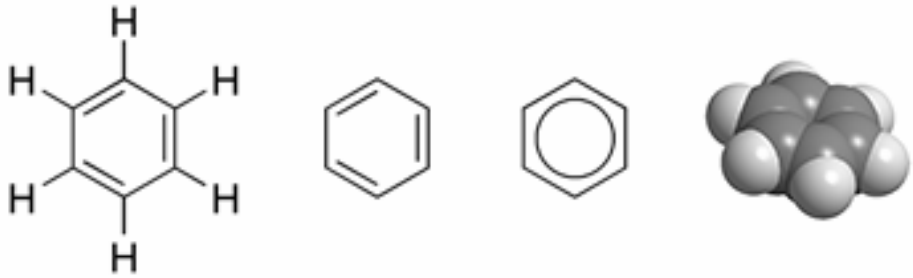
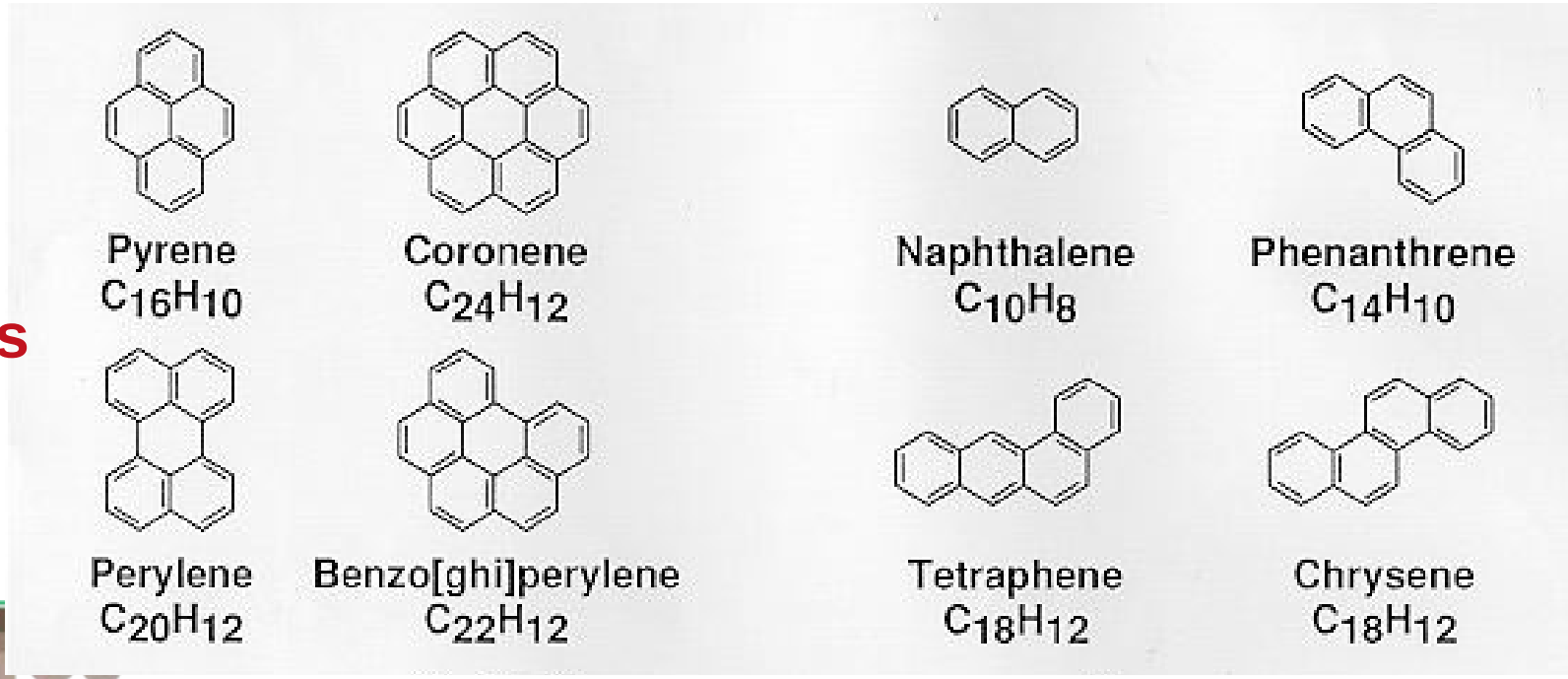
Benzene



PAHs

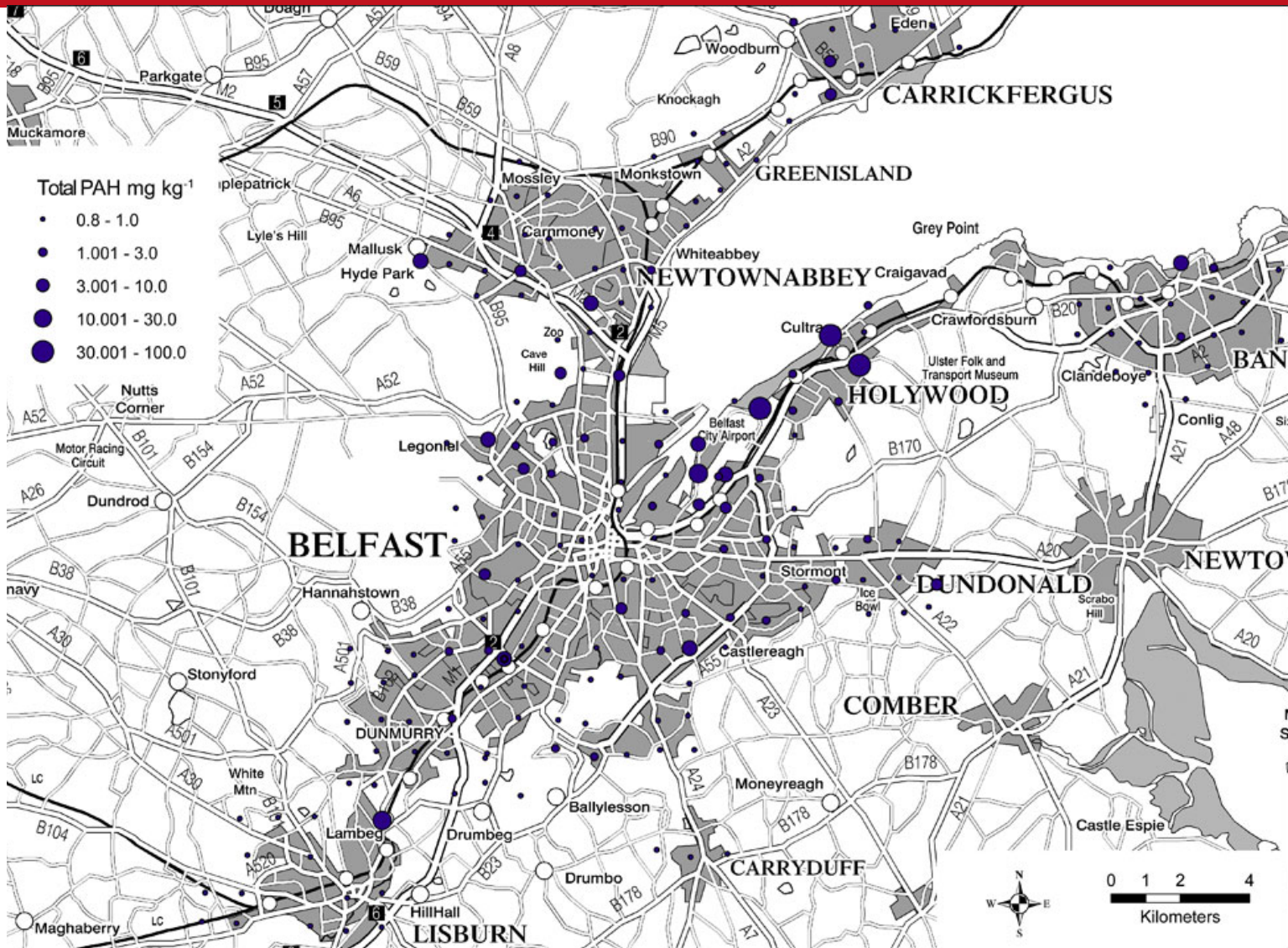


Organics summary

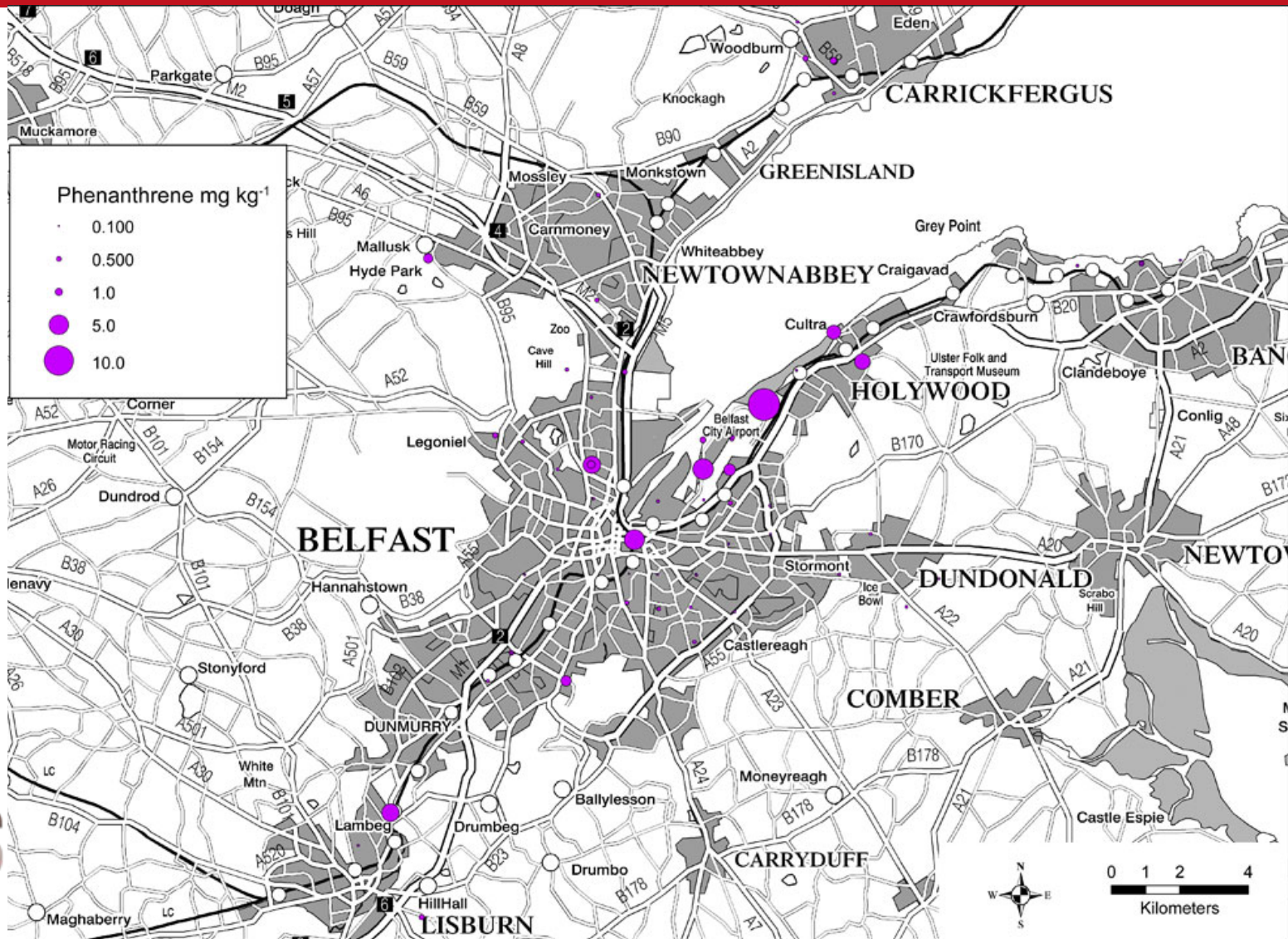
	Belfast	Derry
Number of sites	329	56
Sites with contaminants > detection limit*	112	11
Sites with total PAH > 40mg/kg	5	0
Sites with benzo-a-pyrene > 1mg/kg	10	1

* 100 μg/kg

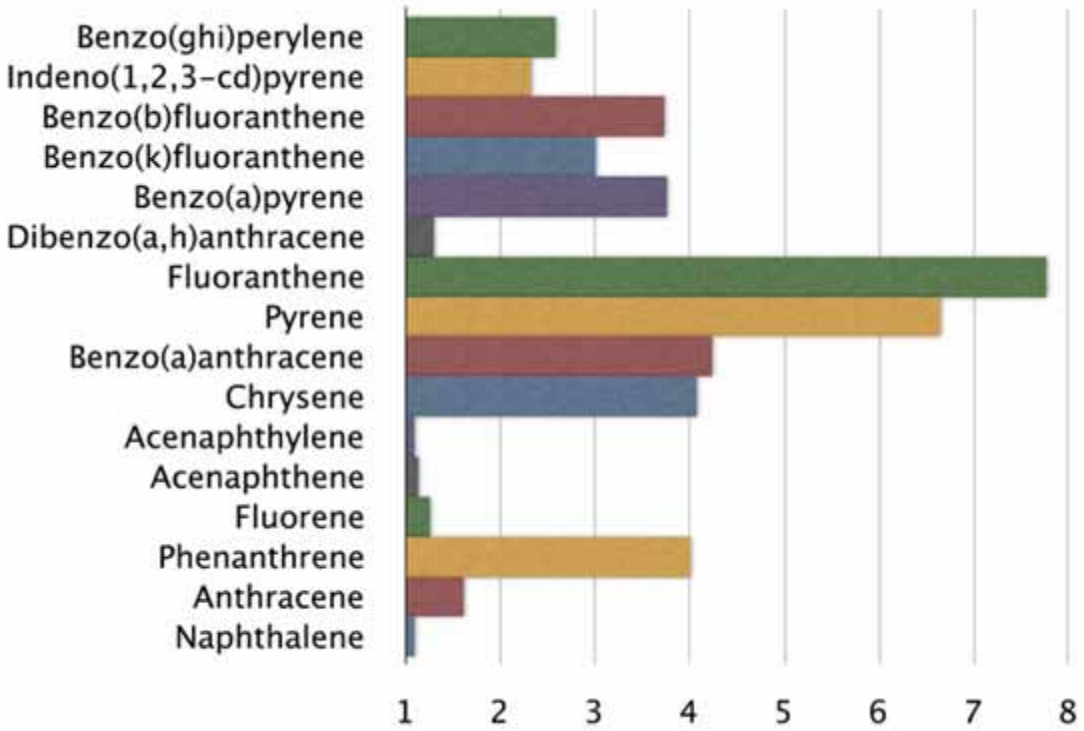
Total PAH


Total PAH mg kg-1
0.8 - 1.0
1.001 - 3.0
3.001 - 10.0
10.001 - 30.0
30.001 - 100.0
Muckamore
Parkgate
Woodburn
Eden
CARRICKFERGUS
Knockagh
Mossley
Monkstown
GREENISLAND
Carnmoney
Grey Point
Whiteabbey
NEWTOWNABBEY
Craigavad
Crawfordsburn
Mallusk
Hyde Park
Lyle's Hill
Zoo
Cave Hill
Cultra
Ulster Folk and Transport Museum
HOLYWOOD
Clandeboye
Nutts Corner
Motor Racing Circuit
Belfast City Airport
Legoniel
Conlig
Dundrod
BELFAST
Stormont
Ice Bowl
DUNDONALD
Scrabo Hill
Hannahstown
Castlereagh
Stonyford
DUNMURRY
COMBER
White Mtn
Moneyreagh
Ballylesson
Lambeg
Drumbeg
Castle Espie
Drumbo
CARRYDUFF
Maghaberry
HillHall
LISBURN
0 1 2 4
Kilometers

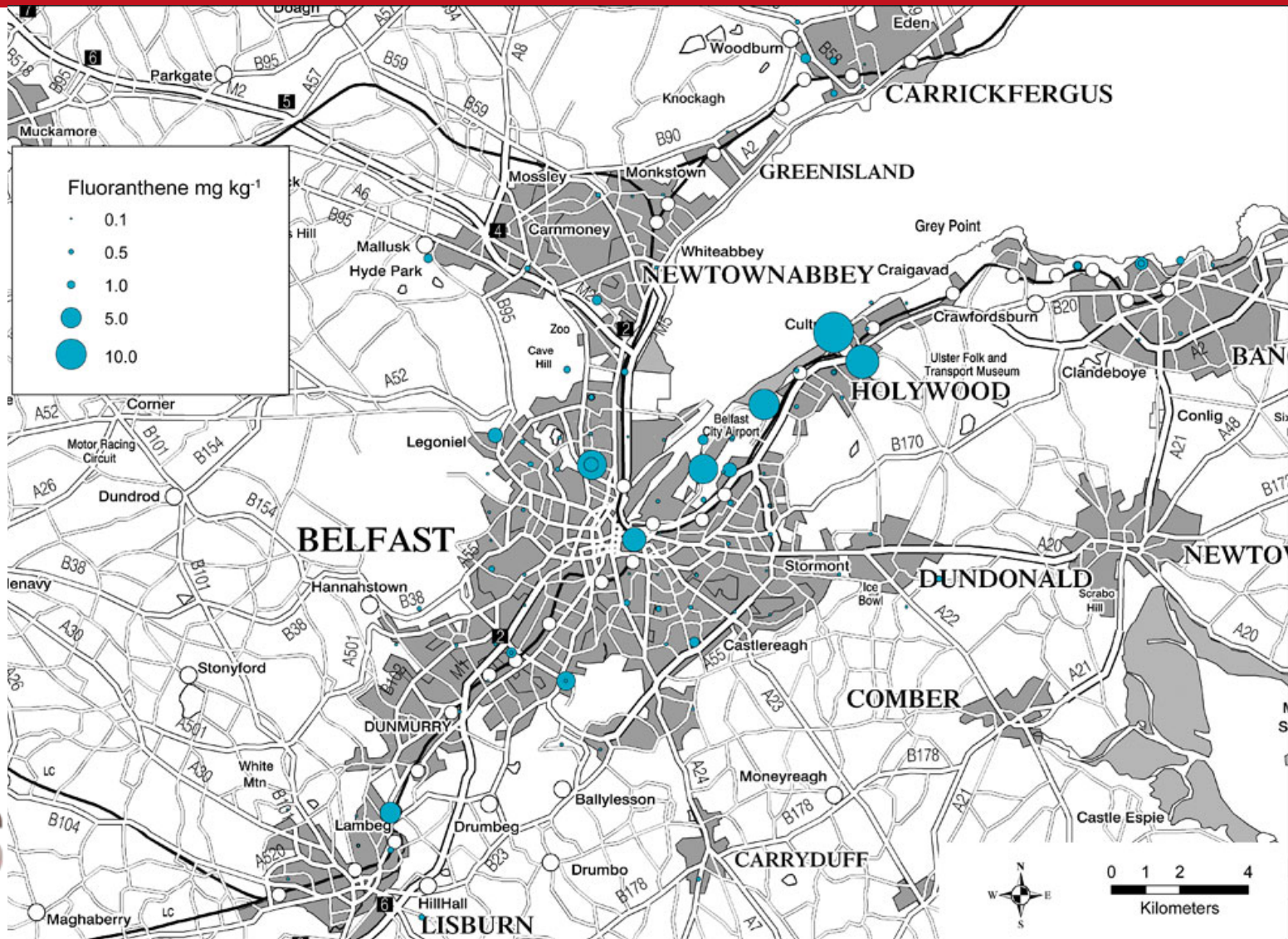
Phenanthrene



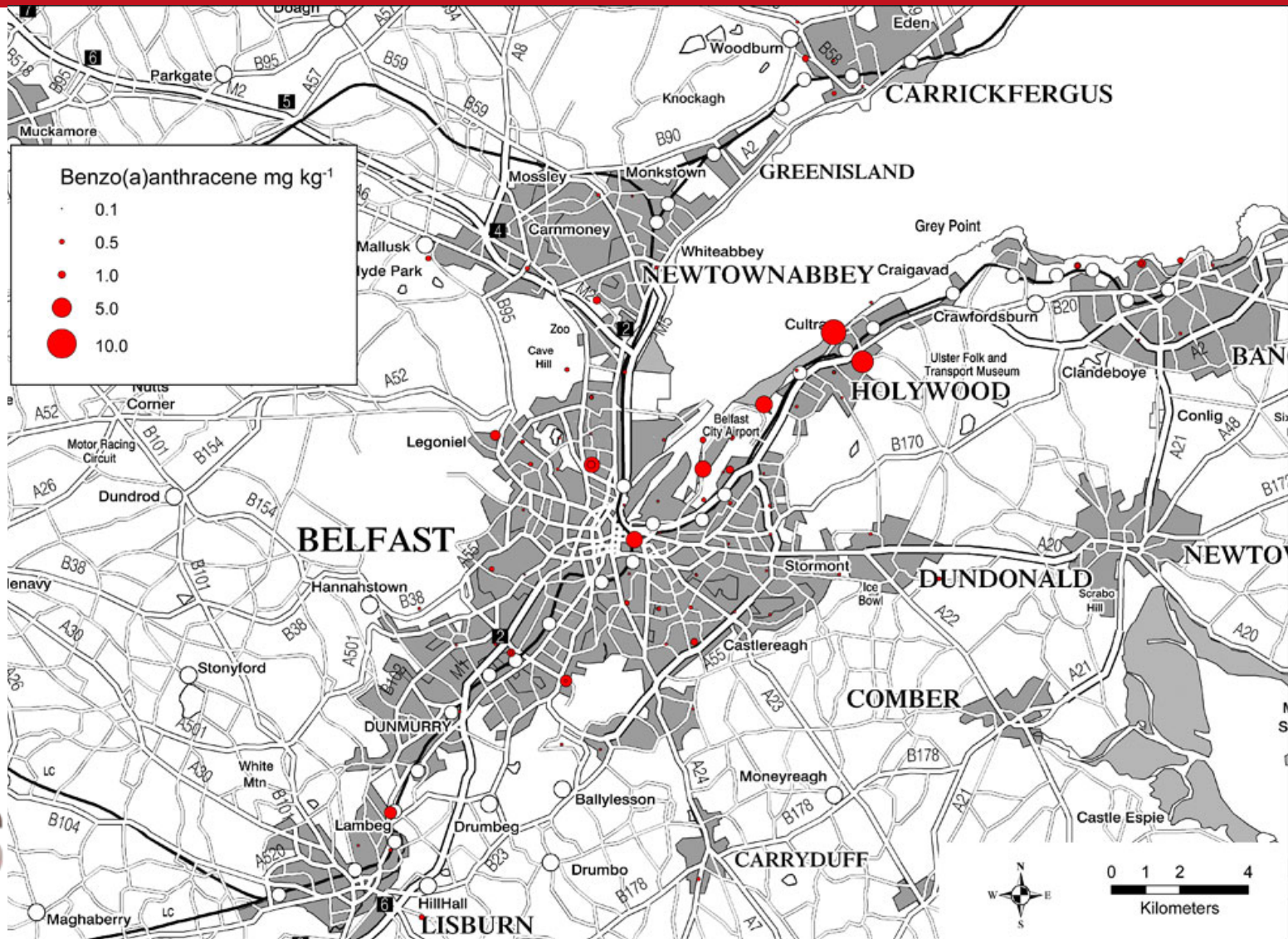
PAHs in Belfast – relative abundance



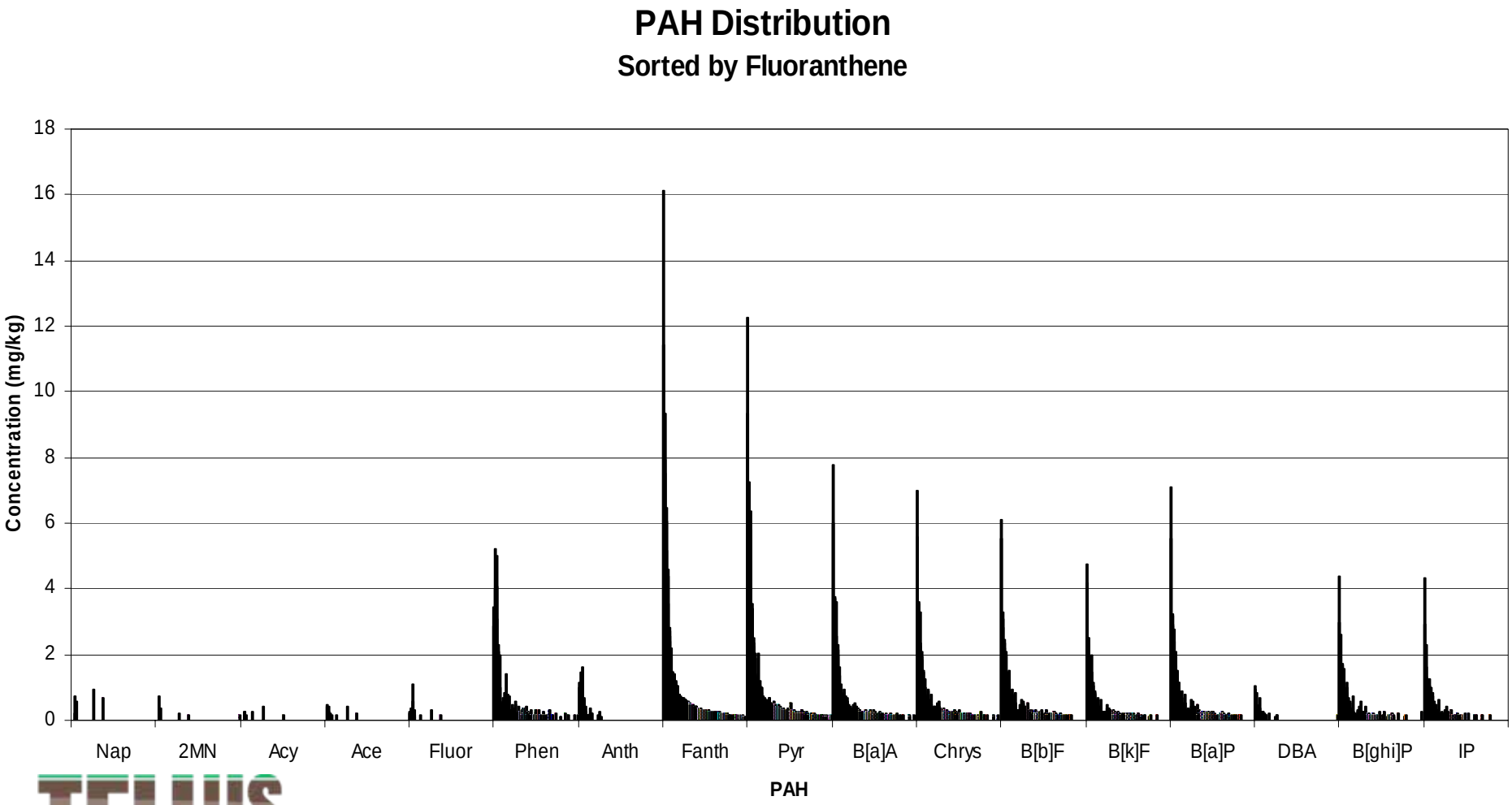
Fluoranthene



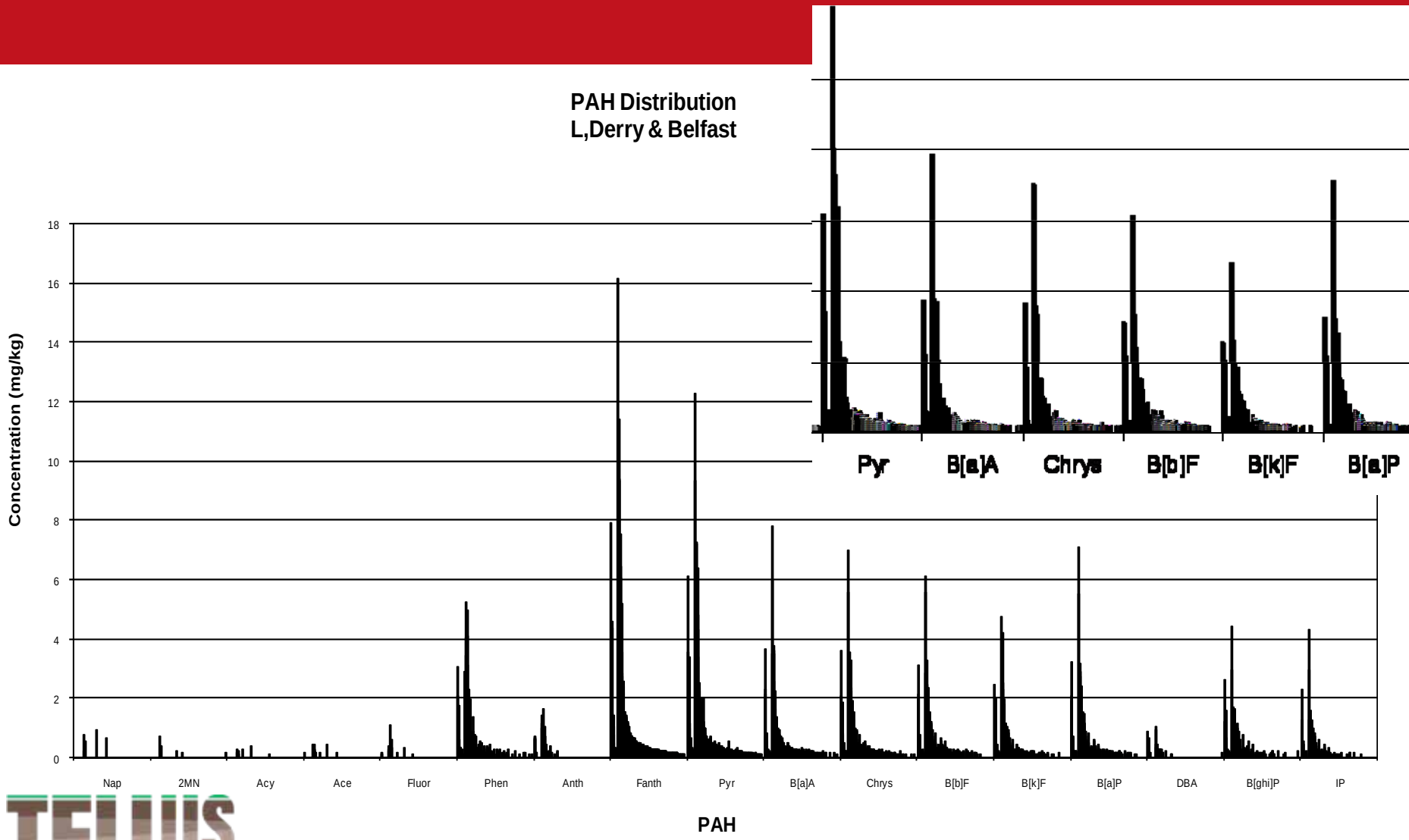
Benzo(a)anthracene



PAH Distribution



PAH Distribution- 2 Cities



In Conclusion

- Geochemistry of some elements is dominated by geology (Nickel & Chromium are related to basalts)
- Other elements (Lead, Arsenic & Zinc) are at levels lower than other industrial cities
- Organic compounds (PAHs) may be related to a diffuse source – combustion possibly from the city's industrial heritage

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