Rialtas na hÉireann
Government of Ireland

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

Sustainably restoring quarry voids: Geochemically Appropriate Levels for soil recovery activities in Ireland

Glennon, M.[1], Gallagher, V.[1], Meehan, R.[1], Scanlon, R.[1], Huskisson, S.[2], Webb, G.[3].

[1]Geological Survey Ireland

[2]Environmental Protection Agency, Ireland

[3]Geosyntec Consultants

EGU Sharing Geoscience Online 2020

Understanding the problem

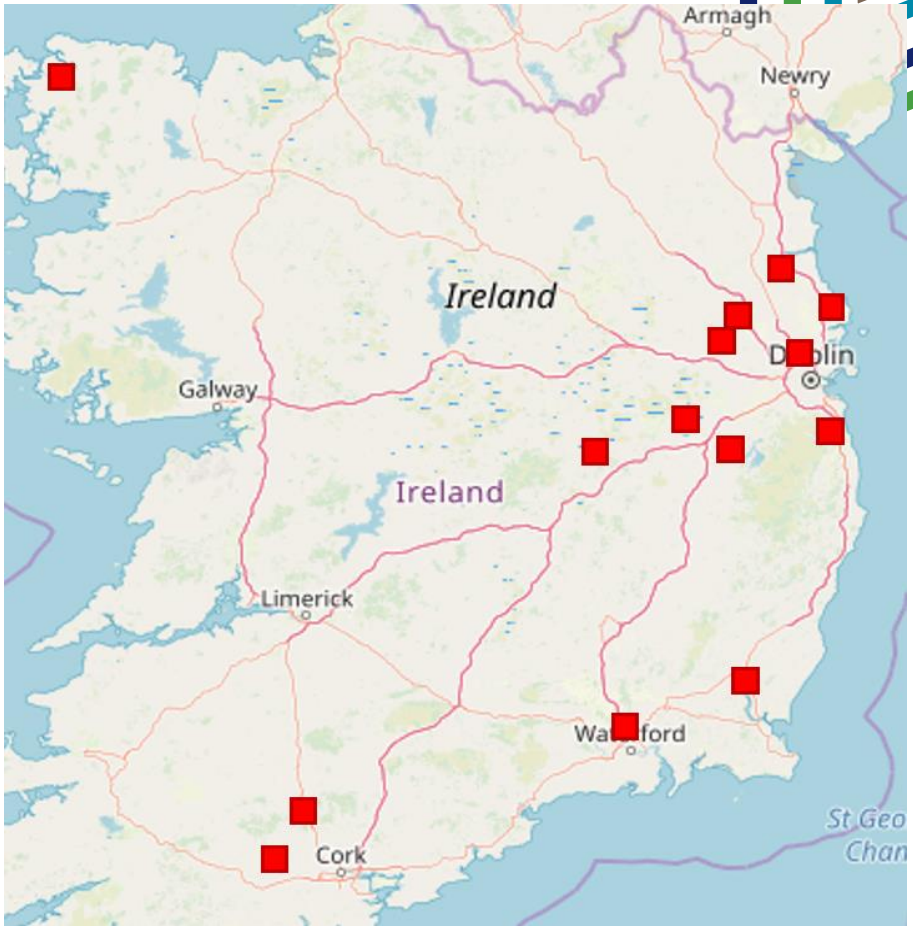
- In Ireland there is extensive, commonly deep subsoil due to glacial deposition
- Building/infrastructure development can produce large amounts of excavated soil
- Failure to understand the chemical composition of subsoil can result in soil going to landfill – expensive and inefficient use of resources
- Uncontaminated soil and stone should be reused where possible

Dublin Port Tunnel –'Dublin boulder clay'. Photo: Mike Long

In Ireland, Soil Recovery Facilities are unlined facilities that are permitted/licenced to accept soil and stone

- SRFs are typically worked-out quarries or pits, but can also be low-lying areas receiving imported material to raise the ground level

- SRFs are not required to have a basal liner or engineered cap like a landfill
- Imported subsoil and stone must be **uncontaminated** to prevent impacts on groundwater
- 14 are licenced by Environmental Protection Agency; >400 smaller facilities permitted by Local Authorities



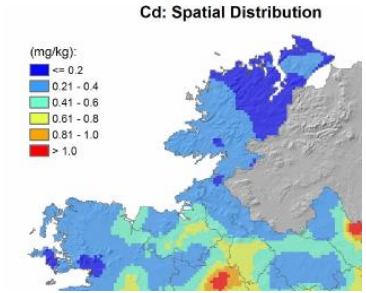
Reuse of soil at Soil Recovery Facilities

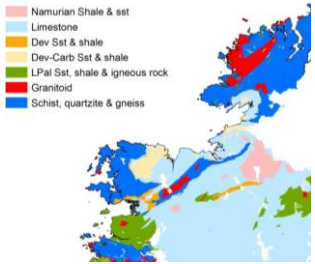
- In 2017 the EPA published draft Waste Acceptance Criteria and Development of Soil Trigger Values for EPA-licensed Soil Recovery Facilities
- Feedback from stakeholders raised concerns that the proposed single set of trigger levels for metals for the whole country was not practical, given the high degree of natural variation in metals content of Irish soils

Questions we sought to answer:

- What levels of naturally occurring metals in soil should be allowed into Soil Recovery Facilities?
- What levels of metals are considered ‘normal’ for uncontaminated Irish subsoil?

What we did…





Oct '18

1. Data review Q4 2018
2. Geochemical domains Q2 2019
3. Site investigation March 2019
4. Trigger level development Q3 2019

Arsenic
Cadmium
Chromium
Copper
Mercury
Nickel
Lead
Zinc

- Proposed trigger levels for 8 naturally occurring potentially harmful elements in subsoil in the different geological areas of Ireland

Feb ‘20

- EPA incorporated the trigger levels in the *Waste Acceptance Criteria and Development of Soil Trigger Values for Soil Recovery Facilities Guidance*

Read on to see how we did it…

Task 1: Data review

We looked at available soil geochemical data in Ireland

- National Soil Database (Fay *et al.* 2007):

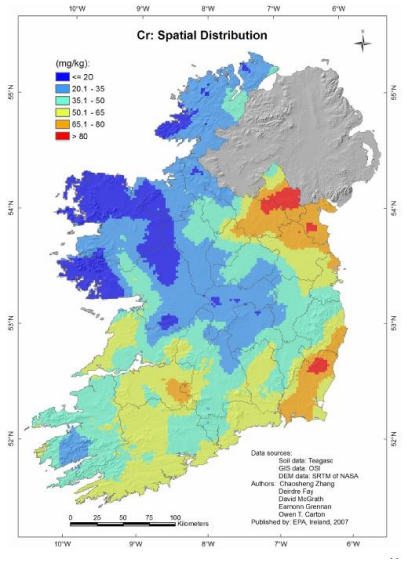
  Topsoil (0–10 cm depth), density of one sample per 50 km^2 (1310 samples nationwide)

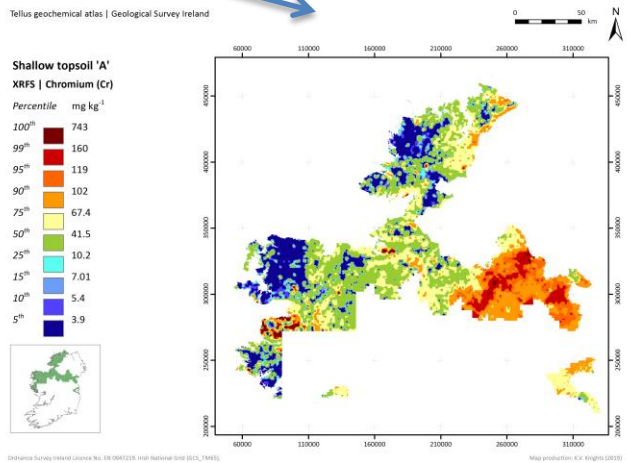
- GSI's Tellus geochemistry (27% complete at time of study)

  Topsoil at two depth levels (5–20 cm and 35–50 cm) at a density of one sample per 4 km^2.

  No regional subsoil data is available. Some questions arose:

- Can we use existing topsoil data as a proxy for deeper subsoil geochemistry?
- How do we account for regional variation in geochemical baselines?





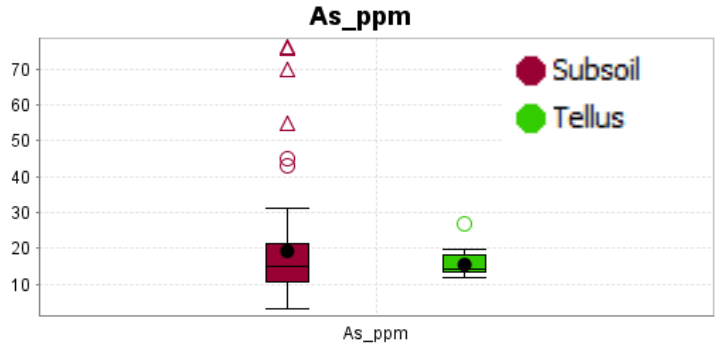
Task 2: Site investigation

To inform the answers to these questions, we decided to drill boreholes around the perimeters of two sites, a disused limestone quarry and an active sand/gravel pit

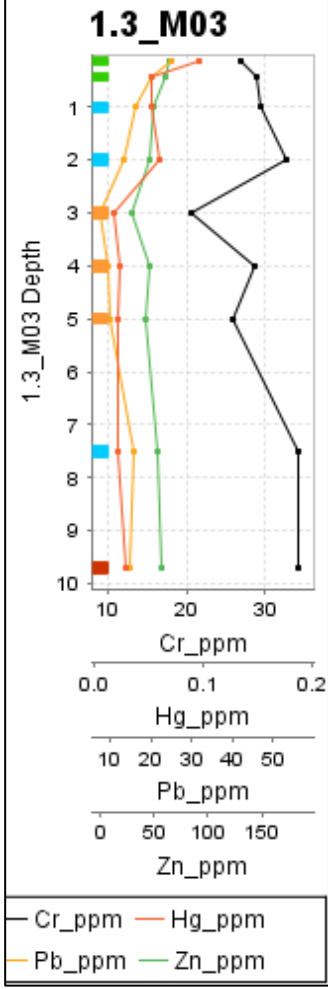
- Cable percussion drilling to a nominal depth of 10m bgl, 12 holes at each site
- Detailed subsoil logging with respect to Quaternary geology and BS 5930
- 175 geochemical (topsoil and subsoil) and 96 particle size samples taken at regular intervals. ‘Tellus’ style topsoil sample taken at top of each hole before drilling
- Geochemical samples analysed for 53 elements by ICP-MS (ALS Loughrea, Ireland)

Task 2: Site investigation – analytical results

Subsoils had some anomalously high concentrations of certain elements compared to topsoil



There was a weak trend for lower concentrations down-hole



- These do not affect the conclusion that topsoils and subsoils share a broadly similar geochemistry.
- These data would support the use of topsoil data as a proxy for subsoil data, in the absence of baseline subsoil geochemical data.

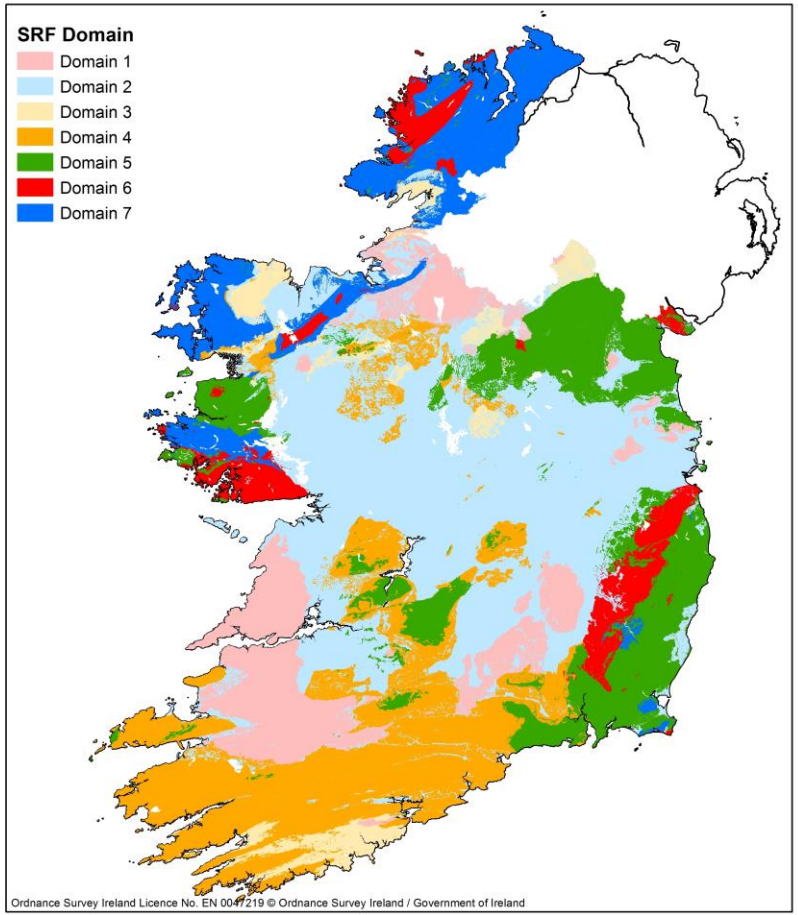
Task 3: Geochemical domains

How do we account for regional variation in geochemical baselines?

There is natural geochemical variation in soils and subsoils in Ireland arising from variation in rock types

We divided the country into 7 zones or domains based on similar subsoil and bedrock composition

- Subsoil map reclassified into geochemical zones based on parent material
- Areas with no mineral subsoil (peat, outcrop) filled in with bedrock geology map classification
- Domains applied to National Soil Database



Final Geochemical Domain map and names

Final Domain map class	Primary Lithology
Domain 1	Namurian shale and sandstone
Domain 2	Carboniferous limestone and related rocks
Domain 3	Devonian to Carboniferous sandstone and shale
Domain 4	Devonian sandstone and shale
Domain 5	Lower Palaeozoic sandstone, shale and igneous rock
Domain 6	Granitic rocks
Domain 7	Schist, quartzite and gneiss

N

0 25 50 100 Km

Rialtas na hÉireann
Government of Ireland

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

Task 4: Trigger level setting

Geochemical background and threshold setting is an accepted way of identifying areas with unusually high or low concentrations of potentially toxic elements[1,2]

- Intended to screen out samples with unusually high concentrations

Here we need to strike a balance between being conservative (protective of the environment) and permissive (allowing the acceptance of material with naturally high concentrations)

We chose the 98th percentile level of National Soil Database samples generated for each domain, due to small sample size in some domains

- Proposed trigger levels for arsenic, cadmium, chromium, copper, mercury, lead, nickel and zinc

[1] e.g. Reimann *et al.* 2005; Ander *et al.* 2013; McIlwaine *et al.* 2014; Reimann *et al.* 2018

[2] Use of geochemical baselines for soil waste characterisation in Finland: http://gtkdata.gtk.fi/TapirEN/index.html

Geochemically Appropriate Levels

Domain	n	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Domain 1	166	15.6	1.50	85.9	51.2	0.254	47.8	48.3	137
Domain 2	431	24.9	3.28	83.9	63.5	0.360	61.9	86.1	197
Domain 3	55	38.1	1.60	79.2	56.9	0.457	54.4	81.3	237
Domain 4	278	32.3	0.97	86.2	80.4	0.285	50.3	91.4	155
Domain 5	205	41.5	1.42	122	77.6	0.302	65.7	109	224
Domain 6	64	85.8	2.38	90.0	40.0	0.527	28.2	108	168
Domain 7	111	30.9	0.542	96.0	83.1	0.262	35.7	61.1	122
NSDB 90th percentile (Draft guidelines)	1310	16	1.3	75	35	0.2	42	48	126
NSBD 98th (all) percentile	1310	33.6	2.28	99.9	65.1	0.299	58.8	86.9	183

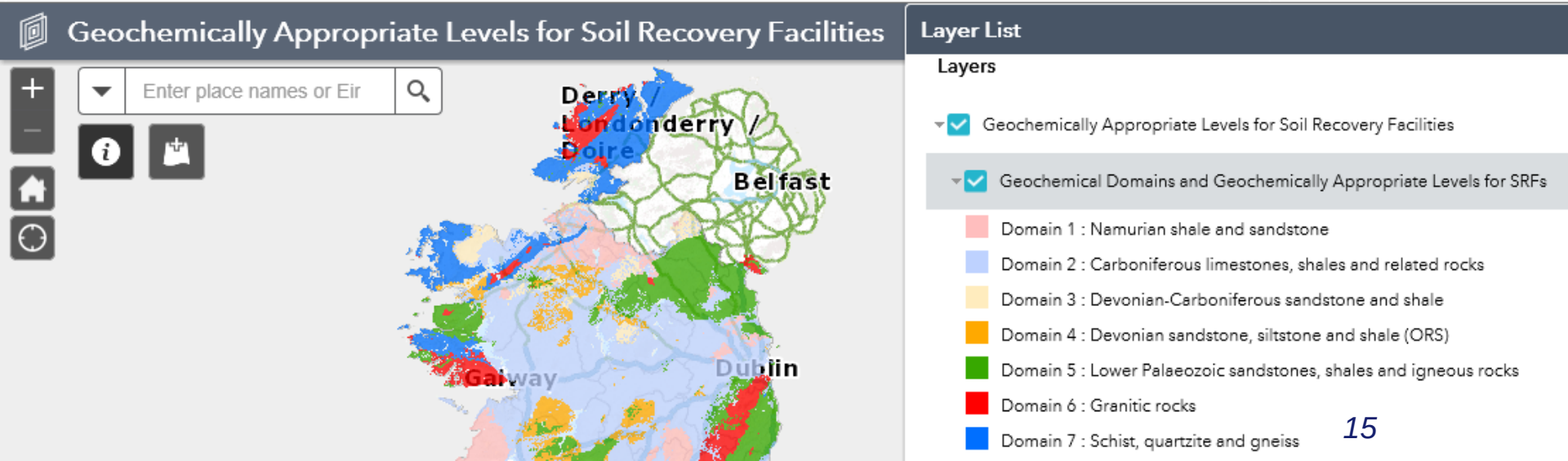
Calculated GALs (98th percentile) for defined geochemical domains. n = number of samples. Units are mg kg^{-1}

There is wide variation in Geochemically Appropriate Levels in different parts of the country

Outcomes

The EPA incorporated Geochemically Appropriate Levels and Geochemical Domains as part of its Guidance on Waste Acceptance Criteria at Authorised Soil Recovery Facilities in February 2020.

Geological Survey Ireland's Geochemically Appropriate Levels for Soil Recovery Facilities web pages host the full technical report and an spatial viewer for interrogating geochemical domains and geochemically appropriate levels.



Further work

- GALs should be periodically reviewed with increased availability of baseline soil geochemistry data in Ireland, most notably the completion of the Tellus soil geochemistry mapping programme (scheduled completion 2028).

- Characterisation of the Dublin Boulder Clay – we note large quantities of this subsoil is being moved from urban areas of Dublin and is known anecdotally to have anomalously high levels of certain metals.

Acknowledgements

Geological Survey Ireland colleagues:

- Tellus: Dr Jim Hodgson, Kate Knights, Barry Crowley
- Groundwater: Monica Lee, Katie Tedd, Taly Hunter Williams
- Land Mapping: Dr Sophie O'Connor, Michael Sheehy, Ivan de Wergifosse, Conor Allen, Dr Clare Glanville
- Drilling: Ger Cott
- Geoscience Ireland: Sean Finlay

Kevin Motherway – Cork County Council, Ireland

Úna Fitzgerald - Eastern Midlands Waste Region office, Ireland

Thank you for reading, please feel free to participate in the live chat!

Contact: mairead.glennon@gsi.ie