British Geological Survey
Expert | Impartial | Innovative

Interreg North-West Europe RAWFILL
European Regional Development Fund
EUROPEAN UNION
Co-funded by the Walloon region

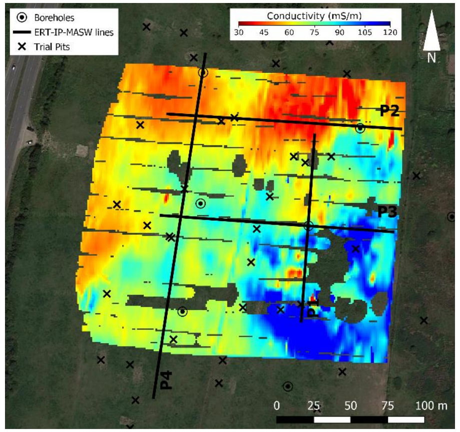
Integrated geophysical imaging of a solid waste landfill (Greater London, UK)

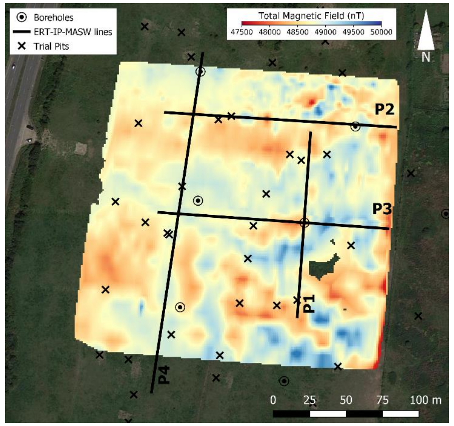
Arnaud Watlet[1], Cornelia Inauen[1], Ben Dashwood[1], Jim Whiteley[1], Tiphanie Creusel[2], Itzel Isunza Manrique[3], David Caterina[3], Duncan Scott[4], and Jonathan Chambers[1]

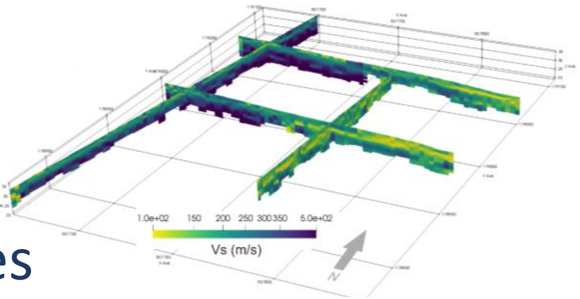
[1]British Geological Survey, Nottingham, UK
[2]Polytech Grenoble, Université Grenoble Alpes, France
[3]University of Liege, Urban and Environmental Engineering, Belgium
[4]Vertase F.L.I. Limited, UK

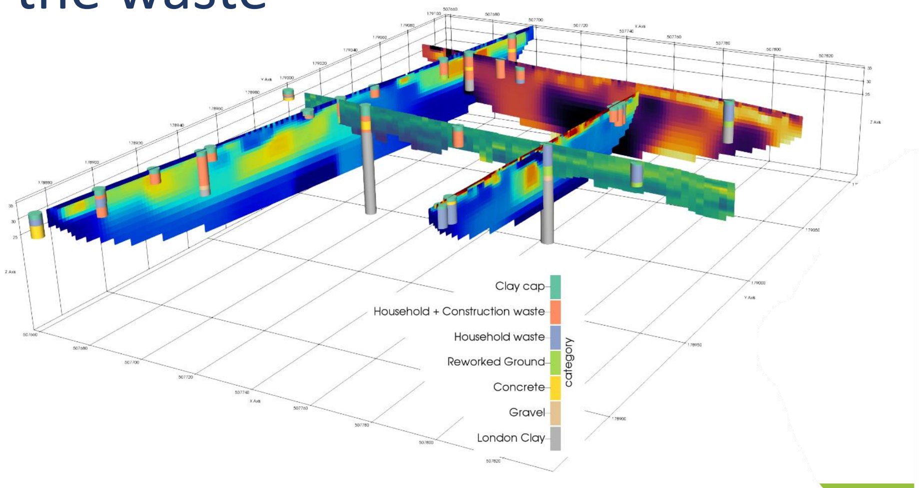
Summary

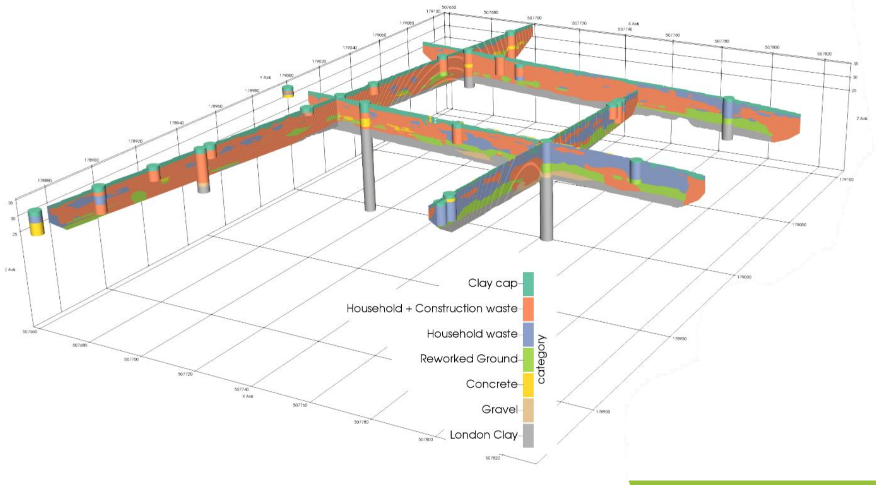
- Characterisation of a former MSW landfill using a combined set of 5 geophysical methods
- Comparison of the geophysical results with ground truth data from previous boreholes and trial pits
- Using machine learning approaches to classify the geophysical data in terms of waste categories visible in the waste











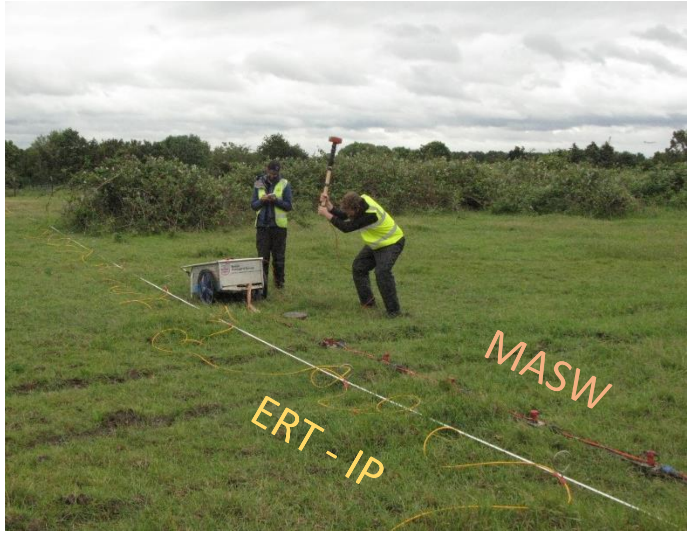
Context and objectives

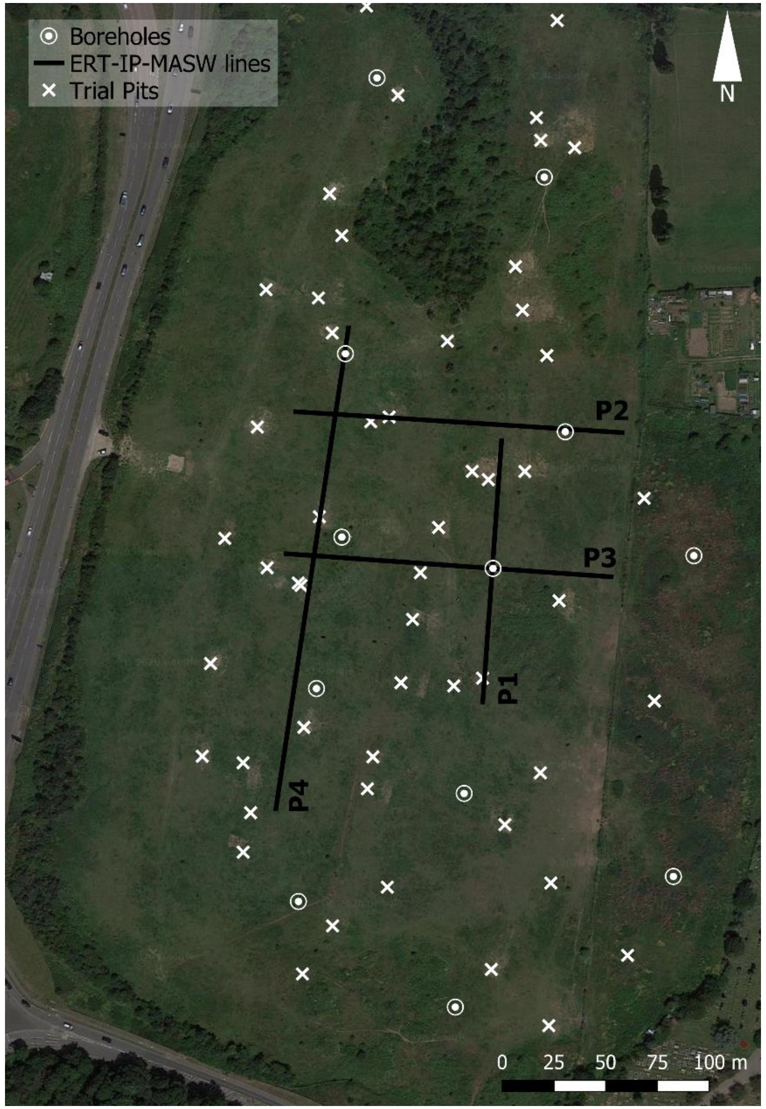
- Increased pressure on land use has underscored the need for the characterisation of waste composition and distribution in old landfills
- Characterising landfills traditionally relies on two main sources of information: historical reports and ground truth data
- Drilling / trenching provide accurate information at point scales, but high spatial resolution is costly, and increase risks of contamination
- **Here, as part of the RAWFILL project, we investigate the use of a combined set of geophysical tools as a non-invasive approach to provide volumetric information complementary to conventional ground truth data**

arnw@bgs.ac.uk

Landfill in Greater London, UK

- Former sand and clay quarry filled with household and industrial waste from the 1940's, with a peak in the 1960's and 1970's
- Ground truth data available prior to the geophysical survey
  - 45 trial pits
  - 12 boreholes
- 5 complementary profiling and mapping geophysical techniques
  - Multi-channel Analysis of Surface Waves (MASW)
  - Electrical resistivity tomography (ERT)
  - Induced Polarization (IP)
  - Electromagnetic survey (EMI)
  - Magnetometry (MAG)





arnw@bgs.ac.uk

Ground truth data

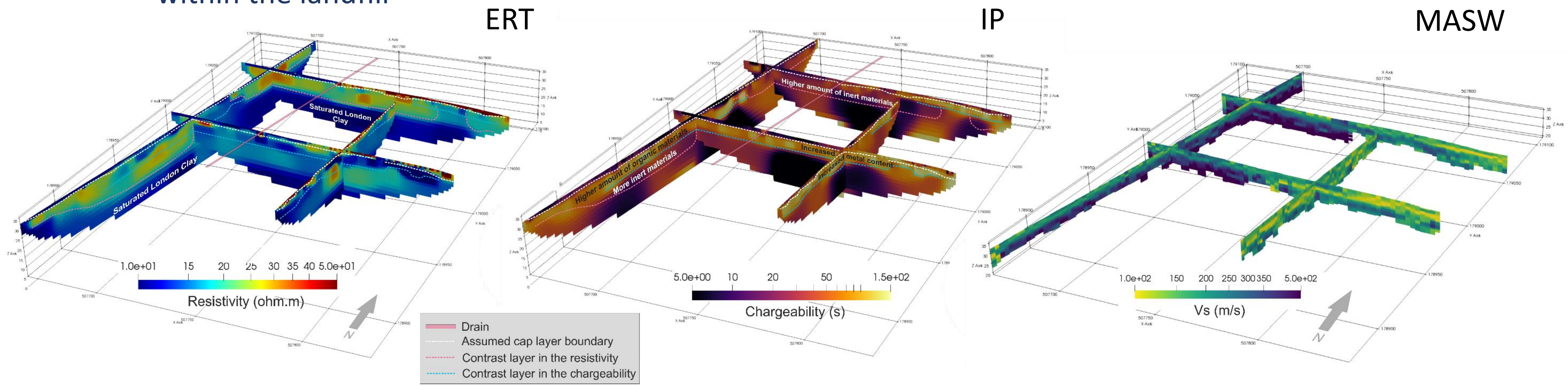
- Based on the boreholes and trial pits from 2 different drilling/trenching campaigns we subdivided the ground truth in 7 main categories, which are not occurring everywhere and in the same order

	Name	Thickness	Description
	Clay cap	0 – 3.4 m	Brown greyish sandy gravelly clay present at the top of the site
Landfill material	Household + Construction	< 12.5 m	Mixed household and industrial waste with higher inert material such as bricks, concrete and gravel
	Household	< 12.5 m	Mixed household waste with higher organic material and greater composition of soils with newspaper fragments dated 1960s
	Reworked Ground	< 3.3 m	Intermittent occurrence of mottled light greyish brown lightly sandy gravelly clay
	Concrete	> 3 m	Bands of hard concrete aggregate used in production
Host	Gravels	< 2.4 m	In situ sandy gravels
	London Clay	> 30 m	In situ very stiff to hard slightly gravelly silty clay

arnw@bgs.ac.uk

Interpretation of the geophysical results

- Strong contrasts in resistivity, chargeability and shear wave velocity highlight different sub-regions within the landfill



- Waste material imaged as more resistive than the host saturated London Clay in the eastern side
- Shifting towards conductive signature in the western side

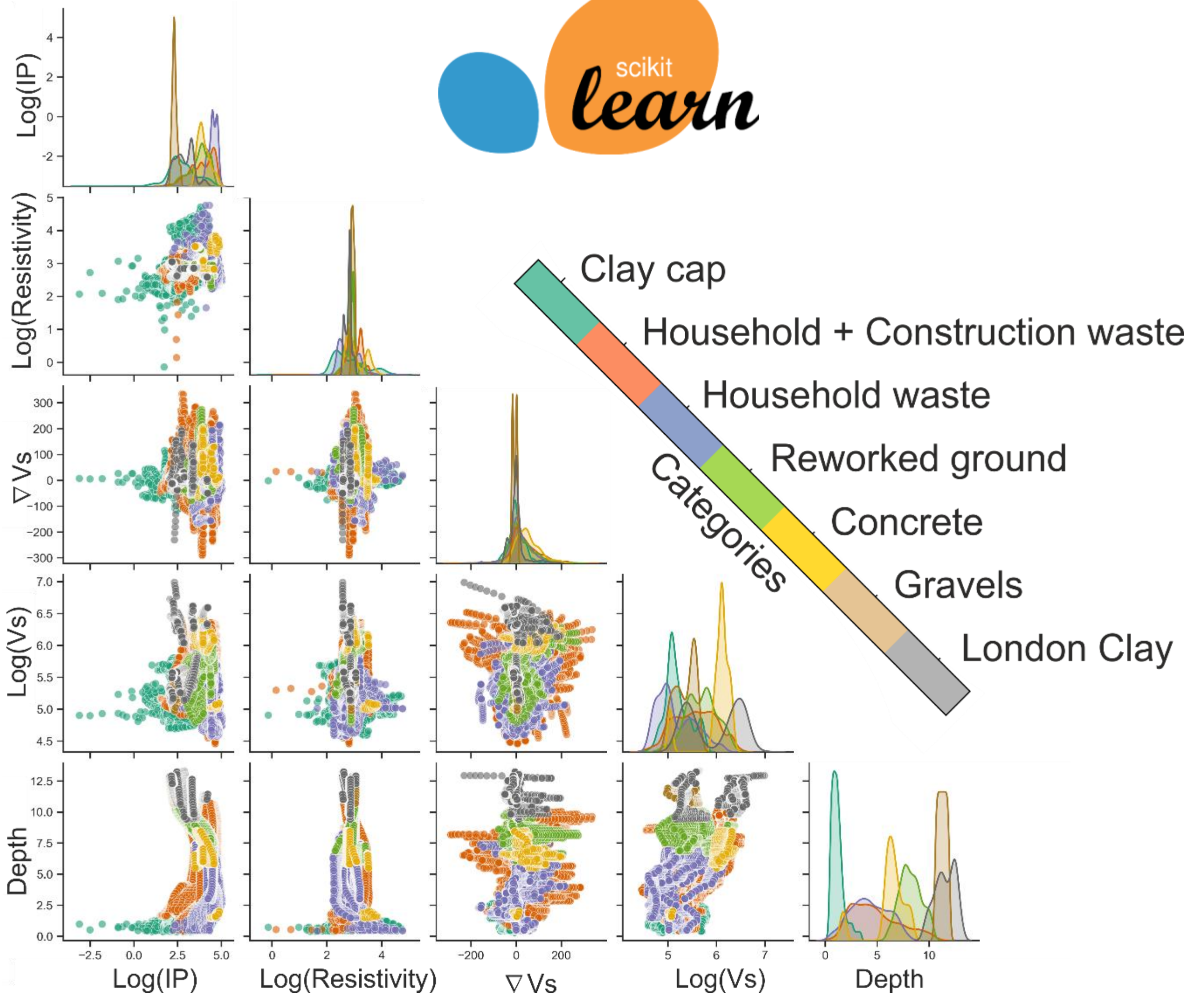
- Mismatch in chargeability and resistivity in the western side highlights a greater content of inert materials (concrete bands identified in boreholes)
- Match in ERT and IP in the eastern side points to increased metal content

- Seismic data confirm the ERT/IP observations of a distinction between both half of the surveyed area
- Lower seismic velocities suggest less compacted waste in the eastern side

arnw@bgs.ac.uk

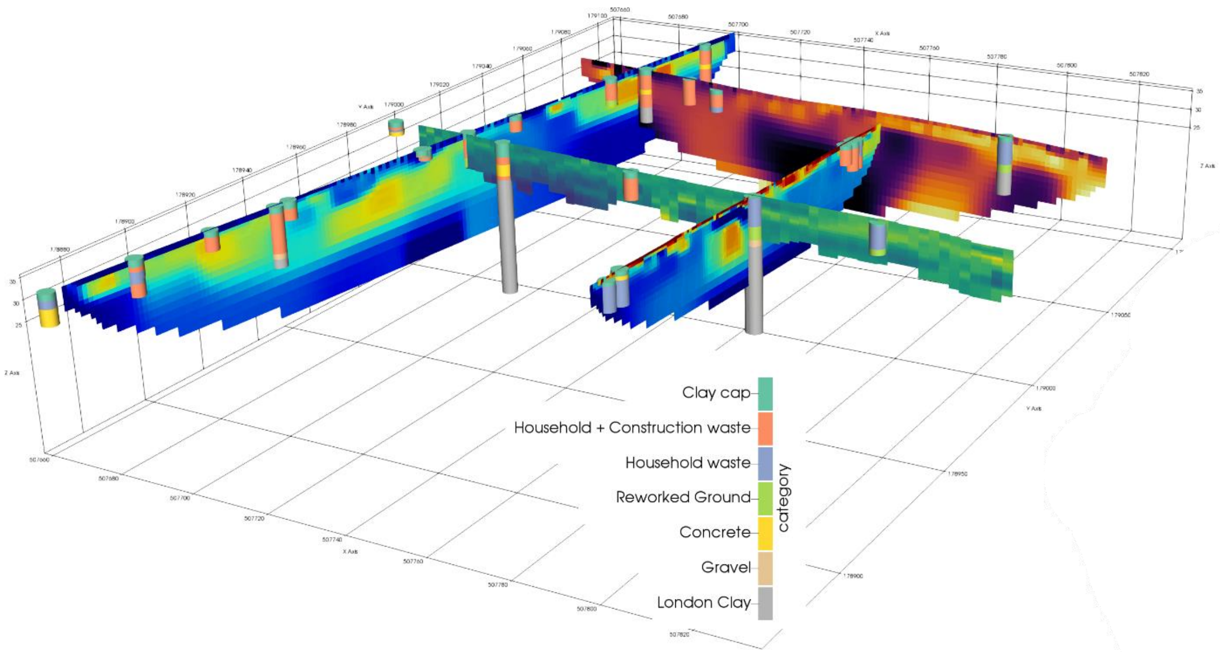
How can we integrate ground truth and geophysics?

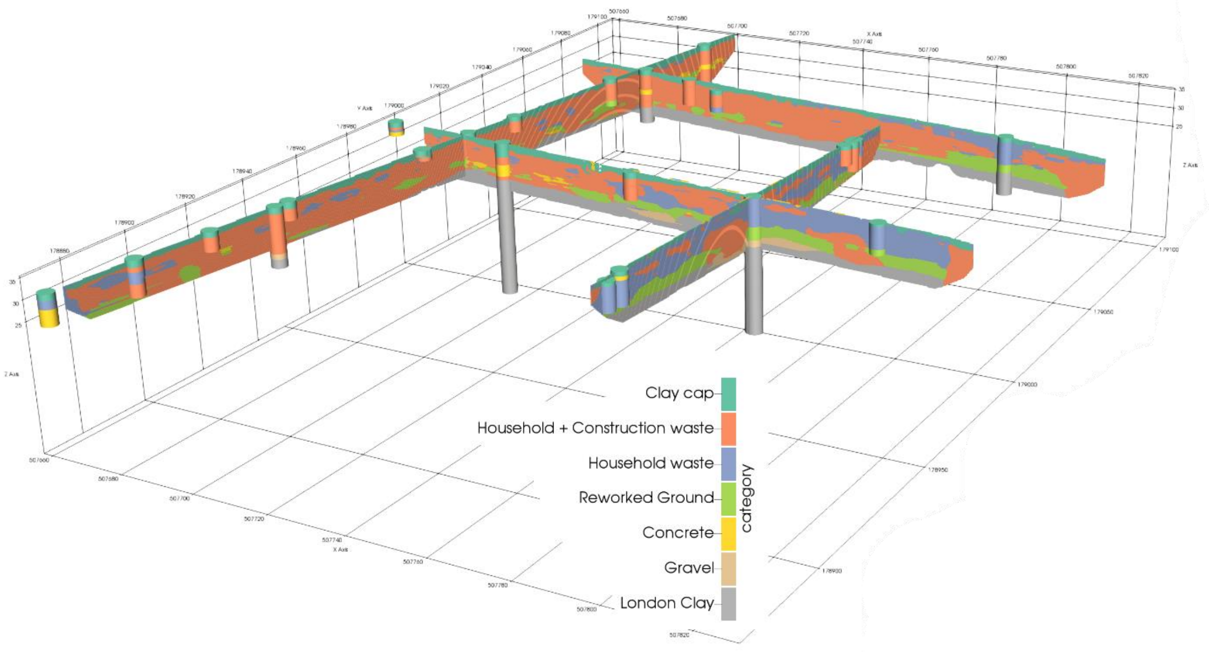
- We used a machine learning approach
  - Extracting geophysical data from profiling methods at the location of borehole and trial pits as standardised data sets of
    - log(resistivity), log(chargeability), log(Vs), ∇Vs and depth
  - Assigning the extracted data to the 7 categories identified in the ground truth data
  - Training the algorithm based on these training data sets
  - Testing the algorithm on the whole geophysical profiles to predict the most probable category



For more information on our approach see this EGU presentation by Inauen et al.

Towards a Resource Distribution Model…





- Projecting boreholes and trial pits onto the profiles for those located < 5 m from a profile
- Resistivity, chargeability, Vs and the depth as training data set using a Neural Networks framework

- Predicted categories on the zones covered by the ERT, IP and MASW
- Some zones are underrepresented in the prediction (concrete and gravels) due to overlapping signatures and fewer observations

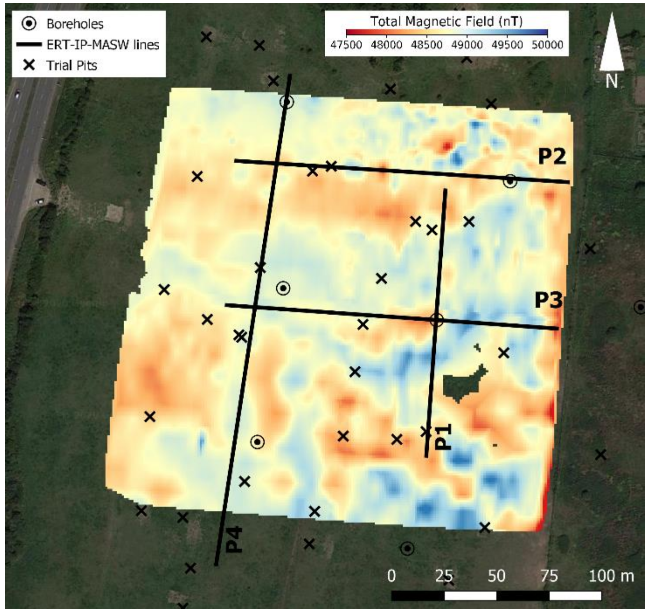
Conclusions

- Our integrated approach aimed to bring a geophysical alternative to conventional landfill characterisation techniques
- In this case study, ground truth data were already available when performing the geophysical surveys ; no targeted sampling based on the geophysical results was possible
- Still, co-located samples allowed to assign geophysical data to identified categories in the ground truth data
- These co-located data could be used as a training dataset to predict the categories in the geophysical profiles, thereby providing information at higher spatial resolution than for the ground truth data
- These types of classification are crucial to build Resource Distribution Models which are needed to assess, e.g., waste volumes or landfill mining potential
- For more information, please visit the RAWFILL Project website

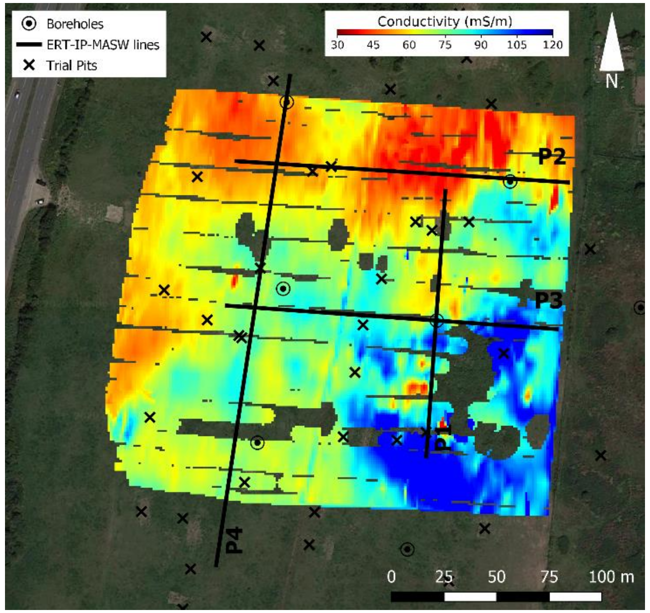
arnw@bgs.ac.uk

Perspectives

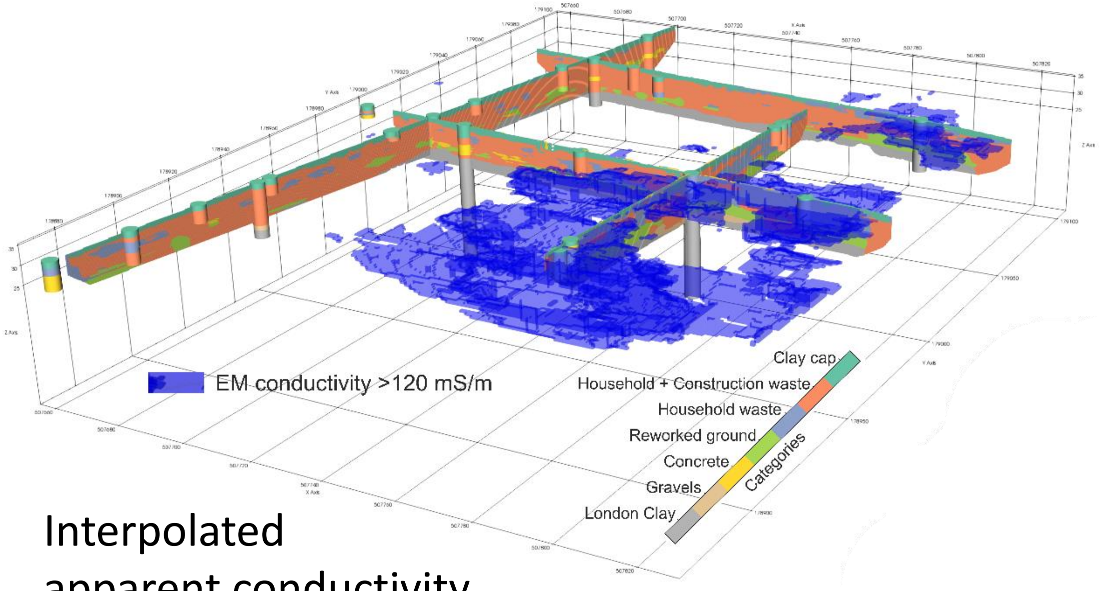
- Testing sensitivity of the classification with different waste categories assigned from the ground truth
- Testing different machine learning algorithms
- Including mapping techniques into the classification: EMI (4 different depths) and MAG data



Magnetometry
Total magnetic field



EMI
Apparent conductivity at 6 m



Interpolated apparent conductivity from the EMI matches the category assigned to the household waste…

arnw@bgs.ac.uk

Interreg

EUROPEAN UNION

North-West Europe

RAWFILL

European Regional Development Fund

Thank you!