Enhanced Landfill Mining in the UK: Resources or fuel?

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Landfills in UK

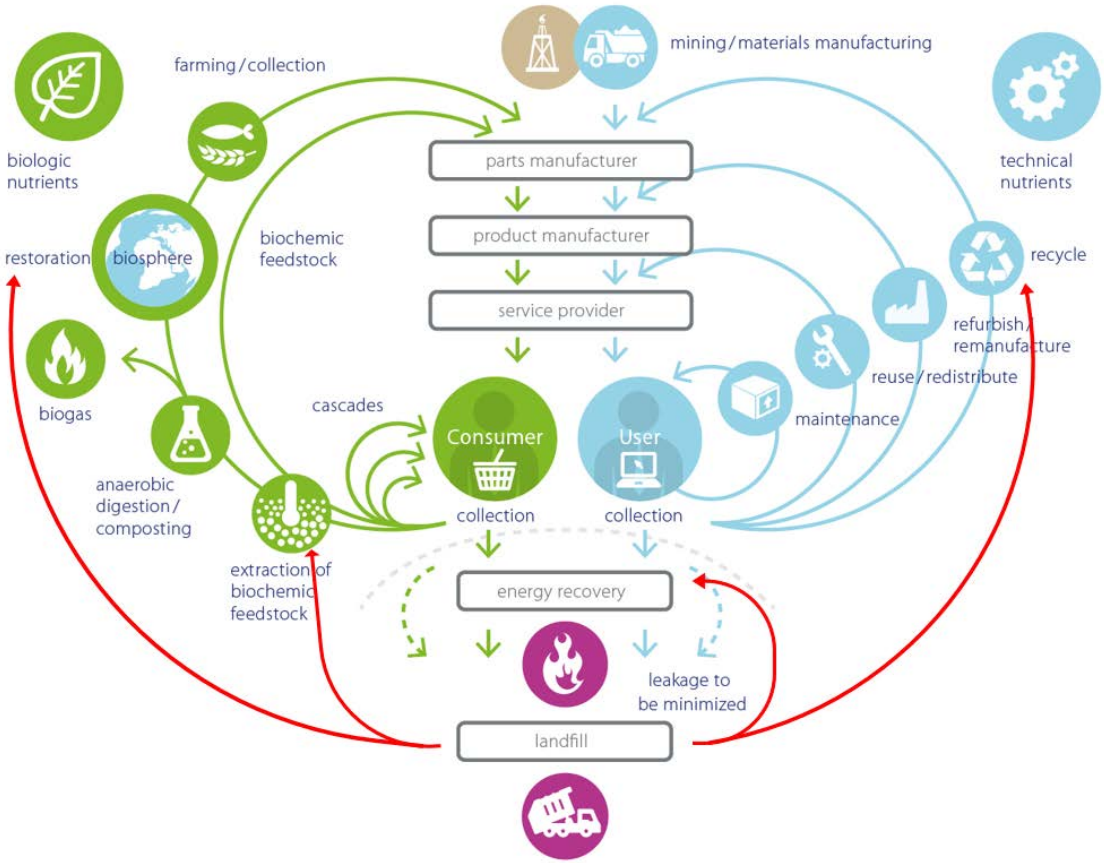
Substantial resource for future exploitation

- Over 20,000 legacy and current landfills in the UK
- Licences required from 1974 under the Control of Pollution Act
- There are over 4,000 licensed sites, most of which are now closed
- Currently over 40 million tonnes of waste from all sources is deposited in UK landfills

Landfill mining in the circular economy

Need to consider the whole picture

- Waste-to-Energy
- Waste-to-Material
- Chemical feedstock
- Land restoration

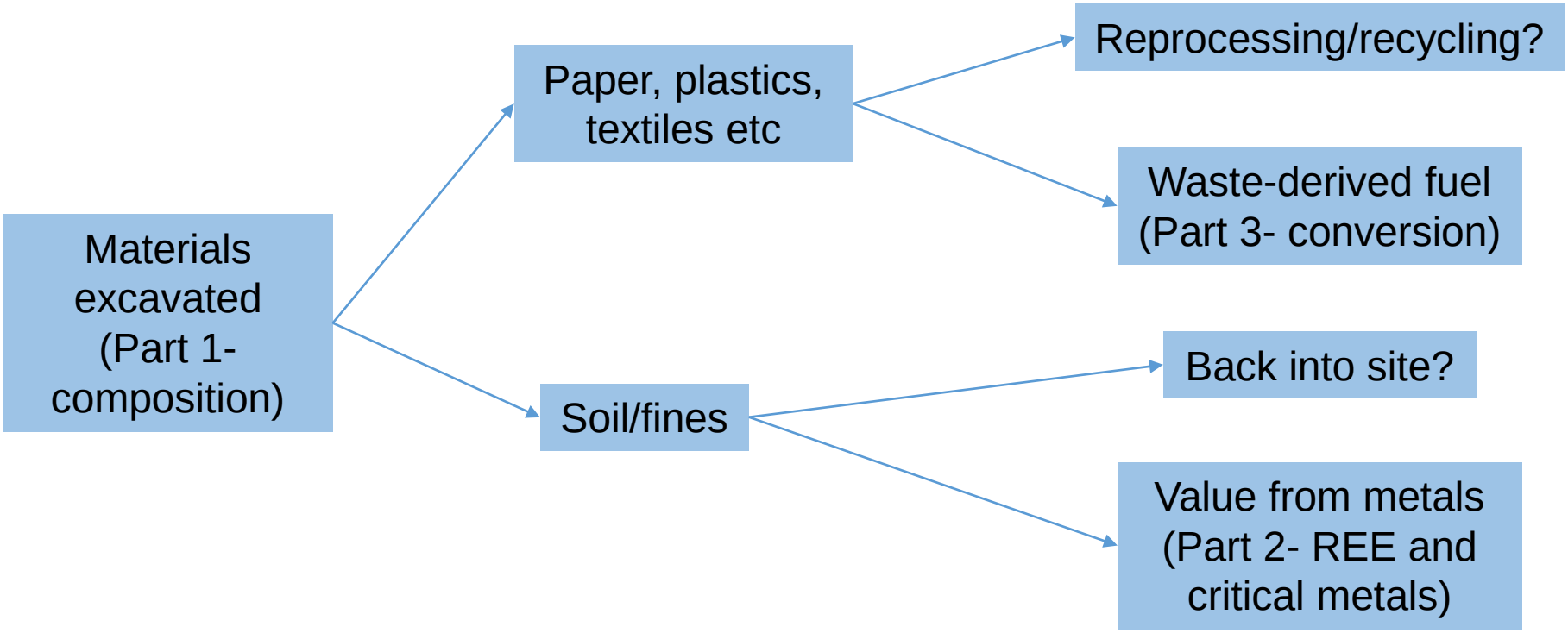


Integration of landfill mining in the circular economy

Modified from Ellen Macarthur Foundation system diagram

Resource or a fuel?

A simplistic overview of ex-situ mining



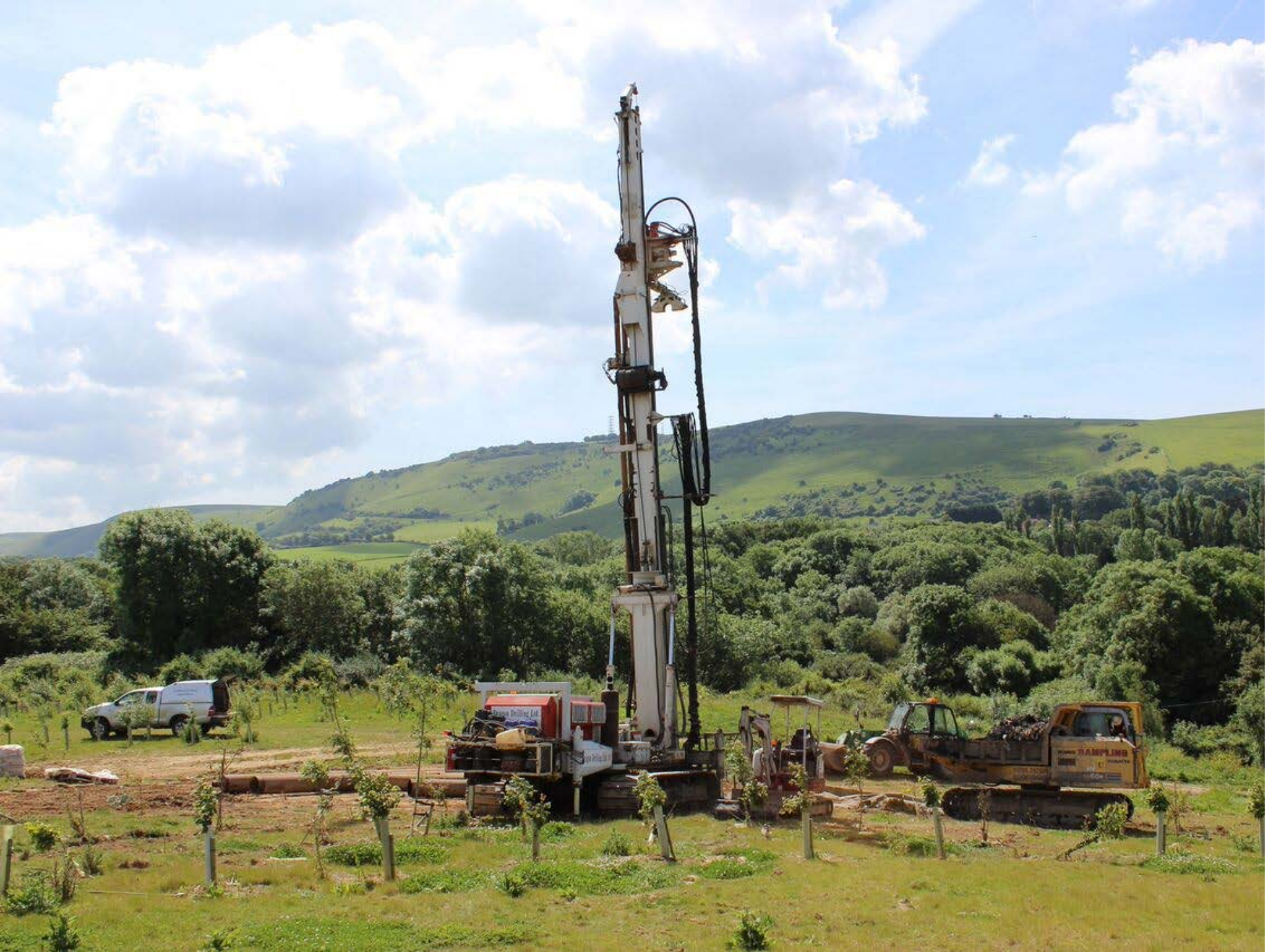
9x landfill sites sampled over past 3 years

Multiple projects and objectives

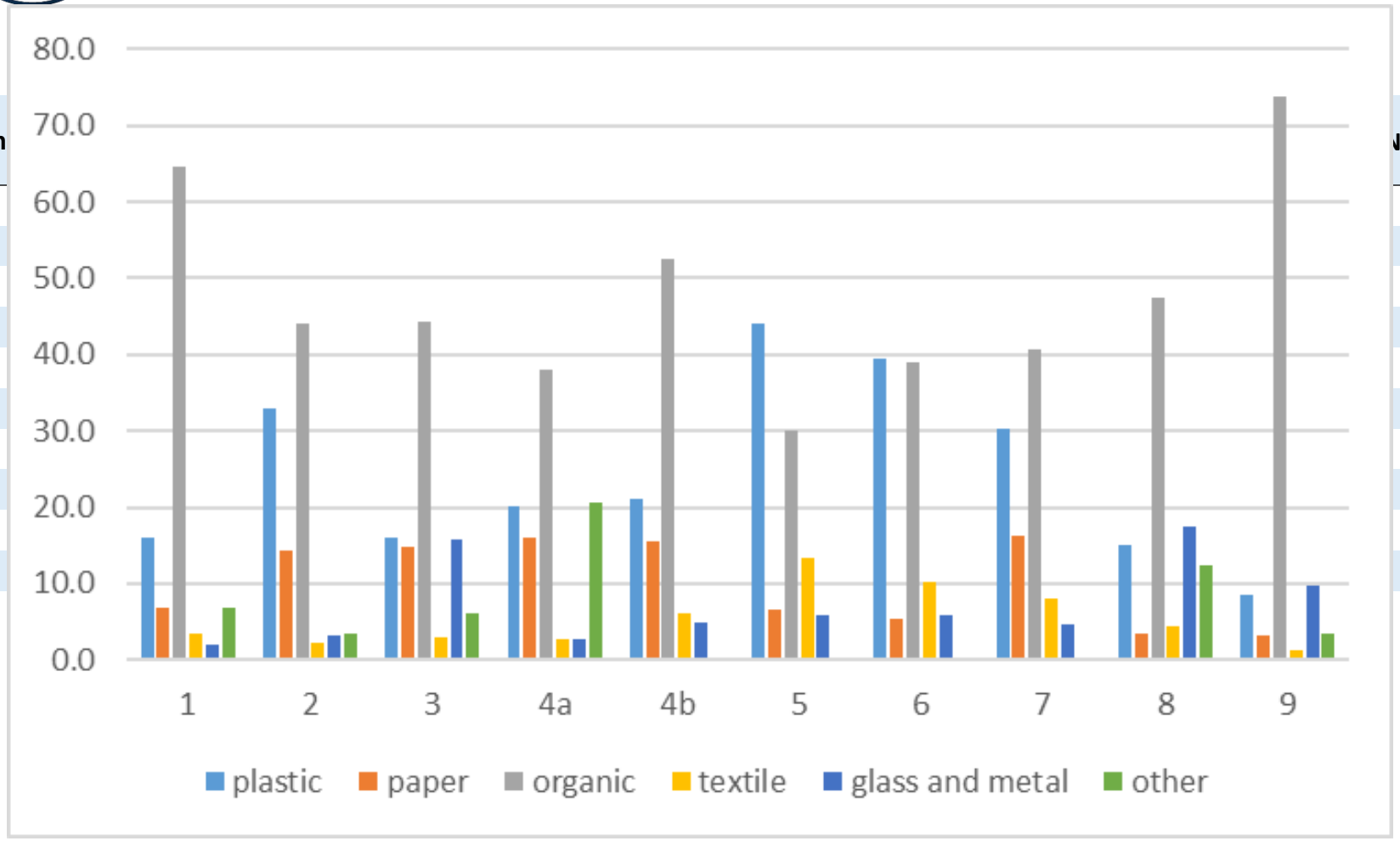
- 7x sites sampled for composition, metals content of soil/fines, residual biogas testing and leachate characterisation
- 2x site for composition, metals and viability as refuse-derived fuel

For further details on sites 1-7, please see:

- Frank, R.R., Cipullo, S., García, J. Davies, S., Wagland, S.T., Villa, R., Trois, C., Coulon, F. Compositional and physicochemical changes in waste materials and biogas production across 7 landfill sites in UK. Waste Management. 2016 IN PRESS
- García, J., Davies, S., Villa R., Gomes, D.M, Coulon, F., Wagland, S.T. Compositional analysis of excavated landfill samples and the determination of residual biogas potential of the organic fraction. Waste Management, 55 (2016) 336–344.
- Frank, R. R., Davies, S., Wagland, S., Villa, R., Trois, C., Coulon, F. Evaluating leachate recirculation with cellulase addition to enhance waste biostabilisation and landfill gas production. Waste Management, 55 (2016) 61–70
- Gutiérrez-Gutiérrez, S.C. , Coulon, F. , Jiang, Y. , Wagland, S.T. Rare earth elements and critical metal content of extracted landfilled material and potential recovery opportunities. Waste Management, 42 (2015) 128–136


RAMPLING

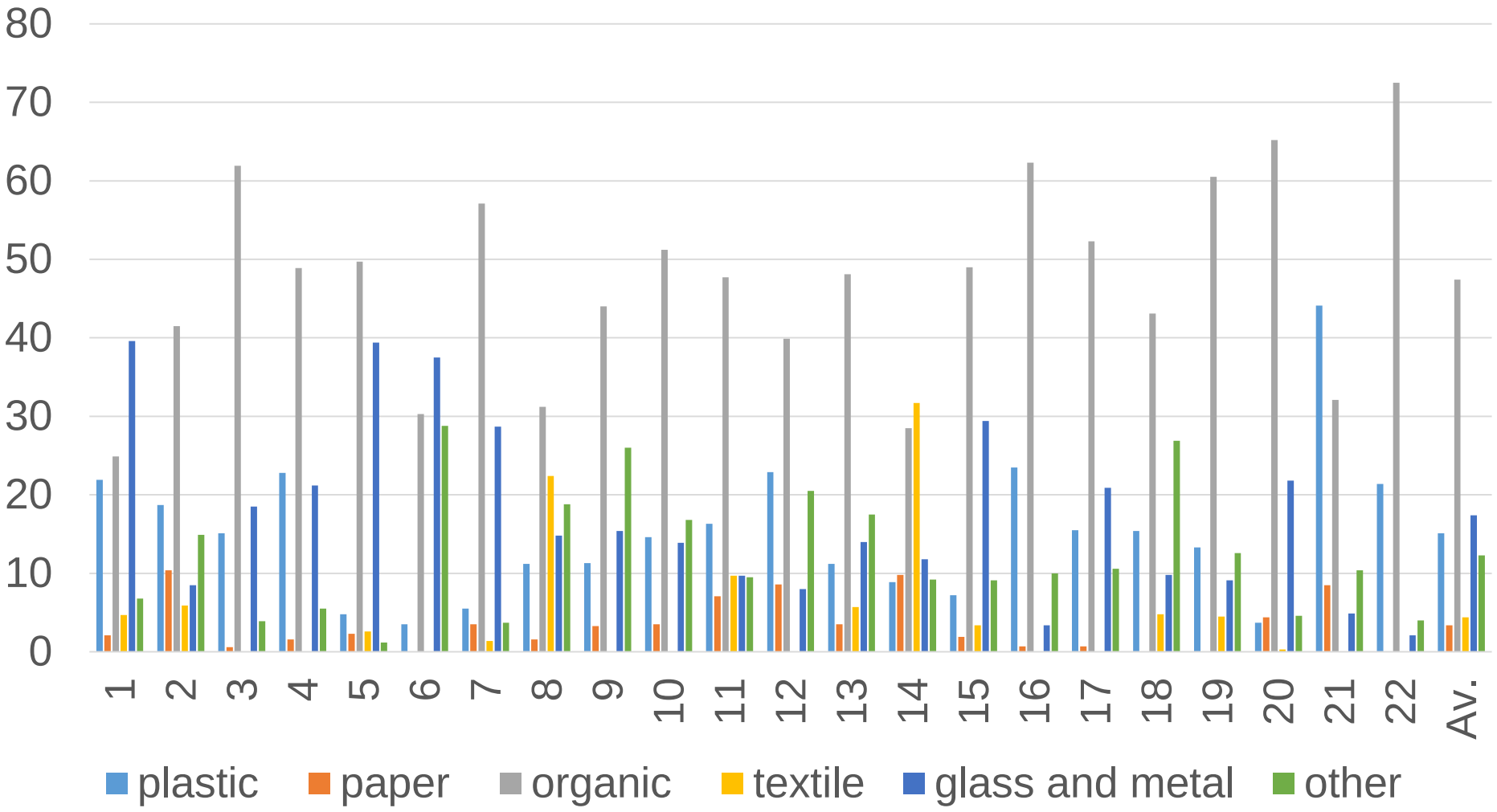
Composition overview (% w/w)



Site n	No. cores
1	1
2	2
3	6
4a	2
4b	5
5	5
6	5
7	7
8	1
9	2

Lots of data accumulated

Site 8- 1x core drill, but split into 22 samples (at 1 metre intervals)



Metal recovery potential

Manual sieving and grinding

- Removal of plastic, metal, paper, textile, glass and other materials >19 mm
- Dried over night at 105˚C
- Ground to ≤1.5 mm

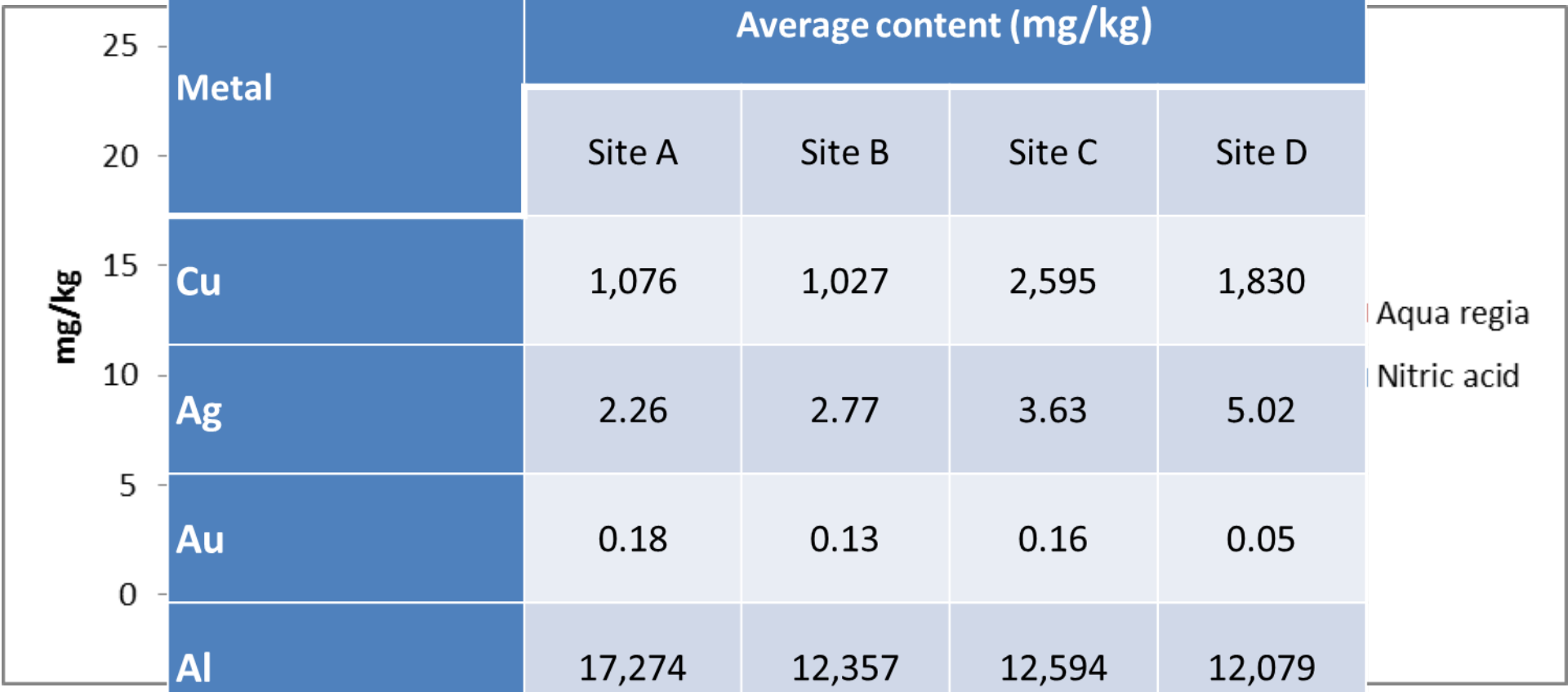
2-stage acid-microwave digestion

- HNO_3 → microwave digestion
- Aqua regia (HCl + HNO_3) → microwave digestion

Inductively coupled plasma mass spectrometry (ICP-MS)

Results from sites 1-4

Metal	Average content (mg/kg)			
	Site A	Site B	Site C	Site D
Cu	1,076	1,027	2,595	1,830
Ag	2.26	2.77	3.63	5.02
Au	0.18	0.13	0.16	0.05
Al	17,274	12,357	12,594	12,079



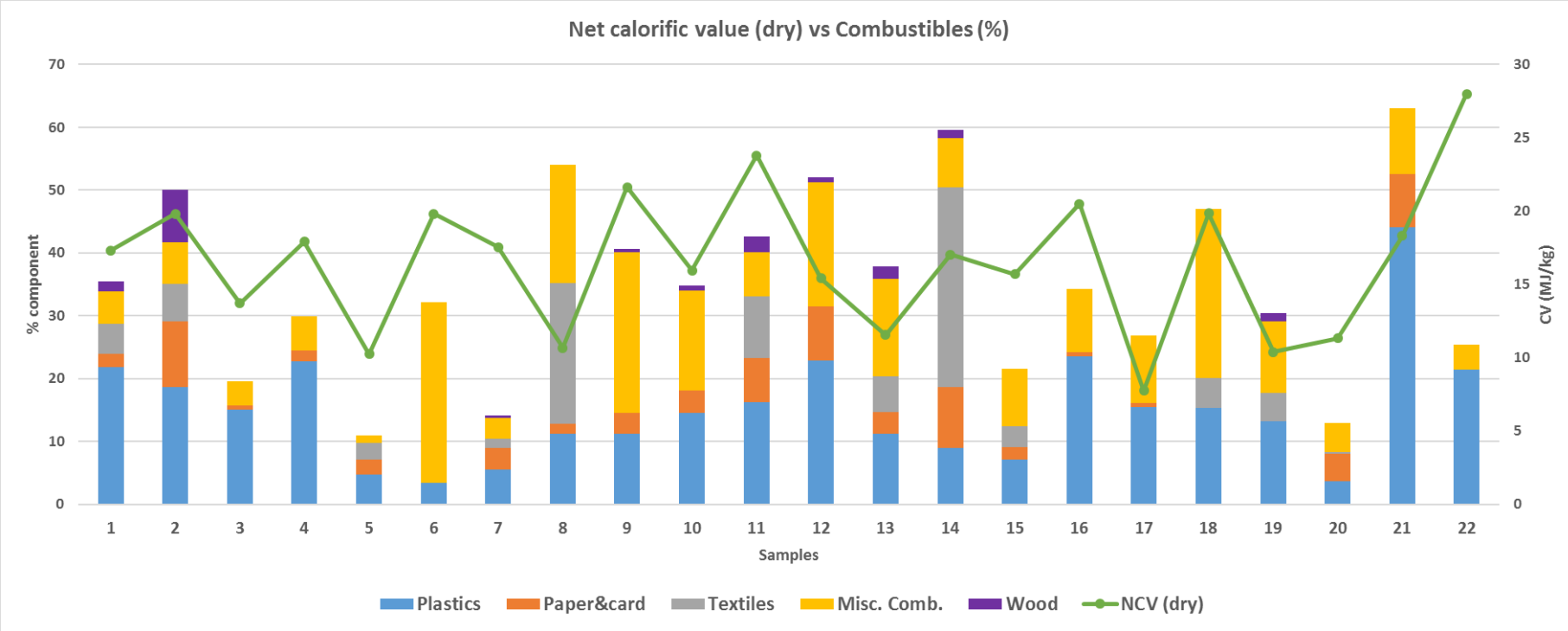
Sites 8 and 9 (all in ppm)

	HEAVY METALS					
	Cd	Cr	Pb	Zn	Sn	As
Paper	0.51	1,056	94.10	215.55	18.44	2.97
Wood	0.77	2,435	175.91	325.32	18.88	6.59
Fines	1.11	834	303.73	565.66	30.83	4.81
Film Plastics	1.27	1,187	293.97	519.89	18.98	3.00
Dense Plastics	1.48	59.14	529.09	1,652	104.96	5.13
Textiles	1.69	1,866	567.91	650.75	35.47	6.23

	Cu	Ag	Li	Sb	Co	Al
Paper	134.38	0.85	5.85	7.08	10.53	10,707
Wood	166.40	2.21	3.49	8.59	24.73	5,045
Fines	254.22	16.66	8.91	58.32	8.49	12,806
Film Plastics	148.43	1.71	4.30	182.64	12.21	6,269
Dense Plastics	588.75	2.61	8.37	16.49	17.43	8,238
Textiles	377.86	2.91	11.94	13.88	19.11	14,182

	LREES				
	La	Ce	Pr	Nd	Sm
Paper	4.17	8.84	1.00	3.67	0.69
Wood	3.97	9.00	0.99	3.76	0.71
Fines	10.07	21.25	2.40	9.22	1.79
Film Plastics	4.09	9.08	1.00	4.07	0.72
Dense Plastics	7.15	15.92	1.78	6.75	1.24
Textiles	8.78	20.52	2.26	8.64	1.69

Combustible fraction as a fuel (site 8)



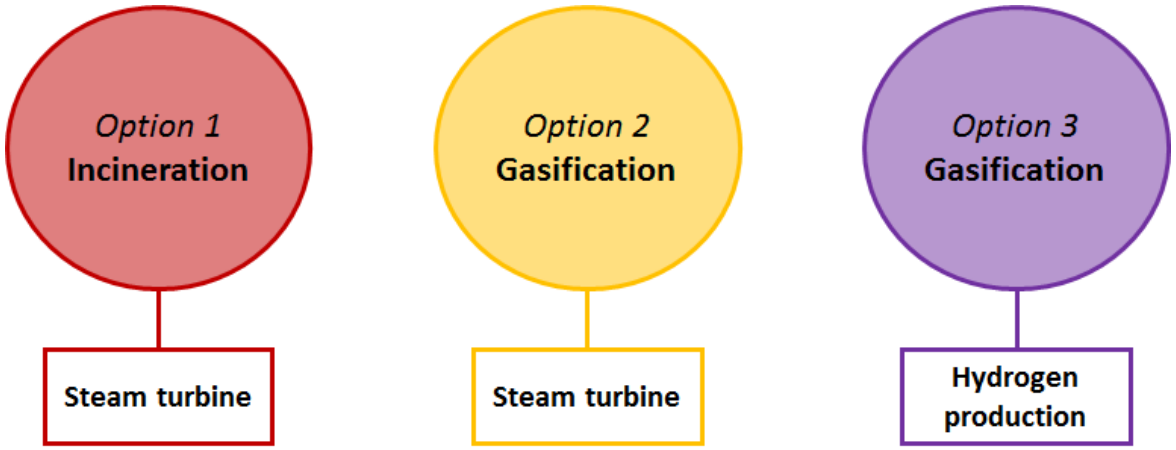
Average moisture content of combustibles: **29.3 %** (12.7-38.5)

Average Gross Calorific Value: **12.9 MJ/kg** (ar)

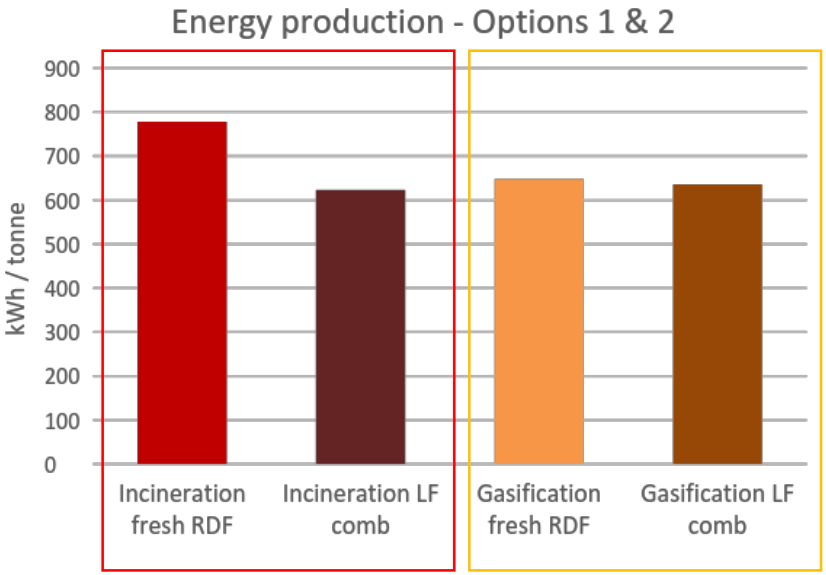
Average Net Calorific Value: **11.0 MJ/kg** (ar)

Thermal treatment options- Models in Aspen Plus (Site 8- 1x core sample with metre intervals)

Simulations of two thermal treatments with ASPEN Plus



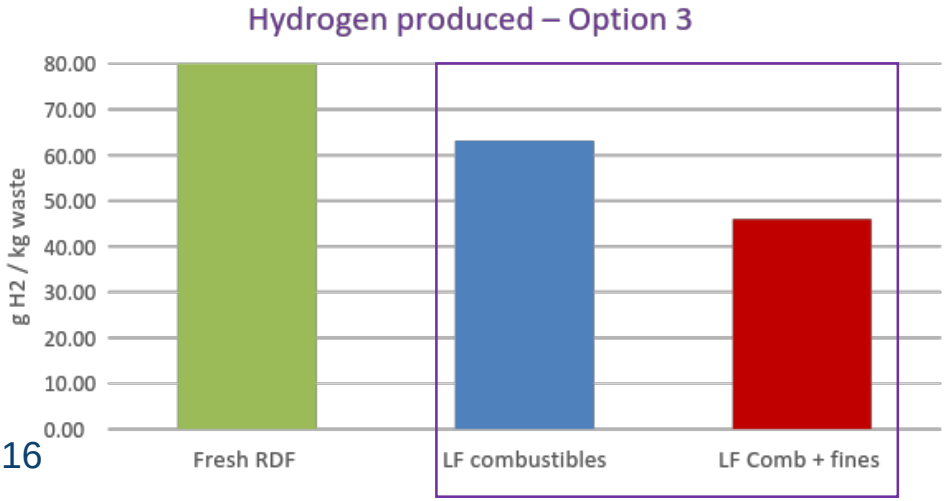
Results: Energy Production



OPTION 1 : INCINERATION – Steam turbine

OPTION 2 : GASIFICATION – Steam turbine

OPTION 3: GASIFICATION – hydrogen production



Upcycling of landfilled plastics to products through pyrolysis- *work on-going*

- EPSRC-funded PhD project

EPSRC Engineering and Physical Sciences Research Council

- Conversion of contaminated and degraded plastics to high-value commodities through pyrolysis

- Watch this space…..

Summary

- High volumes of soil/fines to manage, however potential value exists within
    - Gutierrez et al- over 4x landfill sites ~$400 million in Al and Cu alone
- Direct recycling of remaining plastics/paper/textiles might not be economically viable due to contamination and degradation
- Use of the combustible fraction as RDF is a possibility (gross CV ~ 13 MJ/kg)
- However ATT presents further opportunities- chemicals, fuels and metals

Thank you

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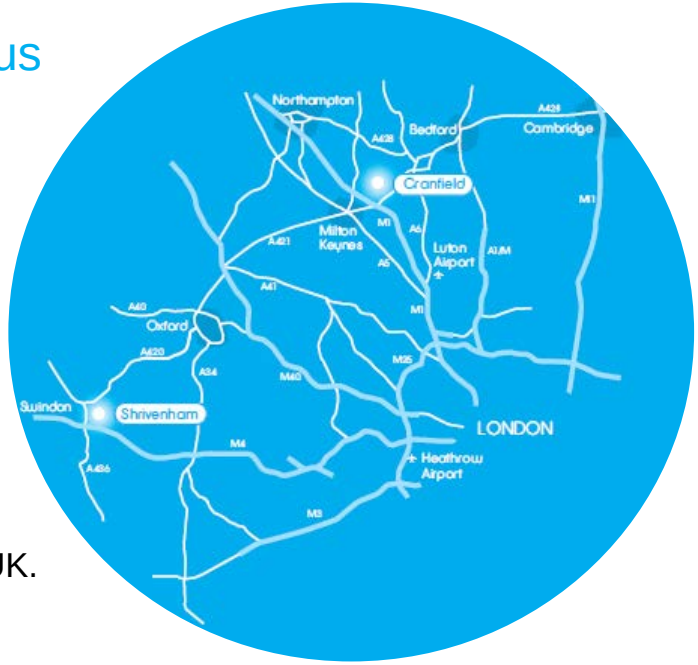

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