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Dilute and disperse landfills: evidence for natural attenuation

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Environment Agency Science Group

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Study of dilute and disperse sites

- 1974 IGS/DoE survey of landfill sites
  - 56 of 3,000+ sites with potential to seriously pollute surface or ground water
- 1973-1978 DoE “Brown Book” study
  - The Behaviour of Hazardous Wastes in Landfill Sites
- 1980s continued investigation of some Brown Book sites
- 1990s NRA (now EA) desk study to identify potentially polluting landfills
  - Thriplow selected for study 1996-2002

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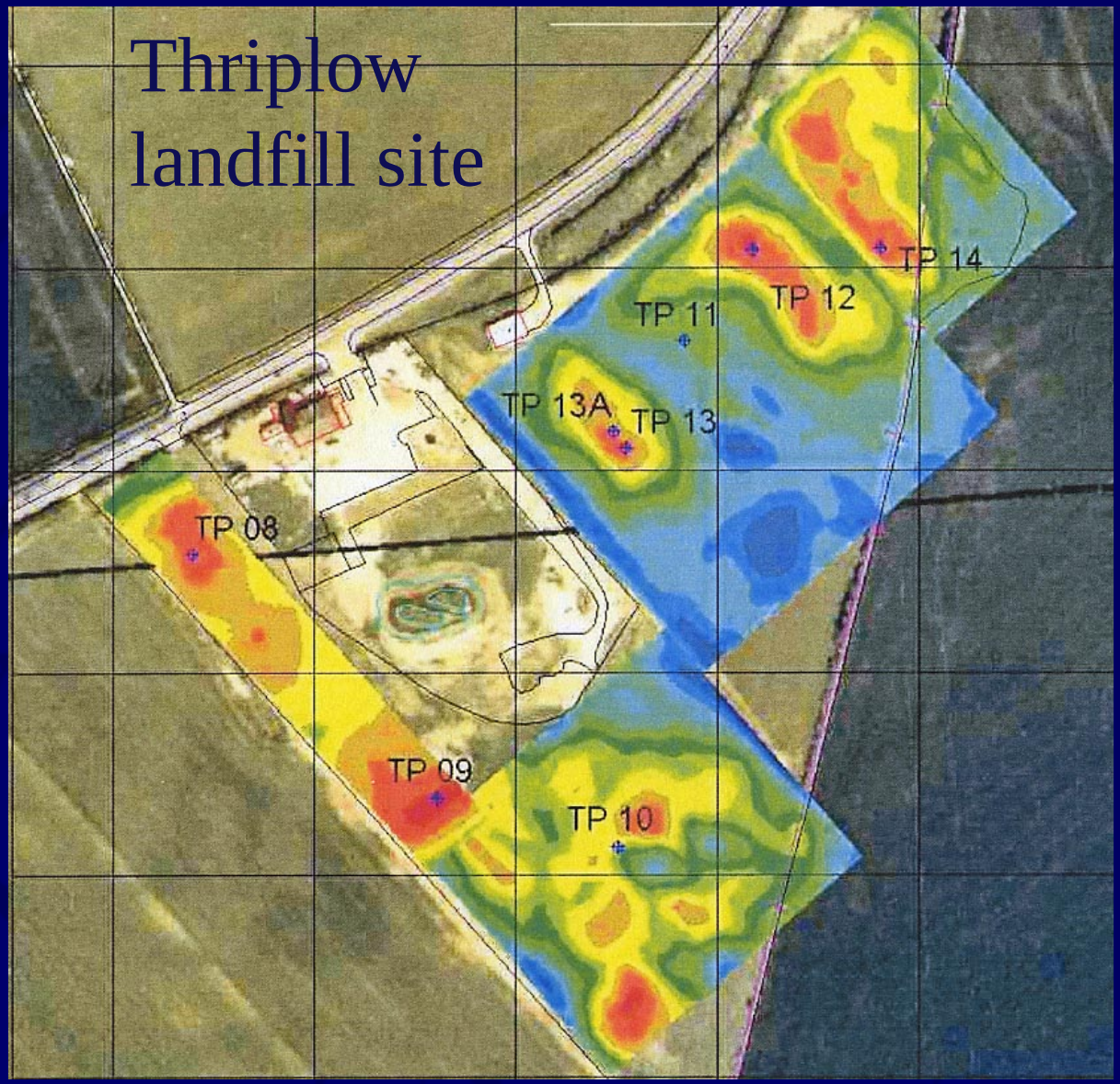
Thriplow landfill site



Phase I

operated 1957 - 1977
household and some commercial/industrial waste
7.2ha, filled to 3 - 9 m bgl
thin soil cover

Phase II

operated 1981 - 1987
household, commercial & industrial waste
4ha, filled to 1.8 - 9 m bgl
contoured “clay” cap

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Study objectives

- Characterise plume/s of contaminated groundwater from the landfill
- Identify controls on leachate migration and attenuation
- Develop a well-constrained model for groundwater flow and mass transport
- Provide facilities for long-term monitoring to determine NA processes and test model predictions

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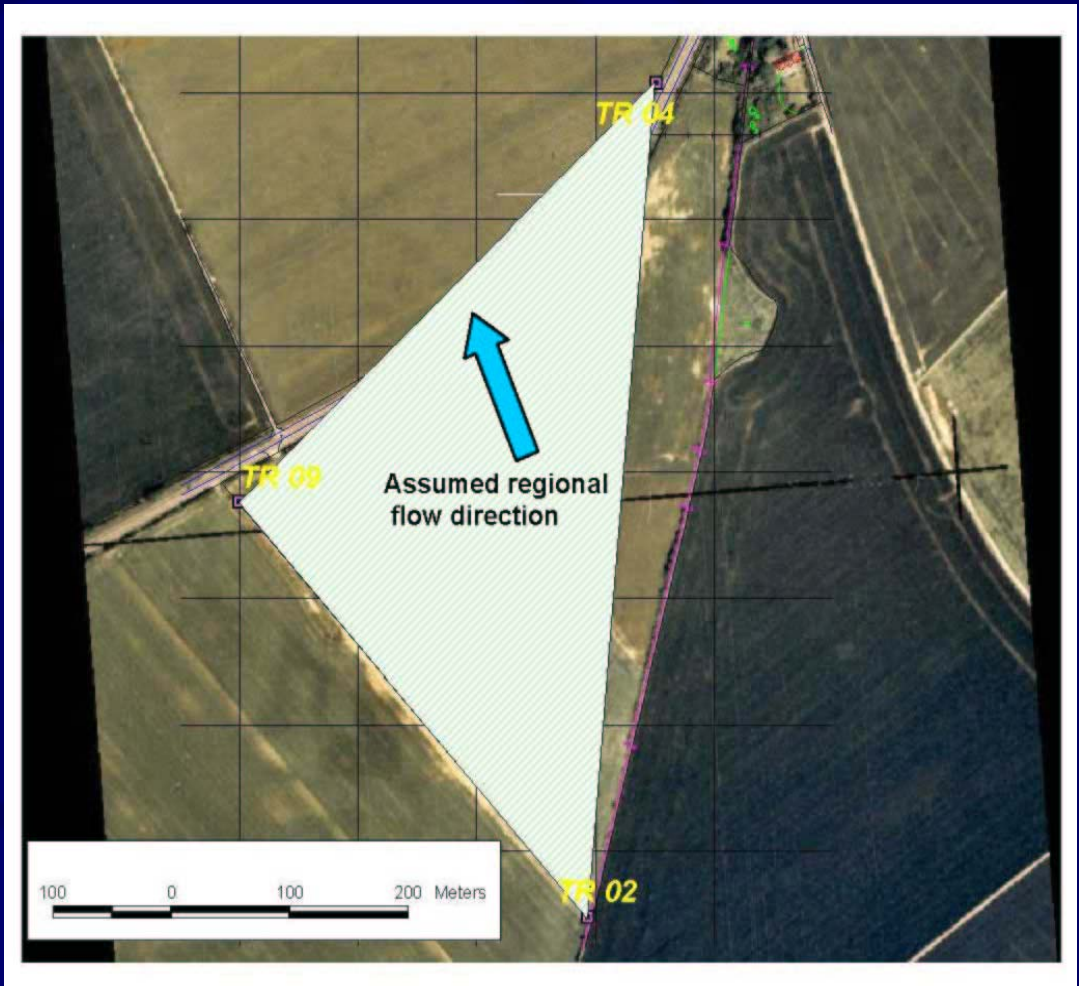
Desk study

- Previous investigations
- Groundwater monitoring data from existing boreholes
- Environment Agency/local authority archives (disposal history)
- Aerial photographs
- Meteorological data

Preliminary conceptual model



- Landfills previously gravel pits, up to 9 m deep
- Leaching may vary seasonally
- Contamination identified in BHs to west
- Regional gw flow to NW
- Vertical flow possibly limited by Plenus Marls

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Uncertainties

- Borehole construction and quality of previous monitoring data
- Borehole coverage
- Waste characteristics and leachate quality
- Hydraulic continuity between Middle and Lower Chalk
- Direction, depth and extent of leachate plume

Site investigations 1996 - 97

- CCTV and sampling from 7 of the 11 previously drilled boreholes (1976 - 1993)
- Landfill characterisation (5 new BHs in waste)
  - waste, leachate, porewater, BMP, gas, infiltration
- Surface resistivity imaging (2D)
- Characterisation of Chalk aquifer (1 new BH)
- Groundwater sampling
- Preliminary modelling

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Waste characterisation

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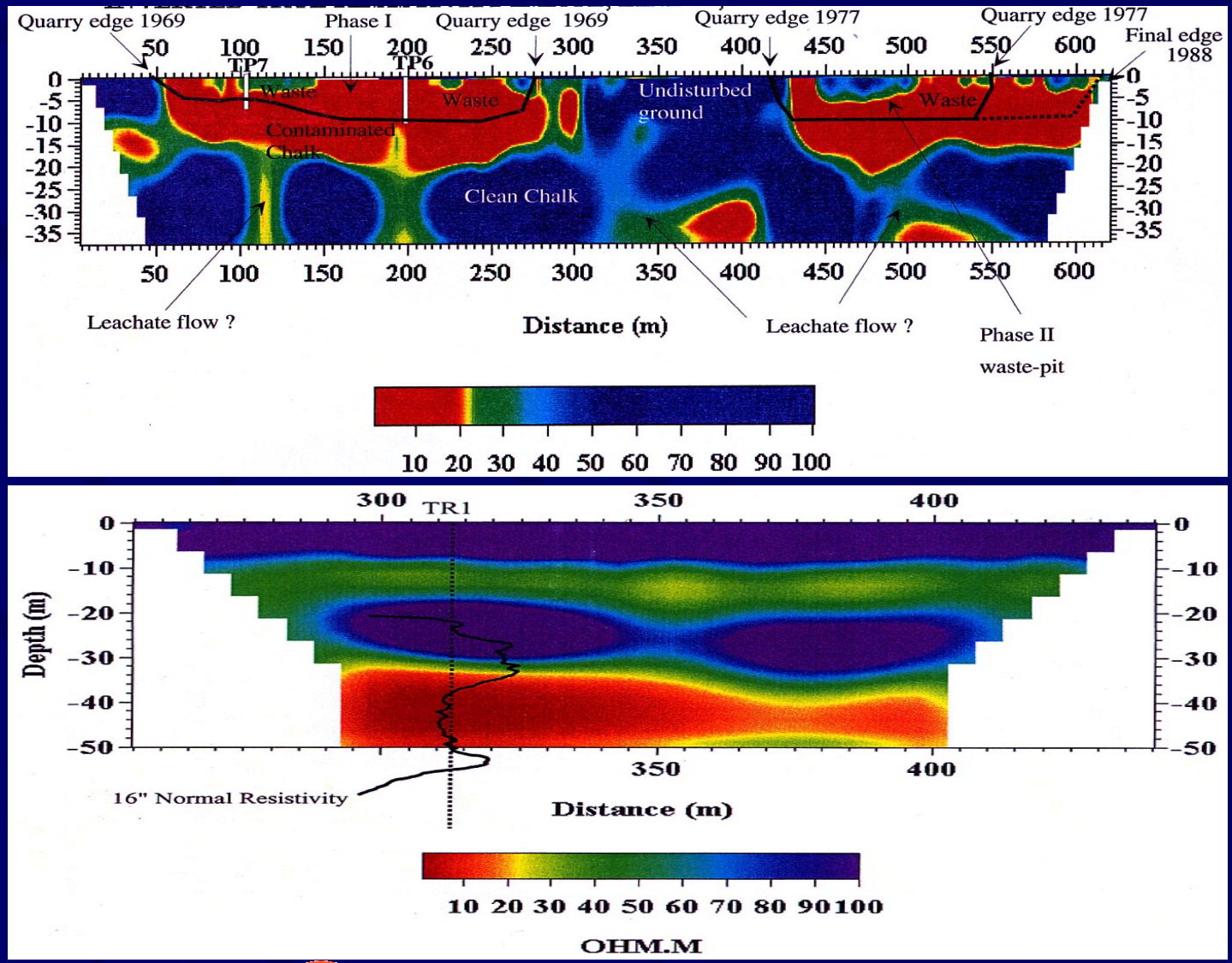

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Significant findings

- Some BH depths at variance with those recorded
- Some BH completions in both Middle and Lower Chalk - distortion of groundwater flow & dilution of leachate?
- Waste in Phase I was more degraded than waste in Phase II (function of age and cover thickness)
- Landfill resistivity appears to reflect leachate front rather than waste - Chalk interface, artefacts below ~ 20 m
- Elevated TOC, Cl and NH_4-N in groundwater downgradient of landfills
- Perimeter resistivity surveys indicate distinct plumes (but one anomaly drilled did not intercept leachate - poor resolution of formation resistivity below 30 m bgl)

Uncertainties

- Drift thickness - geometry of buried channel along western perimeter
- Aquifer properties
- Seasonal variation in groundwater flow
- Calibration of resistivity surveys
- Leachate release from landfill
- Evidence for natural attenuation

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Site investigations 1998 - 2002

- 3D resistivity survey of landfill phases
- 6 (No.) BHs in waste/Chalk
- 3 (No.) BHs north of landfill
- Downhole resistivity arrays in new BHs
- Sampling
  - waste, porewater, leachate, groundwater, gas
- Trace organics analyses
- Stable isotope analyses

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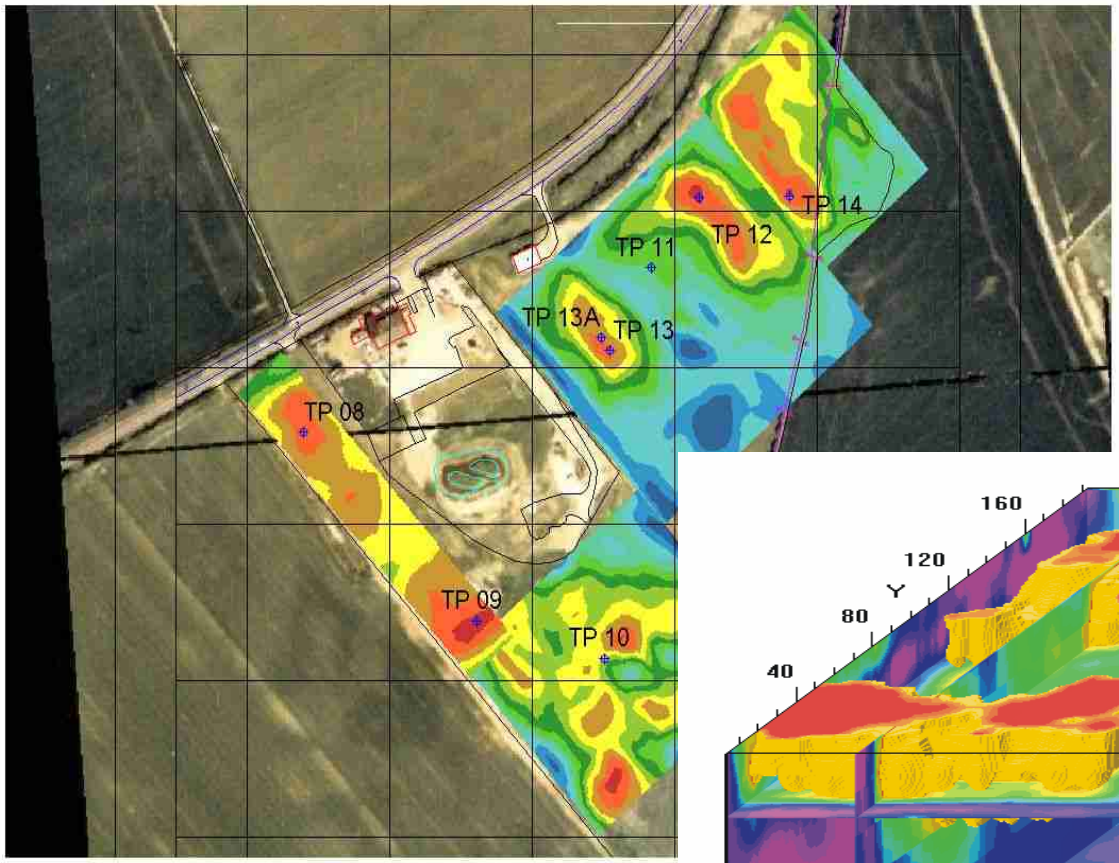
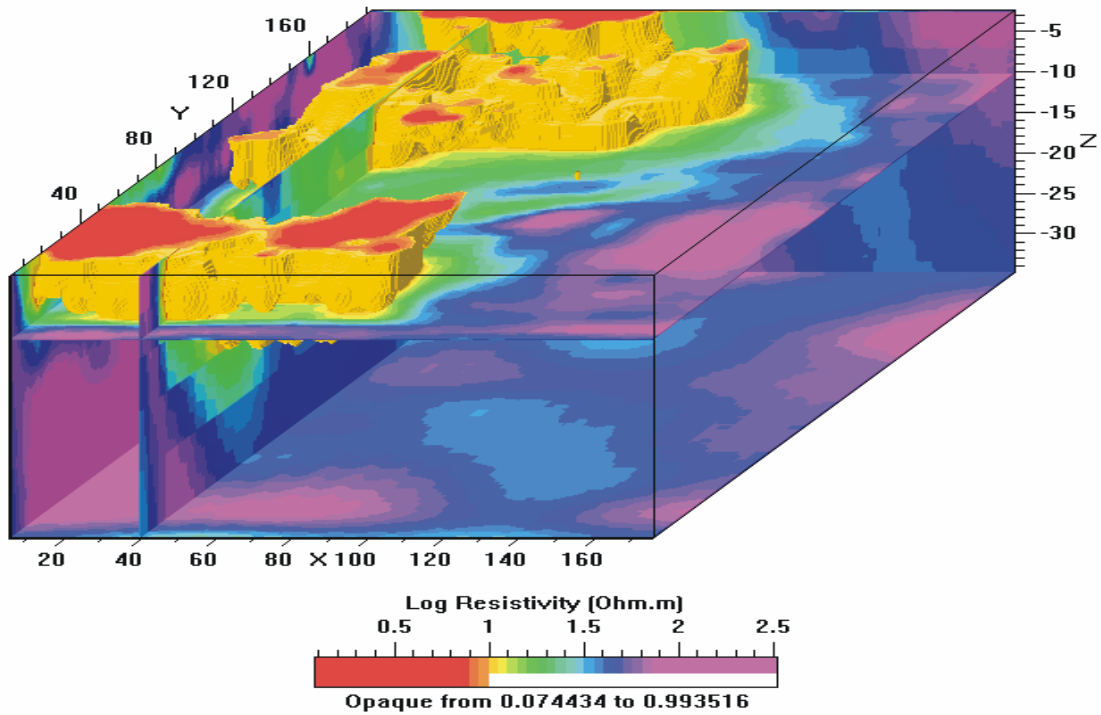
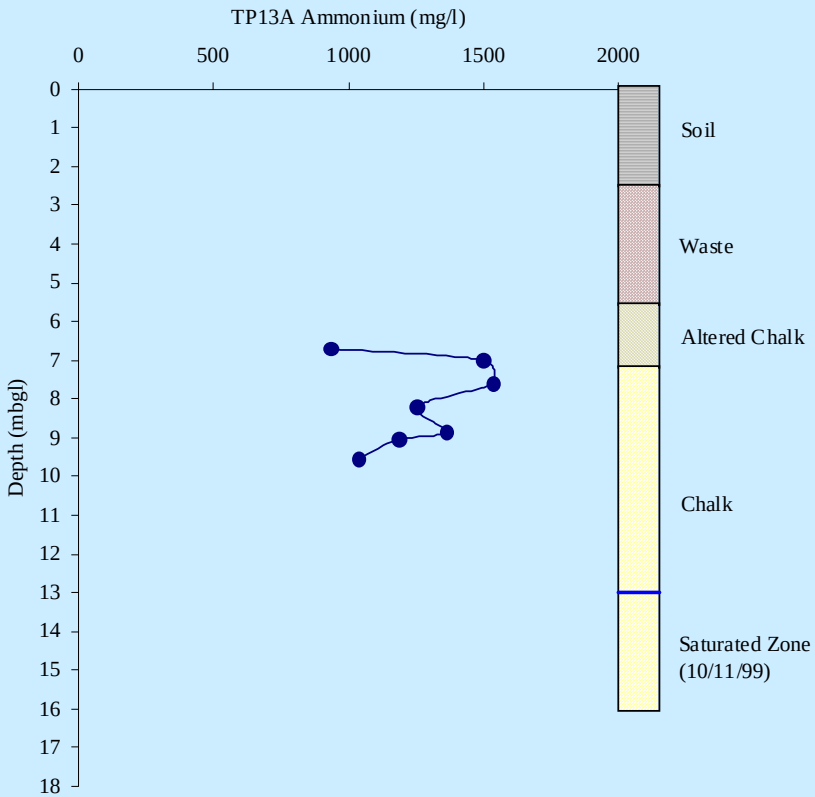
3D resistivity tomography



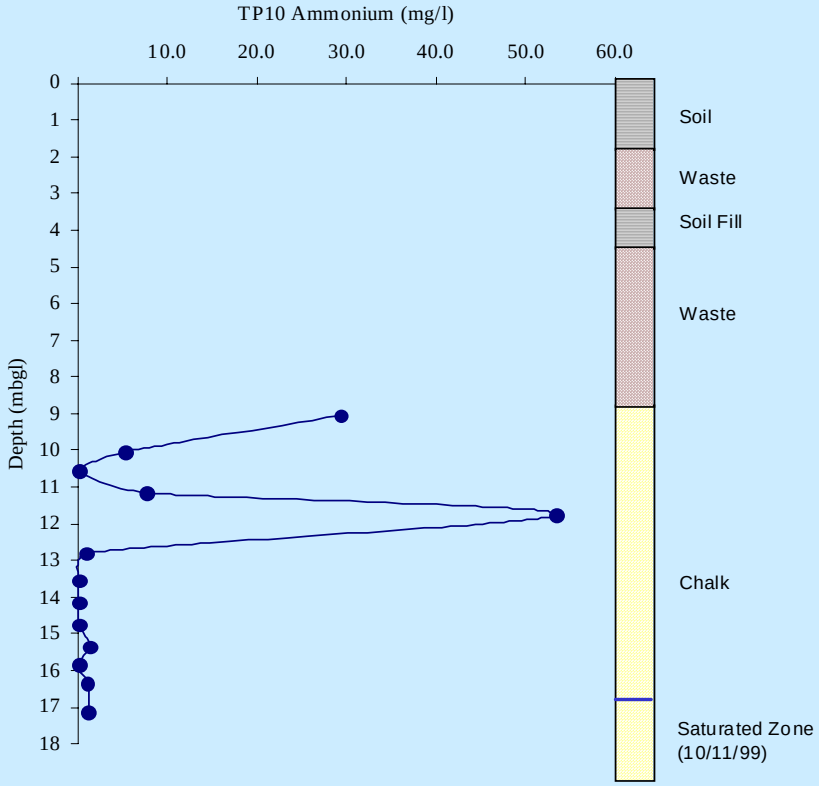


Porewater chemistry below waste

Phase I



Phase II



Time-lapse Monitoring of landfill boreholes to detect transient leachate plumes

Electrode sensors have been permanently installed in landfill boreholes. Monthly monitoring helps to detect transient plumes and seasonal variations in leachate distribution within landfill

Electrodes on outside of PVC casing ensures electrical contact with surrounding material irrespective of water table

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2D inversion results for prism model

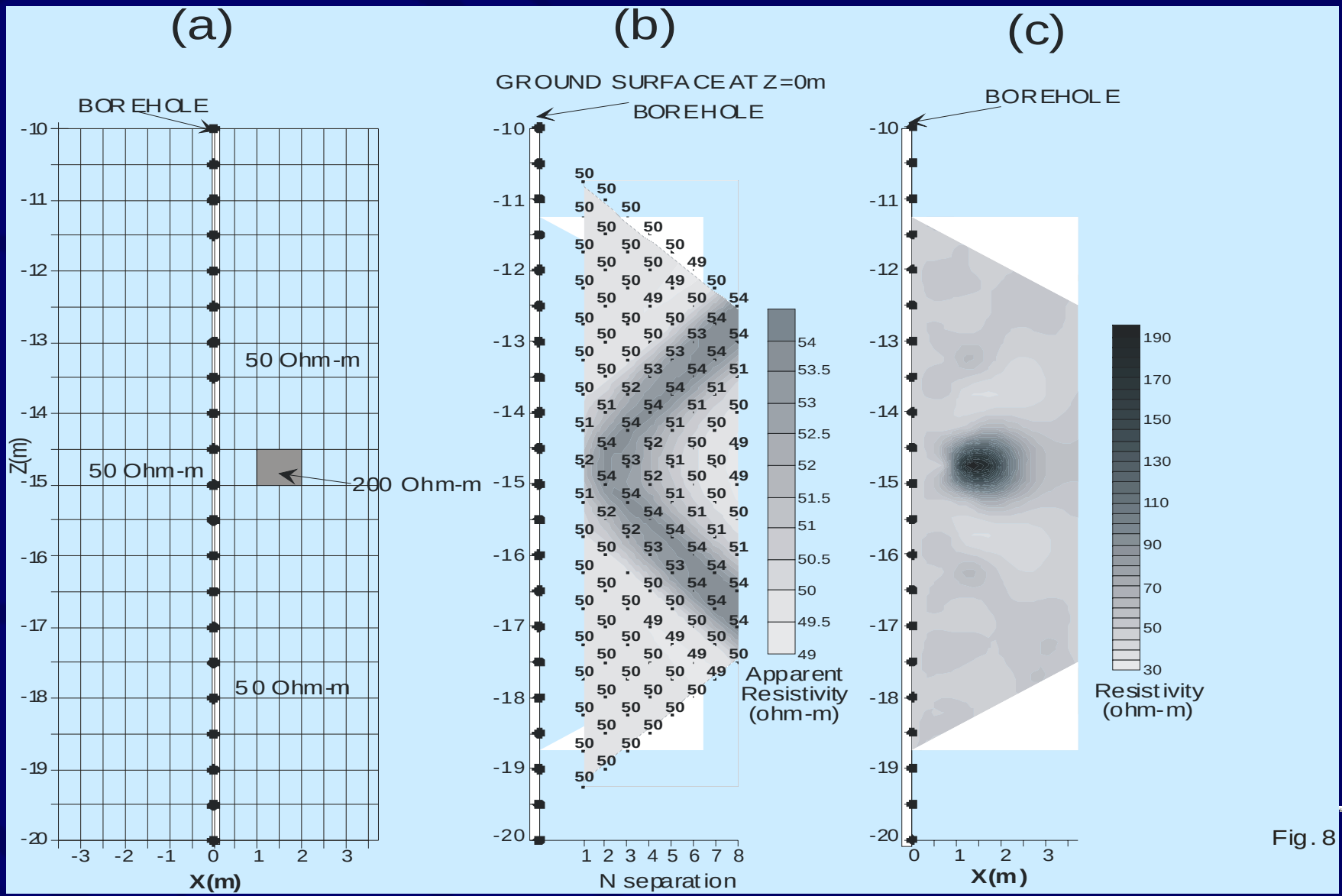

Fig. 8

ERT inversion images for Borehole TP09

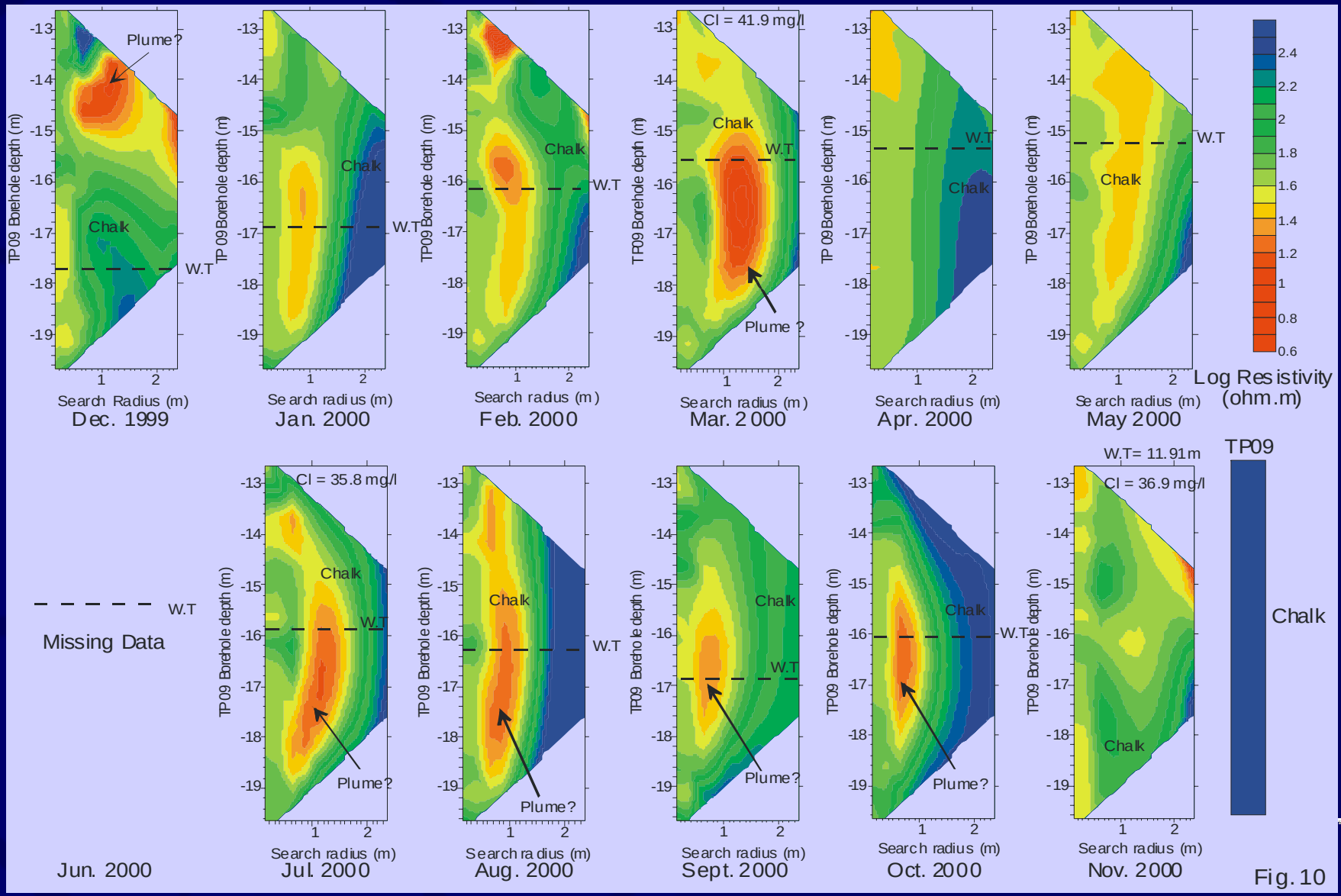

Fig. 10

So, with a better (although not perfect) idea of the waste characteristics, groundwater flow, leachate distribution and flow, is there any evidence for natural attenuation?

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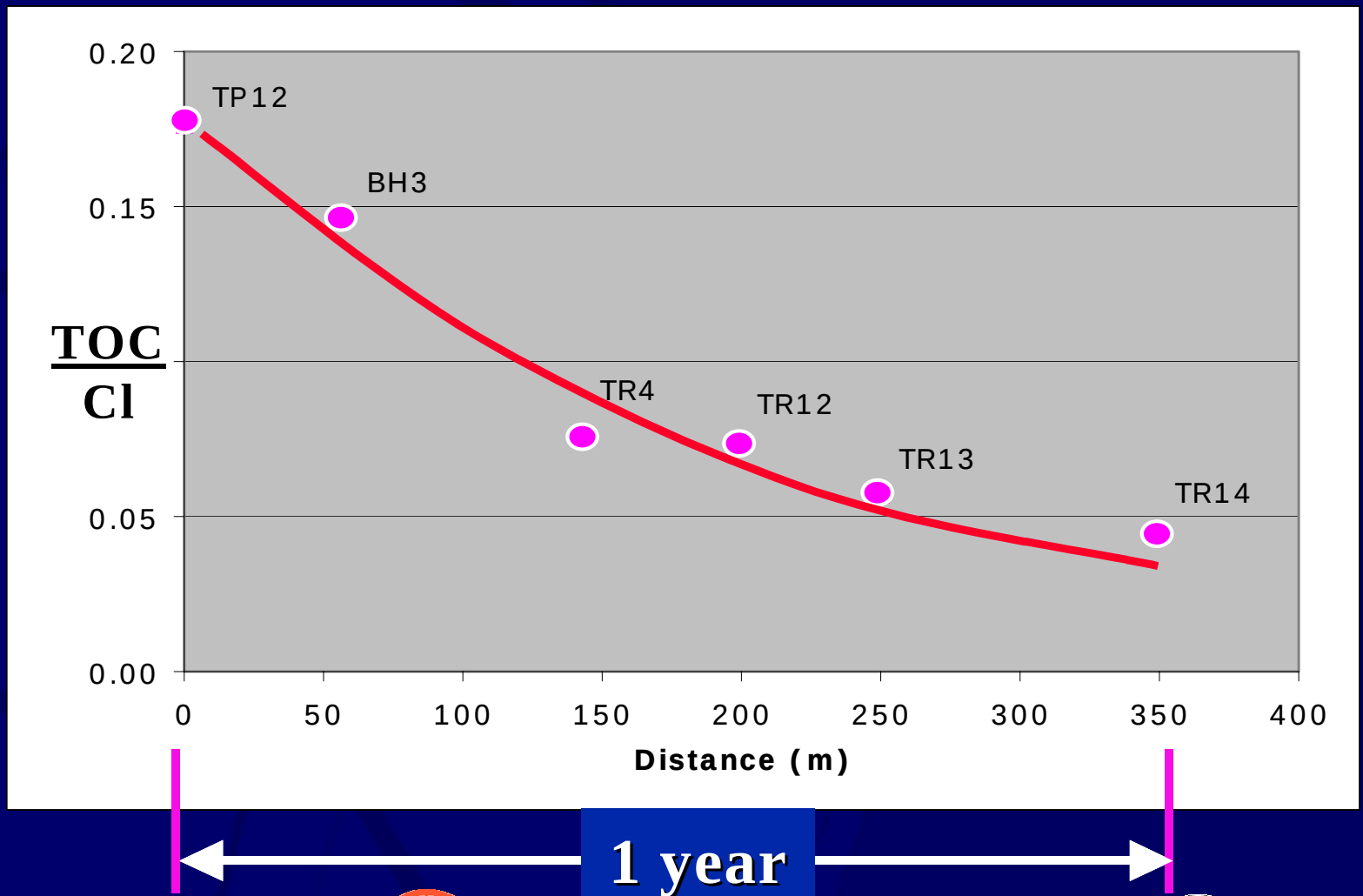
Conventional chemistry



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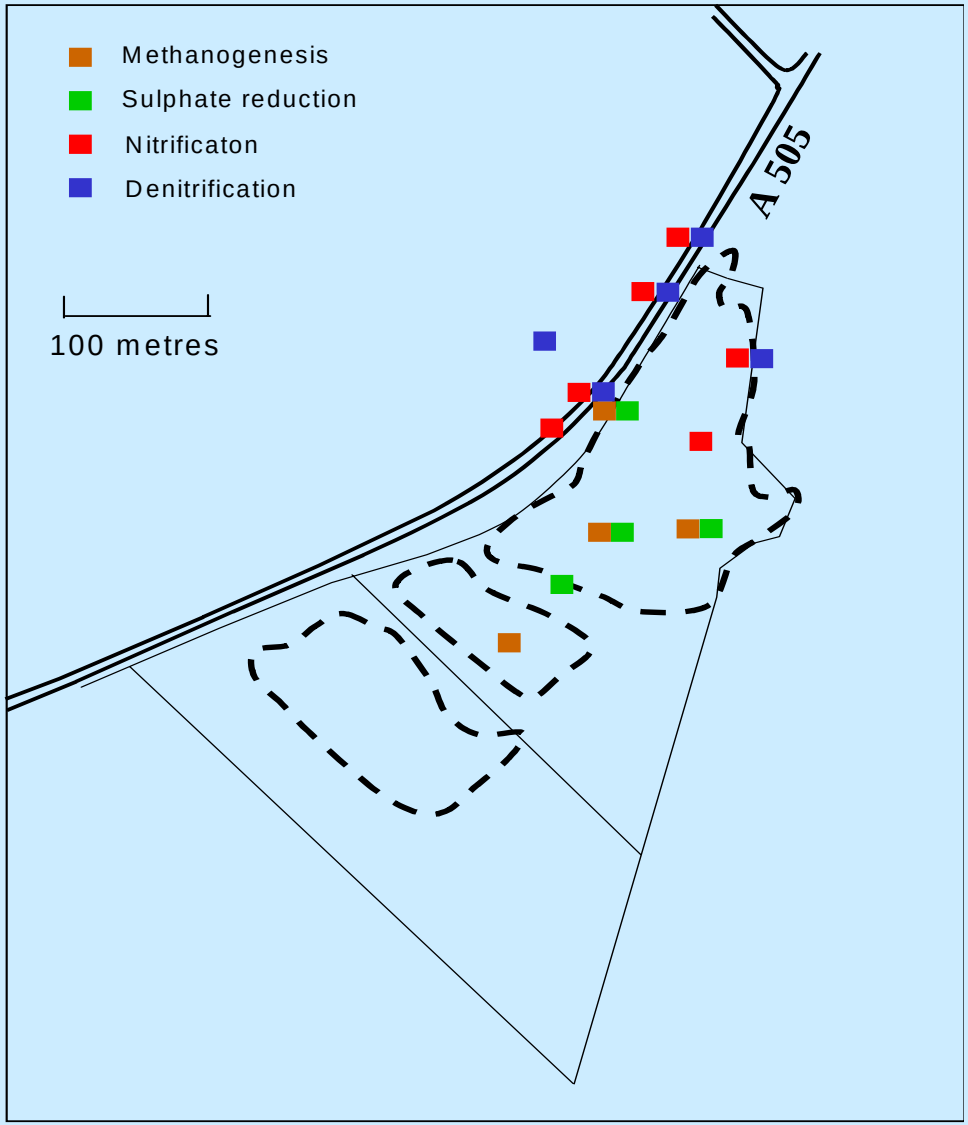
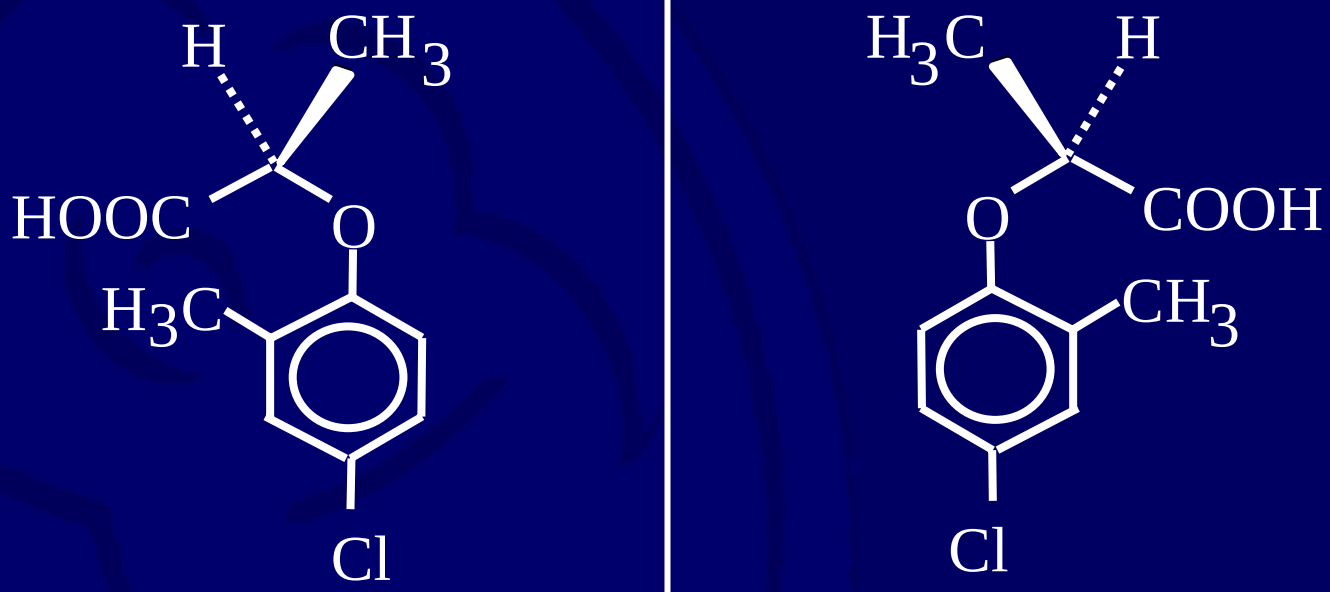
Stable isotope findings (S & N)



Enantiomeric forms of Mecoprop



(R) - Rectus

(S) - Sinister

2-(4-chloro-2-methyl phenoxy) - propionic acid

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Biodegradation of mecoprop

Redox	R-mecoprop	S-mecoprop
Methanogenic sulphate red.	NO	NO
Nitrate red.	YES	NO
Aerobic	YES	YES (faster)

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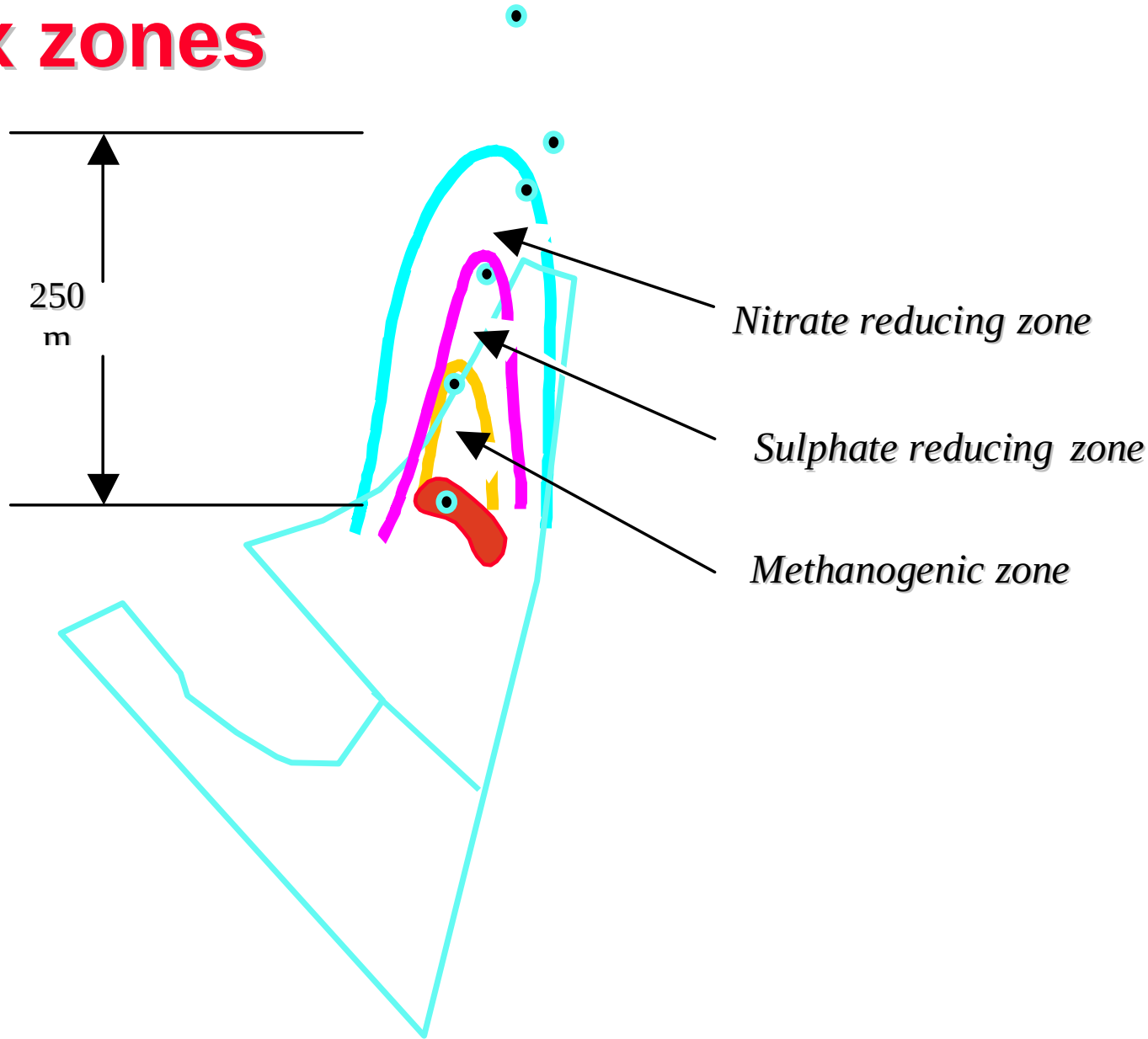
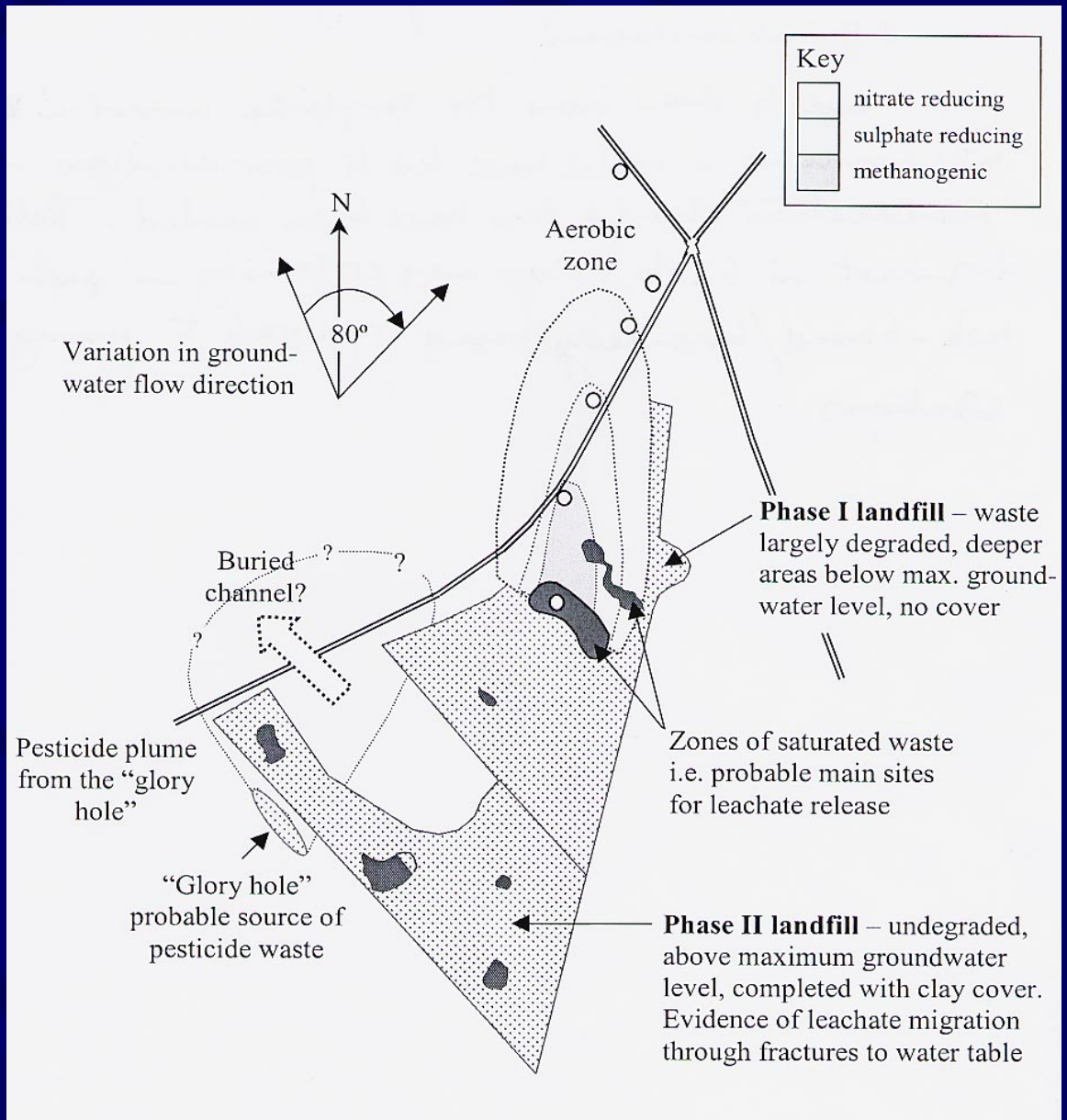
Redox zones


250
m
Nitrate reducing zone
Sulphate reducing zone
Methanogenic zone

Conceptual model (latest)



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Uncertainties/challenges

- Access
- Spatial data
- Source term evolution with time
  - a decade of missing data!
- Significance and frequency of pulsed release of leachate
- Any more plumes?

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