LAND CONTAMINATION
GOOD PRACTICE

GROUND INVESTIGATION TECHNIQUES

CONTENTS

INTRODUCTION

- Ross Cameron BSc (Hons)
- Owner A & I Geotechnical Ltd
- What am I talking about?

BEFORE WE GO TO SITE

- Project Details
- Desk Study
- Strategy
- Engagement with a competent contractor
- Revised Strategy?
- Personnel Selection
- BS10175:2011+A2:2017
- BDA Guidance For Safe intrusive Investigations on Contaminated or Potentially Contaminated Land
- BS5930:2015+A1:2020

INVESTIGATION TECHNIQUES

Non-Intrusive

- BS10175:2011+A2:2017 Table 5
- BDA Guidance For Safe Intrusive Investigations on Contaminated or Potentially Contaminated Land: Appendix F

Intrusive

- BS10175:2011+A2:2017 Table 6
- BDA Guidance For Safe Intrusive Investigations on Contaminated or Potentially Contaminated Land: Appendix G

INVESTIGATION TECHNIQUES

Table 5 *(continued)*

Methods	Applications and advantages	Disadvantages
Ground penetrating radar (GPR)		
Measurement of reflected microwave frequency EM radiation pulsed into the subsurface using an antenna. Equipment is drawn over the ground surface on a grid pattern.	Rapid acquisition of data, highly portable equipment. High resolution of near surface targets, including plastics pipes, metallic objects, voids and mines. Useful for detecting buried tanks. Can detect gross hydrocarbon contamination.	Poor signal penetration in conductive ground. Only suitable for relatively even ground. Can suffer signal interference through reinforced concrete and from adjacent foundations.
Magnetic profiling		
Measurement of the earth's total magnetic field intensity using one or more sensors. Gradient data are acquired by using two or more sensors simultaneously.	Rapid reconnaissance method for ferrous targets. Good lateral resolution facilitated by high sampling rates. Good resolution of shallow ferrous targets using gradient array.	Can be affected by cultural "noise", for example, buried and overhead cables, pipes, fences. Can be affected by temporal variations in the magnetic field and by non-ionizing radiation. Poor resolution of clustered deeper ferrous targets, e.g. drums at >3 m. Interpretation expertise required to model depths/volumes.

INVESTIGATION TECHNIQUES

Table 6 *(continued)*

Methods	Advantages	Disadvantages
Dynamic sampling using window or windowless sampling tubes		
Cylindrical steel tubes (often with an internal plastic sleeve) are driven into the ground by a percussive hammer. Hammers are usually mounted on small wheeled or tracked rigs, but may also be hand-portable. (Some dynamic sampling rigs are also capable of rotary drilling.)	Permits collection of continuous undisturbed samples. Can be used for installation of water and ground gas monitoring wells. Very compact rigs are available which can be used inside buildings or where space is limited. Can be used either for shallow sampling or at depths down to 10 m with appropriately sized equipment. Substantially faster than cable percussion. Does not require flush to be used, minimizing the risk of cross-contamination and waste generated. Effective at retaining volatiles, especially in cohesive soils where a plastic liner is used and because a relatively undisturbed sample can be cut from the extruded core.	Generally, poor recovery in dense sands and gravels, loose sands below the water table and certain types of made ground. Limited depth of penetration compared to other drilling methods, particularly for the smallest rigs. Sample volumes can be relatively small depending upon the diameter of the driven tube. A percussive hammer is noisy. Could be unsuitable in certain locations where noise is an issue. Cannot penetrate through obstructions (except where the drilling rig has a dual percussive and rotary capability). Can cause smearing of hole walls in some strata. Causes compression of some strata, e.g. peat. Holes not cased and could open up migration pathways. Casing can be inserted where the rig has adequate power and a removal system.

INVESTIGATION TECHNIQUES – NON-INTRUSIVE

- Desk Study
- Surface Sampling
- Conductivity Surveys
- Electrical Resistivity Surveys
- Ground Penetrating Radar
- Magnetic Profiling
- Microgravity
- Seismic Refraction
- Infra-red Photography
- Infra-red Thermography

INVESTIGATION TECHNIQUES – NON-INTRUSIVE

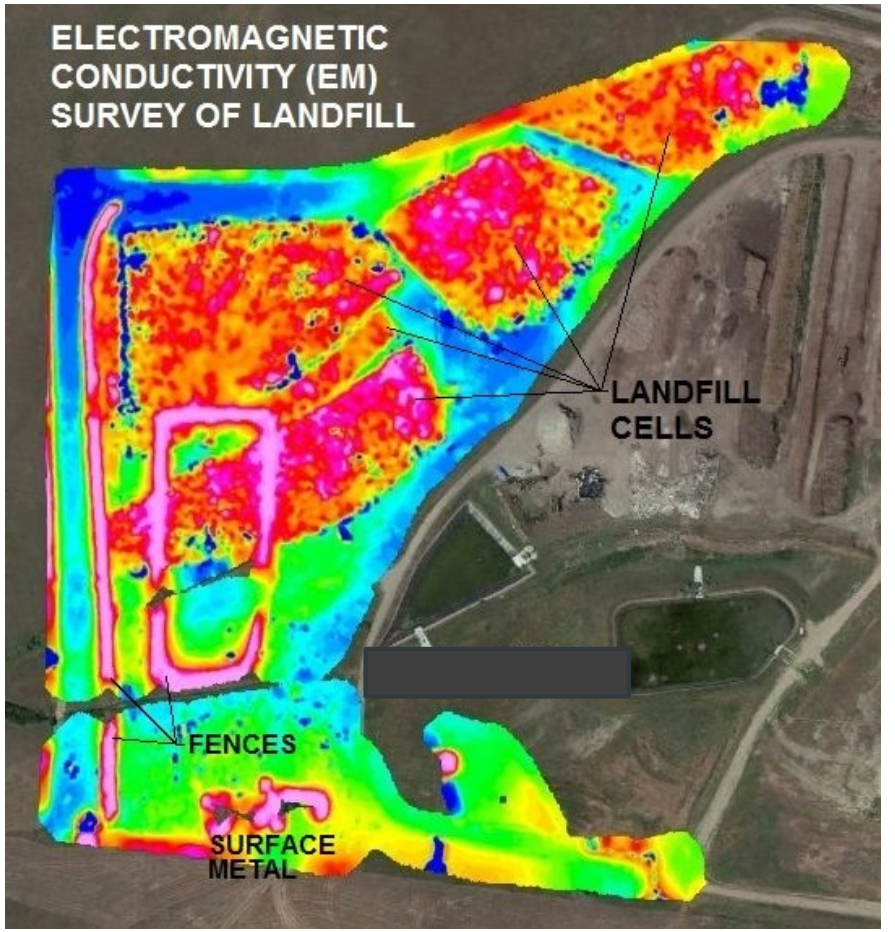
Desk Study

- Historical information for the site and surrounding area
- Review other desk studies or investigations
- Geology, hydrogeology, topography
- Potential receptors on the site or surrounding area
- Sources of potential contamination in the area
- Map review for naturally occurring harmful materials
- Mining
- Site constraints
- UXO
- Is the information reliable?

INVESTIGATION TECHNIQUES – NON-INTRUSIVE

Conductivity Surveys

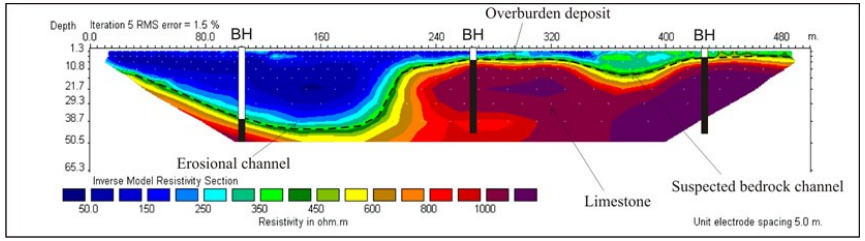
- Use of an elecromagnetic field to induce a current creating a secondary field
- Quickly interpret variations in groundwater quality and buried metallic objects
- Indicate disturbed ground
- Accurate only at certain levels of ground conductivity
- Repeat measurements required for qualitative modelling

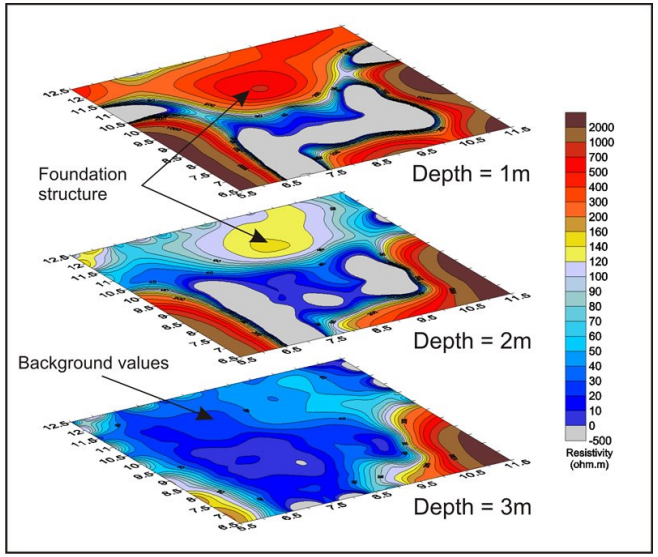


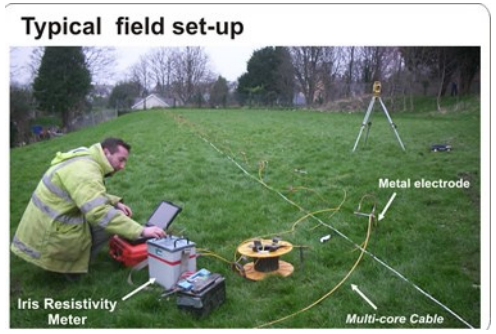
INVESTIGATION TECHNIQUES – NON-INTRUSIVE

Electrical Resistivity Surveys

- Measures apparent resistivity along a linear array of electrodes to produce image contoured 2D sections
- Easy to use and good resolution of resistive layers
- Differentiates saturated and unsaturated layers
- Good interpretation can help profiling of fill
- Difficult if not impossible in areas of hard standing
- Problems in highly resistant ground and with data at great depth.



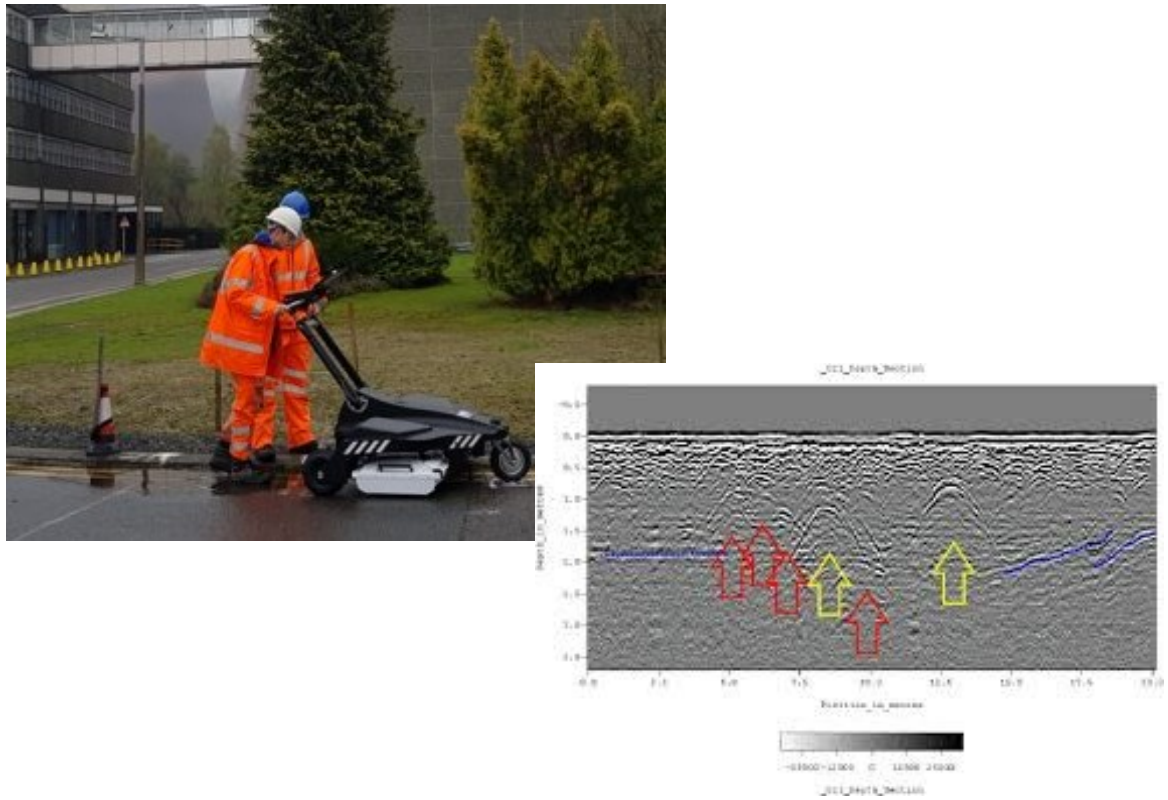




INVESTIGATION TECHNIQUES – NON-INTRUSIVE

Ground Penetrating Radar

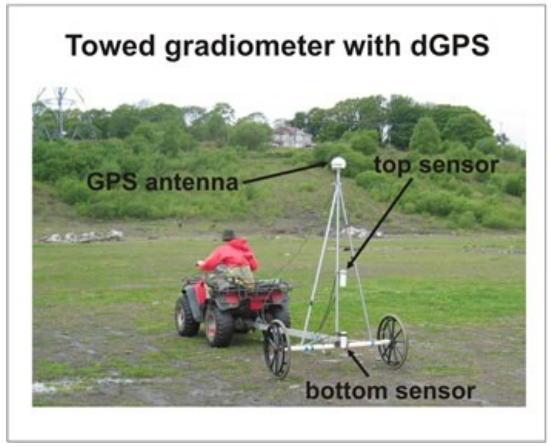
- Measures reflected microwave frequency pulsed into the subsurface using an antenna.
- Quick and portable
- Provides high resolution of near surface targets, pipes, tanks etc
- Can detect gross hydrocarbon contamination
- Poor signal penetration in conductive ground
- Diifficult on uneven ground
- Signal interference in reinforced concrete, foundations

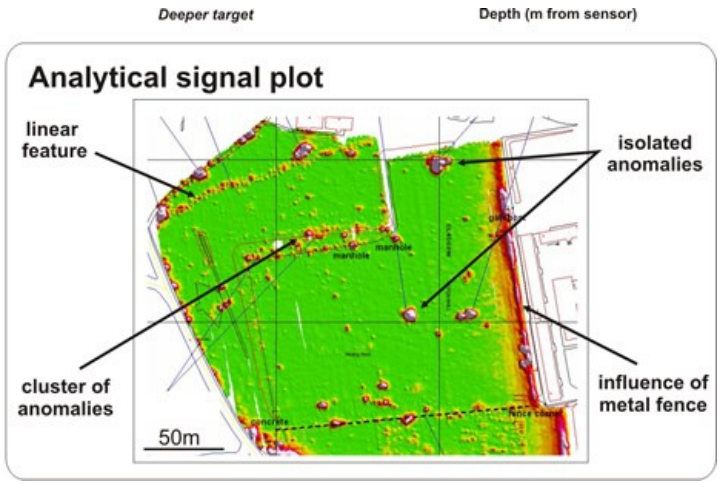


INVESTIGATION TECHNIQUES – NON-INTRUSIVE

Magnetic Profiling

- Measures earths total magnetic field intensity using one or more sensors
- Quick reconnaisence and good resolution of ferrous objects
- Good lateral resolution and high sampling rates
- Affected by cultural noise, variations on the magnetic field.
- Poor resolution at depth.
- Potential difficulties with interpretation





INVESTIGATION TECHNIQUES – NON-INTRUSIVE

Microgravity

- Measures changes in gravity values from vertical and lateral density variations
- Can be undertaken in areas where noise prevents EM and seismic surveying.
- Slow data production.
- Significant terrain corrections for anomalies.

Seismic Refraction

- Measures P and S waves produced by hammering a plate or shots and refracted along acoustic boundaries or radiated back to surface.
- Slow data production.
- Difficult in noisy environments.

INVESTIGATION TECHNIQUES – NON-INTRUSIVE

Infra-red Photography and Infra-red thermography

- Detection of change in reflected energy and temeperatures differences respectively.
- Aerial reconnaisence.
- Difficult logistically and to interpret without expertise.

Surface Sampling

- Quick and easy
- Experience to notice potential contaminants and hazards

INVESTIGATION TECHNIQUES - INTRUSIVE

- SAFETY!!
- Hand Auger
- Hand Excavation
- Trial Pits
- Dynamic Sampling
- Cable Percussion
- Rotary
- Sonic
- Hollow Stem Augers
- Cone Penetration

INVESTIGATION TECHNIQUES – INTRUSIVE

Hand Auger

- Quick and portable
- Limited in use by depth and ground conditions
- Potential cross contamination
- Small disturbed sample
- Physically difficult in coarse soil or stiff gravelly clay.

INVESTIGATION TECHNIQUES – INTRUSIVE

Hand Excavation

- Limited by depth and ground conditions
- Potential cross contamination
- Disturbed sample
- Physically difficult in some made ground
- Exposure to air/ water
- Waste

INVESTIGATION TECHNIQUES – INTRUSIVE

Mechanical Excavation

- Limited by plant type and ground stability/ water entry
- Potential cross contamination
- Exposure to air/ water
- Disturbed sample
- Residual disturbed zones on site
- Waste

INVESTIGATION TECHNIQUES – INTRUSIVE

Dynamic Sampling

- Steel tubes with plastic liners driven into the ground by a mechanical rig mounted hammer
- Small, quick and compact
- Typically 5-10m depth and suitable for well installation
- Continuous 'undisturbed' samples
- Poor recovery/progress in difficult ground, small sample volume
- Difficult to case in certain ground.

INVESTIGATION TECHNIQUES – INTRUSIVE

Cable Percussion

- Large tripod rig with a winch and weighted tools.
- Useful in varied ground conditions
- Potential for cross contamination of underlying aquifers
- Allows multiple strings of casing to be employed for clean drilling
- Integrated sampling, disturbed and undisturbed
- Monitoring well installation
- Waste requires disposal

INVESTIGATION TECHNIQUES – INTRUSIVE

Rotary

- Hydraulic rotary rigs used to form holes typically with the addition of a flushing medium
- Typically used in hard ground or rock (openholing and coring)
- Newer rigs have dynamic sampling function
- Useful in varied ground conditions
- Potential for cross contamination of underlying ground/ acquifers during
- Requires the addition of a flushing medium
- Flush control and storage of returns
- Monitoring well installation
- Waste requires disposal

INVESTIGATION TECHNIQUES – INTRUSIVE

Sonic Drilling

- High frequency energy transmitted through the tooling shears and displaces soil and rock particles.
- Typically mounted on rotary type units and most rigs now have rotary option.
- Will progress through most ground conditions including obstructions.
- Very quick
- Potential for cross contamination during hole formation.
- Flushing medium not always required
- Heating of samples without flush can cause loss of volatiles
- Waste requires disposal

INVESTIGATION TECHNIQUES – INTRUSIVE

Hollow Stem Augers

- Continuous flight auger with hollow stem and sampling barrel
- Fully cased hole may potentially reduce cross contamination
- Not suitable for deep holes.
- Suitable for monitoring well installation.

INVESTIGATION TECHNIQUES – INTRUSIVE

Cone Penetration

- Static or Dynamic Cones suitable for some in situ testing such as pH, O2, redox, temperature
- No waste generated
- Expensive with high mobilisation costs
- Limited sampling and poor recovery typically
- Holes cant be sealed potentially leading to cross contamination.
- Integrated with standard CPT testing.

INVESTIGATION TECHNIQUES

Questions?