Written Scheme of Investigation for Agricultural Soil Mapping of

Manor Farm
East Heslerton

For
IPAAST Project (University of Glasgow)

Agrivation Ltd Ref: AGVIPmf16102022

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Agrivation Limited

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1.0	WSI	Clive Blacker	Clive Blacker	Clive Blacker	16/10/2022

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Acknowledgment

This written scheme of investigation is based on a template supplied kindly by:
Magnitude Surveys Ltd, Bradford (***https://www.magnitudesurveys.co.uk/***)

1. Introduction

1.1 This document details a Written Scheme of Investigation for a geophysical survey by Agrivation Limited for the Ipaast-czo project (University of Glasgow). Commissioned to investigate the direct comparison of data collection and methodologies commonly used in agriculture against those used in archaeology.

1.2 The survey area comprises Field 70 (W3W ///civic.livid.provide, WGS84: 54.174658, -0.582296; BNG: 492637,476357) a *c*. 10ha area of land at Manor Farm, East Heslerton, North Yorkshire, YO17 8RL (see Fig 1).

1.3 The geophysical survey system comprises an RTK GNSS positioned, quad-towed, remote mounted Dualem 2/1 electromagnetic sensor. Electromagnetic induction (EMI) survey provides a standard primary geophysical measurement for soil mapping applications. This provides an ability to detect a range of different soil characteristics and sub surface features. For agriculture the use of EMI is suited for the measurements of mapping soil types; characterizing soil water content and flow patterns; assessing variations in soil texture, compaction, organic matter content, and pH; and determining the depth to subsurface horizons (Doolittle et al., 2014).

1.4 For archaeology the technique is particularly suited for detecting fired or magnetically enhanced features, such as ditches, pits, kilns, sunken earth houses, and industrial activity (David *et al*., 2008). The survey will be conducted in line with the current best practice guidelines produced by Historic England (David et al., 2008), the European Archaeological Council (Schmidt et al., 2015) and the Ipaast-czo project (Ipaast 2022)

2. Objective

2.1 The objective of this geophysical survey is to assess the subsurface variation in soil physical parameters for use in agricultural management where soil changes influence measurement and input management treatment recommendations and for an archaeological potential of the survey area.

3. Methodology

3.1. Data Collection

3.1.1. Geophysical survey will comprise the Electromagnetic induction method as described in the following table.

3.1.2. Table of survey strategies:

Method	Instrument	Traverse Interval (metres)	Sample Interval
Electromagnetic Induction	Dualem 2/1	24, 12, 6, 3	10 Hz reprojected to 0.35 m

3.1.3. Agrivation Limited employs a modular nonconductive cart system, which is configured to be towed by quad or RTV. RTK GNSS is utilized to provide high positional accuracy of the collected data. The georeferenced data collection utilizes the WSG84 coordinate systems for the XYZ positional coordinates, which is common to most agricultural GIS software packages. Navigational guidance and visual feedback are provided to the operator by bespoke mapping software to ensure accurate data surveying is undertaken consistently across the full field area.

3.1.4. Electromagnetic data transmitting the extended menu at data speeds of 10hz will be collected using Agrivations bespoke probe logger software, and quad-towed nonconductive cart. The software combines the GNSS positional data with the extended data outputs from the Dualem sensor. Positional corrections are calculated within the software to allow for antenna offset from the position of the Dualem Instruments which is secured to the cart. Positional referencing will be through a multi-channel, multi-constellation GNSS Smart Antenna. RTK GNSS outputting in NMEA mode at 10hz also ensures high positional accuracy of collected measurements. The RTK GNSS is accurate to 0.008m + 1ppm in the horizontal and 0.015m + 1ppm in the vertical.

3.1.5. Electromagnetic and GNSS data will be stored on the solid-state hard drive of a Panasonic Toughbook. The Toughbook is synced daily with Wi-Fi or personal hotspots, to Microsoft azure cloud servers. This allows data collection, processing and visualisation to be monitored in near real-time as fieldwork is ongoing (see 3.6).

3.1.6. The Probe logger software supports accurate full field data surveying by providing navigation guidance at the desired working transverse intersection (swath width) of data collection. This navigational guidance utilized the RTK GNSS to optimize data collection by generation of a route plan to ensure full field coverage is captured.

3.2. Data Processing

3.2.1. The survey data is collected in a comma separated variables (CSV). There is no header line generated in the file however each line contains the following comma separated variables.

1	Time/Date	DD/MM/YYYY:hh:mm:ss	e.g. 18/02/2011-11:44:48
2	Sampling Company	String Text (a-Z 0-9) spaces allowed	e.g. Agrivation Limited
3	Sampler Name	String Text (a-Z 0-9) Spaces allowed	e.g. Clive Blacker
4	Farm Name	String Text (a-Z 0-9) Spaces allowed	e.g. Manor Farm
5	Field Name	String Text (a-Z 0-9) Spaces allowed	e.g. Field 70
6	Longitude X Degrees Decimal	Float	e.g. -00.59381
7	Latitude Y Degrees Decimal	Float	e.g. 52.58082
8	Altitude m above sea level	Float	e.g. 62.6047
9	Shorter array horizontal Co-planar Conductivity ms/m	Float	e.g. 13.7
10	Shorter array horizontal Co-planarIn Phase Deep ppt	Float	e.g. 0.46
11	Shorter array perpendicular Conductivity Shallow mS/m	Float	e.g. 4.9
12	Shorter array perpendicular In Phase Shallow ppt	Float	e.g. -0.84
13	Shorter array Conductivity Difference mS/m	Float	e.g. 8.8
14	Shorter array In Phase Difference ppt	Float	e.g. 1.3
15	Temperature Celsius	Float inc sign	e.g. +1
16	Pitch Degrees	Float inc sign	e.g. +4
17	Roll Degrees	Float inc sign	e.g. +4
18	Battery Voltage Volts	Float inc sign	e.g. +14.2
19	GPS quality		e.g. 4
20	GPS satellites		e.g. 9

21	GPS HDOP	e.g. 1.34
22	New section flag 1 = start of new logging section, 0 = continuation.	
23	Longer array horizontal Conductivity Deep 2 Float mS/m	e.g. 13.7
24	Longer array horizontal In Phase Deep 2 Float ppt	e.g. 0.46
25	longer array perpendicular Conductivity Shallow 2 Float mS/m	e.g. 4.9
26	Longer array perpendicular In Phase Shallow 2 Float ppt	e.g. -0.84
27	Longer array Conductivity Difference 2 Float mS/m	e.g. 8.8
28	Longer array In Phase Difference 2 Float ppt	e.g. 1.3
29	Accel X Float	
30	Accel Y Float	
31	Accel Z Float	
32	Mag X Float	
33	Mag Y Float	
34	Mag Z Float	
35	Temp Int	

3.2.2. Company policy for all raw data captured is to make this freely available to the client who purchased the survey data. The data collected is their property but Agrivation Ltd reserves the right to hold and use the data on behalf of the client for data mapping and interpretation purposes. IP used to generate and the outputted data from the processing remains to property of Agrivation Limited.

3.2.3. Sensor Calibration – The sensors are factory calibrated and checked on an annual basis, per Dualem instructions for calibration.

3.2.4. Processed Data - Data processing will be through the Farmplan Gatekeeper software. This utilizes data filters to remove any basic gyroscopic sensor roll values above 70 degrees to remove outlier data points. A GNSS positional filter is also applied to the data removing any non-corrected positional data points. Once filtering has been completed the data is processed using a 10 by 10 m grid to which the underlying data is captured. A further inverse distance algorithm with a weighted average processing (average of 1) technique of 30m radius is used to process the data to a smoothed contour vector output. The processing is generated for all 16 data layers from the QP and IP data streams

3.2.5. Projection to a Regular Grid – Data collected using RTK GNSS positioning requires a uniform grid projection to visualize data. Grid data is calculated to matrix cell values (10 x 10m) to support visualization of the numeric values using a 13-colour scale. Attributes are presented in each cell for all horizontal and perpendicular layers. The grid matrix are used for further processing of the data to apply management attributes (seed, fertilizer) for the generation of agricultural variable rate prescription maps with the grid generator features within the software allowing users to generate their own interpretation formula the outputs of which are exported in machine readable files.

3.2.6. Interpolation to contour map – Grid data is also typically interpolated to vector contour polygons by clustering similar classification data ranges into management polygons (Zones) which are further utilized to define soil sampling methodology to inform nutritional concentrations of each of the defined management zones. These contour outputs are also colour coded using the same 13 colour legend to support interpretation by untrained people.

3.3. Data Visualisation and Interpretation

3.3.1. On completion of the scanning and data processing a PDF Report is produced. The report highlights all fields across the farm and individual representation of each field. These present the gradient of the sensors' total field data as colour images, as well as the total field data from the upper and/or lower sensors. The gradient of the colour scheme minimises external interferences and reduces the blown-out responses from ferrous and other high contrast material. However, the course griding of the data by agricultural systems to a 10 by 10m grid lose a lot of detail relevant to archaeological requirements. If Archaeological maps are required, the recommendation would be to utilise domain specific software.

3.3.2. Geophysical results will be interpreted using coloured images and XY traces in a layered environment, overlaid against OS Open Data, satellite imagery

3.3.3. Geodetic position of results - All vector data will be projected in WSG84 and provided upon request in ESRI Shapefile (.SHP). Figures will be provided with raster and vector data projected against OS Master Mapping.

4. Reporting

4.1 Detailed reporting of the survey will be produced after the data collection and processing is completed. It's recommended that interpretation of the results is discussed with an agronomist and service provider to delineate the management zones from the data.

5. Quality Assurance

5.1 Project management, survey work, data processing and report production have been carried out by qualified and professional agriculturalists to standards exceeding the current best practice (CIfA, 2014; David *et al*., 2008, Schmidt *et al*., 2015). All managers, field and office staff have relevant qualifications related to agriculture production and recommendation systems, fertiliser (Facts) and plant protection (Basis) and/or field experience.

5.2 Director Clive Blacker has a HND in Agriculture, is BASIS and Facts Qualified and worked and operated in precision agriculture and mapping systems for over 25 years.

5.3 Agrivation has developed a bespoke geophysical mapping system whereby data is collected, visualized and route planning assistance is provided to ensure accurate data capture is delivered. All data is remotely uploaded to cloud servers post collection and auto processed allowing visualization and access by managers, farmers and operators. Data interpolation and transfer systems are in place to categorize fields, define operational zones and soil sampling strategies to allow efficient management of variability and cost-effective soil sample collections to take place. This data processing capability supports monitoring of coverage gaps or small errors within the data can be quickly identified and rectified, improving quality control of field surveys. The data streaming allows Agrivation to provide post processed data to the client at regular intervals, allowing all parties to be informed of the field survey's progress. Should it become apparent that the survey is being compromised by local conditions, such as field cultivations, soil/ crop conditions, livestock presence or the spreading of fertiliser, farmyard manure or green waste, this will be reported back to the client and a mitigation strategy can be devised if necessary.

6. Risk Assessment

6.1 Aggravation's standard EMI fieldwork risk assessment and site-specific risk assessment have been appended to the end of this document. Before geophysical survey commences, a brief walkover will be undertaken to identify any additional hazards of an unusual or site-specific nature. If any additional hazards are identified, the site-specific risk assessment will be updated to include these hazards and all surveyors will be informed of the risk. If appropriate mitigation factors cannot be put in place, then the field or part thereof will not be surveyed.

6.2 Field staff will attend a site induction if required. Necessary PPE will be supplied and worn. Wet and cold/hot weather protection is also supplied.

6.3 All surveyors have been issued mobile phones and vehicles fitted with remote telemetry. Survey teams are expected to make regular contact with the office to keep all parties updated with survey progress. Any change in conditions that may affect the health and safety, or operational efficiency of the survey team must be reported immediately, to the office and client.

6.4 The equipment transportation systems contain suitable welfare facilities. Antiseptic hand gel is provided, as is bottled drinking water. A first aid kit is stored in the cab of the vehicle, with a second kit near personnel within the survey area.

6.5 The nearest NHS Urgent Care Centre is at Malton community hospital, Maiden Greve, Malton, YO17 7NG. Should toilets be unavailable on site the nearest public accessible toilet is located at 25 Market Place Malton YO17 7LP.

7. Archiving

7.1 Agrivation maintains an in-house digital archive with metadata requirements conforming to minimal core elements as recommended for archaeological prospection by Schmidt and Ernenwein (2013) and Ipaast-czo (2022). This archive stores the collected measurements, minimally processed data, georeferenced and un- georeferenced images, raw data files, and a copy of the final report. A copy of this archive will be included with the final printed report for the client.

8. References

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David, A., Linford, N., Linford, P. and Martin, L., 2008. Geophysical survey in archaeological field evaluation: research and professional services guidelines (2nd edition). Historic England.

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Ipaast, 2022. Draft guidance [for public review] on the use of electromagnetic induction (EMI) data in archaeological prospection: guidance on 'archaeology to precision agriculture' data exchange. University of Glasgow. https://doi.org/10.5281/zenodo.7472497

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