



12.2.1 Deliverable

Survey Design Report (Les Champs Jouault)

Date: January, 2020



SUBJECT: Survey Design Report

☒ report
 ☐ information
 ☐ consideration
 ☐ decision

To: ... **From:** ULiege and BGS

D I2.2.1 Pilot site 2 – Les Champs Jouault, France

Introduction

This report describes the geophysical survey design of the two investigations carried out in the landfill Les Champs Jouault, Cuves, France. It is based upon the outcome of the SWOT analysis of geophysical methods for LF characterization (T1.3.1: Swot analysis of LF characterization methods), the prior information gathered and conclusions from desk studies about the site (see DI2.1.2 Remote imaging report). The survey was prepared in close cooperation with the members of SAS Les Champs Jouault.

The first geophysical survey in Les Champs Jouault was planned to take place from November 12-15, 2018. After data processing and the design of the sampling plan, a second geophysical investigation was planned from November 25-28, 2019. Adjustments of the survey design presented here might have occurred during the site investigation according to unexpected site conditions.

1. First geophysical survey

1.1 Survey coverage

Within the first geophysical survey, investigations will be limited to cells 1 to 4 (see Fig.1, green area). We decided to focus on these cells because:

- 1) they are the oldest and therefore will be the first to be landfill mined,
- 2) their waste composition differs (for example, cell 1 contains more industrial wastes – 60% - than the other cells – around 45%) which can produce interesting contrasted geophysical signatures,
- 3) cells 3 and 4 are already equipped with buried electrodes to perform ERT and IP measurements. Moreover, ERT and IP chronicles are already available for these two cells.

The survey might be extended and/or adapted into other cell zones depending on the preliminary results.

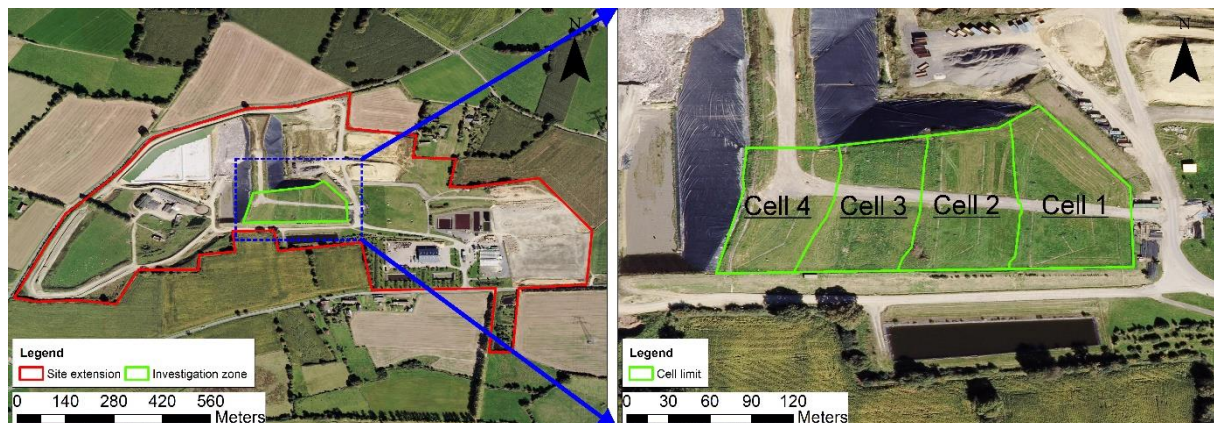


Figure 1: Planned extent of the first geophysical survey (green zone) in Les Champs Jouault. General aerial view from 2017, Institut National géographique et forestière (IGN), France.

2.1 Geophysical Methods

The following geophysical methods will be tested (for method suitability description see T1.3.1 SWOT analysis):

- Magnetometry
- Electromagnetic survey (EM)
- Seismic methods: multichannel analysis of surface waves (MASW) and the Horizontal to Vertical Noise Spectral Ratio (HVNSR)

Magnetometry

We plan to cover the investigation area with 59 parallel survey lines (East-West oriented) spaced by 2 meters. In addition, at least 9 perpendicular survey lines will be deployed for calibration and comparison (Fig. 2, blue grid).

For the positioning, a GPS will be coupled to the device. To ensure consistent coverage and positioning with respect to the other surveying methods, tape measures will be used and start-, centre- and endpoints will be marked.

A base station will also be recording the total magnetic field variations during the survey to apply later corrections to acquired maps.

System planned to be used: portable caesium magnetometer model G-858 from Geometrics with GPS positioning. For the base station: FGM3D Fluxgate from SENSYS.

EM surveying

The EM survey will be conducted on the same grid as the magnetic survey. The area will be covered with two antennas in order to reach investigation depths of 1.2 m and 3.0 m (2 m antenna) and 2.5 m and 6 m (4 m antenna). Both, quadrature (apparent conductivity) and in-phase (related to apparent magnetic susceptibility) will be recorded simultaneously.

System planned to be used: DUALEM-2/-4 with GPS positioning (no RTK) and mounted onto a cart.

MASW

We plan to measure at least three seismic profile lines E-W oriented across all cells (Figure 2, yellow lines).

We will use two geophone spacings, 1 and 2 meters respectively, to try to get information from shallow and deeper structures of the cells. By hitting a metallic or plastic plate with a sledgehammer and recording the emitted signal with vertical geophones, we can in theory obtain data for P- and S- wave refraction as well as MASW simultaneously.

System planned to be used: data will be acquired using a Geometrics Geode Seismograph, utilising a towed geophone streamer deployed from a wheelbarrow. The streamer will consist in 24 vertical geophones (4.5 Hz natural frequency), mounted on ground-coupled base plates and connected by woven Kevlar reinforced webbing.

HVNSR

The HVNSR-system will be deployed at several locations along the MASW profiles (see black dots in Fig. 2). We will combine the information provided by both methods to estimate the thickness of the waste deposits in the different cells.

Data will be recorded in the three components (vertical, north-south, east-west directions) using one seismometer LE-3Dlite MkIII with eigen periods of 1 second and upper frequency of 100 Hz.

Positioning

Differential GPS with real time kinetic (RTK) corrections will be used to ensure precise positioning to provide coordinates for later ground truthing and sampling.

All geophones, edges and intermediate points of the EM/MAG grid will be surveyed to correct for the lower precision of the GPS devices.

System planned to be used: Leica Viva differential GPS with RTK corrections

3.1 Timing and staff

The survey will involve at least four people.

Planned time schedule:

- Day 1: grid layout, EM mapping
 - Day 2: grid layout, MAG mapping
 - Day 3: seismic profiles will be acquired
 - Day 4: seismic profiles will be acquired
- If enough time: ground penetrating radar measurements could be conducted to estimate the thickness of the cover layer and detect gas extraction and leachate recirculation network.

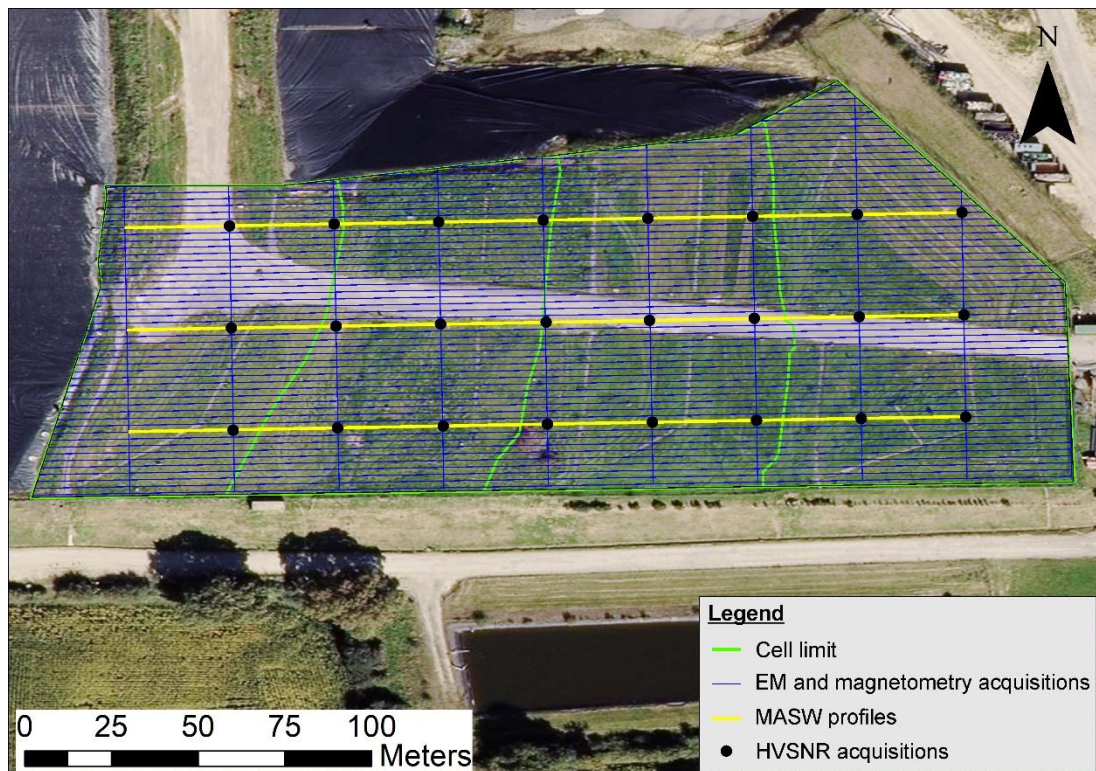


Figure 2: Planned measurement layout. Blue grid represents the magnetometry and EM acquisitions, yellow lines indicate the location of MASW profiles and the black dots represent HVSNR acquisitions. General aerial view from 2017, Institut National géographique et forestière (IGN), France.

2. Second geophysical survey

1.2 Survey coverage

The second survey is designed mainly to correlate with the information coming from the sampling survey, to offer a comparison with the previous collected data and to identify possible variations in time. Therefore, the geophysical acquisition covers the zone of cells 1 to 3 located north of the road where the boreholes and trenches were positioned.

2.2 Geophysical survey

The following geophysical methods will be applied (for method suitability description see T1.3.1 SWOT analysis):

- Electromagnetic survey (EM)
- Seismic methods: multichannel analysis of surface waves (MASW)
- Electrical resistivity tomography (ERT) and Induced polarization (IP)
- Capacitively-coupled resistivity

EM surveying

The EM survey will be composed of several lines oriented in the northwest-southeast direction (see Fig. 3). This first grid will be measured with the longest antenna of 4 m. This would allow to reach an approximate investigation depths of 2.5 m and 6 m. Afterwards, using the antennas of 2 m (depths of investigation of 1.2 and 3.0 m) and 4 m, two more grids will be located in the position of the trenches (Fig. 3) after the cover layer removal. Both, quadrature (apparent conductivity) and in-phase (related to apparent magnetic susceptibility) will be recorded simultaneously.

System planned to be used: DUALEM-2/-4 with GPS positioning (no RTK).

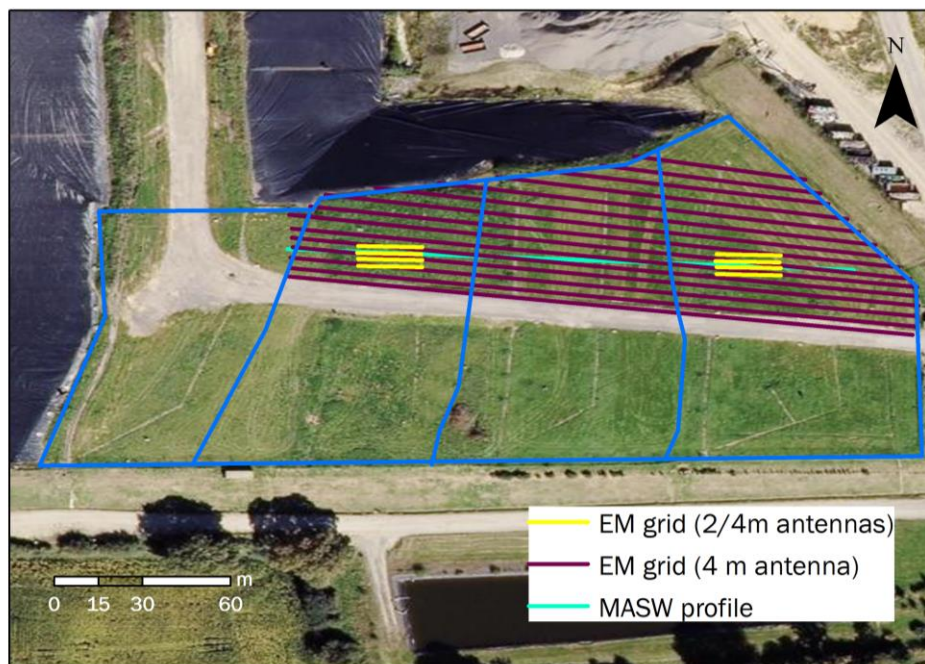


Figure 3: Planned measurement layout. Brown lines represent the EM acquisition grid with the 4 m antenna and the capacitively-coupled resistivity lines. The yellow lines represent the EM grid inside the excavated trenches. The green line indicates the position of the MASW acquisition line. General aerial view from 2018, Institut National géographique et forestière (IGN), France.

MASW

We plan to measure one seismic line oriented in the west-east direction, crossing both trenches (Figure 3). We will use a geophone spacing of 2 meters respectively, to try to get information from the bottom of the cells. By hitting a metallic or plastic plate with a sledgehammer and recording with vertical geophones, we can in theory record data for P- and S- wave refraction as well as MASW simultaneously.

System planned to be used: data will be acquired using a Geometrics Geode Seismograph, utilising a towed geophone streamer deployed from a wheelbarrow. The streamer will consist in 24 vertical geophones (4.5 Hz natural frequency), mounted on ground-coupled base plates and connected by woven Kevlar reinforced webbing.

ERT/IP

The ERT and IP acquisition will be deployed along several profiles inside of the two excavated trenches where the top geomembrane will be drilled (see Fig. 4). For each profile, we plan to deploy 32 electrodes with a spacing of 45 cm and use both gradient and dipole-dipole acquisition arrays.

System planned to be used: Resistivity Meter ABEM Terrameter LS

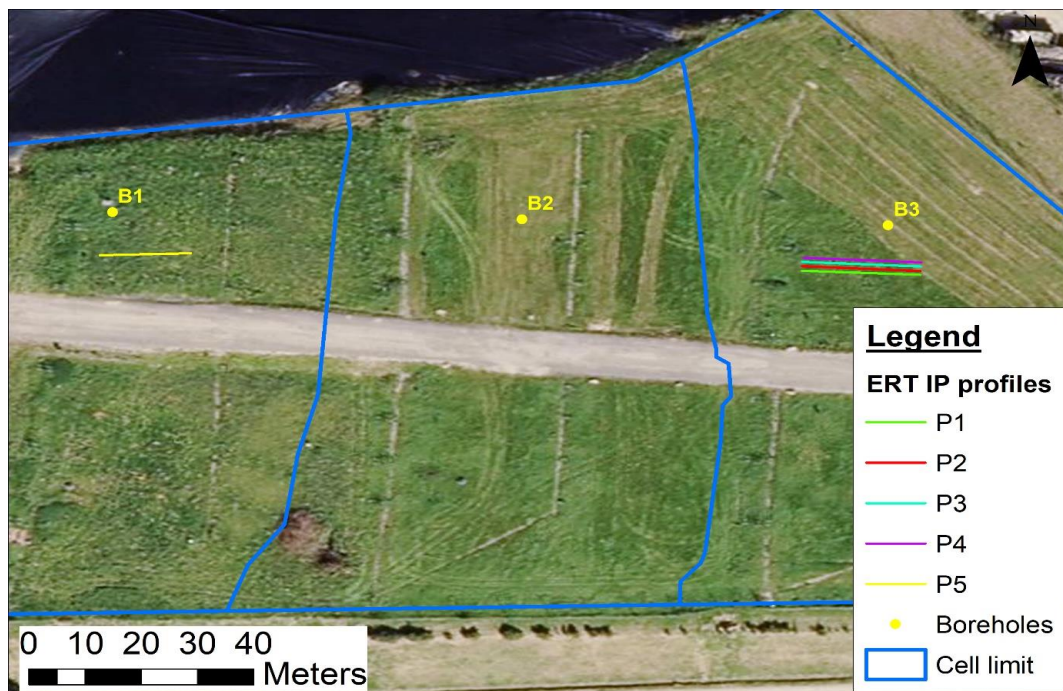


Figure 4: Planned ERT/IP acquisition lines inside the excavated trenches.

Capacitively-coupled resistivity

To test this method, we plan to use the Ohmmaper from Geometrics. The system is composed of one dipole transmitter and four receivers according to a dipole-dipole array type. The distance between the transmitter and receivers will be determined in the field after conducting several tests. The acquisition grid for this system will be the same as EM grid (north zone of the road from cells 1-3, see Fig. 3).

System to be used: Ohmmaper Resistivity Mapper from Geometrics

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