Use of 3D digital models for characterisation of a former landfill site and contamination assessment of a key groundwater resource

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INTRODUCTION

The site is an unlined 'dilute and disperse' landfill located directly onto a Principal Chalk aquifer. The Chalk is used for abstraction of drinking water in the area, with a Public Water Supply well (PWS) located 1.5km north east of the site. The site is proposed to be redeveloped for a large infrastructure project which will require remodelling of part of the landfill and piling through it into the underlying chalk. A key consideration for this project is protecting the underlying aquifer from contamination in the overlying landfill by avoiding the creation of pollution pathways during construction.

SITE SETTING

The groundwater regime in the area is complicated. The site is located at the head of a dry valley, and in the sides of the valley Clay-with-Flints deposits confine the Chalk. However, there are no Clay-with-Flints deposits in the base of the valley, which means that for a large area of the site the landfill sits directly on the Chalk.

A detailed desk study indicated that the landfill was filled from the 1940s to the 1980s, with the major periods of filling during the 1950s and 1970s. A detailed ground investigation was undertaken at the site (55 boreholes 39 window sample locations, 76 trial pits, and 76 dynamic probe locations). The landfill was found to contain up to 20m of waste at its thickest.

The Chalk is described as a dual-porosity aquifer, where the matrix provides the storage and the fractures provide permeable pathways. The groundwater is known to be influenced in the area by solution features in the chalk which can lead to interlinkages between groundwater catchments, making it difficult to predict potential flow paths of contaminants.

It is likely that the PWS 1.5km north east of the site is influencing the flow direction, making it more easterly than the anticipated south easterly regional flow direction towards the nearest designated main river located approximately 4.5km south east from the site boundary.

DEVELOPING THE MODEL

A 3-dimensional (3D) ground model of the area has been created by collating the following data sources:

- Photogrammetry data at 5m resolution;
- Topographical survey of the site;
- Historical aerial photographs;
- Historical maps; and
- Data from Ground Investigation (GI) undertaken at the site.

Figure 1 : Use of historic mapping to create a digital surface of the filling history of the landfill

USE OF THE INTERACTIVE 3D MODEL

Accurate characterisation of the waste through ground investigation and chemical testing is important in order to achieve a comprehensive assessment of the risk posed by the landfill to human health and controlled waters in the area. The 3D model has been used to great benefit in this process.

The different filling periods were modelled prior to the commencement of the GI, and used to target locations into different eras of the waste to enable a full characterisation of the landfill. The model has been used interactively during the GI to react to findings and to modify the GI design.

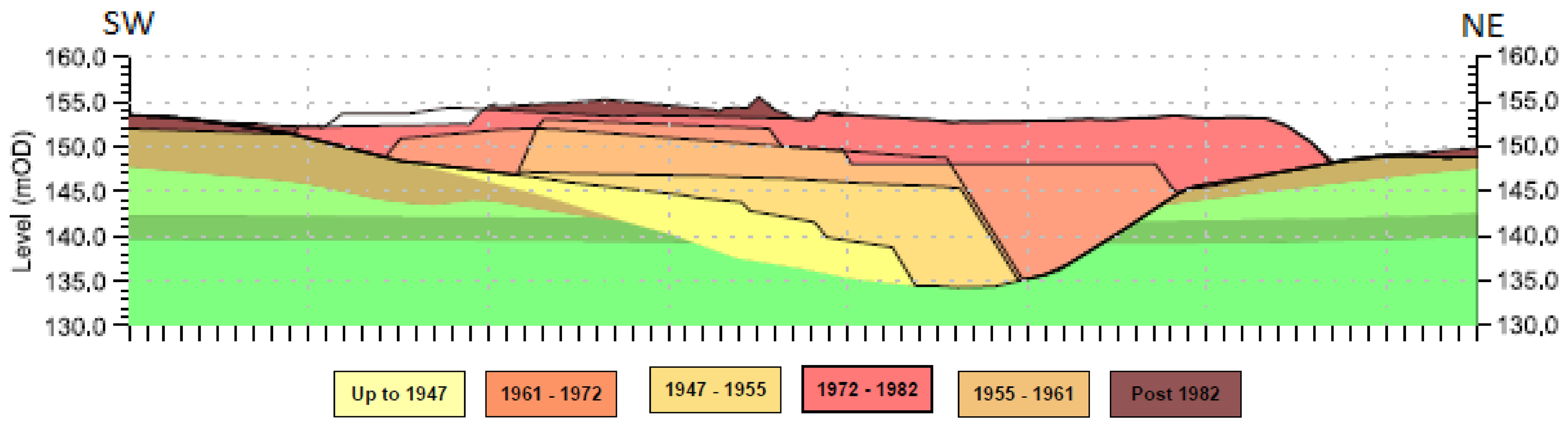

Figure 2 : Illustrating the thickness of the waste and the different eras of deposition.

(Scale: Horizontal = 1:5000, Vertical = 1:1000)

It is being used in real-time during the GI to plot the results of the on-site testing of the waste and other observations to inform decision making on-site and to allow targeting of the GI in a cost effective manner.

Data collected from packer testing and other in-situ tests has also been incorporated into the model to enable understanding of the groundwater flow within the chalk and interactions with the landfill.

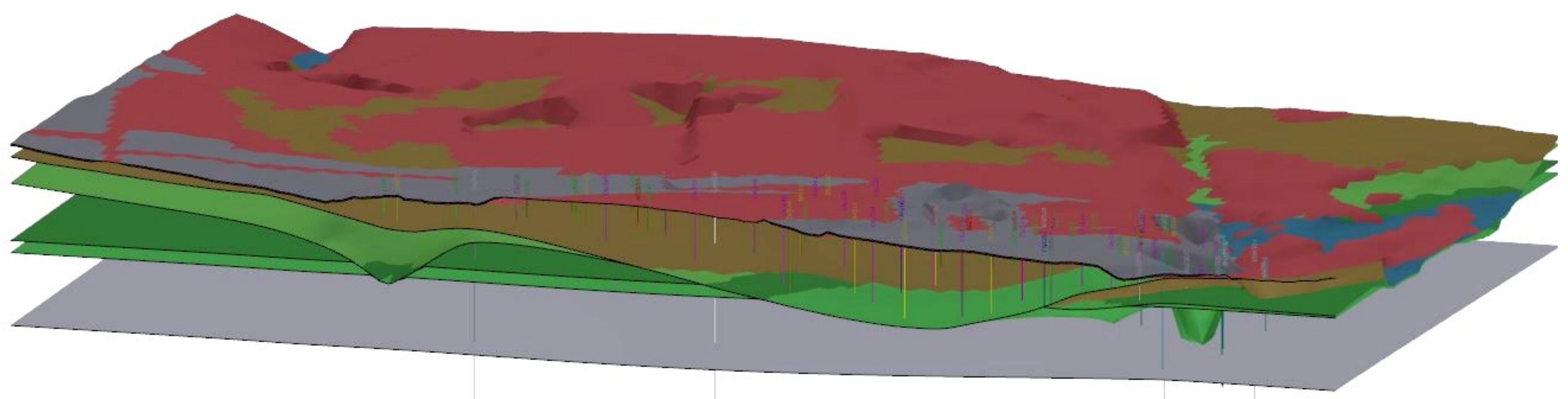

Figure 3a : 3D Ground model of the site.

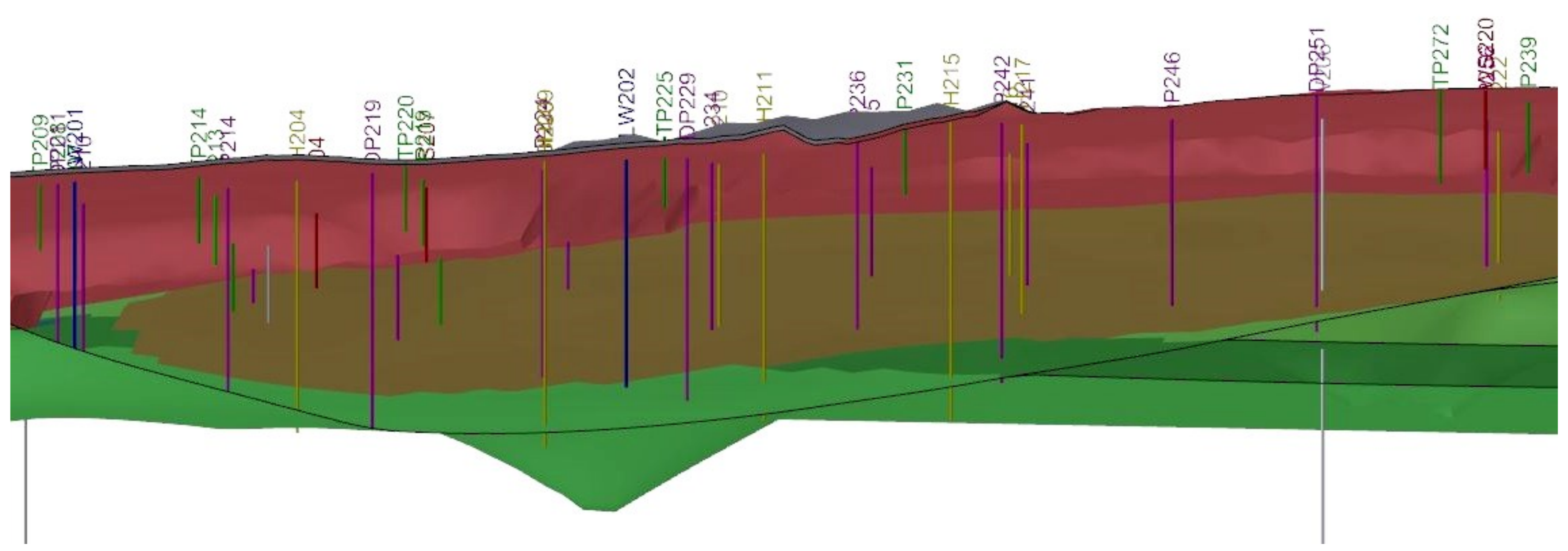

Figure 3b: Showing the borehole 'sticks' of GI information used to build the model

CHARACTERISATION AND ASSESSMENT OF THE LANDFILL

During the GI, it was observed that the waste types encountered are typical of the eras during which the landfill was made. iPad devices were used on site to check expected waste composition and depths of waste against the model. 'Forensic logging' of the waste was undertaken during the GI, in which detailed percentages and volumes of the waste types were recorded. Generally, the waste types encountered agreed with those predicted by the model.

Figure 4a: Example of industrial waste in the older landfill waste

Figure 4b: Example of more modern waste containing paper and plastic packaging material.

Figure 4c: Example of older ashy waste

The earliest parts of the tip contain ashy domestic wastes including brick and glass. In the later parts the waste contained more plastics and paper. Three boreholes in the older material were found to contain industrial waste. Layers of cover fill with varying amounts of chalk were observed throughout the landfill.

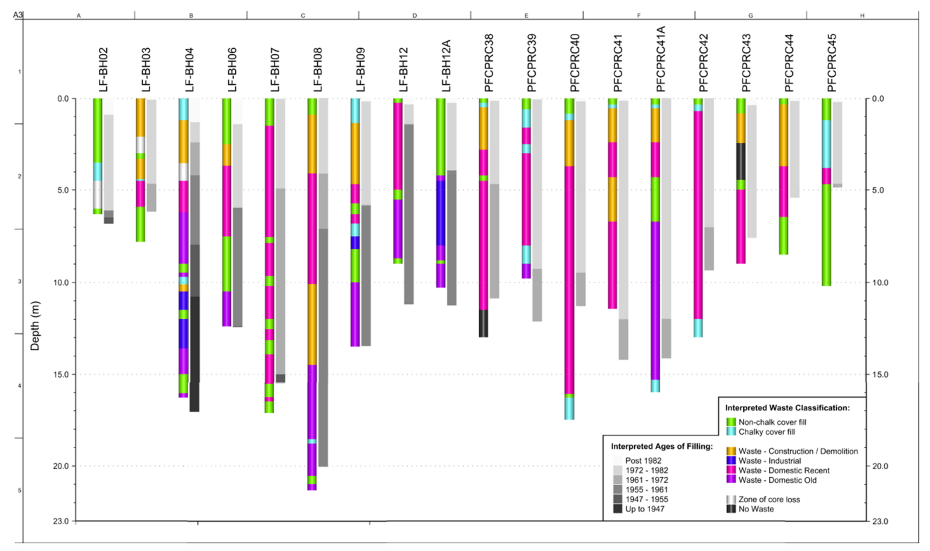

Figure 5: Graphical representation of waste ages encountered during the GI.

Boreholes were installed on and off-site, both down and up gradient of the landfill, to monitor the groundwater quality. The contaminant concentrations were plotted in the model to provide a visual representation of groundwater quality and to inform the assessment and the requirement for any further quality monitoring.

BENEFITS OF THE INTERACTIVE 3D MODEL

The use of the 3D interactive model enabled cost effective targeting of the ground investigation locations. The use of the model in real-time allows a holistic view of the contamination conditions compared to traditional techniques, and the following benefits:

- Provides a visual understanding of complex data;
- Time and cost effective – once modelled can be updated quickly;
- Can be used to provide real-time accurate information via a remote location: e.g iPads on site using data-driven model to locate GI;
- Is an accurate method of checking information – discrepancies that are often missed in numerical formats within spreadsheets are instantaneously visible in 3D for further interrogation and analysis;
- Can be used for both illustrative purposes as well as data analysis; and
- Accessible to all – developing technology is enabling sharing 3D models easier, removing the need for everyone to have specific software to view them.

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