Morphology and Quaternary geology of the Thames floodplain around Oxford

Groundwater Resources Programme

Open Report OR/08/030

BRITISH GEOLOGICAL SURVEY

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Morphology and Quaternary geology of the Thames floodplain around Oxford

A J Newell

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Map

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1 Introduction

This report provides a summary of work undertaken on the geology and morphology of the River Thames floodplain around Oxford in the 13 km reach between Cassington in the northwest and Sandford-on-Thames in the southeast (Figure 1). The major part of the work was constructing 3D models and thickness maps of the valley gravels and alluvium using ArcGIS in conjunction with the 3D visualisation packages GSI3D and GOCAD. This work requires consideration of the available digital terrain models and how man-made features contribute toward the present-day floodplain topography. Surfaces were also constructed for areas of flooding based on their mapped extents from aerial photography. This allowed the interaction between terrain and flooding to be visualised in three dimensions.

2 General floodplain morphology

2.1 ELEVATION

Elevation data for the Thames floodplain between Cassington and Sandford-on-Thames were available as NEXTMap and LIDAR digital elevation models. Each elevation model was available in two forms, (1) a digital surface model (DSM) which includes all buildings and vegetation and (2) a digital terrain model (DTM) in which an attempt is made to filter these features and generate what is commonly termed a bare-earth model.

Filtering of digital elevation models to produce bare-earth models does not remove larger areas of made-ground or the general build-up associated with urbanisation of the floodplain surface. This can create errors when producing thickness maps of underlying natural deposits. Further filtering of the terrain model was therefore undertaken by manually-selected points which were considered likely to represent the original floodplain surface (Figure 2). These points were triangulated into a surface using GOCAD and this natural floodplain terrain model (NFTM) was used to derive thickness maps of alluvium and terrace gravel deposits.

The elevation of the Thames floodplain falls from 59.5 mOD near Cassington [445908 209784] to 52.86 mOD at Sandford Lock [453226 200914] at approximately 1 m every 1700 m (Figure 3). The floodplain surface has an extremely low gradient of less than 0.1 degrees but locally contains shallow channels and raised interfluves (e.g. between the Thames and Seacourt Stream) which can influence the distribution of flooding (Figure 4, 18).

There is significant man-made build-up of the Thames floodplain around Oxford. Urban areas generally contribute 1-2 m of additional elevation while road embankments may contribute up to 5 m of elevation (Figure 4). At Cassington the floodplain elevation has been reduced by gravel extraction (Figure 6).

2.2 WIDTH

The Thames floodplain ranges from 413 m to 2175 m in width (Figure 7). The widest area of the floodplain occurs after the abrupt 90 degree bend in the course of the Thames at King’s Weir, north of Wolvercote. The Thames splits into an anastomosing, multichannel river across the wide part of the floodplain, which is underlain by erodible Oxford Clay bedrock. Just south of New Hinksey, the Thames cuts through resistant Corallian limestones and sandstones (Figure 8). The floodplain narrows to around 500 m and the Thames reunites into a single-channel river.

3 Terrace gravels and alluvium

The River Thames and its tributaries have been draining the Cotswold dip-slope and flowing past the present Oxford area for over 1.8 million years. During this time the climate has fluctuated from temperate to arctic producing much variation in river systems and associated deposits. Owing to the regional uplift of southern England and long-term river incision, the river deposits are now preserved as a staircase of terraces at up to 30 m above the present river level (Sandford, 1924). The oldest deposits occur at the highest elevation.

The two lowest and youngest terraces (Summertown-Radley and Northmoor) are the most likely to influence flooding around Oxford. The Northmoor terrace is overlain by alluvium deposited by the Thames during the Holocene (Figure 9). Thickness models for the gravels were constructed by building cross sections from boreholes using GSI3D and then triangulating the points in GOCAD to produce surfaces and solid models (Figure 10**)**.

3.1 SUMMERTOWN-RADLEY TERRACE

The base of the Summertown-Radley terrace lies at an elevation of approximately 3-7 m above the present floodplain and was deposited during the latest Anglian Glaciation (125 ka). The terrace is composed of interbedded gravels, sands and silts and ranges up to 6 m thick. The terrace has been dissected and eroded by younger fluvial incision and mass wasting and it now remains only as a few isolated patches, the largest of which underlies north Oxford (Figure 11). The base of the terrace gravel is generally not flat but slopes toward the modern floodplain. Springs often mark the contact between the gravels and the Oxford Clay.

3.2 NORTHMOOR TERRACE

Northmoor Terrace gravels underlie the modern floodplain and were deposited by Late Devensian rivers which incised approximately 10 m below the base of the Summertown-Radley Terrace (Figure 12). The depth of incision was of sufficient magnitude to limit connection between the Northmoor and Summertown-Radley gravels which are often separated by a step of Oxford Clay bedrock. Locally, however, the two terrace gravels are in connection, for example, in Oxford city centre (Figure 11).

The Northmoor gravels generally form a relatively uniform sheet underlying the modern floodplain. The gravels are typically 2 to 4 m thick over much of the area from Cassington to Sandford-on-Thames (Figure 13). Thicker areas of gravel up to 8 m underlie the Hinksey Stream to the west of Grandpont and south of New Botley. The gravels also thicken (4 to 8 m) in the Wytham, Wolvercote and northern Port Meadow area. To the north of the Thames near Cassington, a linear, sinuous zone of thicker gravels (4-6 m) may represent an incised channel.

The gravels are composed predominantly of Jurassic limestones with the remaining 10-15 percent including ironstone, quartz, flint, sandstone and quartzite. Information on the grain-size distribution of the Northmoor terrace can be found in BGS Mineral Assessments Reports 28 (Harries, 1977) and 38 (Corser and Hopson, 1978). Sand constitutes 30-50 per cent of the deposit and silt or clay 10-15 percent. There is no evidence for a systematic change in grain size across the Oxford area, although there appears to be a high silt content to the east of New Hinksey (Figure 14).

Detailed descriptions of the Northmoor gravel at Cassington gravel pits (Maddy et al., 1998) show that it is not a homogeneous deposit but is vertically stratified into temperate and cold climate fluvial facies (Figure 15). The temperate fluvial deposits at the base comprise gravels and laterally persistent units of laminated sands and organic-rich silts and clays. They can be up to 1 m thick and probably represent overbank flood deposits and the fine-grained infills of floodplain pools. The bulk of the Northmoor terrace is composed of coarse gravel arranged in laterally continuous sub-horizontal gravel sheets. Multiple shallow channel fills and coarse gravels suggests deposition in braided glacial outwash channels of the type shown in Figure 12. Ice-wedge casts support deposition under arctic climate conditions.

3.3 ALLUVIUM

The Northmoor Terrace is overlain and largely occluded by a cover of alluvium deposited by the Thames and associated streams under temperate climatic conditions during the Holocene. Alluvium is mostly a fine-grained deposit of dark silt, or silty clay with thin beds of peat and lenses of gravel and sand. Calcareous molluscan remains are locally common. Over most of the Thames floodplain, alluvium forms a relatively uniform blanket around 1 m in thickness (Figure 16). In some areas (e.g. on Port Meadow) it thins to a few decimetres thick. Many of these areas are shown as uncovered windows into the underlying Northmoor Gravel on the 1:50 000 scale geological map (Figure 9). Exceptionally, up to 4 m of alluvium can be present, for example, at the confluence of the Cherwell and the Thames and in the area to the east of Grandpont. Trenches in the Oxford area show that in urban areas the alluvium becomes intimately associated and interbedded with man-made structures and deposits.

4 Flood visualisation

The terrain models constructed for this work can be used to visualise areas of overbank flooding in three dimensions. The basic method is to attribute the polygons which delimit the areas of flooding with an elevation value and then construct surfaces in GOCAD using the polygons. In practise, the elevations of the polygonal flood limits show considerable vertical scatter and a median elevation usually needs to be taken. The method can nonetheless be used to demonstrate how man-made features such as road/road embankments, landfills and general urban build-up influences the distribution of flooding (Figures 17 and 18)). These man-made features can be converted in triangulated solid-objects for the purposes of volume calculation (Figure 19).

Glossary

ArcGIS: ESRI's geographic informations system (GIS)
http://www.esri.com/software/arcgis/about/desktop_gis.html

GOCAD: Advanced 3D visualisation software widely used in the oil industry and earth sciences
http://www.earthdecision.com/

GSI3D: GSI3D utilizes a digital terrain model, surface geological linework and downhole borehole data to enable the geologist to construct cross sections by correlating boreholes and the outcrops to produce a geological fence diagram http://en.wikipedia.org/wiki/GSI3D.

LIDAR: Light Detection and Ranging (LIDAR) is an airborne mapping technique which uses a laser to measure the distance between the aircraft and the ground surface
http://www.environment-agency.gov.uk/science/monitoring/131047/

NEXTMap: A terrain model with 5 m resolution and complete England, Scotland and Wales coverage generated by airborne Interferometric Synthetic Aperture Radar (IFSAR) http://www.intermap.com/right.php/pid/4/sid/328

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British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact libuser@bgs.ac.uk for details). The library catalogue is available at: http://geolib.bgs.ac.uk.

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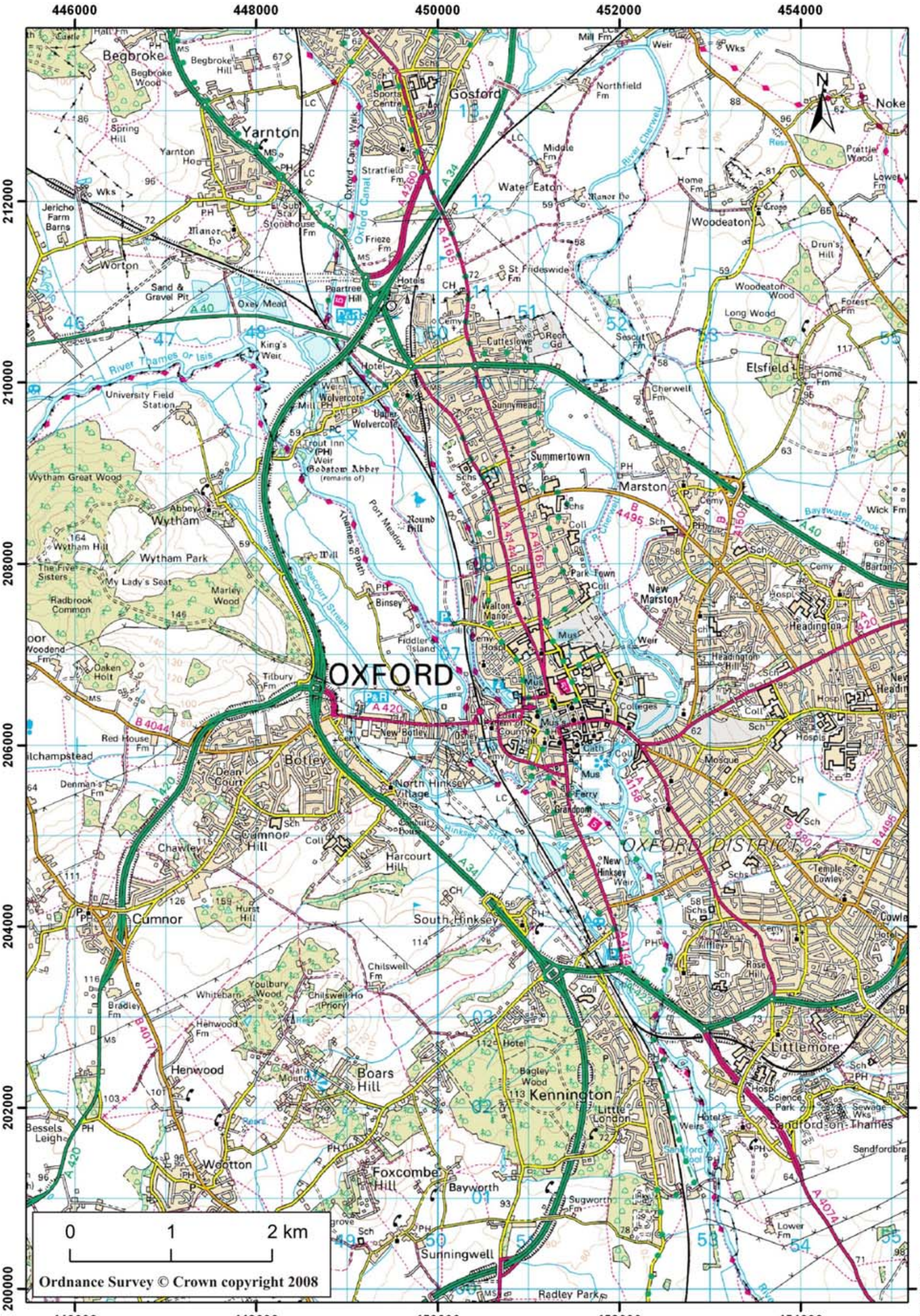
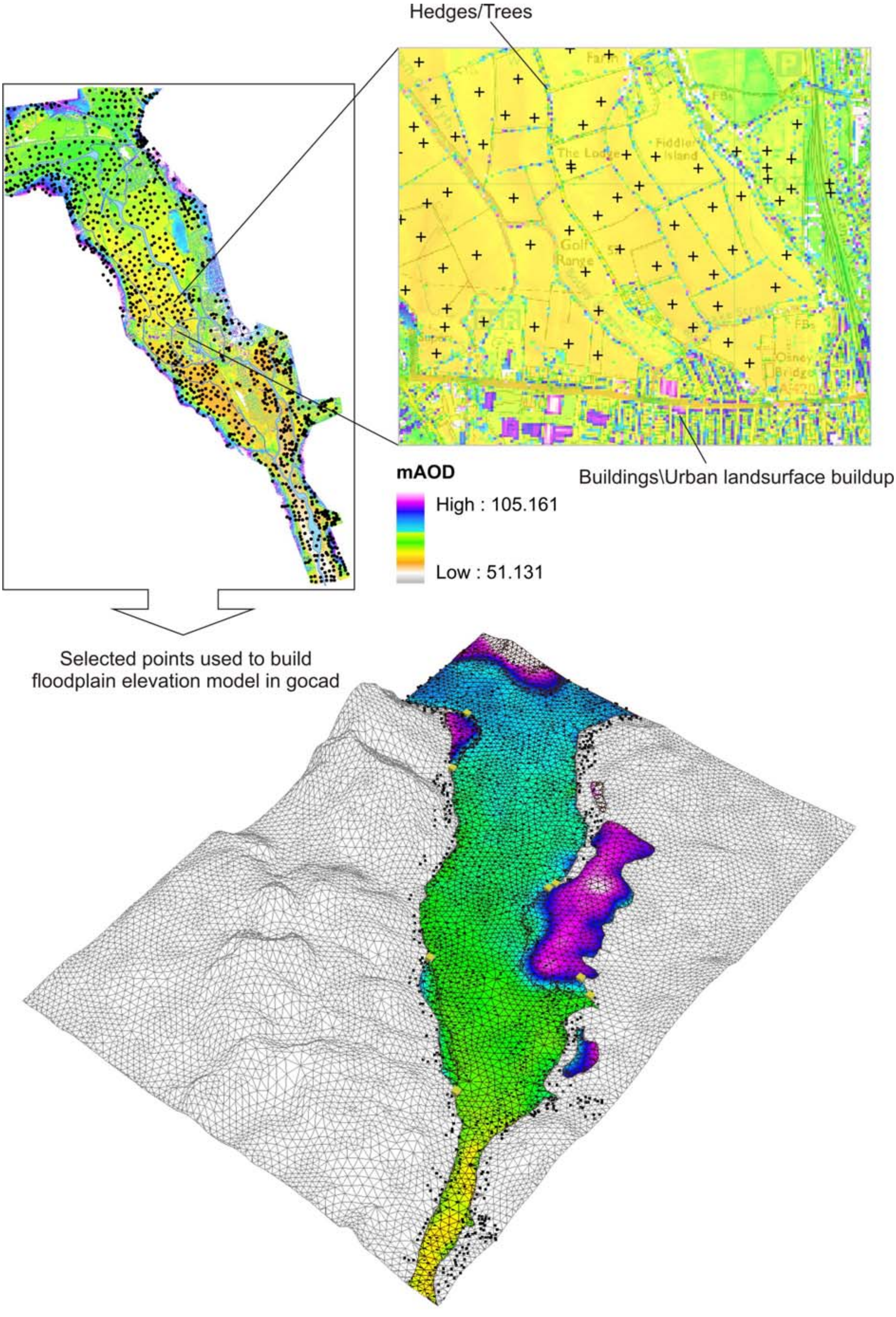


Figure 1. Location map



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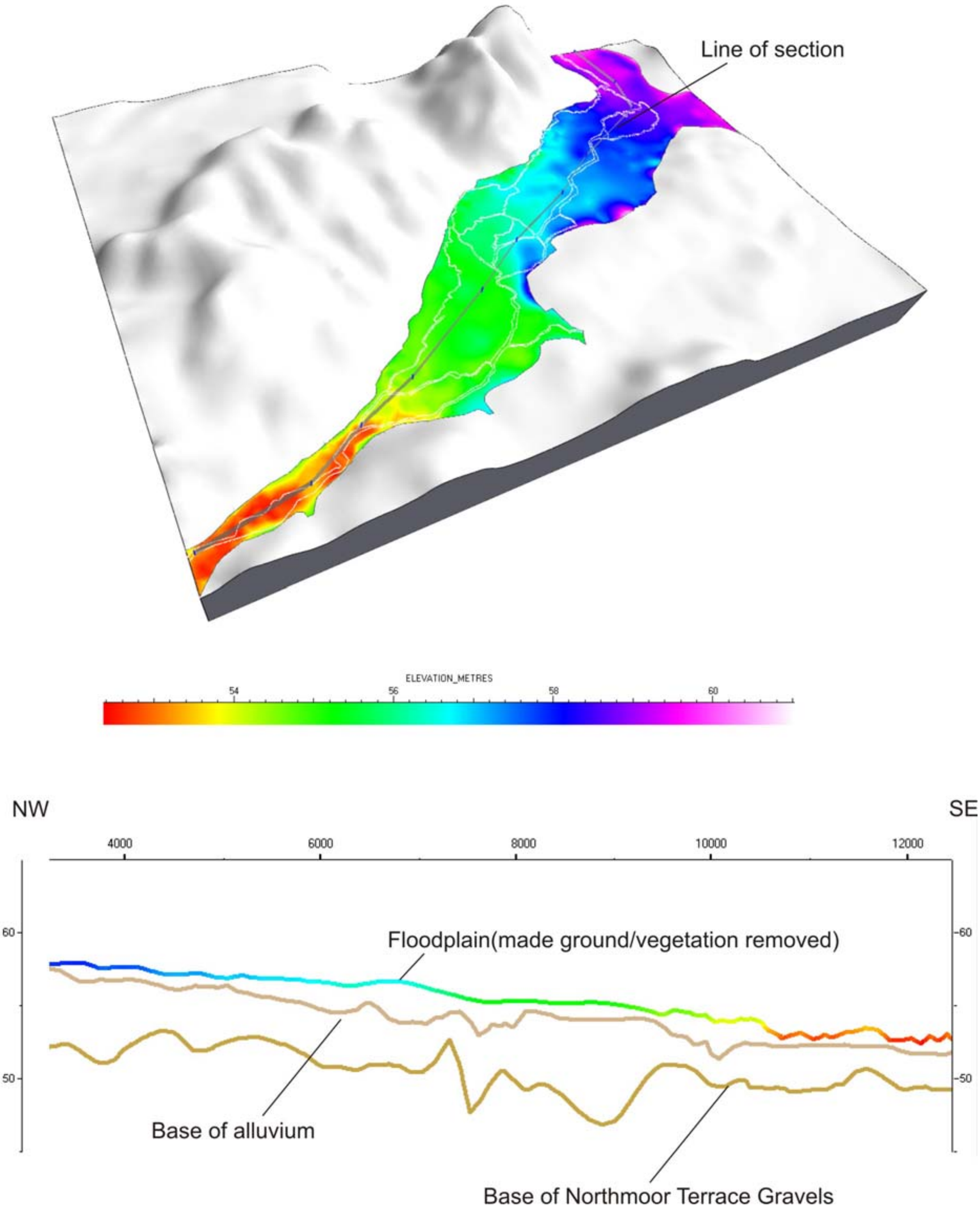

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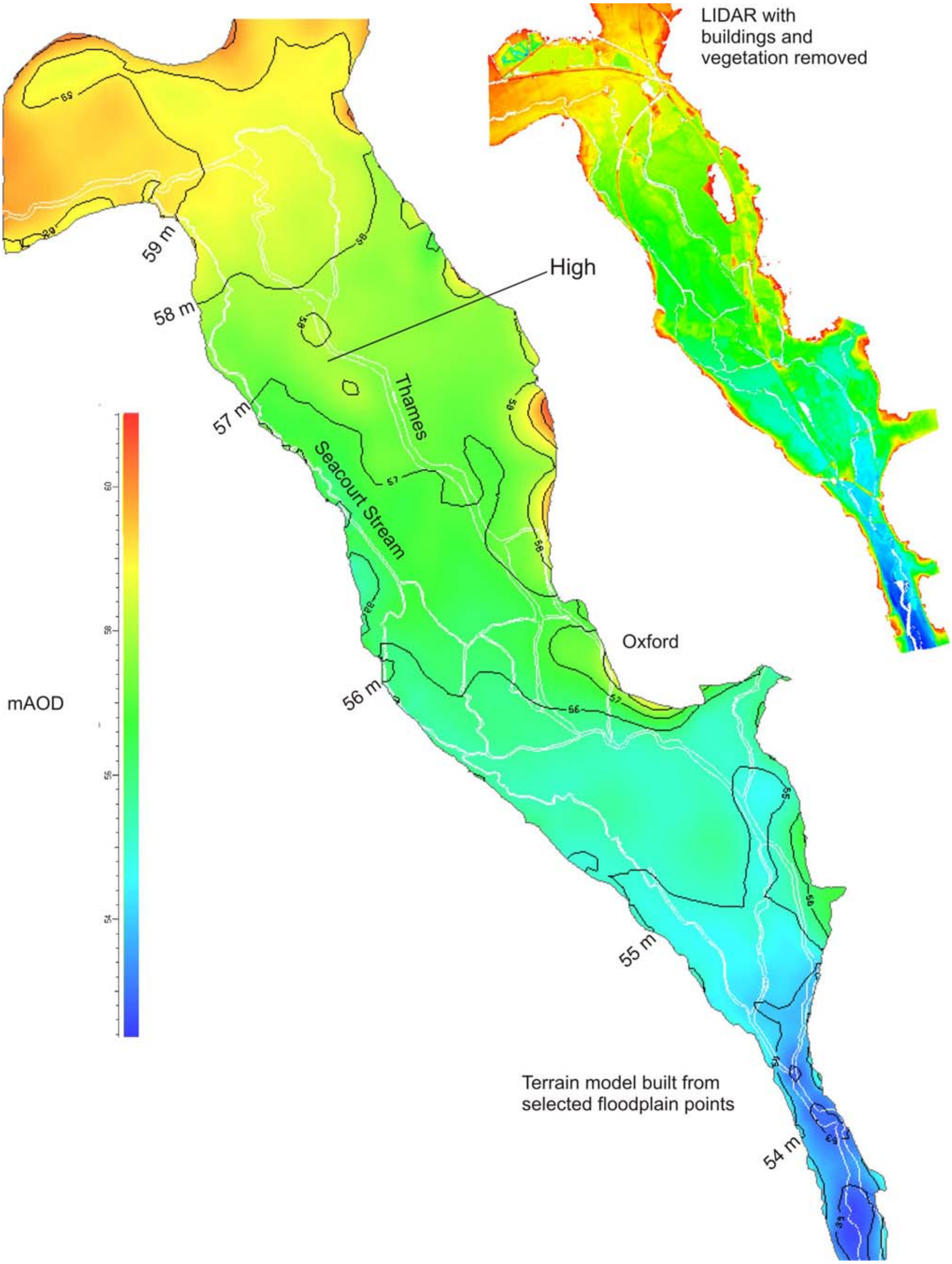
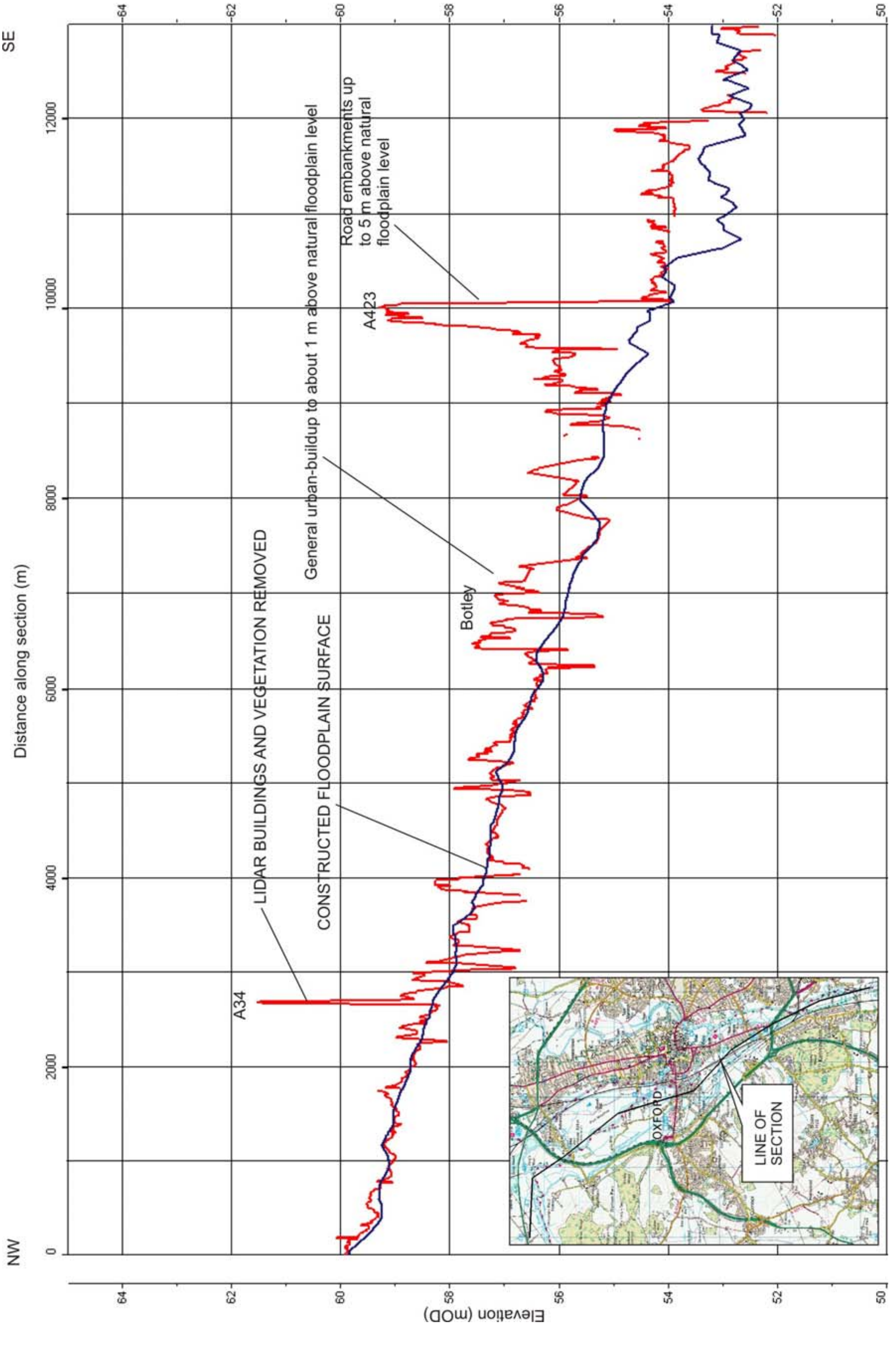


Figure 4. Natural floodplain terrain model (centre image) compared with the LIDAR bare earth model (top right).



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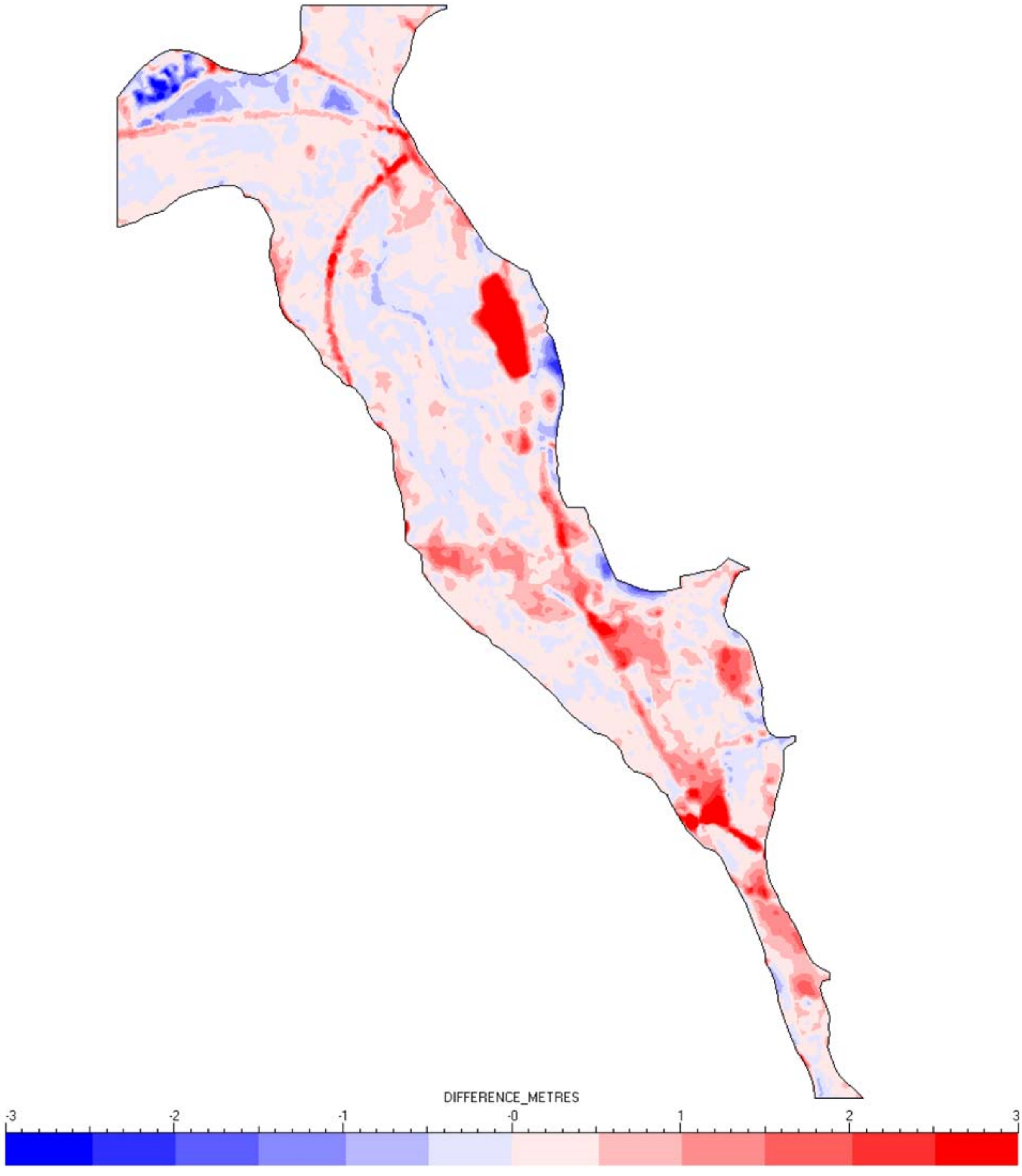

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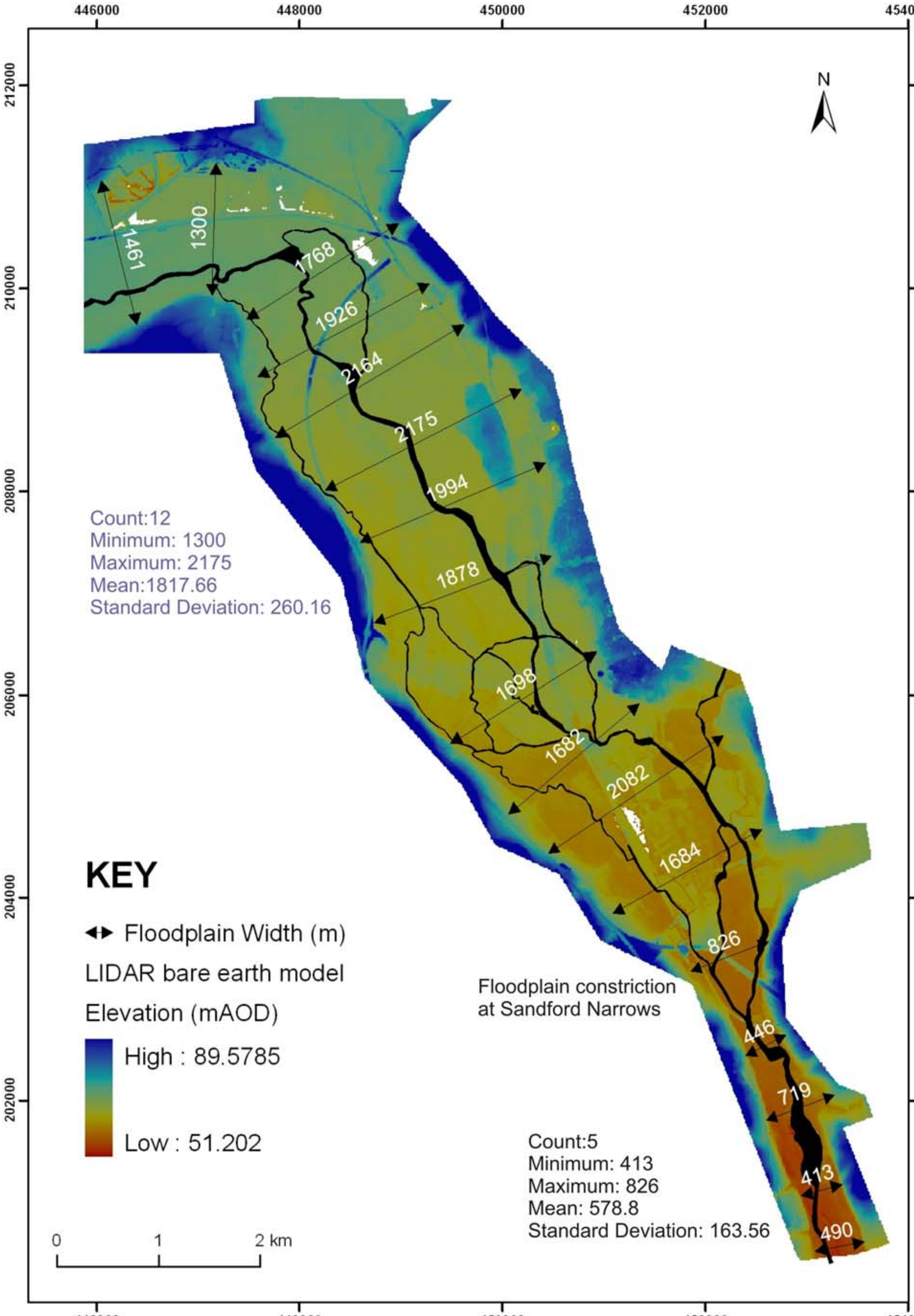

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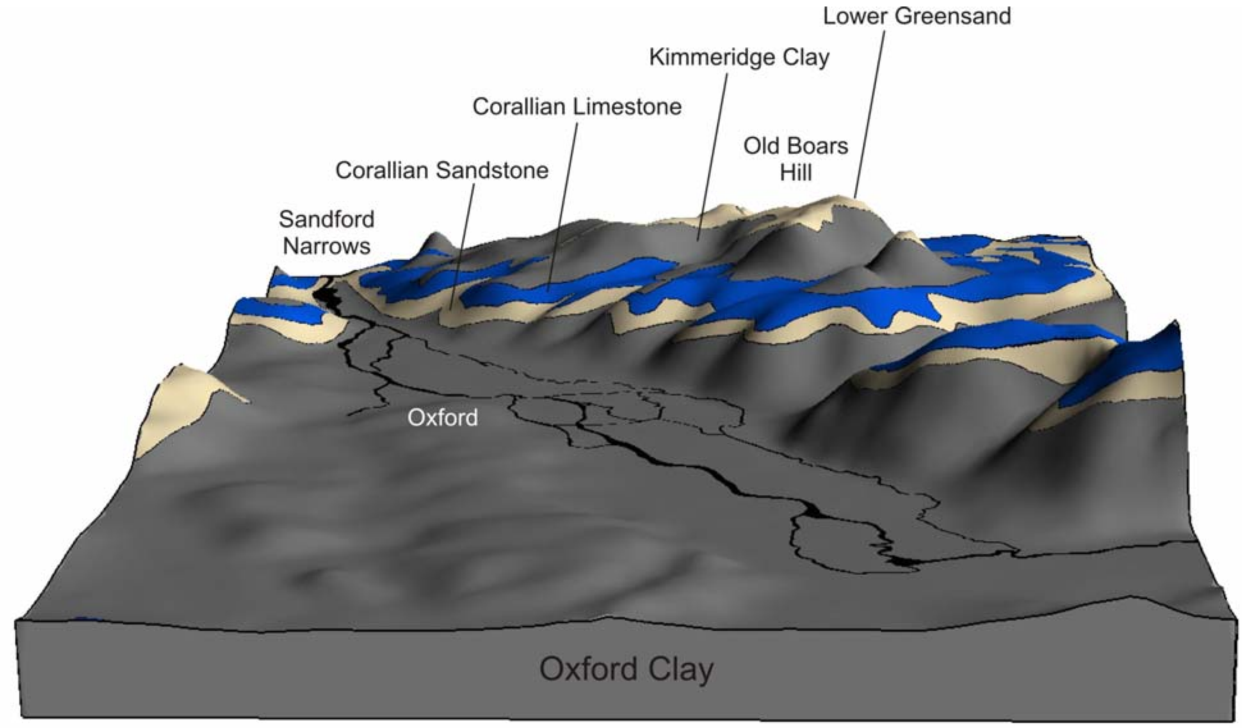
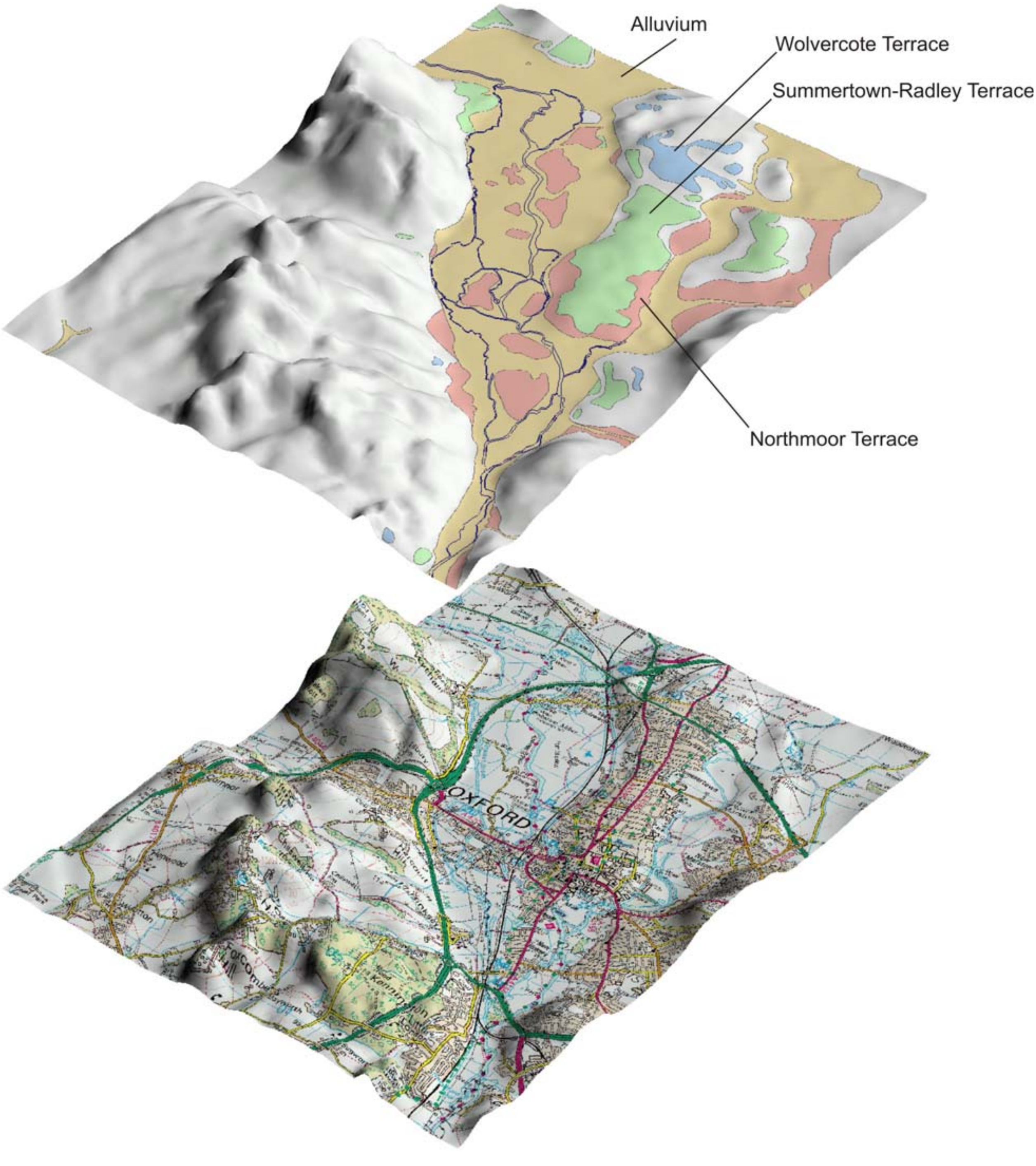


Figure 8 Solid geology of the Oxford area showing how the abrupt narrowing of the Thames floodplain is related to location where the Thames crosses resistent Corallian limestones and sandstones. The wide floodplain and anastomosing river pattern is underlain by erodible Oxford Clay.



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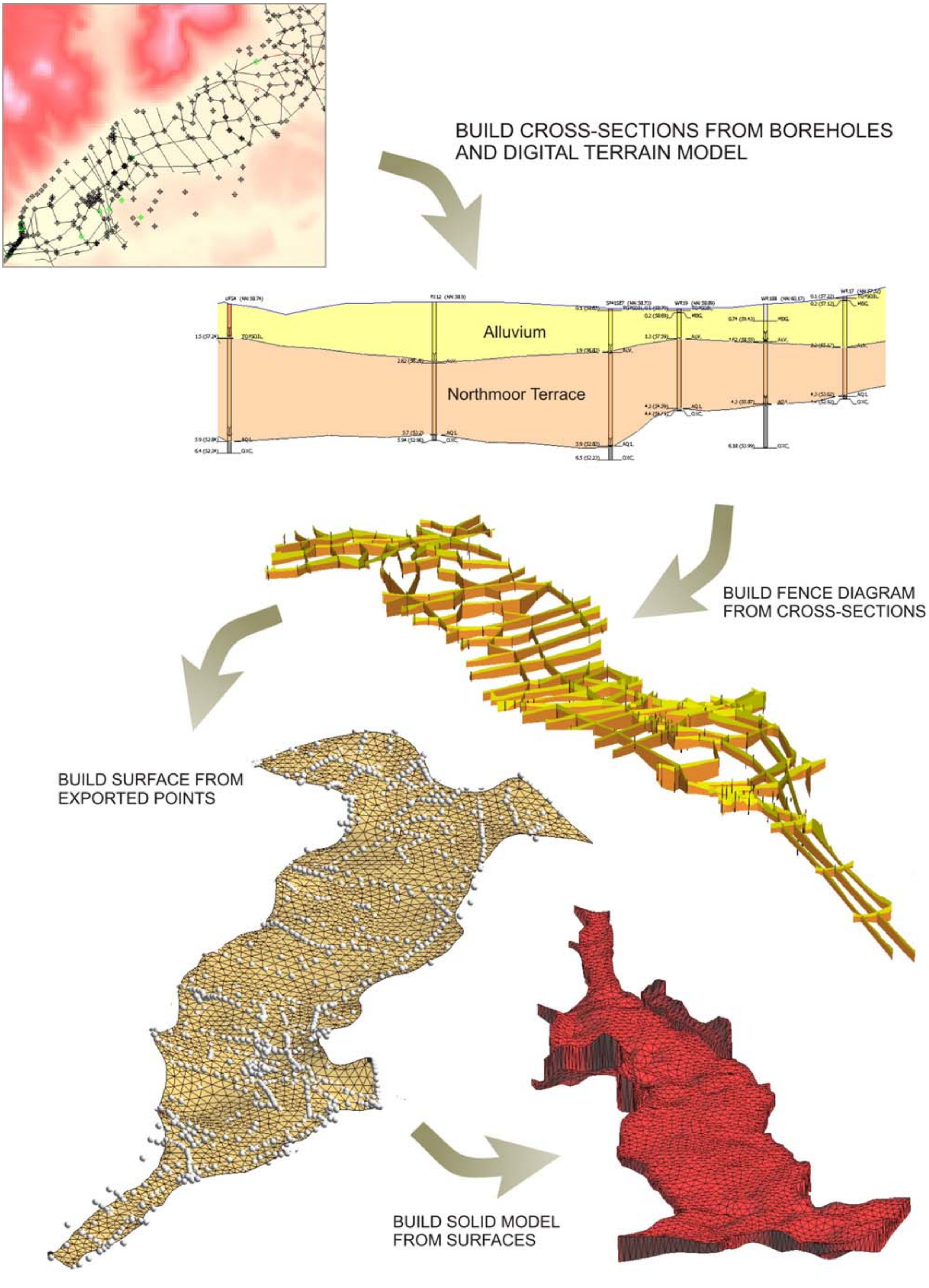


Figure 10. Workflow for building geological models using GSI3D and GOCAD

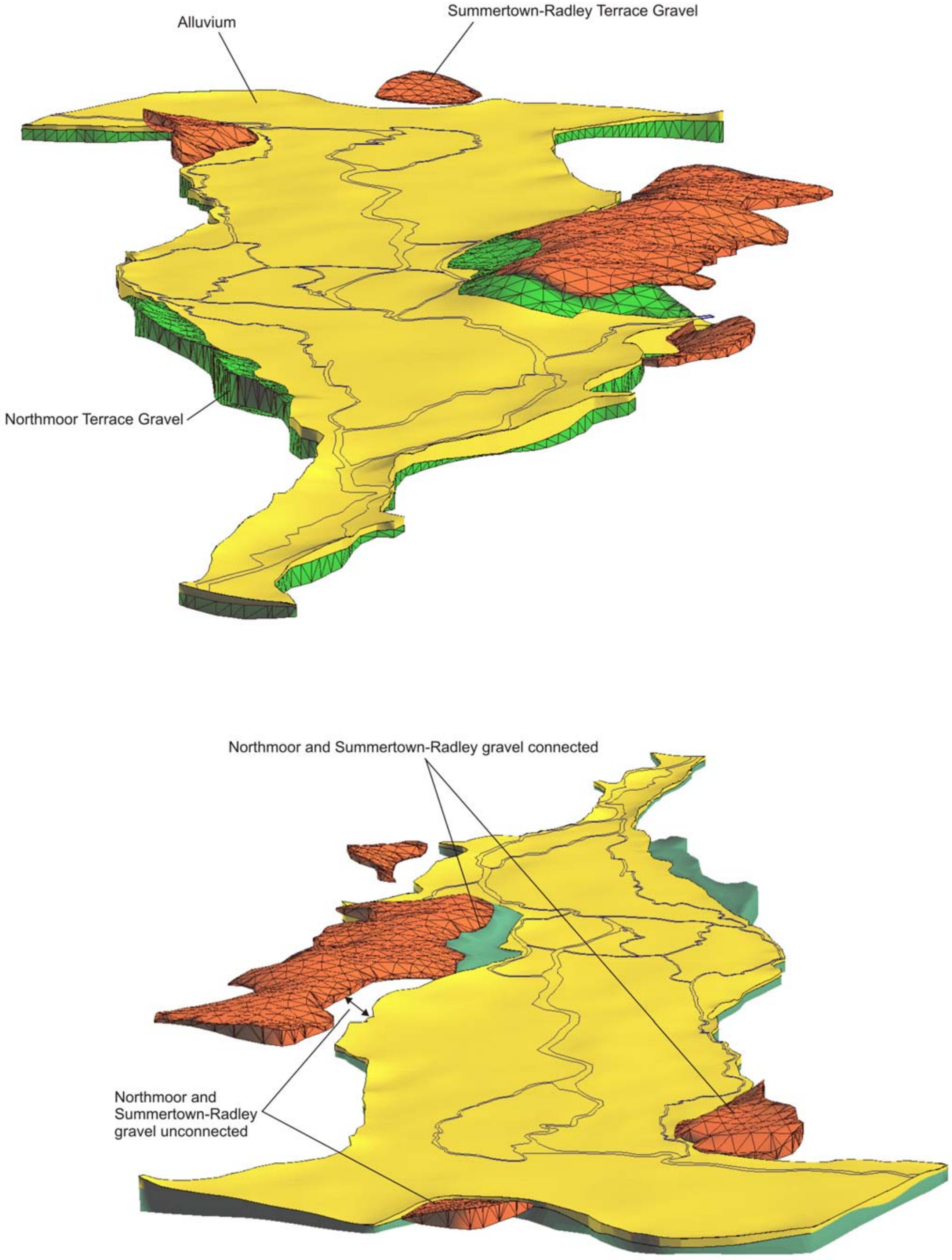
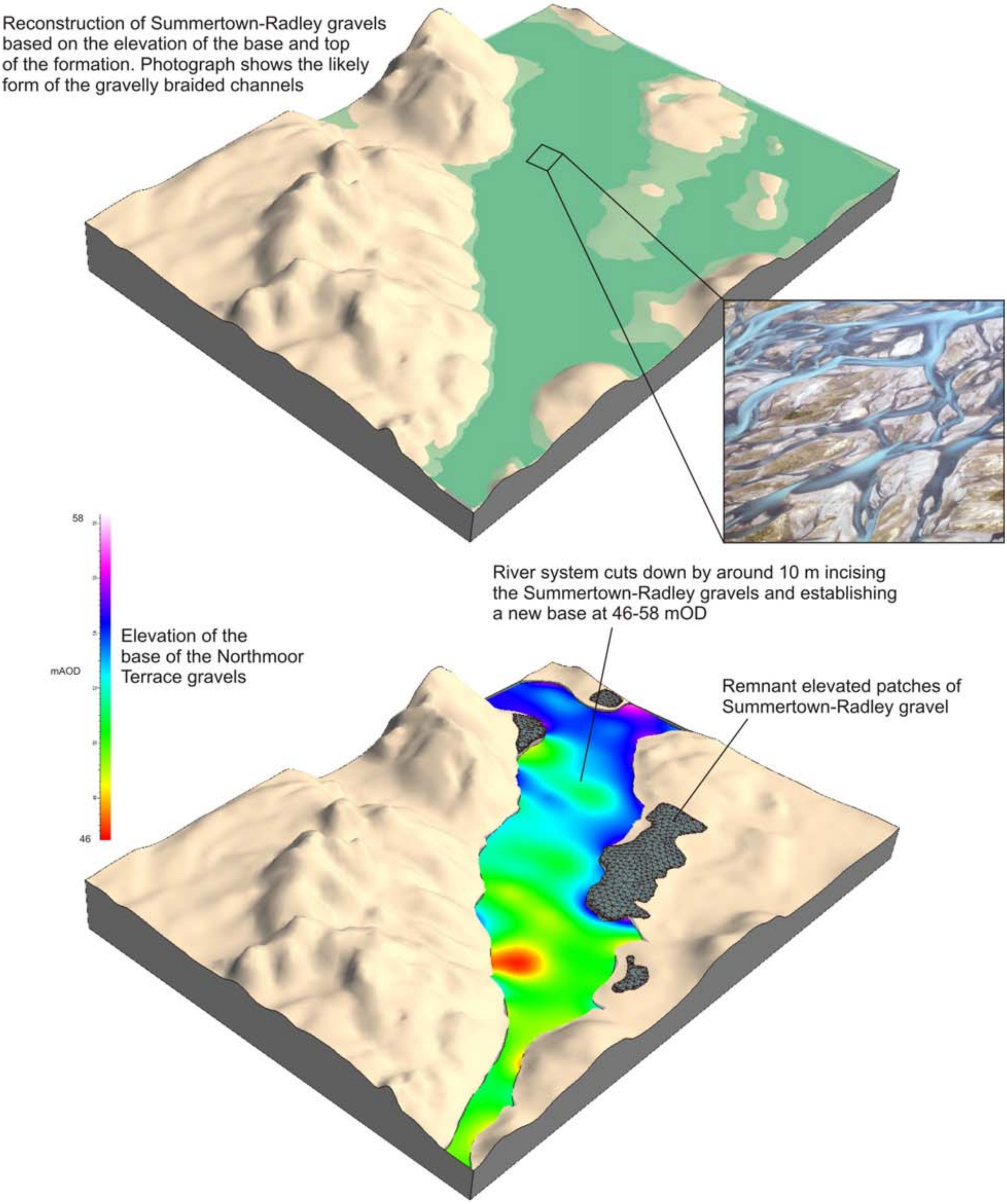


Figure 11 Views north (top) and south (below) over the main superficial deposits in the Oxford area



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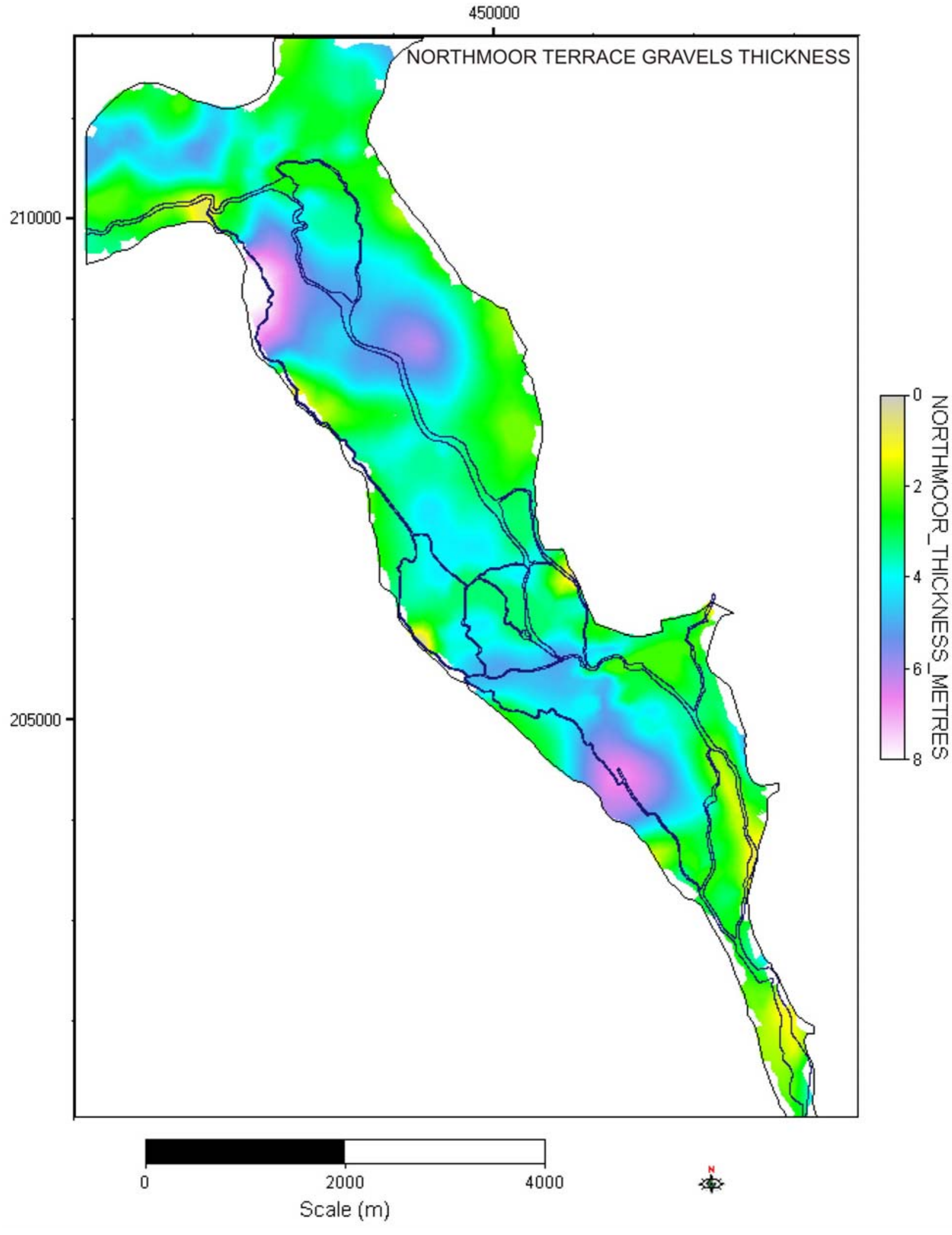


Figure 13 Thickness of the Northmoor Terrace gravel

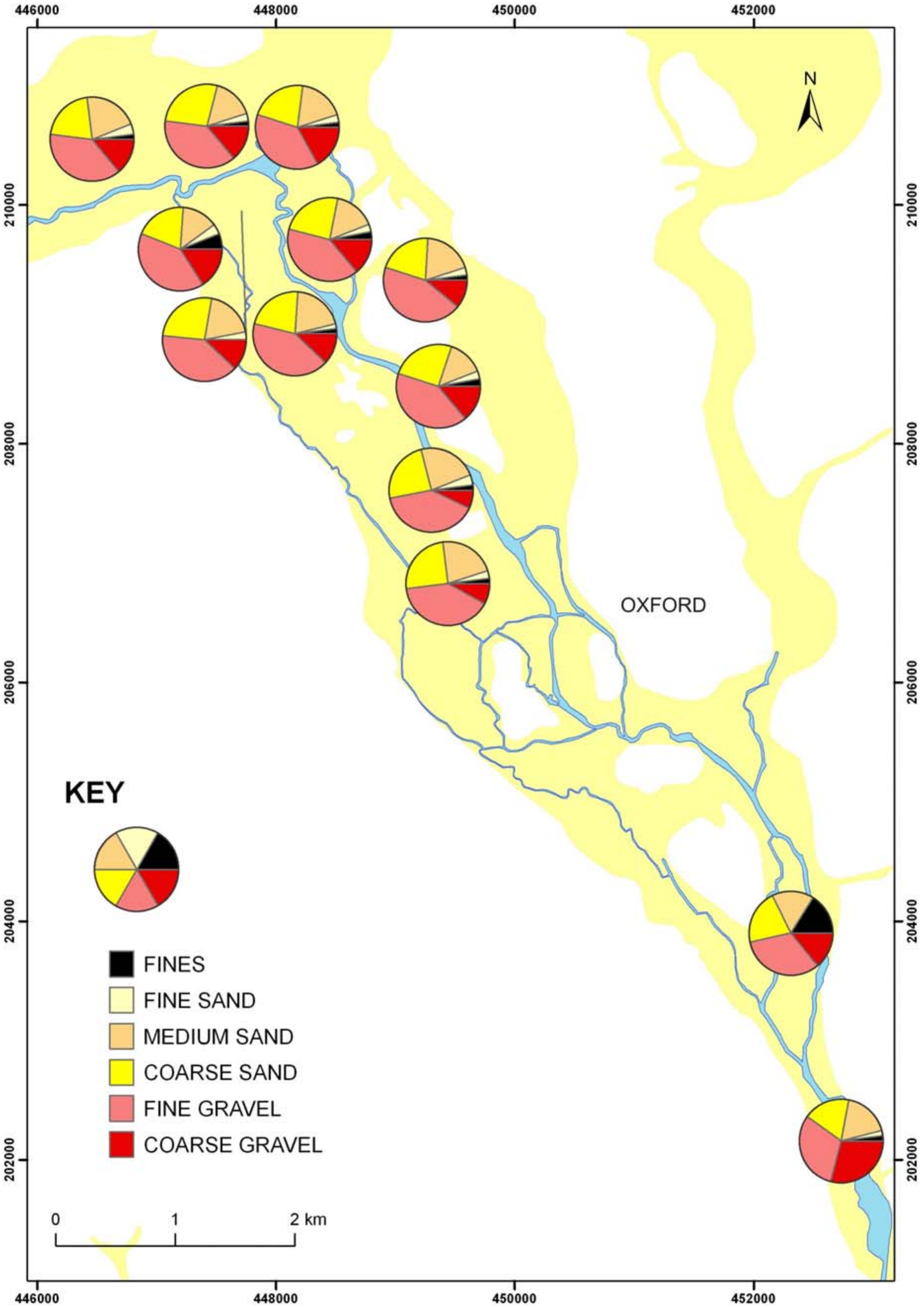
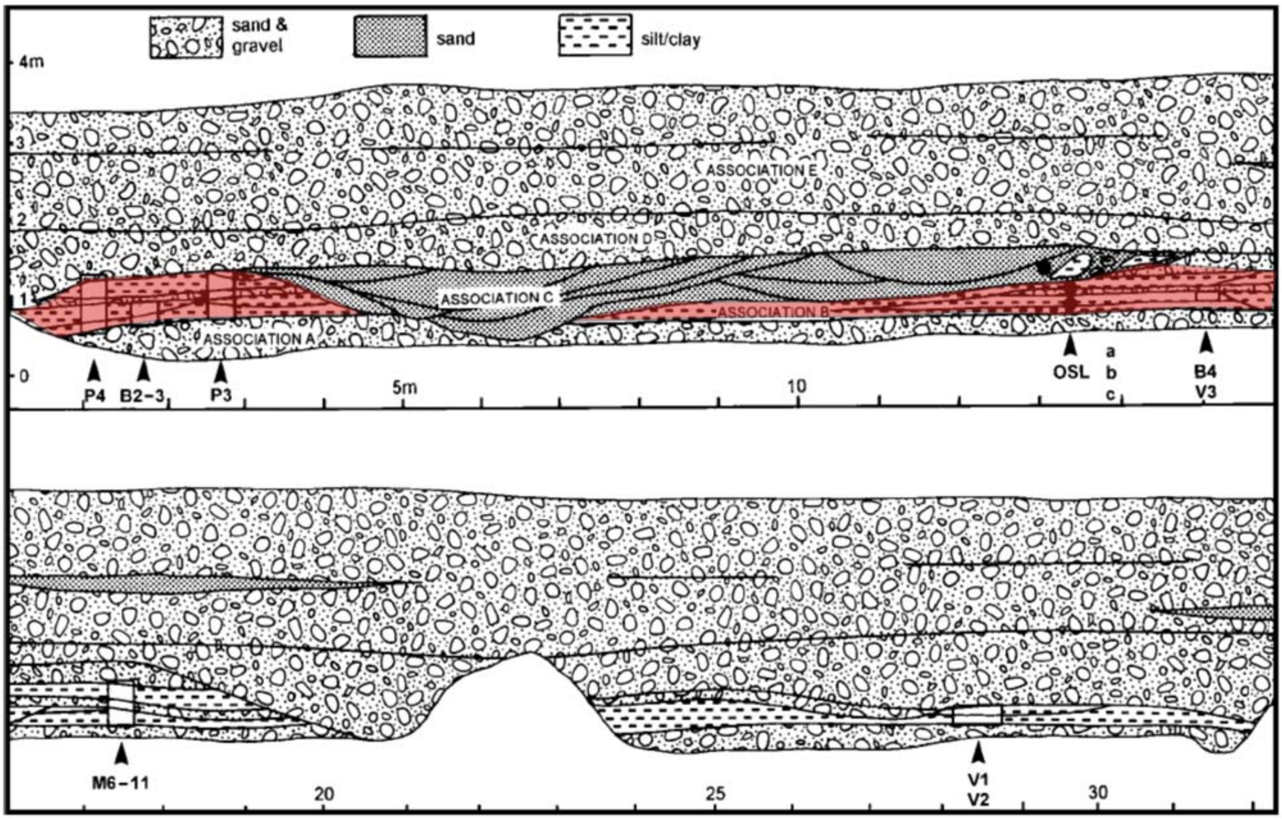


Figure 14. Mean gradings percentage for the Northmoor Terrace gravel derived from BGS Mineral Assessment Reports 38 and 28



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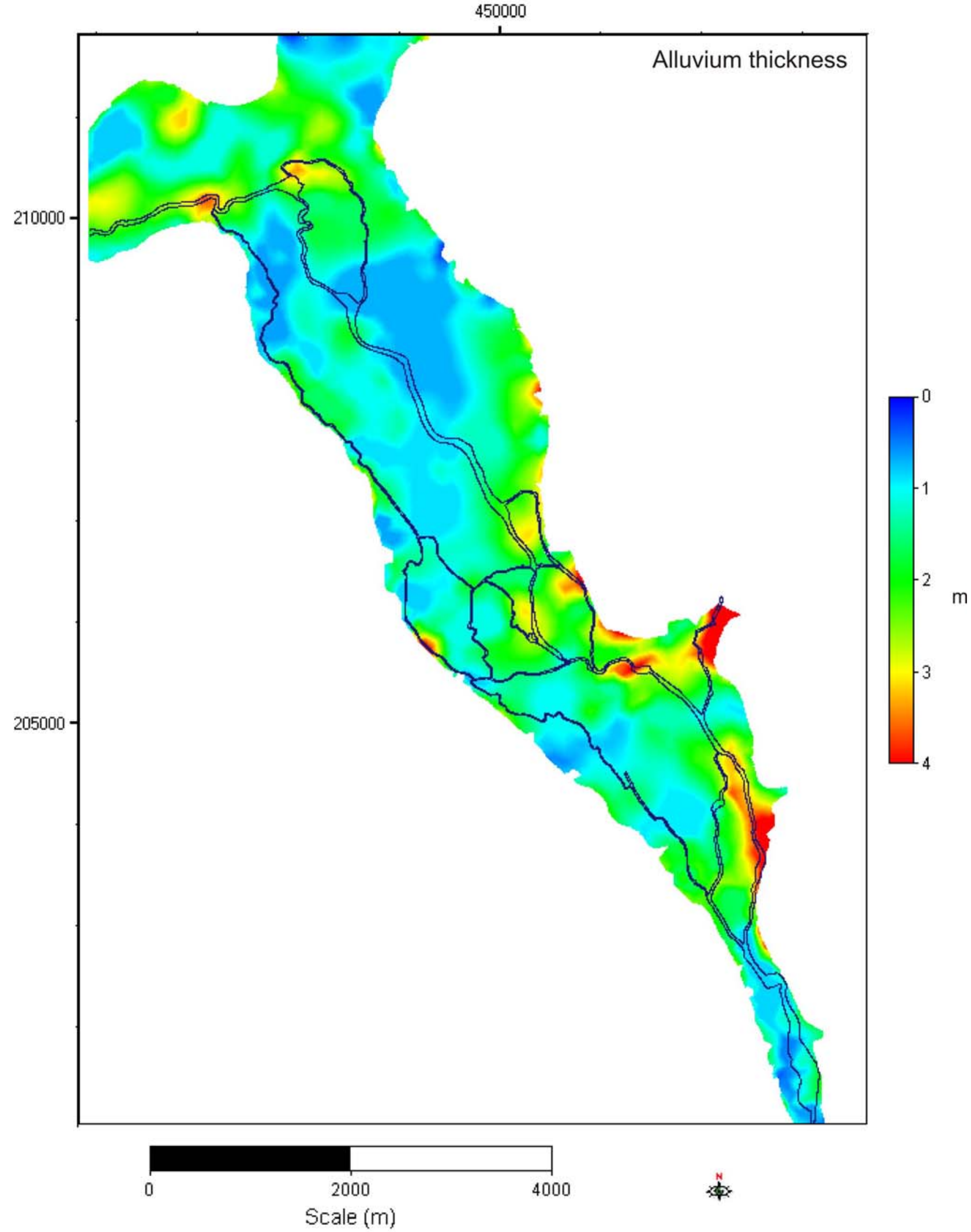


Figure 16 Thickness of alluvium in the Oxford area

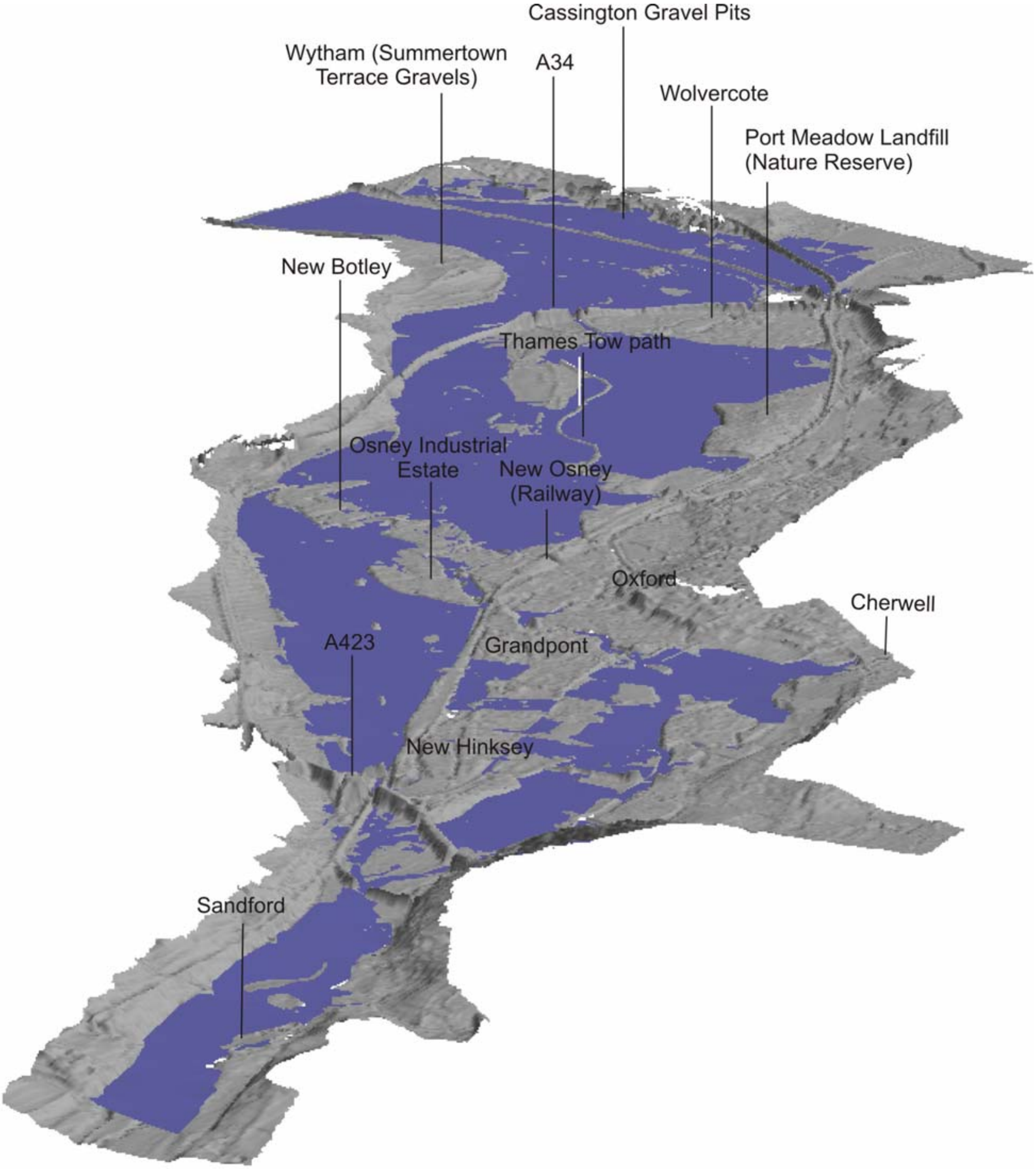


Figure 17. Summer 2007 flood levels plotted on LIDAR terrain model

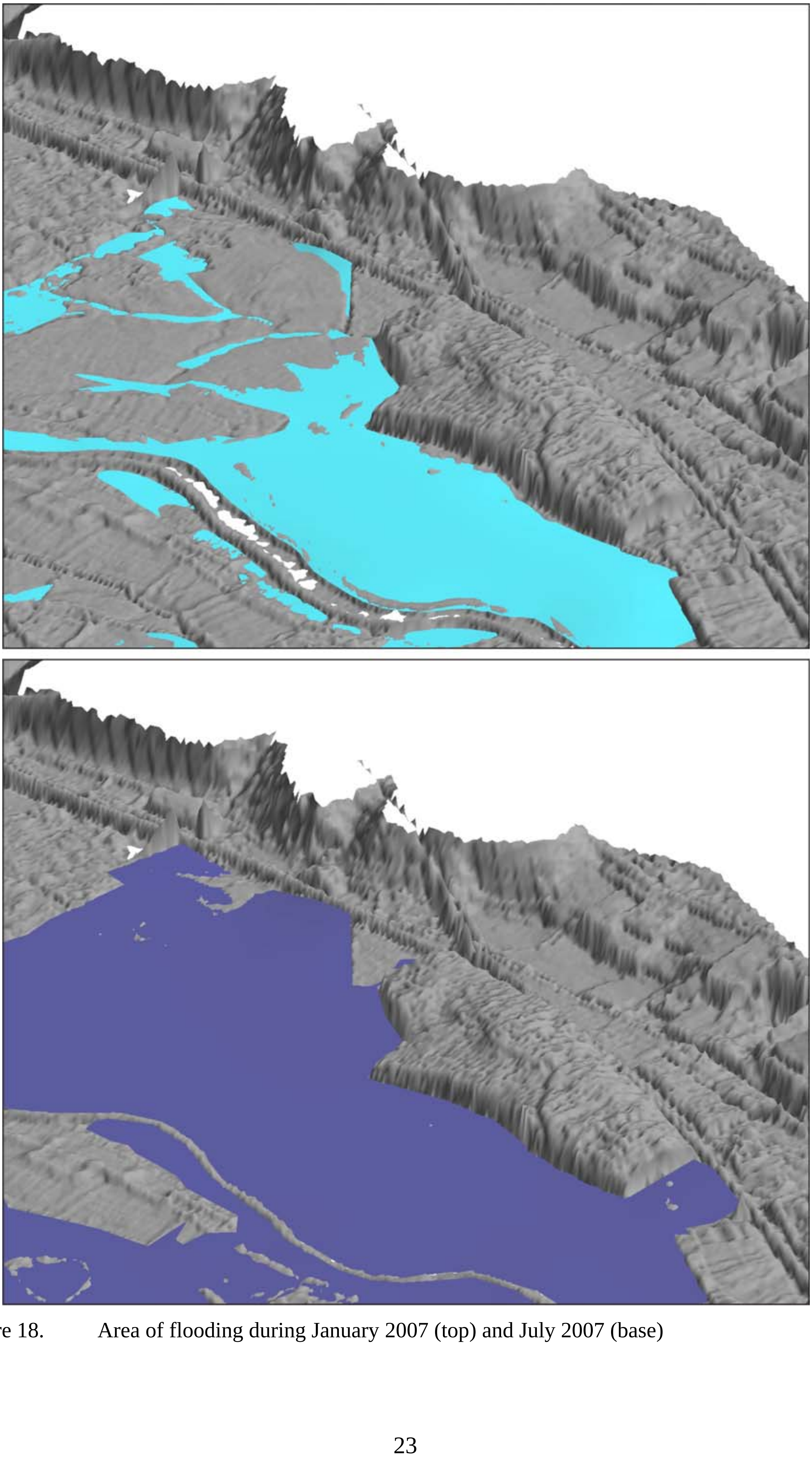
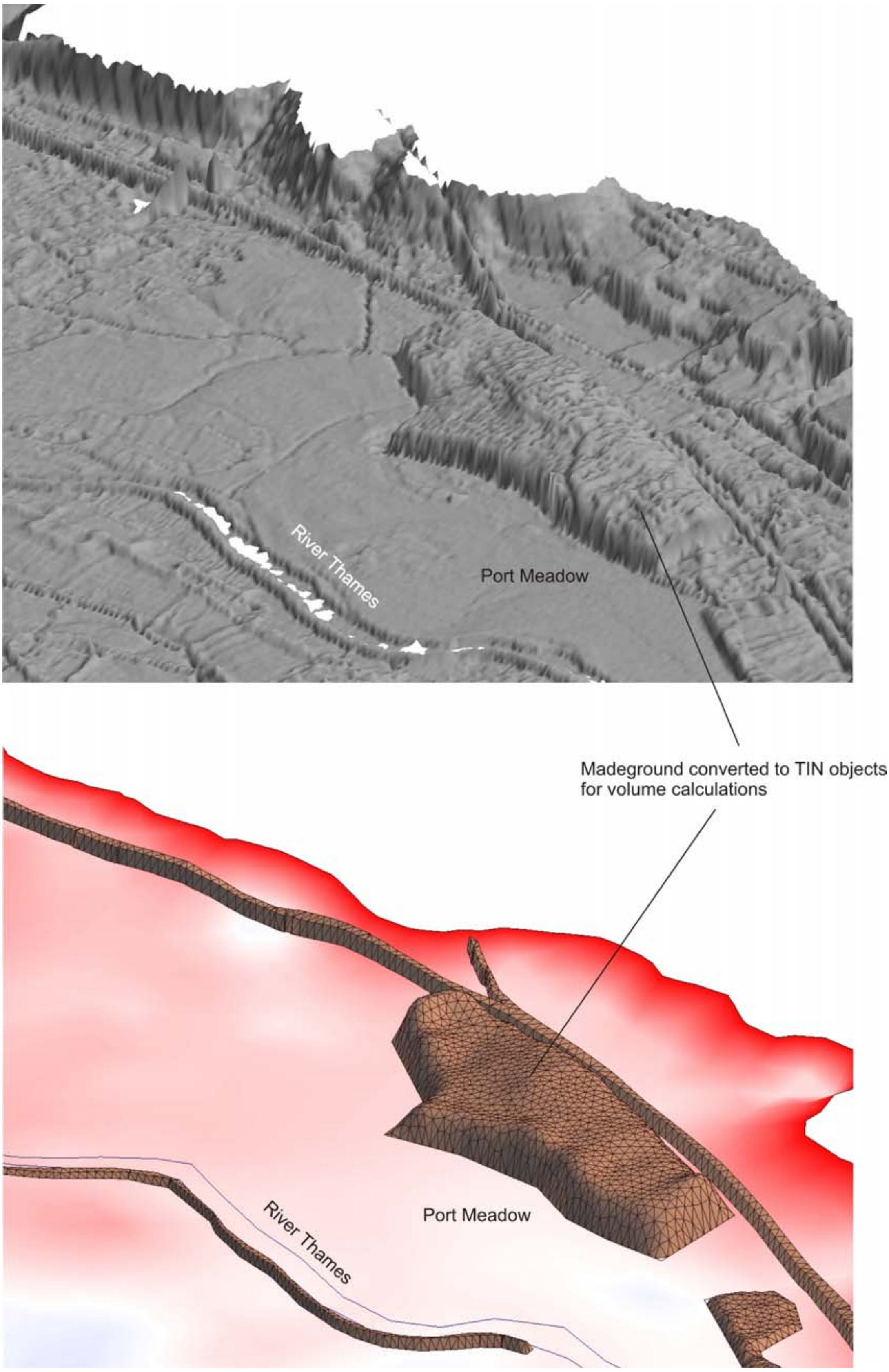


Figure 18. Area of flooding during January 2007 (top) and July 2007 (base)



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