

# Anthropogenic contribution to the geological and geomorphological record: A case study from Great Yarmouth, Norfolk, UK



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## ABSTRACT

Reconstruction of artificial or anthropogenic topographies, sediment thicknesses and volumes provides a mechanism for quantifying anthropogenic changes to sedimentary systems in the context of the proposed Anthropocene epoch. We present a methodology for determining the volumetric contribution of anthropogenic deposits to the geological and geomorphological record and apply it to the Great Yarmouth area of Norfolk, UK. 115 boreholes, drilled to a maximum depth of 6 m below ground level, were used to determine the thickness and distribution of seven geo-archaeological units comprising natural and anthropogenic deposits in the central Great Yarmouth area. This was supplemented by additional depth information derived from 467 existing ground investigation boreholes and published 1:50 000 scale geological maps. The top and base of each geo-archaeological unit were modelled from elevations recorded in the borehole data. Grids were produced using a natural neighbour analysis with a 25 m cell size using MapInfo 8.0 Vertical Mapper 3.1 to produce palaeotopographical surfaces.

Maximum, minimum and average elevations for each geo-archaeological unit generally increase with decreasing age with the exception of the Early-Medieval palaeotopographical surface which locally occurs at higher elevations than that of the younger Late-Medieval unit.

The total sediment volume for the combined Modern, Post-Medieval, Late-Medieval and Early-Medieval geo-archaeological units is  $10.91 \times 10^5 \text{ m}^3$ . The total sediment volume for the Aeolian, River Terrace and Marine geo-archaeological units combined is  $65.58 \times 10^5 \text{ m}^3$ .

Anthropogenic sedimentation rates were calculated to increase from  $\sim 590 \text{ m}^3/\text{yr}$  during the Early-Medieval period,  $\sim 1500 \text{ m}^3/\text{yr}$  during the Post-Medieval period and  $\sim 2300 \text{ m}^3/\text{yr}$  during the Modern period. It is estimated that the combined anthropogenic geo-archaeological units contribute approximately 15% of the total volume of sediments that would have been traditionally considered natural Holocene deposits in the Great Yarmouth area. The results indicate that an approach combining geological and archaeological deposit modelling can be used to quantify anthropogenic landscape impact and its associated sediment flux.

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## 1. Introduction

Humans are leaving an ever-increasing footprint on the Earth's atmosphere, biosphere and lithosphere. This anthropogenic impact is developing to such an extent that proposals are being taken forward for a geological epoch defined by the action of humans: the Anthropocene (Crutzen and Stoermer, 2000; Steffen et al., 2007; Zalasiewicz et al., 2010). Consensus is yet to be reached on how best to define and characterise this proposed epoch (Zalasiewicz et al., 2010, 2011a; Certini and Scalenghe, 2011). However, a number of indicators exist which can be used to quantify the impact of human activity. These include

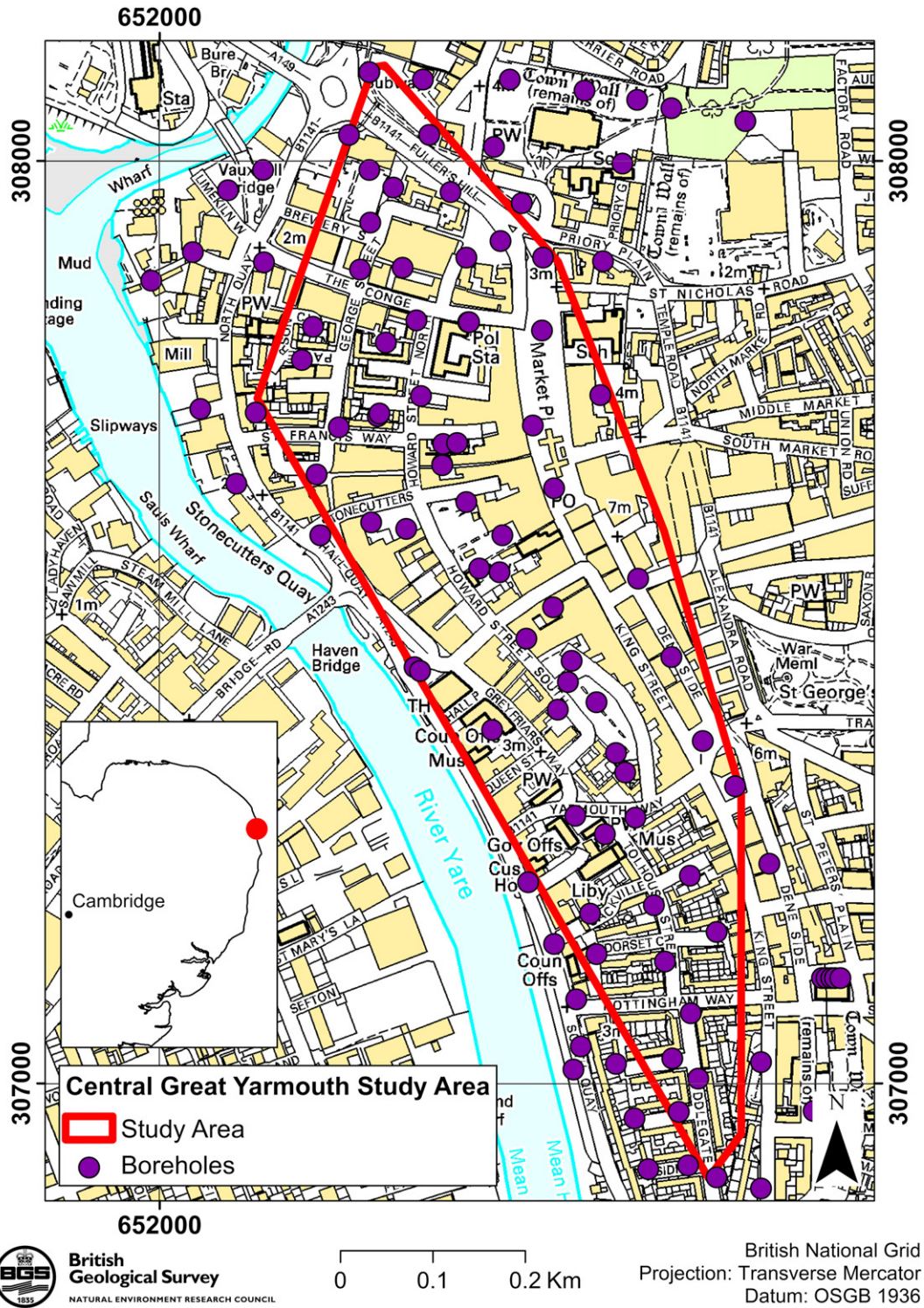
atmospheric greenhouse gas concentrations (Steffen et al., 2011); rates of human-induced animal extinctions (Zalasiewicz et al., 2011b) and; the distribution and type of anthropogenic deposits in the geological record (Price et al., 2011). It is this latter indicator that forms the focus of this paper. The geological and geomorphological significance of humans as landscape transforming agents is described further in Price et al. (2011) and Ford et al. (2014).

Anthropogenic deposits may comprise 'natural' deposits that have been reworked by humans and/or manufactured and processed materials such as those found in household rubbish and building rubble. The systematic geological and geomorphological characterisation, classification and volumetric assessment of anthropogenic deposits and landforms are limited. Landforms may be shown on topographical maps along with anthropogenic features including roads, canals and buildings. Landforms and associated deposits are shown on 1:50 000 scale geological maps in the UK based on their geomorphology and origin.

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**Fig. 1.** The central Great Yarmouth study area and location of boreholes drilled for the Great Yarmouth Archaeological Map. Inset: point denotes location of study area in Eastern England. The National Grid and other Ordnance Survey data ©Crown Copyright and database rights 2013. Ordnance Survey Licence No. 100021290.

Anthropogenic landforms and deposits are considered together as artificially modified ground and divided into classes of Made Ground, Worked Ground, Disturbed Ground, Landscaped Ground or Infilled Ground (Ford et al., 2010). These classes are further subdivided into progressively more detailed types and units. Buildings and infrastructure at the ground surface could also be considered as anthropogenic deposits, although extant construction materials used in dwellings and infrastructure are excluded. Processes that occur in anthropogenically modified environments but that do not result in the direct emplacement

of anthropogenic deposits are excluded from the classification of artificially modified ground considered here. These processes include agricultural ploughing and the creation of warp from deliberate sediment trapping during flooding in coastal or low lying areas.

Characterisation and classification of anthropogenic deposits created by direct human emplacement of modification, beyond the UK, is often undertaken on the basis of their lithology, landform or soil properties. For example, Dávid (2010) and Sütő (2010) describe a system for the geomorphological classification of quarrying and mineral extraction. The

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