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The York archaeological assessment: computer modelling of urban deposits in the City of York

A. Paul Miller

(Department of Archaeology, University of York, York, UK)

21.1. Introduction

Throughout the 1970s and into the 1980s, archaeology in British towns was largely driven by the philosophy of rescue, and the concept of 'preservation by record' (Biddle *et al.* 1973).

With increasing emphasis upon applying theory to the traditionally pragmatic world of urban archaeology (*e.g.* Carver 1987), it became clear that preservation by record was unattainable for many reasons. Primarily, it was argued that archaeologists are unable to objectively excavate and analyse a site without applying their own inherent biases to the work.

A decrease in government funding along with this theoretical reassessment led to a gradual decline in large-scale rescue excavations such as Brook Street in Winchester (Biddle 1975), or Coppergate in York (Hall 1984), and a move towards smaller scale evaluations.

At the end of the last decade, sites such as Queen's Hotel in York, the Rose Theatre, and Huggin Hill Baths in London (Biddle 1989) seriously damaged public and professional confidence in the existing approaches, and new solutions were felt to be necessary. This accelerated the move away from large scale excavation towards the now fashionable evaluation.

21.2. Background

In York, the City Council and English Heritage reacted to the mistakes made at Queen's Hotel by commissioning Ove Arup & Partners and York University's Department of Archaeology to study methods for better integrating archaeology within the planning and development processes. As well as suggesting guidelines for archaeological provision, the study (Ove Arup 1990) created a database of known archaeological interventions within the city, and produced deposit models using the UNIRAS package (Richards 1990).

The Ove Arup report set new standards for integration of archaeology within a unified planning strategy, but was of greatest value as a guide to areas of urban archaeological methodology in need of further development. These, and other, matters have been addressed successfully in the new Local Authority planning guidance issued in York (York City Council 1992b). This document points the way towards legislation that could be introduced to further the guidance laid down in PPG16 (Department of the Environment 1990).

To date, few researchers have looked at the formation and transformation of urban deposits. While the work of Michael Schiffer (1987) on transformation processes is relevant, this largely deals with short term occupations of rural sites, and is perhaps not wholly applicable to the deep and complex deposits of a multi-period urban setting. Recent work in the Swedish cities of Lund and Uppsala (Beronius-Jörpeland 1992) represents a valuable step towards consideration of these important urban deposits and their formation.

The current research project is investigating the application of Geographical Information Systems (GIS) to problems of urban deposit modelling and evaluation. It is felt that GIS provide the ideal tool with which to model urban deposits for both management and research purposes, while also allowing flexible testing of hypotheses relating to deposit formation. The more advanced GIS functions (Burrough 1986) will be used to investigate techniques for scoring deposit quality, possibly building upon recent research undertaken at the University of York (Emery 1991).

21.3. Archaeology of York

York was founded in AD 71 by the Roman IX legion. Their fortress sat on a ridge of moraine set above the wet Vale of York and controlled east-west movement across the Vale, as well as the confluence of the rivers Foss and Ouse.

By AD 237, a colonia had been established on the west bank of the Ouse and York became a thriving commercial centre, as well as being the military headquarters for northern Britannia. Deposits of this period can survive to thicknesses of around 2m in some areas of the city, with occasional anaerobic preservation of organic material.

With the decline of Imperial power in Britain, large areas of York appear to have been abandoned, but documentary sources (Goodman 1982) and several archaeological excavations (Kemp 1987) suggest that at least some areas of the city thrived. Certainly, York was considered important enough for it to become an ecclesiastical and royal centre (Sherley-Price 1968). Many York excavations fail to discover firm evidence of occupation within the excavated deposits. Most tend to suggest areas of grass rather than any identifiably urban settlement (Kenward *et al.* 1986).

With the arrival of the Vikings in the Ninth century (Hall 1984), York again became an archaeologically highly visible centre, with excellent anaerobic preservation in deep deposits such as those from the famous Coppergate site. At this time, York was capital of the Viking Danelaw.

York continued to prosper throughout the Middle Ages as the second city of England, as can be seen from the construction of impressive monuments such as York Minster in the centre of the old Roman fortress, and it was only with the rise of Hull as a maritime centre that the city declined in importance. This decline is fortunate for us, as it was largely responsible for the preservation of a city full of historic buildings. There are currently 1,500 Listed Buildings in the city (York City Council 1992a), with the prospect of many more being added in the current resurvey (Grenville *pers. comm.*). The Middle Ages are well documented within the excavated deposits; these, too, show signs of excellent anaerobic preservation, often to some depth, and allow insights into many aspects of life within the city.

So, we have a city that has been historically important for 2,000 years, that has excellent deposit survival — in places both anaerobic and over 10 metres deep, and that is now threatened by modern development. The relative quiet of the later Middle Ages and Industrial Revolution has been reversed by an influx of tourists and fast railway communications out of York in all directions; despite the recession, York is again booming. This modern 'heritage' boom is unfortunately a threat to the very past that so many visitors come to see, and the York Archaeological Trust has been hard pressed since its establishment in 1972 to cope with the archaeological demands of development within the city.

It is felt by many that a more proactive archaeology would allow better co-ordination and planning of interventions. To expedite this proactive approach, people such as Martin Carver (1987; 1990) have suggested that a detailed knowledge of the deposits beneath a town is essential.

A major failing inherent within the current approach to archaeology is that in many cases little is known about subsurface survival until development begins and the bulldozers actually move in. This means that developers are unable to plan adequately and build archaeology into their timetable for development. In many cases the unexpected recovery of archaeological deposits leads to unforeseen delays, and, often, to huge extra expense. The Queen's Hotel site in York, which sat empty for 14 years before development, is a case in point.

The Ove Arup consultancy (Ove Arup 1990) suggests that many developers are willing to budget for archaeological work; it is merely the unknown elements of what is likely to be found, how long it will take to recover, and what this will cost that cause dissatisfaction.

My work follows on from that of the Ove Arup report and others, and is looking at ways of quantifying the preservation and quality of deposits surviving beneath the streets of York.

21.4. Hardware

The computing system is based on a Silicon Graphics UNIX Compute Server. Day-to-day access is provided by a PC running the Teemtalk terminal emulation package. For tasks beyond the limitations of Teemtalk, command-line UNIX and a 14" monitor, Silicon Graphics Indigo workstations are used.

Much of the digitising for the project is undertaken in house, using a 386-based PC and an A3 digitising tablet. Output is currently produced on a Hewlett Packard LaserJet and a wax thermal colour Postscript printer.

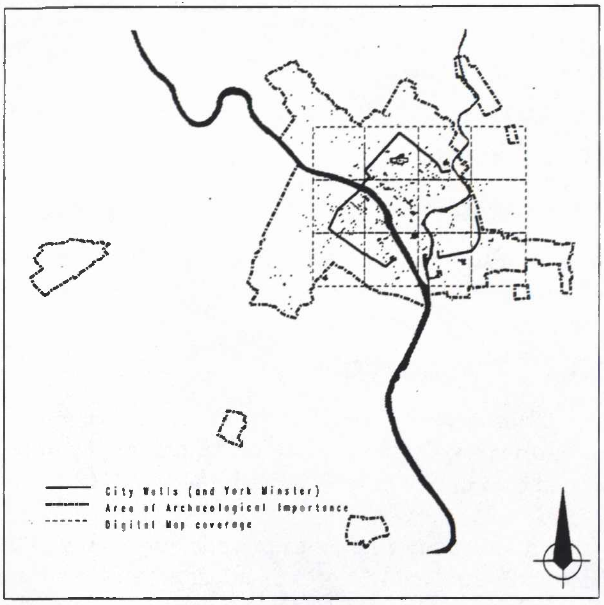

Figure 21.1: Available digital data for the City of York.

21.5. Software

The primary software package is version 6.1 of ARC-INFO from Environmental Systems Research Institute of California. The main reason for initially choosing this software is that it was readily available to UK universities through a CHEST deal, and considered as something of an industry standard. It has turned out to be an excellent package.

The database being used is INFO. This software is bundled with ARC-INFO, and is at the time of writing the only relational database available on the UNIX machines at York. Much of the initial data input and modification has been carried out within PARADOX on a PC and has then been transferred to INFO. Despite the slight inconvenience of converting between databases, it is felt that the huge gains made in using the much friendlier and faster PARADOX are worth it.

Any digitising needed for the various non-digital map sources is undertaken using version 10 of AUTOCAD. Although ARC-INFO has its own digitising tools, it seemed sensible to continue with a package already supported, especially when ARC-INFO's ADS apparently offered no real benefits over AUTOCAD. Maps are easily imported into ARC-INFO using the standard DXF format.

UNIMAP, a part of the UNIRAS package, was used by the initial Ove Arup study to generate the original deposit models (Richards 1990). Further work will be undertaken with this package in order to compare results from various terrain modelling techniques.

21.6. Data sources

Much of the textual data comes from the original Ove Arup study. This study produced a database of over one thousand records for interventions within the city. Information was gathered from the archives of the York Archaeological Trust and a number of other sources including the Royal Commission surveys of York.

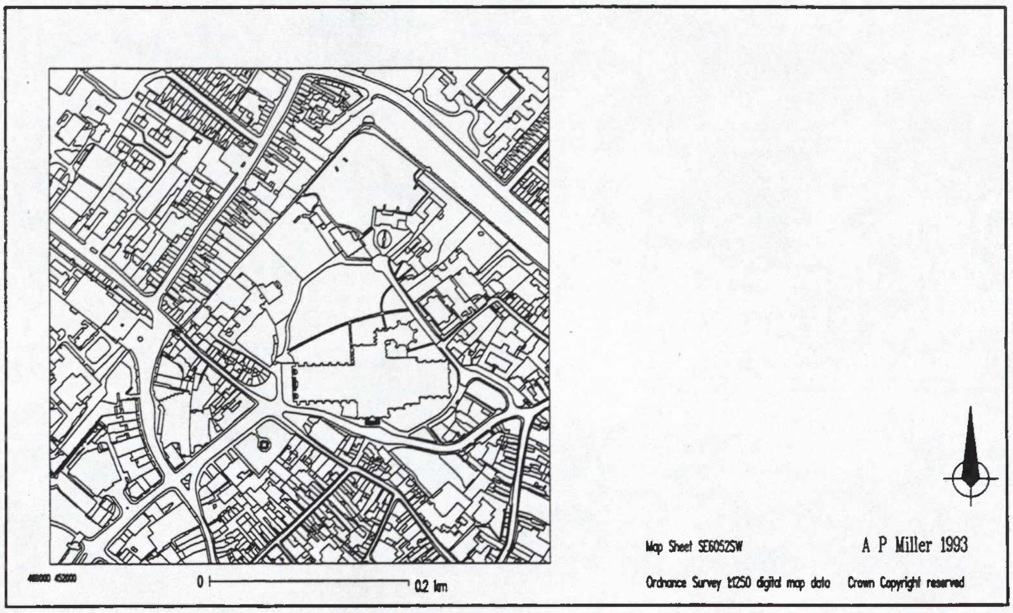

Figure 21.2: The pilot study area.

The project is also undertaking to gather new information, both from the same sources as used in the Ove Arup study and from others as they are discovered. While not having time to gather everything in the three years of a doctoral programme, I would hope to at least illustrate the different sources of data available for the city. I am indebted to John Oxley, Principal Archaeologist in the City Council, and to the York Archaeological Trust for their continuing support in the data collection programme.

Basic map data is in the form of the Ordnance Survey 1:1250 digital map series. Currently 12 of the 500m squares are available, covering the walled city (Fig. 21.1). It is hoped to study the whole city eventually, but with the expense of digital map data it may be necessary to digitise these other maps in house.

An often unforeseen cost in GIS planning is the time taken to actually convert data into a usable format. For the 500m square of the Pilot Study area (Fig. 21.2) it took a week just to clean the Ordnance Survey data enough so that it was recognisable to the GIS. It is estimated that it would take 6 months to clean all 12 map squares, and to then input the address information for each property and attach this to the property polygons. A useful application of the Pilot Study will be to investigate whether or not this huge expenditure of time is worth the gains that may be made.

A number of non-digital sources have been consulted and input in to the various databases making up the GIS. These include the statutory roll of Listed Buildings, the Land Use register and maps defining Scheduled Ancient Monuments and Areas of Archaeological Importance within the city.

As yet, an accurate topographical model for the city does not exist, limiting the effectiveness of any deposit maps that are created. The Ove Arup study worked from a map of geological Natural generated from borehole information as the basis for its maps, meaning that all period models were based upon a heavily interpolated 'origin' (Richards 1990).

The Ordnance Survey Digital Terrain Models were examined with a view to using them as the basis for terrain modelling, but their expense and low level of accuracy make them useless for detailed modelling of surfaces. The NAVSTAR Global Positioning System (GPS) technology is under investigation as a method by which the city may be mapped. Manufacturers now claim sub-centimetre accuracy for their receivers (Trimble publicity material), even with the well publicised military jamming, or 'Selective Availability'. This makes GPS a viable alternative to more traditional Theodolites and Total Stations for rapid 3 dimensional mapping of large areas.

With information coming from so many sources, the design of a database capable of handling such disparity was seen as essential. Therefore, time was spent in the consideration and design of a database structure (Fig. 21.3) in conjunction with Jeff Chartrand of the York Environs Project (Chartrand & Miller, forthcoming). This database is designed to allow information from the 4,200 km^2 Environs Project to be combined with detailed site data from within the city.

21.7. The pilot study

Initially, a pilot study (Fig. 21.2) is being undertaken looking at one small area of the city. This is intended to allow the testing of various techniques, and will be used to examine the validity of laborious entry of such data as Land Use coding.

Before any analysis may be undertaken, the relevant data has been input and transformed where necessary to fit the desired project design. Within the pilot area, every building on the map has been given an address and Land Use data based upon the Local Authority Use Classes Order is being input. Over three hundred Listed Buildings within the Study Area have also been coded, as has information on Scheduled Ancient Monuments and the Areas of Archaeological Importance and Significance.

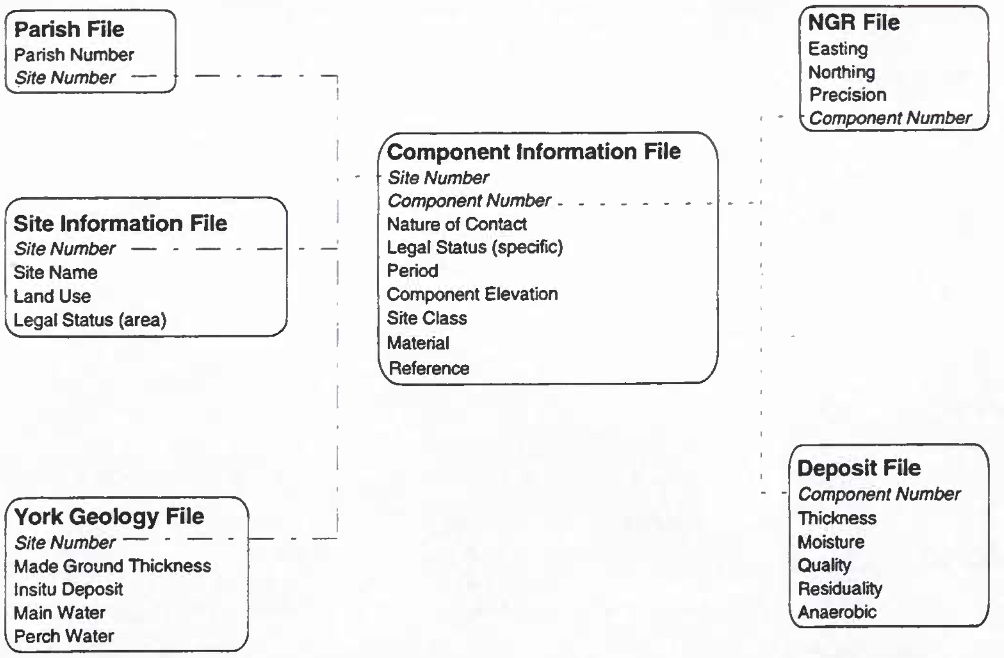

Figure 21.3: Database design.

All of the data from the Ove Arup database has been transformed and merged in to the Project database design and ARC is handling interrelationships between 5 separate database files. At present, these are tied to *points* within one of the GIS coverages (Fig. 21.1), allowing interactive on-screen querying of the database by pointing at or selecting points. The York Archaeological Trust are digitising the outlines of all their excavations, and when this process is completed, the point coverage will be replaced with one consisting of polygons. This will allow the easy generation of maps showing the actual *areas* excavated, rather than clusters of points.

The addition of a Digital Terrain Model to this mass of information will allow work to begin on the modelling and visualisation of the deposits themselves. Fig. 21.4 shows a terrain model built using the TIN module of ARC-INFO from Roman and natural data; Fig. 21.5 shows a similar terrain model from Roman and natural data using the UNIRAS package.

This modelling of deposits is the main focus of the GIS-based work and will be more detailed than the earlier Ove Arup UNIRAS models (Fig. 21.5). Using the TIN module of ARC-INFO it will be possible to test various surface interpolation algorithms by removing points from the known modern surface, remodelling that surface and comparing the two. Given the results of statistical analysis based upon the reasonably well known modern surface, it will be possible to analyse the apparent accuracy of the modelled sub-surface deposits. Based upon far fewer points than the modern surface survey, it is of great importance where potentially expensive planning decisions are concerned that the levels of confidence for various parts of the model can be quantified and then clearly laid out. In some areas of the city where coverage is good, deposit models may approach reality, whereas in other areas where the distribution is less representative it is vital that the level of faith that can be placed in any images generated is understood.

Presentation of this multi-dimensional information which consists of 3-dimensional location and associated attributes places a great strain upon both modern 2-dimensional display media, and upon human cognitive ability (McLaren & Kennie 1989). Work will be undertaken to study methods of actually displaying this information to end users (Fig. 21.6). It may be that transparent wire frame models are used, where the subsurface deposits are visible through the virtual topographic simulation.

Only a few months into the project, the GIS already provides a useful means of displaying archaeological and administrative information from a variety of sources. Before this project, the data existed in a number of locations and in a variety of formats. To create even simple images would have taken a significant outlay of time, whereas now all that is required is a quick, automated, search of the database.

The true power of the system will become apparent when work starts in earnest on investigation of the deposits themselves. GIS techniques, and the powerful investigative tools within the system, will be used to explore research questions relating to the deposits of York. These research questions will include such problems as the changing of the river regime, and the lasting effect that the Roman fortress walls may have had upon deposits within and outside the old fortress.

As an experiment, the data on modern land use that has been coded into the database for the Pilot Study area will be investigated in relation to archaeological excavations and other planning applications. Rather than assuming that all areas within the city are equally prone to development, as has been the case previously, a hypothesis has been prepared suggesting that the potential threat to an archaeological deposit may be related to the modern land use of the site under which the deposit lies. Using the land use data and information relating to archaeological interventions and other planning proposals it will be possible to test this hypothesis and hopefully find a quantifiable relation-

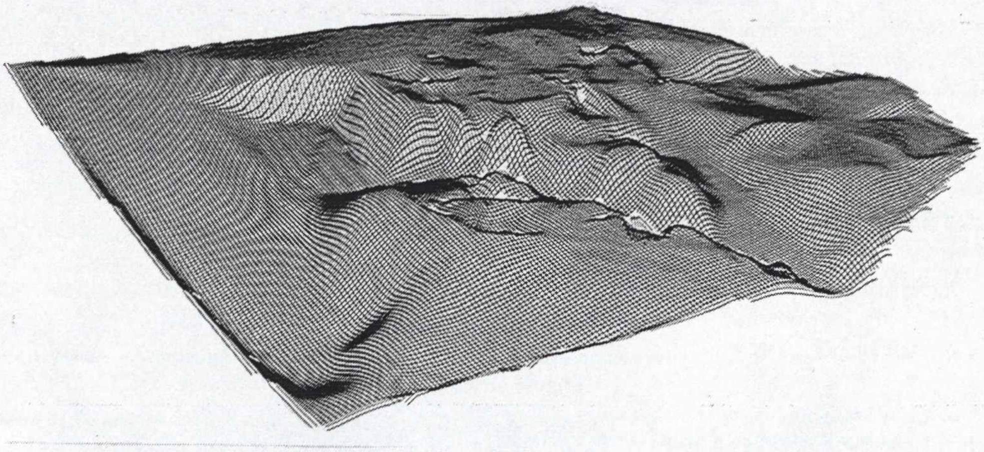

Figure 21.4: Terrain model built using the TIN module of ARC-INFO from Roman and natural data.

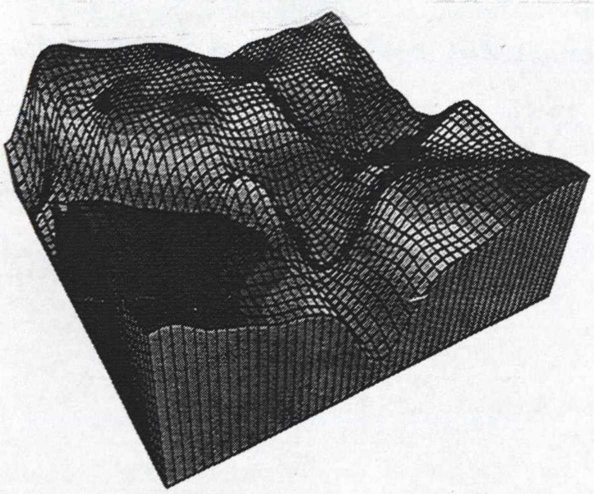

Figure 21.5: Terrain model built from Roman and natural data using the UNIRAS package.

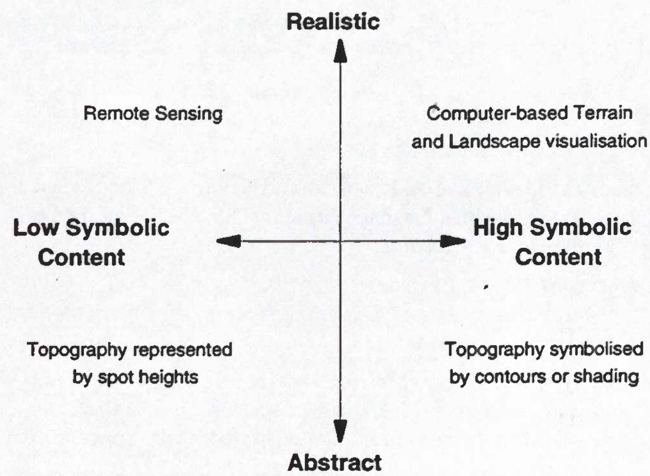

Figure 21.6: Visualisation of terrain (after McLaren and Kennie 1989).

ship that would allow certain areas within the city to be quickly designated as 'safe', 'under threat', *etc.*

21.8. Conclusions

When completed, the creation of this system will provide a valuable case study for the creation of an urban archaeological GIS, and will outline the problems of merging disparate data sources, as well as the benefits of being able to seamlessly query multiple databases. If expanded, the core of the system as designed will allow the creation of a GIS dealing with all aspects of York archaeology and history, including those not included in this study. The modular database structure will allow the easy addition of further databases such as the York Archaeological Trust Context Recording System (CRS) and Computerised Integrated Finds Recording System (CIFR), allowing analysis of individual contexts. The database of land deeds created by the York University History department could also be attached, making analysis of medieval ownership patterns possible.

From a planning perspective, the system would allow the City Archaeologist to provide developers with detailed information upon their proposed sites. It would also ease the process of constructing archaeological mitigation strategies, as are now required within the York Planning procedure (York City Council 1992b).

In short, this project will answer questions of deposit creation and survival within the city, and will look at how these deposits reflect past human activity within the city. It will investigate methods of displaying multi-dimensional deposit information and of integrating disparate data. Finally, it will provide pointers to the way in which archaeological and Planning matters may be integrated and better understood using GIS technology.

Acknowledgments

This work is a CASE studentship funded by the Science and Engineering Research Council (SERC) and York Archaeological Trust. Supervision, advice and support are provided by Dr. Julian Richards of the Department of Archaeology and Jef Maytom from York Archaeological Trust.

Thanks are also due to John Oxley, the York Principal Archaeologist, Jeff Chartrand of the York Environs Project and Peter Halls of the York University Computing Service.

Finally, many thanks to Dr. Julian Richards for repeatedly reading and commenting upon various drafts of this paper.

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A.P. Miller
York Archaeological Assessment
Department of Archaeology
University of York
Micklegate House
88 Micklegate
GB-YO1 1JZ York
apm9@vaxa.york.ac.uk