



TERRA NOVA

Geotechnical Recording and Archaeology

A comparison of geotechnical and archaeological
recording from Bristol and Dover

Terra Nova Ltd.
Llwynfedwen, Libanus, Brecon, LD3 8NN, Great Britain
Tel/fax 01874 636345 Mobile 0797 11 66 380
E-mail: terra@celtic.co.uk

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Part 1:

Introduction

This review forms part of English Heritage grant funded project ‘Geotechnical Recording and Archaeology’, which is being undertaken by Terra Nova Ltd.

The aim of this project is to develop new, standardised criteria by which archaeological deposits can be simply but correctly recorded during geotechnical investigations. In order to develop these criteria we have reviewed sites in Bristol and Dover where geotechnical investigations have been followed by archaeological excavation. Comparing the geotechnical and archaeological reports for a site shows how differently archaeologists and geotechnical workers record the same deposits. From these differences we can then determine what changes in general geotechnical recording practice are needed in order for the geotechnical records to produce reliable archaeological information, and how archaeologists could be trained to better interpret geotechnical reports.

Part 2:

A Review of Geotechnical and Archaeological Records from Redcliffe, Bristol

Background

Bristol is a city with a wealth of human history, having been continuously occupied since pre-Medieval times. This review of archaeological and geotechnical data concentrates in that area of Bristol which lies within the Medieval suburb of Redcliffe. Development of the area from the Medieval period to the present-day has concentrated around the two original main streets; Redcliff Street (then Redcliffe Street) and Thomas Street (then St Thomas Street). The properties on the western side of Redcliff Street originally extended back to the River Avon. As land to the rear of the properties was reclaimed, the rear parts of properties were developed, and then from the mid C14th began to be divided off into new tenements fronting a street lying along the bank of the Avon. The newly created area was named Redcliff Backs (Williams and Cox, 2001).

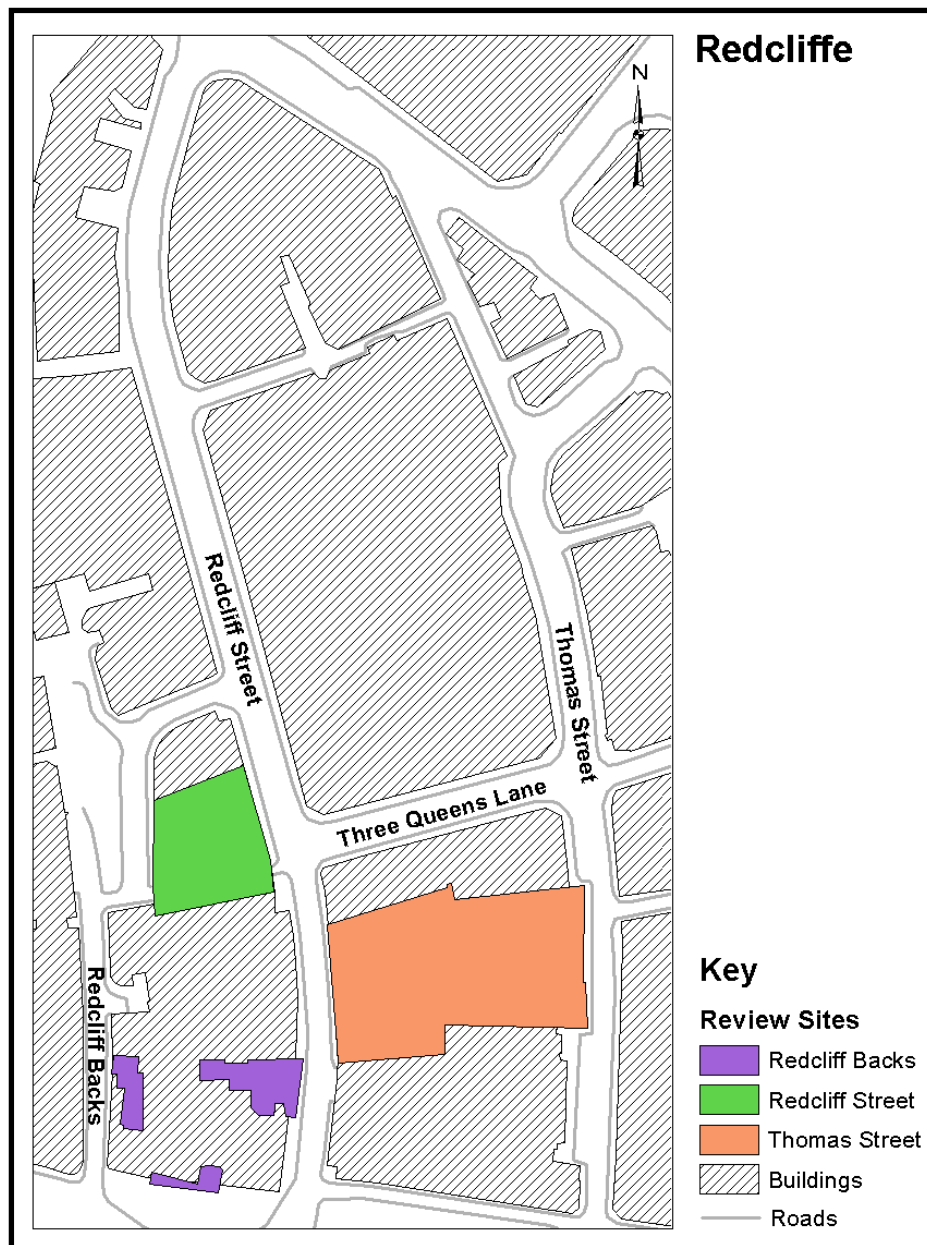


Figure 2.1: The Redcliffe area.

Historical and archaeological records show that the buildings in Redcliffe have been redeveloped continuously over the years, seeing such diverse uses as alehouses, glassworks, dyers and tanneries. More recently, they have been used as car lots and warehouses. From the late 1900s, Redcliffe has been undergoing another phase of piecemeal redevelopment into residential and retail premises. Both geotechnical site investigations and archaeological excavations have been required for many of these developments.

The Redcliffe area of Bristol is of interest to this study not only for the completeness of the historical, archaeological and geotechnical records associated with it, but also because of its position. Redcliffe lies on a meander, at the transition between the deep channel alluvia of the River Avon and alluvium that is now dry land and upon and within which archaeological deposits lie. This means that this review covers a representative range of the geology over which the town centre lies.

Three sites were chosen for this review in order to compare archaeological and geotechnical records and define what more could reasonably be recorded in the geotechnical investigation. The selection of these sites from all those which had been redeveloped was based on the location and proximity of the sites, the thoroughness of the archaeological excavation and geotechnical investigation reports, and the availability of these reports and permission from the copyright holders to consider them in our review. In practice, finding sites that met these criteria was a difficult and time-consuming task. Bob Jones (County Archaeologist) and Jon Brett (Archaeological Officer) of Bristol City Council were very helpful in compiling a shortlist of potential sites, and Bristol and Region Archaeological Services (BaRAS) was very helpful in providing archaeological reports, but acquiring the geotechnical reports for each site was a very different matter.

Problems were encountered in obtaining copies of the geotechnical reports and permission to use them. These arose primarily because the companies who carry out site investigations are not those who own the copyright to the report. Indeed, the two are usually separated by a chain of subcontracting; of client (in the cases of the sites reviewed here, the clients were all developers) to agent to consulting engineers to geotechnical investigation firm. The geotechnical company responsible for a site investigation holds a copy of the report, but cannot release it without the permission of the copyright holder.



For this review, we needed to study sites for which the archaeological excavation reports had been completed. With the usual time lapse between geotechnical and archaeological investigations and the additional fact that some archaeological investigations were over two years old, this meant that the geotechnical records could easily be over three years old, in which case they had often been archived by the geotechnical firm. Personnel familiar with the geotechnical investigations had sometimes moved on. Furthermore, the chain of sub-contracting often meant that the geotechnical investigation firm did not always have a record of the ultimate client's identity. This meant that it was necessary to work back up the sub-contracting chain to determine the client. Due to the time since the reports were made, it could take several days for each step in the chain to recover the information about the next step up. An additional complication existed if the site had been sold on by the original developer (along with the geotechnical report copyright), the developer had been taken over or changed names or the site had been split into smaller parcels, the owner of each needing to give permission before a copy of the geotechnical report could be released by the geotechnical investigation company.

In any of these situations, the person ultimately responsible for giving permission to use the report had then to be persuaded to take time out of their schedule to write a letter of instruction to the geotechnical company to release the report. The geotechnical company had to then retrieve the report and copy it, which again could take several days, and could involve a charge. The entire process could (and did) easily take over a month.

These problems were encountered because of the time passed since the original geotechnical site investigations. They are likely to hinder any future development of an archaeological database that includes existing geotechnical data, created, for example, in order to aid planning and the targeting of archaeological works. However, when archaeologists are working on site, usually they are working under the same client as the geotechnical firm, so obtaining a copy of the geotechnical report to aid planning of their investigation should prove considerably less problematic.

For each site, a brief summary of the history of the site and the order of proceedings and a representative comparison of geotechnical and archaeological records will be presented, along with any site-specific comments on problems encountered in the review. In the Discussion section, a description of the problems common to all sites will be presented, and conclusions about the current and potential usefulness of geotechnical records in archaeology will be drawn.



Going into the analysis of these sites, certain perceived problems with the nature of geotechnical data had already been raised by archaeologists. These included a lack of recording of heights above Ordnance Datum (aOD) (or the use of an arbitrary datum) and the lack of recording of changes in the nature of the Made Ground/Fill (the geotechnical terms for ground showing evidence of human disturbance respectively above/below the interpreted 'natural' ground surface – i.e. that part of the ground which is of interest to the archaeologist) (Cox, Straker, Insole and Jackson, pers. comm.).



98-103 Redcliff Street

98(a and b)-103 Redcliffe Street was originally a block of seven tenements, the boundaries of which survived mainly intact up to the time of World War II, after which the site was redeveloped with altered property boundaries. In 1999, prior to the demolition of the derelict buildings on site to make way for a new residential development, an archaeological evaluation consisting of five trenches was undertaken (Insole, 2001). A geotechnical investigation followed in 2000 (Geotechnical Engineering Ltd., 2000), consisting of four boreholes and five trial pits, at which time the archaeological evaluation pits were still open. The derelict buildings were then demolished, and an archaeological excavation consisting of two further trenches was then undertaken in 2001 (Insole, 2001).

The archaeologist felt that the geotechnical data (which was concentrated over cellars and walls to determine the nature of the modern fill) was of little or no value when there were already archaeological evaluation trenches open in more archaeologically sensitive areas, which provided much more detailed information than would be available from the geotechnical data (Insole, pers. comm.).

Since the majority of the archaeological trenches were excavated before the geotechnical investigation was carried out, the excavations and boreholes/trial pits were often close to each other, but not co-incident. In one case, archaeological excavation was carried out on the location of a logged borehole. However, the borehole was not reduced to datum and the archaeological excavation was not excavated from ground level and additionally had only heights aOD recorded. In order to compare the logs in this and other cases, archaeological sections that were logged to pre-demolition ground level were used to work out the *approximate* reduced level for nearby boreholes, which could then be compared with trench records. A typical comparison between nearby geotechnical borehole/trial pit and archaeological section logs is presented in Figure 2.2.

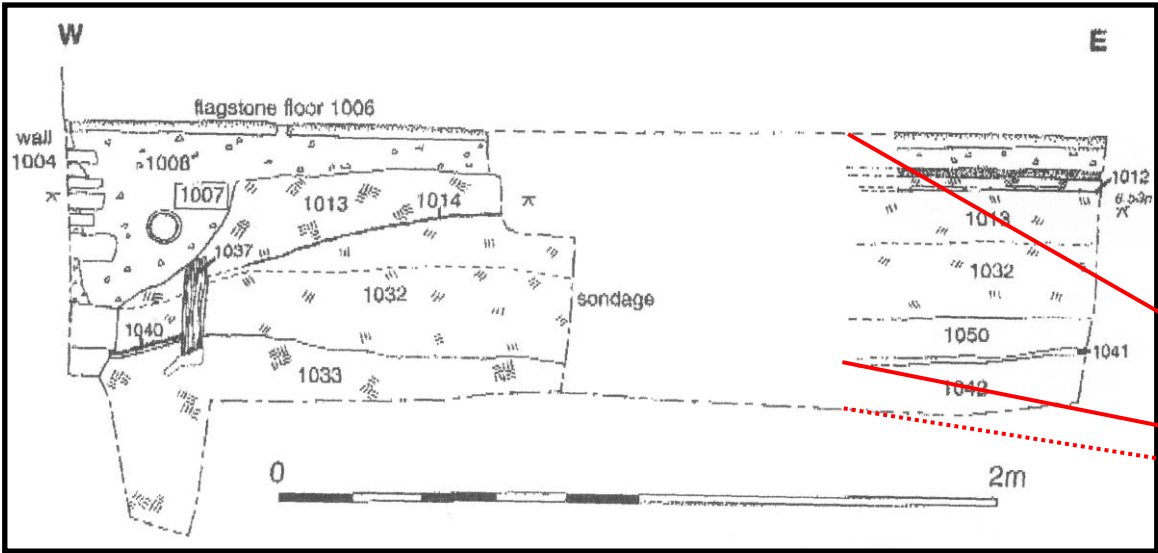
Unfortunately, because of the uncertainty involved in the conversion of borehole depths to height aOD, it is not possible to say whether the depth to natural strata (this being in archaeological terms the shallowest part of the ground that shows no evidence of human influence) has truly been misinterpreted by the borehole loggers (1033/1042 is interpreted by the archaeologists to consist of the shallowest undisturbed layer; an alluvial deposit).



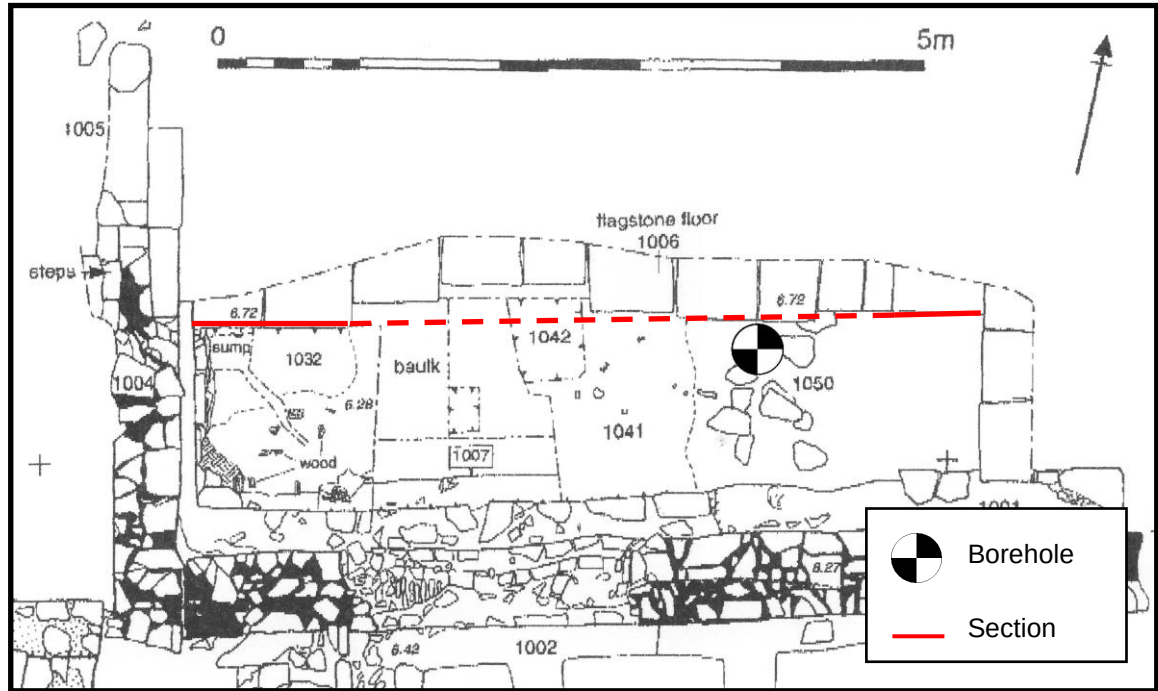
The first evidence of human activity was the driving of several wooden stakes (e.g. stake 1037) into this alluvium to form a makeshift revetment). Additionally, it is clear from the trench plan that the rubble layer (1050) should have shown up clearly as a distinct layer within the borehole.

Most seriously, we can see that the drillers have failed to log the boundary between the modern cellar fill and the Medieval fill below the cellar flagstones. The drillers have given descriptions of all the inclusions encountered within the whole Made Ground unit within which the cellar floor is located; however, even if a section of flagstone was misinterpreted as a loose clast, if the geotechnical workers had noted the colour and texture of the deposits and the nature of the inclusions as they varied within the Made Ground, this would have told them that they had reached a significant boundary within the Made Ground unit. The fact that this interface was missed, rather than merely omitted from the log, is indicated by the fact that elsewhere on this site units of varying character within the Made Ground have been logged.

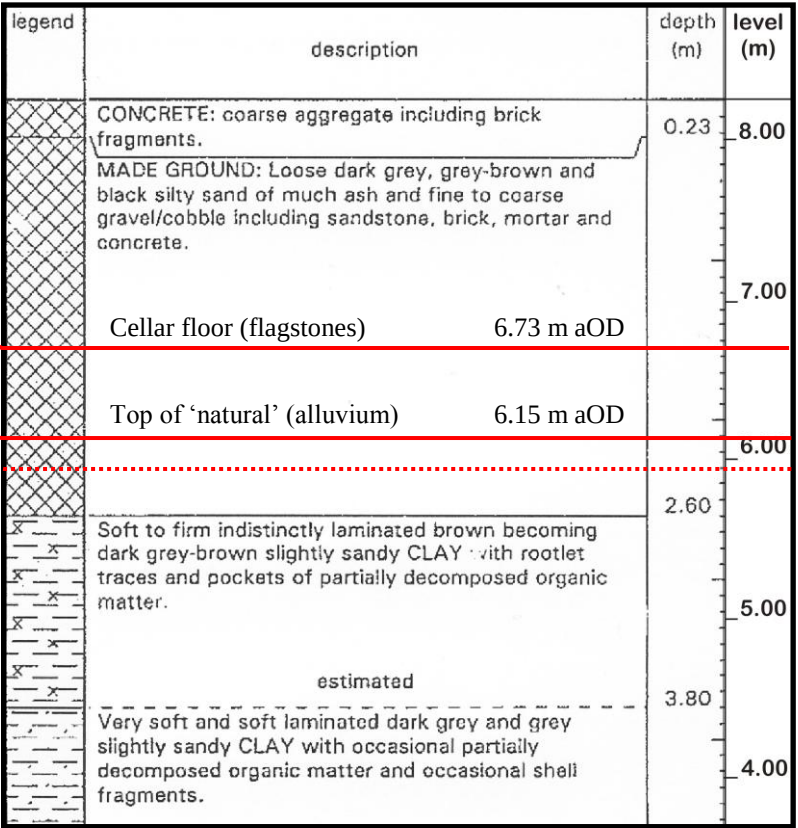




a. Section log.



b. Relative section and borehole locations.



c. Borehole log.

Context	Description
1050	Dumps of rubble (deliberate).
1040	A thin organic deposit, potentially a strand line.
1037	An upright timber, probably part of a makeshift revetment.
1033/1042	A stratified, strongly mottled grey silty clay and clayey silt containing organic lenses. Containing also small wood fragments and very occasional animal bones, debris possibly associated with low energy tidal/fluvial deposition.
1032	A stratified, slightly brownish grey clayey silt; an alluvial deposit.
1014	A thin organic band, similar to 1040.
1013	A pale brownish-grey, micro laminated silty clay; an alluvial deposit. Contains organic clay loam strata with charcoal, mortar, oolite and red sandstone.

d. Context descriptions.

Figure 2.2: Redcliff Street borehole/section comparison.

Redcliff Backs

By the end of the C18th, Redcliff Backs consisted of nine tenements. The properties developed there were leased to brewers, drapers and boot-makers, amongst others, before eventually being destroyed in World War II, and then redeveloped with altered property boundaries (Williams and Cox, 2000). Prior to the redevelopment of Redcliff Backs into residential housing, a geotechnical investigation consisting of ten boreholes and five trial pits was carried out in 1998 (Geotechnical Engineering Ltd., 1998). An archaeological excavation was then carried in 1999 (Williams and Cox, 2000).

There was no interaction between the geotechnical investigators and the archaeological excavators, and the archaeologists did not use the geotechnical data when planning their excavation (Cox, pers. comm.).

Archaeological excavations and geotechnical trial pits or boreholes had not been carried out in exactly the same place anywhere on site, though some excavations and boreholes/trial pits were in close proximity. The geotechnical logs had been reduced to an arbitrary datum of 10m sighted on a manhole cover at the entrance to the site (the location of which is unclear), making it impossible to accurately compare these logs to archaeological excavation logs (as archaeological logs are reduced to Ordinance Datum as standard practice).

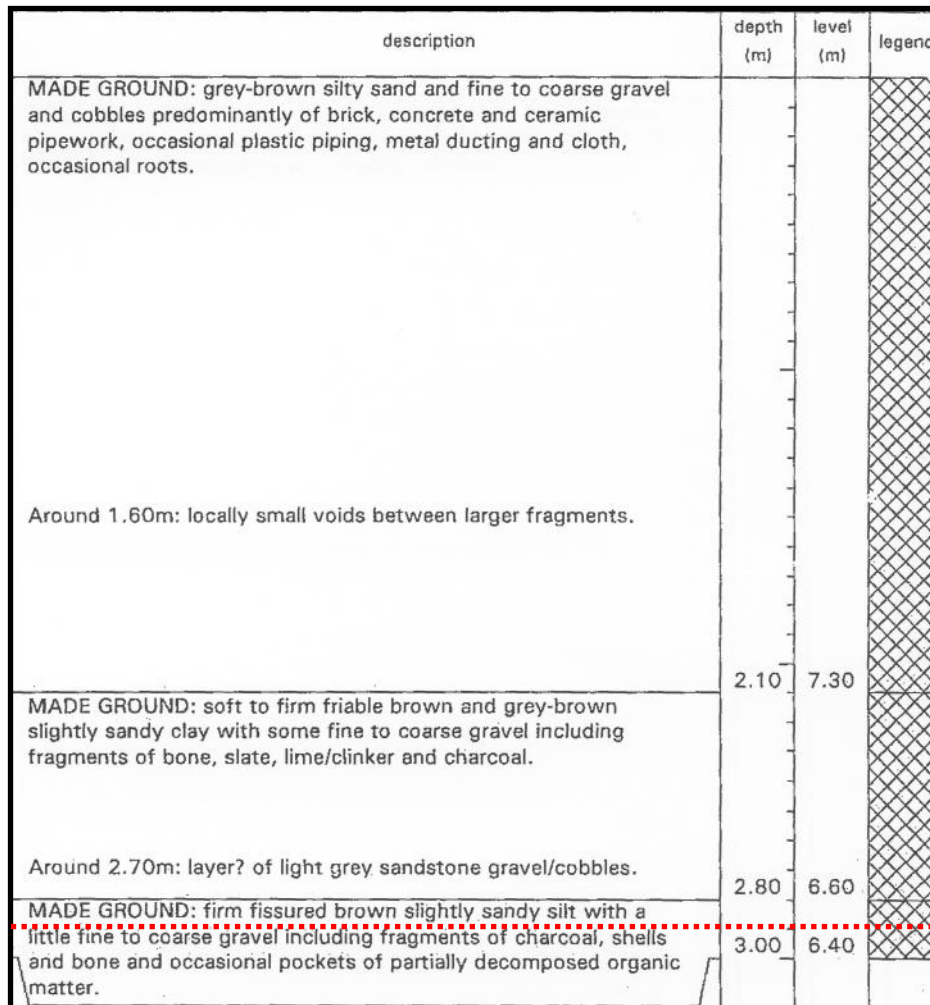
Figure 2.3 presents a typical comparison between archaeological and geotechnical logs for this site. As there were no co-incident archaeological and geotechnical records and true heights aOD for the geotechnical data could not be established, only generalised comparisons could be made. Figure 2.3 illustrates one problem with this site; that in some cases where geotechnical and archaeological records had been logged close to each other, there was little vertical overlap between them (as little as 20cm). On this site, geotechnical recording had been done from surface through modern Made Ground, whereas the archaeologically uninteresting modern Made Ground was stripped away before archaeological trenching took place. Although this case may be an extreme example, it is true that sometimes archaeologically significant deposits are buried by more recent Made Ground, so geotechnical test pits don't penetrate deeply enough to reach the archaeological deposits.



We can see that the trial pit log distinguishes between different ‘units’ of Made Ground, which is not uncommon on this site. Unfortunately it is not possible to correlate interfaces marked on the geotechnical and archaeological logs due to the lack of vertical overlap between the records and the uncertainty over the true reduced heights of the trial pit and borehole records. Additionally, the depths at which interfaces have been recorded in the trial pit probably represent averages across the pit face. If the trial pits had been logged with the same resolution as the archaeological excavations, correlation might have been possible.

The archaeologist’s report does not mention the sketch map associated with the trial pit (see Figure 2.3), which shows that possible wall footings were encountered. Although the footings were at shallow depth (0.4 to 0.8 m below ground level) they may have represented rebuild of an older wall. Unfortunately, both the archaeological and geotechnical plans do not make it clear if the footings could be an early stage of a modern wall. It is not possible to determine which is the case without further investigation, which is beyond the scope of this review.



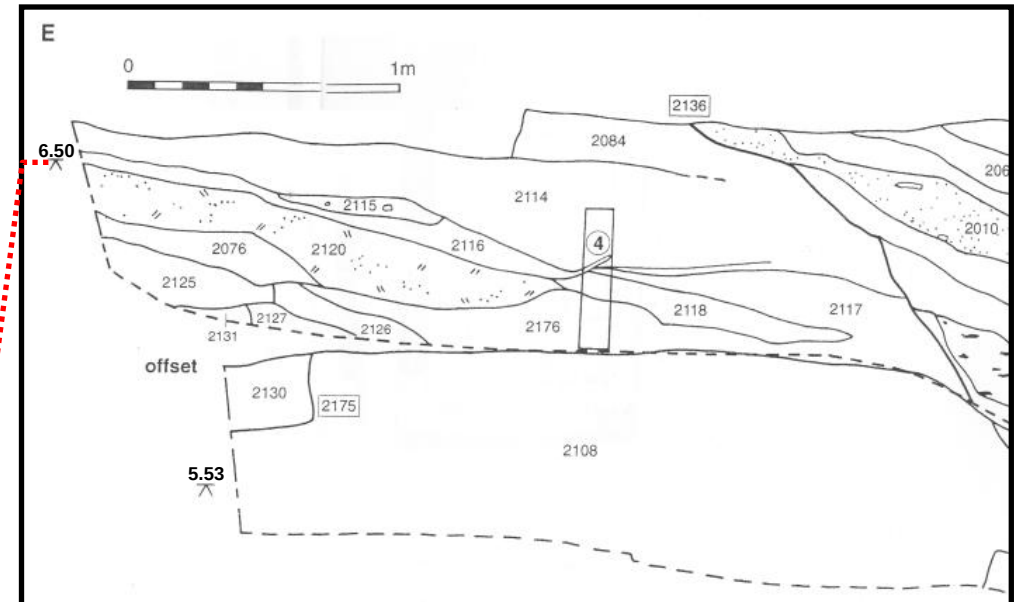


a. Trial pit log.

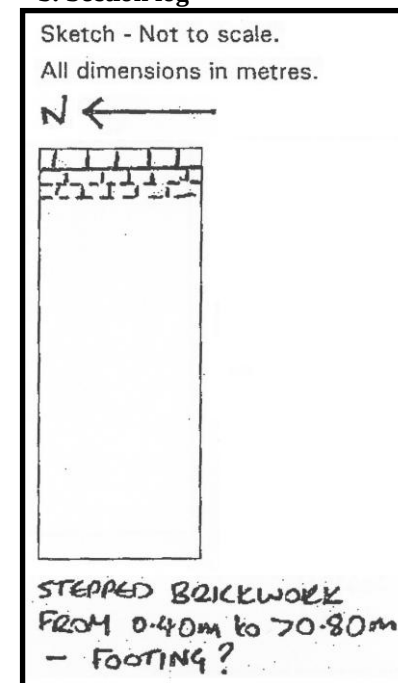
Context	Description
2108	A black, highly organic very soft, silty clay. An alluvial deposit.
2130	A blue, silty clay. Ditch fill.
2116, 2127	Tipped refuse containing charcoal, ash, mortar and rubble.
2117, 2118 etc	Alluvial silts and clays interleaved with tip layers (2116, 2127).
2114, 2084	Brown, silty clays, fairly clean apart from charcoal inclusions.

c. Context descriptions.

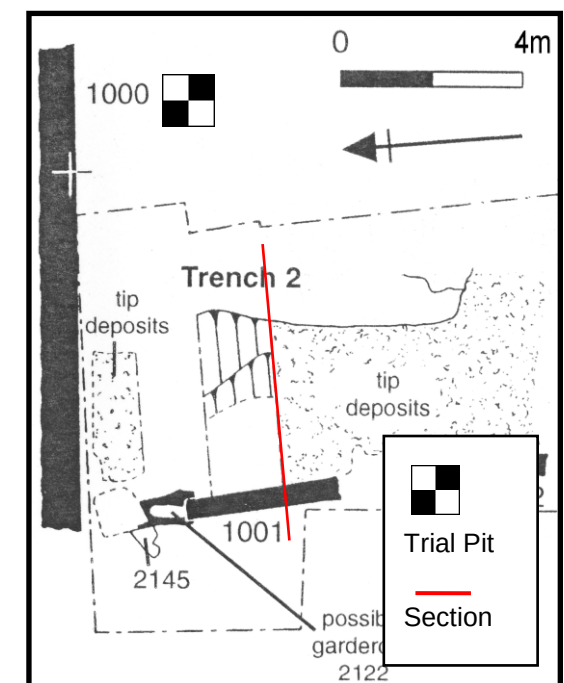
Figure 2.3: Redcliff Backs trial pit/section comparison.



b. Section log



d. Trial pit plan sketch.



e. Relative Section and trial pit locations.

30-38 Thomas Street

Development on Thomas Street started during the C12th or C13th. The land was split into tenements, each of which had land associated with it used for gardens, orchards and small-scale industrial activities. The Medieval layout of the site probably survived well into the post-Medieval period. At the beginning of the C18th a ‘glasshouse’ (a building in which glass was made) was constructed on the site, now recognised by English Heritage’s National Monument Protection Programme as being of national importance. The area was redeveloped in the 1880s with the development of a tobacco manufactory, which extended to cover the whole site by the early 1900s (Jackson, forthcoming).

Prior to development of residential housing on Thomas Street and the adjacent areas, an archaeological evaluation was carried out in 1999, consisting of the excavation of five evaluation trenches within the Thomas Street properties. During this work, the foundations of the C18th Glasshouse were partially uncovered. Excavation work was carried out in 2000 (Jackson, forthcoming). A limited programme of geotechnical works was undertaken through 1998 and 1999 at 30-38 Thomas Street and adjacent properties as the basis for a geotechnical desk study (rather than a full site investigation), during which a single borehole was drilled on the site of 30-38 Thomas Street by a geotechnical investigation company (Structural Soils Ltd.) sub-contracted to Hyder Consulting (Hyder Consulting, 2002). The records of other trial pits and boreholes were not available within the timeframe of this review; however the archaeologist observed that trial pits appeared to have been excavated in locations that suggested that the geotechnical investigation was focussed on looking for foundations (Jackson, pers. comm.).

There was no crossover between the archaeological excavations and the geotechnical works. The borehole record from Structural Soils Ltd. had been incorporated into Hyder Consulting’s report without notification as to whereabouts on the site of 30-38 Thomas Street the borehole had actually been drilled; nor was there any indication of heights aOD. However, as both the borehole and archaeological excavations were logged to surface, generalised comparisons about such things as recording of depth to natural could be made. The surface of the natural across the site was determined by the archaeologist to be on average about 7m aOD. Comparison of the archaeological sections across the site demonstrates that the ground surface is very flat and level, allowing heights aOD to be assigned to the borehole record. The borehole log records a transition from Made Ground to clay (alluvium) at approximately 7.8m aOD.

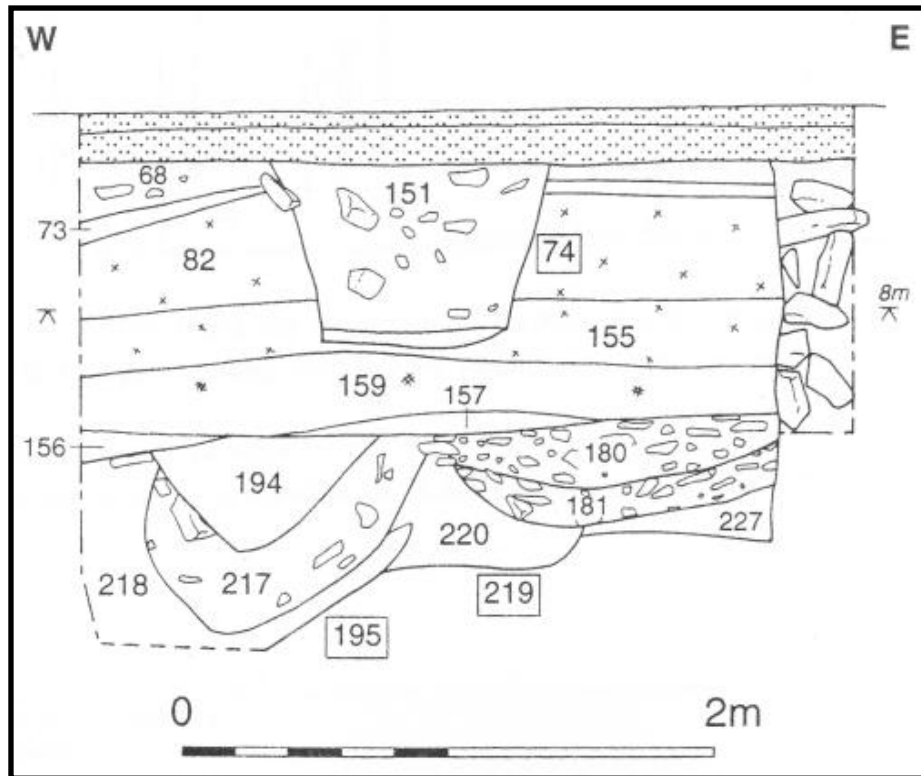


This implies that the geotechnical workers may have misinterpreted human influenced deposits of alluvium as natural alluvium.

It is interesting to note that, as observed with the two previous sites, distinctions between types of Made Ground have been made in the geotechnical logs, contrary to expectations. This is particularly interesting because while the previous two site geotechnical investigations were undertaken by the same company (Geotechnical Engineering Ltd.), this borehole was drilled by a different company, Structural Soils Ltd. It is also worth noting that their description of the Made Ground unit between 0.80 and 1.00m below ground level seems to be a good description of the garden soil (82).

It is not possible to draw any further conclusions due to the uncertainty of location of the Thomas Street borehole.





a. Section.

Description of Strata	Depth (Thick- ness)	Legend
MADE GROUND: Reinforced concrete	0.30	
MADE GROUND: Brown clayey sand with much fine to coarse gravel and cobbles of brick, concrete, clinker. Oily odour	(0.50) 0.80	
MADE GROUND: Firm dark brown slightly sandy clay with some fine to medium gravel of brick, concrete, sandstone and clinker. Oily odour Stiff grey becoming grey and brown mottled CLAY (Alluvium)	1.00 (1.80)	
Very soft grey and brown mottled CLAY/SILT (Alluvium)	2.80 (1.10)	
Soft to firm becoming firm grey CLAY (Alluvium)	3.90 (0.45) 4.35	
Soft becoming very soft grey CLAY/SILT (Alluvium)	(0.65) 5.00	
Very soft brown slightly sandy CLAY/SILT (Alluvium)		

c. Borehole log.

Context	Description
180, 181	Demolition rubble. Ditch fill.
157, 159	A clayey silt containing large quantities of Pennant sandstone roof tiles and other building debris.
155	A light brown slightly clayey loam containing small stones, oyster shells, animal bones, frequent flecks of charcoal, pottery sherds and clay pipes. A Garden Soil.
151	Drain fill.
82	A dark brown, heavily charcoal flecked loam containing small stones, pockets of a soft grey lime mortar, animal bone, oyster shell, large amounts of a lightweight clinker-like material, pottery sherds and clay pipes. A Garden Soil.
Below 195, 219, 227	A grey-brown silty clay containing charcoal flecks, occasional fragments of oyster and mussel shell, angular stone fragments, a few pottery sherds, bone fragments and small lumps of iron slag. Redeposited alluvium. Average thickness of 0.3m. OVERLYING A grey-brown silty clay loam containing at top (possibly a buried soil, welded) very occasional charcoal flecks, a few sherds of pottery and fragments of animal bone. An alluvial deposit.
217, 218, 220, 194	Pit fill.

b. Context descriptions.

Figure 2.4: Thomas Street borehole with typical section.



Part 3:

A Review of Geotechnical and Archaeological Records from the Dover Area



Background

This investigation was undertaken as part of an English Heritage funded project to examine the use of geotechnical data in archaeological projects. The selection of Dover (Figure 3.1) as an example area was determined due to the familiarity of one of the authors (MRB) with both the field geoarchaeological program as well as the archaeological investigations.

The majority of the information was collected as part of works undertaken in the Dover area, during the collection of archaeological information as part of a mitigation strategy during the construction of the new A20 Road and Sewer Scheme in Dover, in the early 1990's. A procedure of routine evaluation followed by mitigation was difficult to follow due to the nature of the urban topography and the short lead in time to the project. As a consequence of the many difficulties encountered a strategy for monitoring works and recording sub-surface stratigraphy was put in place that utilised:

1. historical borehole and archaeological section data. Sources were of variable quality due to the objectives of the investigations. This information provided an approximation of the distribution of key stratigraphic units that may be of archaeological significance, i.e. depth of Made Ground and depth to buried late glacial gravels.
2. geotechnical data collected as part of the advance ground investigation for the A20 works. This information provided an approximation of the distribution of key stratigraphic units that may be of archaeological significance, i.e. depth of Made Ground and depth to buried late glacial gravels.
3. purposive borehole data collected under the supervision of a geoarchaeologist. These data were gathered to provide detailed information on the nature of the sediments in advance of construction activity moving into given areas. Detailed information on the nature of the sediments, distribution of sediment bodies and locations of buried land surfaces were extracted from this information.
4. information collected from the excavated contexts by the Canterbury Archaeological Trust. In general, excavations were not conducted in advance of construction activity on this project due to the majority of the work taking place beneath roads and other amenities that were only closed when construction activity commenced. The majority of archaeological works were of therefore of watching brief standard.



Specifically, boreholes were used to examine the nature of the sub-surface stratigraphy in a rolling program in immediate advance of construction activity. The borehole information provided information on the nature and depths of the stratigraphy that was shortly to be impacted by the construction activity while also providing reasonably high quality samples for the impact area, where collection of continuous samples during the watching brief may have been difficult.



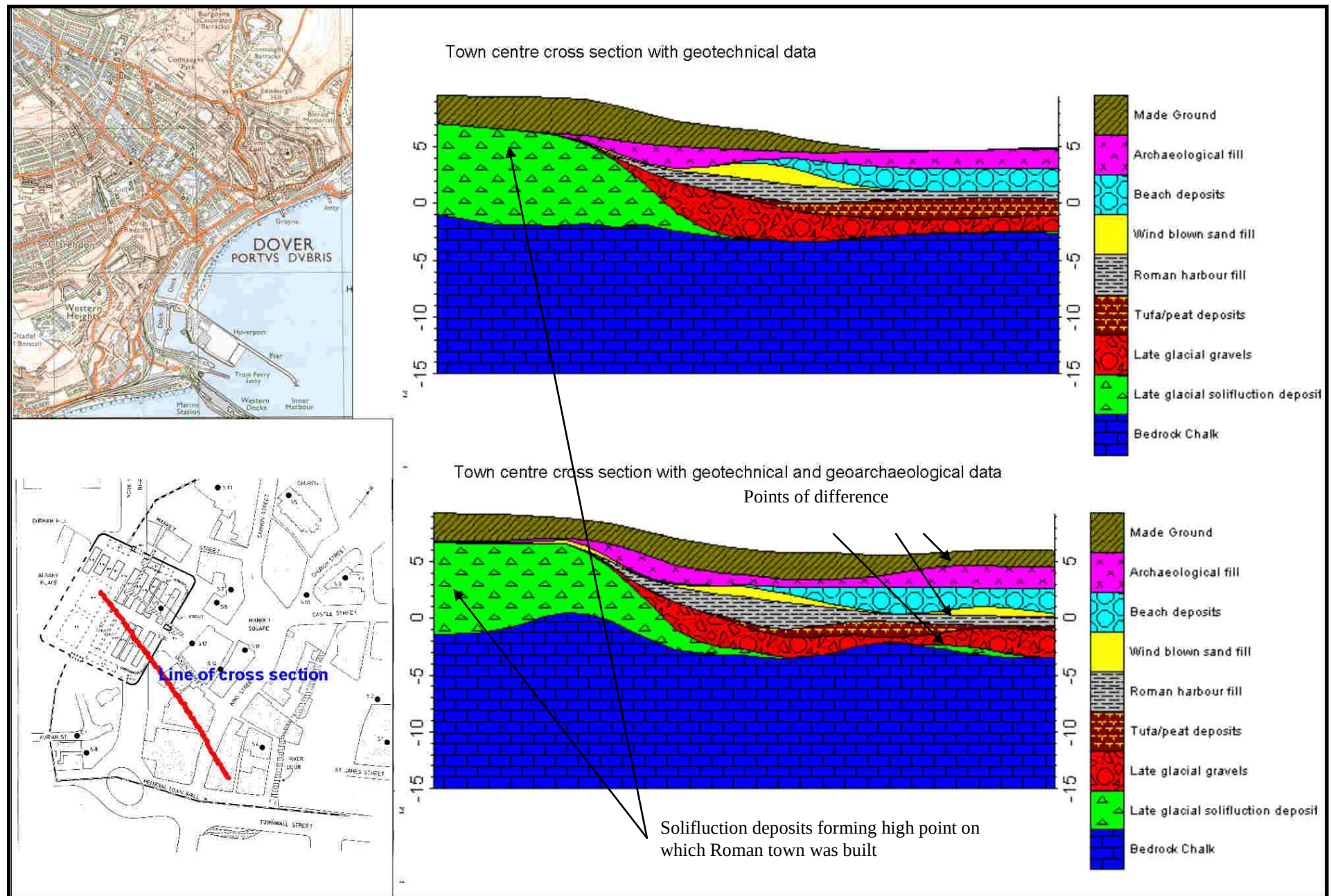


Figure 3.1: Site location plan, detail of Roman town centre and reconstructed sub-surface profiles.

Despite a considerable quantity of fieldwork being undertaken in the town centre area since the 1970's, a surprisingly small amount of well researched information has been published on the archaeology of the town centre area, with the exception of information on the Classis Britannica fort and the Painted House (Figure 3.1). The origins of the town can be traced back to the Roman period when the Roman navy established the principle base for the Classis Britannica on the edge of the harbour that underlies much of the modern centre of Dover. Later, after partial infilling of the harbour the Saxon Shore Fort was built out over reclaimed ground. Evidence of Saxon occupation is scarce although traces of late Saxon occupation were found at the Crypt site during the A20 works. Extensive Medieval occupation occurs across much of the modern town centre. Traces of prehistoric occupation are rare; however, the well publicised Dover Bronze Age Boat attests to occupation in the area since at least 3000 B.P.

Archaeological interventions in the town have been known since the 19th century and Mortimer Wheeler (in conjunction with a local archaeologist Mr Amos) produced an early summary of the archaeology of the Roman period in the 1920's. Considerable damage to the town infrastructure occurred during WW2 and extensive rebuilding programs during the 1950's allowed the Dover Excavation Committee to record elements of the archaeology. Rescue archaeology on the site of the Classis Britannica fort in the 1970's was undertaken by Brian Philp and most recently work by Oxford Archaeology and the Canterbury Archaeological Trust has provided information on the Medieval town.

As part of the Dover A20 project it was decided that geotechnical data could provide important information on depth to key stratigraphic horizons in advance of traditional archaeological interventions. Additionally, due to the urbanised nature of the area of impact, additional boreholes were to be logged by a geoarchaeological team to provide information suitable for alerting the archaeological team to the location and distribution of key horizons during construction. Consequently, as part of this investigation it was considered necessary that the nature of the geotechnical information used was considered in some detail and its limitations highlighted. It was recognised that although geotechnical data collected in advance of design and construction of roads, buildings and industrial developments (Clayton *et al.* 1995) may provide information suitable for deriving predictions relevant to the archaeological evaluation strategy of an alluvial area, there were limitations on such information.

The information considered was derived from borehole, geophysical and laboratory investigations obtained during the design stages of development.



These techniques can be targeted to record most sediment types encountered during archaeological works by geoscientists where recording criteria are designed to address research objectives. However, as most of the studies from which information is available are geotechnical ground investigation studies only geotechnically relevant data may be present and geoarchaeological, palaeoenvironmental or sedimentological information is only rarely available. The use of such information has previously been described (Barham and Bates 1994, Union Railways 1999; Bates et al., 2000).

When used as part of archaeological investigation strategies geotechnical information should be treated with caution (Barrett 1989; Arthur and Annels 1994) and re-interpretation of the logged data by geoarchaeologists, possessing a detailed knowledge of the local geology and geomorphology, is necessary to avoid erroneous conclusions being drawn regarding the archaeological significance of this data. Furthermore geotechnical investigations measure parameters that differ significantly from the parameters required by the geoarchaeologist and this information will vary in quality depending on the skill and training of the drillers in the field, the geotechnical brief, sampling design and time availability set by the engineers. Standard geotechnical borehole logs provide a data source that, taken in conjunction with i) other known stratigraphic data, ii) a knowledge of processes likely to have operated in the area and iii) a knowledge of geomorphological principles, can yield useful archaeologically predictive information (see for example Barham 1993 and Barham et al. 1995). Additionally it should be remembered that the process of investigation of an archaeological landscape is often driven by research led questions where individual geoarchaeologists will develop a working model that will influence sample locations, recording strategies and interpretation. This will differ significantly from the paradigms that geotechnical personnel will operate with.

If sufficient information is available within the geotechnical logs, whether collected by the geotechnical industry or practising geoarchaeologists, the information may be interrogated subsequently within an archaeological context in order to consider factors such as:

- Ë comparisons between surface and sub-surface stratigraphies (in terms of lithofacies/context characteristics).
- Ë definition of the processes responsible for forming the stratigraphy and, in particular, the likely positions and extent of buried surfaces.



- Ë definition of the vertical and lateral distribution of sub-surface contexts of potential archaeological and/or palaeoenvironmental significance, i.e. the three-dimensional extent and architectures of deposits lying at depth, together with the varying probabilities of past human activity/occupation occurring on the accumulating surfaces of the units as they were deposited.
- Ë specification of sub-surface conditions controlling the preservational status of contained features, contexts and artefacts, e.g. groundwater flux, seasonal variations in zones of saturation, pH, Eh and geochemistry of the sediment matrices at depth.
- Ë definition of ground conditions likely to impact on archaeological investigation strategies, including ground contamination, water table levels and related site safety evaluations for archaeological field teams.
- Ë modelling of the long-term impact of development on the buried archaeological resource.

However, because such data collection is driven by commercial requirements, it may have only restricted predictive value in archaeological terms. In such situations, preliminary models derived from engineering boreholes may be usefully supplemented by “purposive geoarchaeological boreholes” during a second phase of drilling investigation (Bates *et al.*, 2000).

It is now apparent that a wide range of levels of data recording can be encountered in sub-surface ground investigations. These can be divided into four major ‘levels’ at which data are recorded.

- Ë **Level 1.** This is the basic level at which recording may take place. Typically very basic levels of recording; in Dover sequences of deposits of potential archaeological significance were subdivided into tripartite sequences of Made Ground-Alluvium-River Gravels/Head above bedrock. This level of detail is primarily interpretive with little detailed information on the precise nature of the deposits.
- Ë **Level 2.** Level 2 records may contain detail of the nature of the subsurface stratigraphy where sediments such as peats, clay-silts, sands etc. are noted and recorded. The majority of the records held in geotechnical archives are of this standard.



- ☞ **Level 3.** Level 3 records contain a wealth of information where detailed notes of sediment structures, grain sizes, fossil content etc. may be supplemented by core photographic records. These types of survey are rarely undertaken except on major construction projects or where specifics of the ground conditions or construction project warrant detailed investigation. Competent drill crews may be instructed relatively quickly to record many of the additional properties required by Level 3 records.
- ☞ **Level 4.** Level 4 records are detailed records produced by geoarchaeological specialists where detailed background knowledge and an active interest in the area are likely to be background prerequisites to investigation. In this case levels of recording and the nature of information routinely noted may in part be driven by the research goal and model for the area held by the investigator.



Geotechnical borehole data and geoarchaeological recording: the Dover case

A review of a significant borehole data set from Dover was undertaken in order to examine the quality of data recovered under standard geotechnical conditions.

A number of points arose from the retrospective examination of the data:

1. The basic historical data available before the commencement of the A20 project was typically composed of Level 1 information (see Figure 3.1). The data allowed crude estimates to be made of Holocene sequence thickness through much of the area. Archaeological information from the area (collected mainly before 1950) indicated that complex sequences, including archaeological and ‘natural’ sequences, would be expected however, it was difficult to ascertain this complexity from the historical geotechnical data.
2. Construction geotechnical data for the A20 project only minimally advanced the level of knowledge from the historical data. Much of the information quality was of Level 1 grade. In places these data suggested the local presence of peats, sands etc. (see Appendix I, A20BH1, HC/BH10).
3. The geoarchaeological investigation of the area through purposive boreholes provides an illustration of the considerably higher levels of data recovery that may be obtained. Prior to commencing drilling and recording all drill crews were briefed regarding the objectives of the site investigation, the types of material likely to be encountered (peats, tufas, laminated organic silts etc.) and the potential interpretation and significance of the results. The logs presented here (TW/BH5, TWS/BH5g and DBS/BH3, DBS/BH3g – see also Figure 3.1 and Figure 3.2), indicated that the drill crews were capable of providing very detailed records; similar levels of information being noted in those logs produced by the geoarchaeologist monitoring drilling. The resulting logs were of Level 3 status for both. Level 4 recording was only achieved by the geoarchaeological team when laboratory descriptions were integrated with the field notes.
4. A high degree of information regarding the nature of the ‘natural’ sediments associated with the Roman harbour, the Prehistoric environments and the Saxon contexts was achieved by both the geoarchaeological and geotechnical teams.



5. Archaeological excavations indicated that the nature of the archaeological units varied considerably across space. Considerable complexity was noted in the sequences. Little of the detail of the archaeological contexts (commonly recorded as 'Fill') were noted by either drill crews or geoarchaeologists. This is primarily a function of the coarse grained nature of the sediments that make U4 recovery difficult. Consequently, many of these deposits are being sampled either in an open clay cutter or disturbed in a bailer. The results are that the sediments are mixed and difficult to resolve.
6. Criteria have been identified that when explained to drill crews significantly added to the information available for geoarchaeological interpretation. These criteria include trends in grain size, patterns of mottling, zones of rooting, the nature of sub-fossil assemblages, the presence of archaeological material (i.e. pottery, brick debris etc.) and the nature of contacts between individual units.



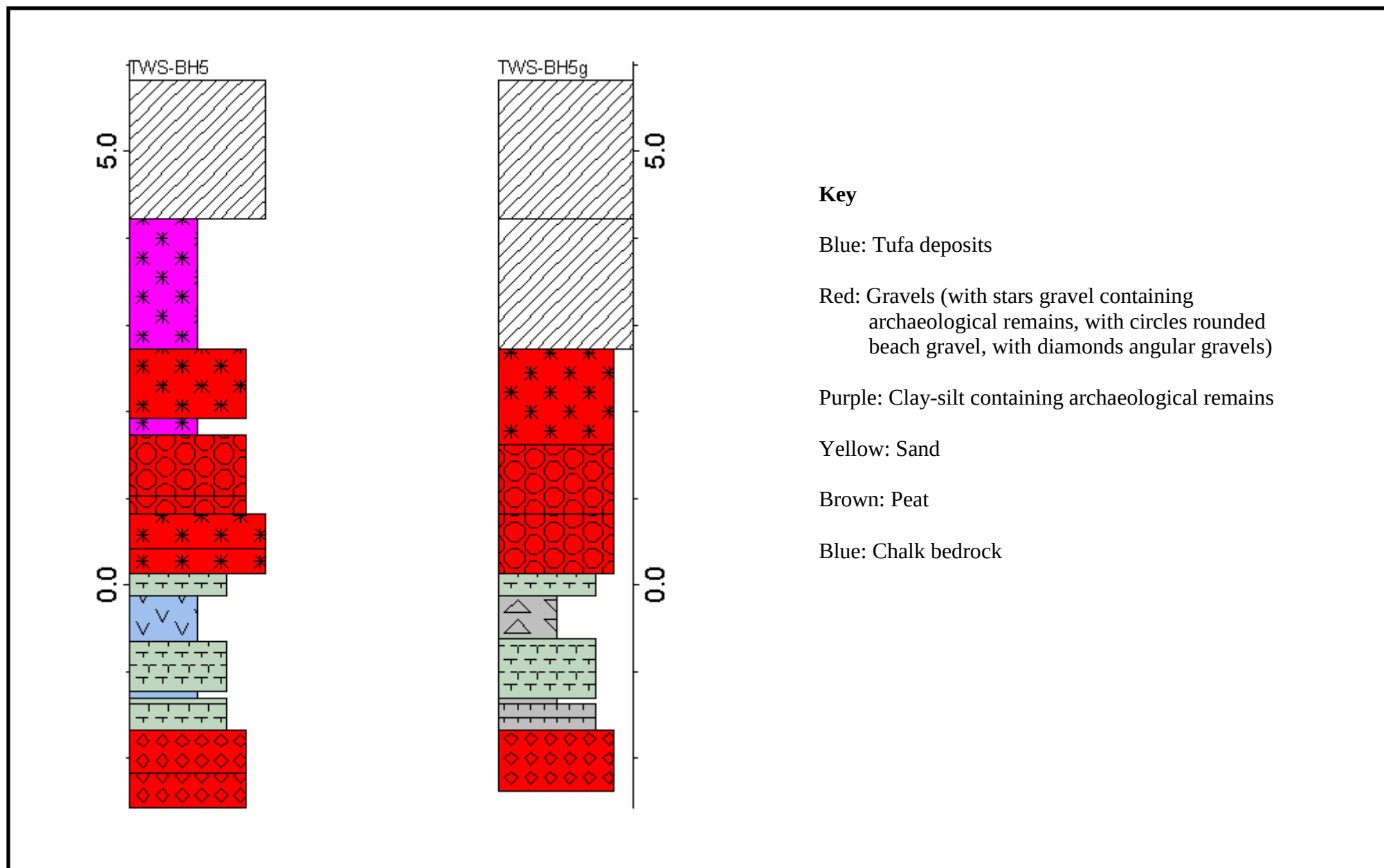


Figure 3.2: Comparison of stratigraphy from a borehole in central Dover recorded by geoarchaeologists (TWS-BH5) and the geotechnical industry (TWS-BH5g).



Russell Street

This site lies in the centre of Dover and covers approximately 0.8Ha close to the foot of Castle Hill. The site was excavated by the Oxford Archaeological Unit in 1990. Previous work indicated that the site lay within the projected boundary of the Roman harbour and the 1860 Ordnance Survey plan indicated that streets and property boundaries within the area may have dated back to the Medieval period. Elsewhere in Dover centre, similar sites had produced evidence for a complex Medieval stratigraphy overlying the predominantly unexplored levels below the ground water table.

Archaeological investigation was preceded by a geotechnical ground investigation. The six boreholes drilled (see Figure 3.4) indicated that the bedrock, Chalk, was likely to be encountered at -20m aOD and this was overlain by 8-9m of chalk rubble (probably of soliflucted origin). Angular flint gravels up to 8m thick in places predominantly extended across the lower chalk rich deposits and Made Ground capped the site (up to 3.7m thick). No significant evidence for extensive Roman Harbour fill deposits were encountered, although the presence of peat was noted in one place.

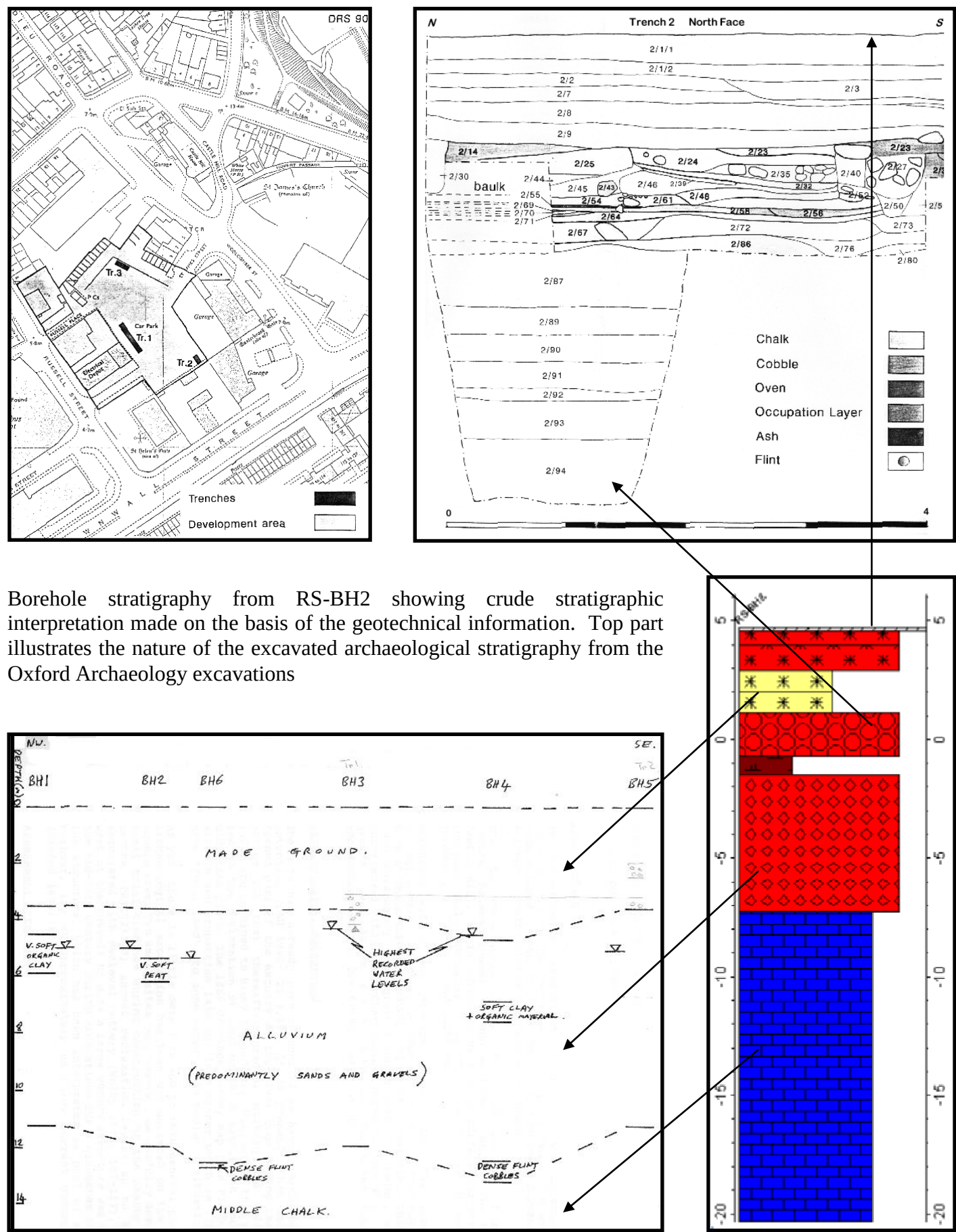
Depth below ground surface	Stratigraphic description	Inferred environment of deposition (geoarchaeological)	Geotechnical classification
0.00 – 0.15	Flexible surfacing.	Modern Car Park surface	Made Ground
0.15 – 0.70	Brown sandy brick rubble.	Surface make up	Made Ground
0.70 – 1.80	Soft grey sandy silty clay containing some coarse flint gravel brick and chalk fragments.	Levelling dumps and some archaeology?	Made Ground
1.80 – 2.70	Loose grey clayey very silty sand containing some flint gravel and occasional pockets of light brown sandy clayey silt with some chalk fragments.	Archaeological horizons?	Made Ground
2.70 – 3.60	Loose light brown sand containing some gravel, occasional chalk fragments and very occasional pockets of dark grey brown silt very sandy clay.	Fluvial or shallow brackish water. Late Holocene	Made Ground
3.60 – 5.40	Loose grey brown sandy gravel containing some chalk fragments.	Fluvial or marine medium to high energy channel/sub-channel situations. Middle Holocene	Alluvium – recent
5.40 – 6.20	Very soft dark grey silty amorphous granular peat with some pockets of fibrous peat and fine chalk particles.	Low energy wetland with tufa formation in shallow pools. Temperate Holocene	Alluvium – recent t
6.20 – 10.00	Loose grey sandy gravel with some chalk fragments. Becomes light brown and grey silt depth. More chalk appears towards base of unit.	High energy fluvial under cold climate periglacial conditions. Late Pleistocene	Alluvium – recent
10.00 – 11.95	Dense light brown and grey clayey sand gravel with some chalk fragments.	High energy fluvial with eroded chalk – cold climate periglacial. Late Pleistocene	Alluvium – recent
11.95 – 23.00	Medium firm to firm rubbly partly weathered white chalk with some remoulded chalk.	Bedrock (weathered)	Middle Chalk – Cretaceous

Figure 3.3: Comparison of geotechnical and archaeological deposit descriptions.



Geotechnical subdivision of the borehole suggested the presence of a relatively simple tripartite subdivision into Made Ground, Recent Alluvium and Bedrock Chalk (see Figure 3.3). However, despite this apparent simplicity considerably more information was included in the drillers' logs than was used in the geotechnical interpretation and a geoarchaeological interpretation indicated that a considerably more complex stratigraphy was present with a range of environments of deposition and archaeological horizons present. From an archaeological perspective the Made Ground was considered to be of potential interest and it was noted to consist of concrete overlying soft to firm sandy gravely clasts, clayey chalk, loose gravely sands with fragments of brick, concrete, wood and ash. Of particular significance was borehole 2 located immediately to the north of Trench 2 (see Figure 3.4) where 3.6m of Made Ground had been recorded.





Borehole stratigraphy from RS-BH2 showing crude stratigraphic interpretation made on the basis of the geotechnical information. Top part illustrates the nature of the excavated archaeological stratigraphy from the Oxford Archaeology excavations

Figure 3.4: Russell Street (for key see Figure 3.2).



Information from the OA excavation suggested that true recent build-up (Made Ground) extended to a depth of 0.8-1.0m, below which lay up to a metre of thin chalk and cobble surfaces in the form of low chalk walls and occupation surfaces. Within the borehole logs (taken beyond the limit of the trench) these occupation horizons appear to most closely resemble the deposits between 0.7m and 2.7m depth. In this case the apparent reason for classification of these sediments as Made Ground appears to be based on the 'dirty' or mixed up nature of the sediments.

From this it is clear that the uppermost archaeological horizons within the site were represented in the borehole records by the presence of chalk clasts etc. in the stratigraphy. All evidence for stratification, presence of walls, floors etc. was destroyed by the drilling process and not recorded by the drillers. However, in this case the possible presence of archaeological horizons near the surface was considered likely by the geoarchaeologists investigating the archive borehole data.



Crypt site

This site lay along the line of the pathway of the sewer scheme. The site was available for investigation in advance of the construction program due to the fact that a major fire on the site of a former restaurant had led to the destruction of the building well in advance of construction. The site lay within the known core of the Medieval town as well as immediately beyond the limits of the known Roman town.

Depth from	Depth to	Stratigraphic description (borehole DSC-BH2)
0.2	1.78	Flint/chalk/archaeology/silt/clay
1.78	3.2	Sandy gravel
3.2	4.3	Sand/flint gravel
4.3	4.7	Sand/flint gravel
4.7	4.9	Sand
4.9	4.94	Sand
4.94	5.03	Peat
5.03	5.1	Sand organics
5.1	5.16	Sand organics
5.16	6.1	Silt organics
6.1	6.17	Sand organics
6.17	6.89	Clay silt organics
6.89	7.01	Pellet tufa
7.01	7.12	Peat
7.12	7.3	Pellet tufa
7.3	7.78	Clay silt organics
7.78	8	Angular flint gravel

Depth from	Depth to	Stratigraphic description (borehole A20-BH1)
0	0.05	Fill
0.05	2	Flint gravel
2	3	Flint gravel
3	6	Rounded flint gravel
6	6.3	Peat
6.3	9.2	Angular flint gravel
9.2	11	Chalk

Figure 3.5: Stratigraphic description (borehole A20-BH1).

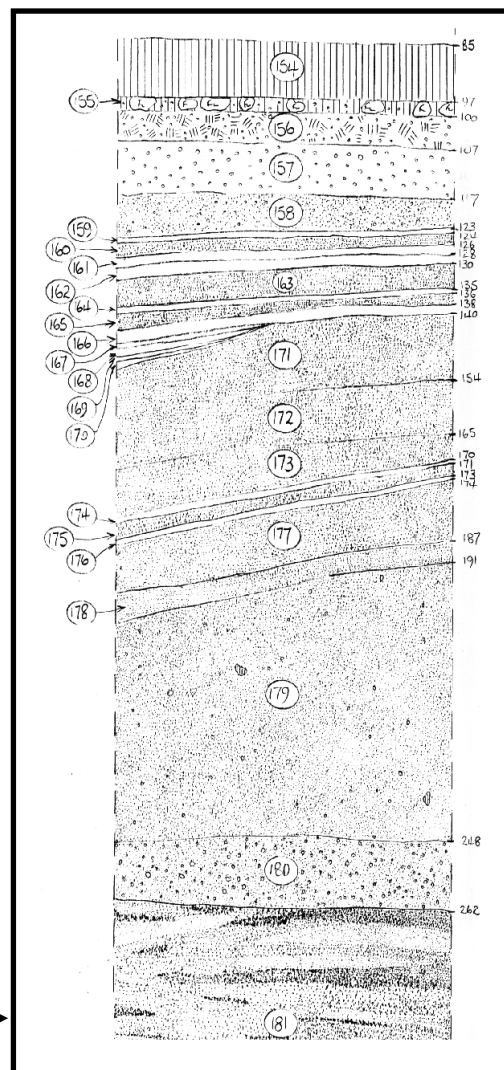
Figure 3.6: Stratigraphic description (borehole DSC-BH2).

The evidence from the borehole drilled as part of the A20 works prior to archaeological investigation provided a very simple stratigraphy dominated by material recorded as gravels but with a thin seam of peat between 6 and 6.3m depth (see Figure 3.5). Comparison with the borehole drilled as part of the site works and the archaeological trenching is difficult because the geotechnical log is located some 20m to the south of the trench. The stratigraphies indicate that while the basic pattern of gravel/alluvium/gravel is present in both, considerable additional information is present in the geoarchaeological borehole. Of greater significance is the comparison between the archaeological sections and the geoarchaeological borehole (see Figure 3.6 and Figure 3.7). Despite close supervision of the drill crew and careful observation of the sediments removed during drilling, the geoarchaeological logs can be seen to be very crude when compared to the excavated sections.



In both illustrations of sections from the immediate vicinity of the borehole it is clear that the stratigraphy is very complex with very close interval horizontal bands of sand and gravel or interstratified layers and pits. This complexity of stratigraphic sequence was not observed during the drilling because the process of the shell and auger drilling method through sediments rich in coarse, clastic material is destructive, and retrieval of undisturbed U4 samples is impossible.





Borehole DSC-BH2 and logged section from Dover Crypt site showing possible correlations.

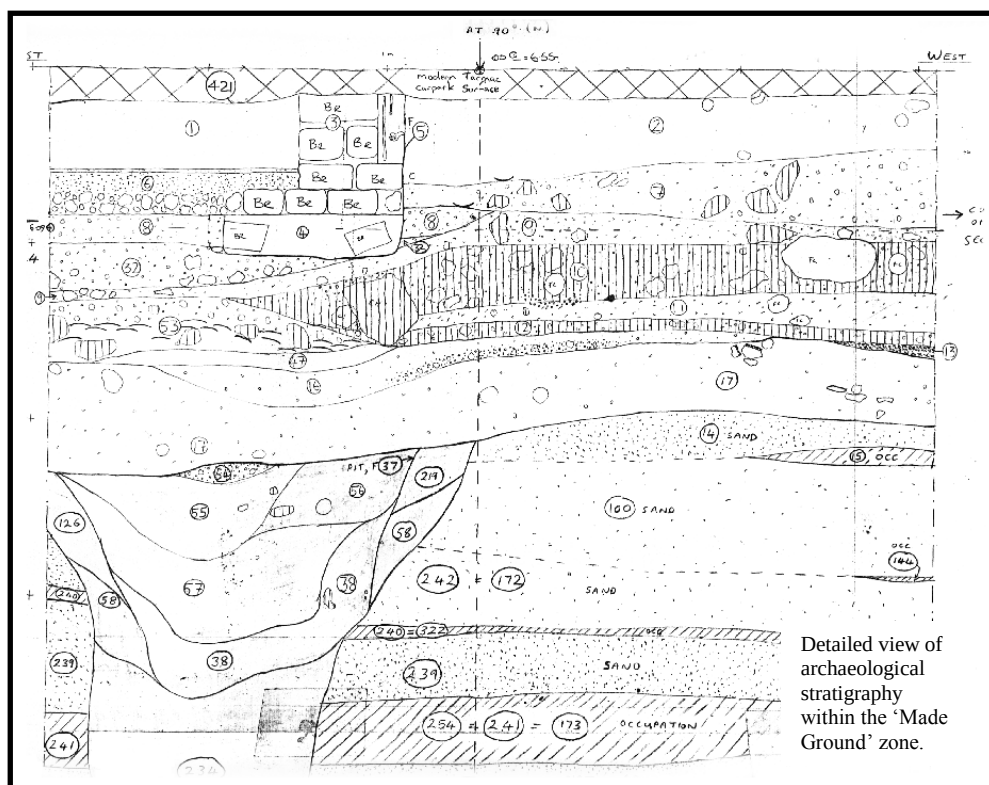
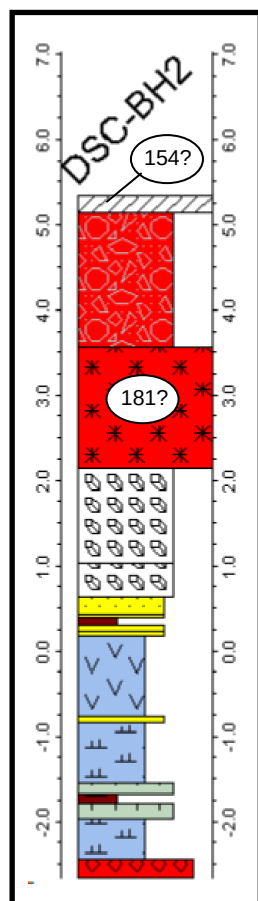


Figure 3.7: Dover Crypt site location and examples of site stratigraphy.

Dover town centre cross sections

A further example of the comparison between geotechnical data and geotechnical data augmented by geoarchaeological information is provided in the two generalised cross sections through the town centre area (see Figure 3.1). Both profiles were generated by the Rockworks software (see Appendix II) from the correlated stratigraphies interpolated between identical end points in the town centre area.

The immediate impression is that both sections appear very similar with the major stratigraphic units clearly present in both illustrations. However, the evidence indicates that local details have been modified as a result of the observations added through the geoarchaeological observations.



Part 4:

Discussion



Discussion

It has emerged from the consideration of these sites that geotechnical workers are actually recording much data that could be of use to archaeologists. These include:

- depth to 'natural' on site.
- interfaces within the made ground, most often distinguished by type of inclusion (thus allowing the distinction at least between 'modern' Made Ground, containing for example plastic bags, and 'old' Made Ground). The fact that two separate companies are routinely recording Made Ground distinctions in Bristol implies that this may be common practice in the geotechnical industry. Both companies commonly work in the archaeologically rich city of Bristol so may not be representative of geotechnical companies nationwide, but if they are doing this type of recording without the urging of archaeologists, then this implies such recording is driven by clients' requirements.
- notes about the presence of inclusions and a brief description of their nature.
- the depth of concrete above the Made Ground.
- annotated sketches of obstructions such as foundations encountered in geotechnical trial pits. Most of the trial pit logs contained annotated sketches of any significant features that were encountered during excavation (see
- Figure 4.1). Although for the sites reviewed most of the trial pits were in positions of little interest to the archaeologist, on sites where foundations or other features are unexpectedly encountered in trial pits these sketches could give archaeologists at least a basic idea of what they might be looking at and if it might be worth investigating further.



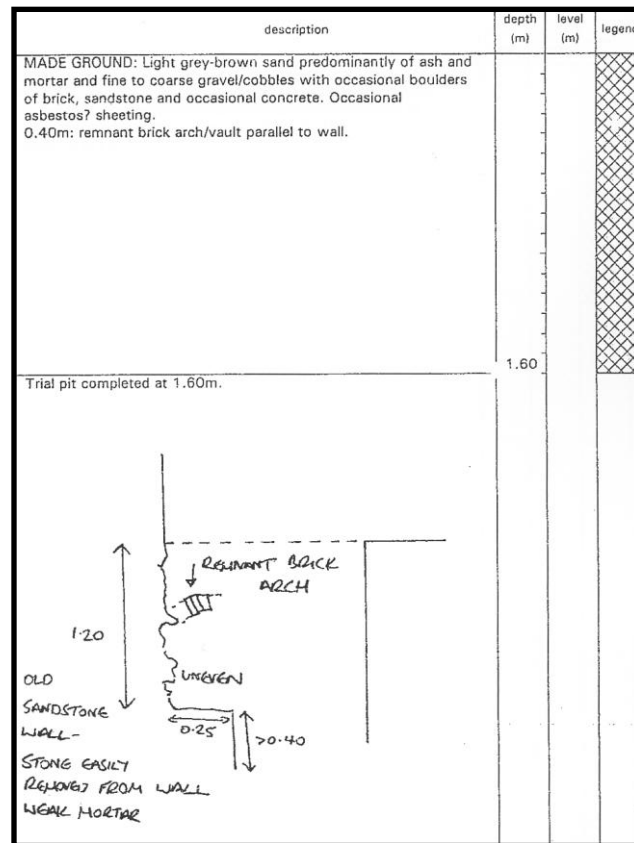


Figure 4.1: Trial pit log and associated sketch (from 98-103 Redcliff Street).

Additionally, the archaeologist can derive:

- ☞ the slope of the natural (but *only* where heights relative to a datum are given in geotechnical logs).
- ☞ the thickness of the part of the ground that might contain archaeology (a useful guide to approximate volume of excavation, which would help to predict costs).

There are certain unavoidable problems with using geotechnical data in archaeology that are caused by the nature of geotechnical investigations. Even in more complex sites where more detailed geotechnical investigations are undertaken, there will always be a relative paucity of information compared to the coverage of archaeological data.

From the review of the boreholes from Dover, it is particularly apparent that however well logged boreholes are, and however carefully U4/U100 samples are taken, the process of cable percussion/shell and auger drilling within coarse grained sediments is unavoidably destructive. However, there are some problems with geotechnical data that *could* be remedied.

It is obvious that a lot of useful and easily recorded information is missed, such as:

- ✘ the location of most interfaces within the made ground. We know from photographic evidence from the archaeological investigations (Insole, 2001) that although not all interfaces that were not noted by the geotechnical workers were clear, some could easily be distinguished by sharp changes in colour and/or texture, for example.
- ✘ although a list of inclusions was provided in the borehole logs, they were assigned to no particular depth. Even gross vertical variations in the nature of inclusions can give valuable information, not only to the archaeologists but also to the geotechnical workers, as demonstrated by the failure to recognise the cellar floor at Redcliff Street.

In addition to the waste of unrecorded data, there are more serious problems with the standard way in which geotechnical records are made.

- ✘ Heights above Ordinance Datum (aOD) are commonly not recorded on the geotechnical logs.
- ✘ In the above case, it is usual that neither relative heights (borehole to borehole) nor even an arbitrary datum established.
- ✘ Borehole and trial pit co-ordinates are almost never recorded on geotechnical logs, but must be approximated from paper site plans.

When archaeological excavations are not logged to surface and contain only heights aOD, archaeological excavations and geotechnical logs cannot be correlated. This is a problem not just for this study, but also for current urban archaeological databases (UAD's) and sites and monuments records (SMR's), and for archaeological databases that might be compiled in the future to aid the planning of both geotechnical and archaeological investigations. The lack of accurate co-ordinates can be crucial when dealing with an archaeologically complex site which can easily have very different characteristics only metres apart, and deriving the locations from paper plans assumes that the boreholes/trial pits were accurately surveyed in to begin with. It is worth noting that it is actually a requirement of BS5930: 1999 that both heights aOD and co-ordinates are recorded during geotechnical investigations.



The sites discussed here show that there are several needs on the part of archaeologists that could easily met by those in the geotechnical industry. Archaeologists need:

- Ë recorded heights aOD.
- Ë *accurately* recorded co-ordinates.
- Ë increased resolution of core recording, i.e. the accurate recording of boundaries that are close together rather than an ‘average’ boundary location which effectively ‘removes’ narrow layers from the log. If this is not possible because the disturbance of cores is so great that narrow layers cannot be seen, or boundaries are churned up and their original form cannot be observed, then this uncertainty needs to be noted on the borehole logs. Even a small increase in log detail would make a great difference to archaeologists, especially if it was consistent.
- Ë more detailed recording of inclusions; their type, concentration, nature (i.e. if the inclusions are ‘construction debris’, what kind of debris – brick, concrete, mortar or other? If ‘brick rubble’ is found, what kind of bricks are represented, and in what condition – intact, naturally eroded, worked?). Most useful would be a specific indication of ‘modern’ inclusions (e.g. plastic). Geotechnical logs need to indicate vertical changes in the nature or concentration of inclusions *within* the made ground, if not using these variations to define individual Made Ground units, rather than just listing every inclusion category detected at the top of the log for that unit.
- Ë recording of colour changes.
- Ë consistent recording of interfaces within made ground and notation on the type of interface (gradual, sharp; defined by a change in colour or texture, for example).
- Ë better discrimination between Made Ground and natural, especially in the case of alluvium – is the alluvial layer laminated and undisturbed, or churned and possibly redeposited? If the geotechnical worker is unsure, this should be noted to avoid misleadingly confident reports. This review has illustrated quite clearly that geotechnical workers are capable of producing very detailed logs, so our aim of improved recording as standard is achievable.

Archaeologists also have a part to play in encouraging better geotechnical recording. Currently there is little cooperation between site archaeological investigators and geotechnical workers. Often mutual planning of works is not possible because geotechnical investigations are often undertaken long before archaeological excavation, but in cases such as Redcliff Street where the geotechnical investigation took place between the archaeological evaluation and excavation there was a missed opportunity for more co-operation, in the placing of trial pits and trenches for example, to the benefit of both parties, and more importantly, the client.



There is obviously a limit on how much influence either the archaeologist or geotechnical team can have on the planning process, as it is ultimately under the control of the client or the client's representative. However, if the geotechnical team and archaeologists are aware of each other and communicate, plans for combining works can be suggested to the client, who will be much more likely to agree to such a thing if the benefits have been made obvious.

These reviews have demonstrated that although there are indeed problems with geotechnical recording, certain assumptions, such as 'geotechnical records don't discriminate in Made Ground', are not always borne out. From the Bristol case, we can see that geotechnical workers are already recognising these differences and attempting to record them, and when geotechnical workers were briefed in advance of drilling on the Dover A20 project, they were able to significantly improve the amount of information available for geoarchaeological interpretation. This bodes well for both their attitude to undertaking archaeological recording and their ability to do so (note also the description of the Garden Soil in the Thomas Street borehole log, Bristol). What is obvious is that there is no standard way of recording these discriminations, and each geotechnical worker has an individual way of doing it, and it is certainly true that even when geotechnical data is potentially useful, lack of standardisation presents problems when comparing sites investigated by different geotechnical companies, or trying to collate regional geotechnical data.

The discrimination of different and distinct 'levels' of data recording within both the geotechnical and archaeological professions provides an excellent basis for the criteria development stage of the Geotechnical Recording and Archaeology project (task 4). They will aid the determination of precisely what improvements in geotechnical recording are required, and what specific benefits these improvements will provide for workers in both professions. These reviews also demonstrate that the improvement of geotechnical recording practice is a realistic and achievable goal.



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Appendix I: Borehole Logs - Dover A20 Project.

Borehole number	A20/BH1	Grid reference	
		Ordnance datum	6.37
Depth below ground surface	Description	Unit Number	
0.0-0.05	Paving stone		
0.05-2.0	Loose, becoming medium dense, dark grey-brown, silty, sand and gravel – comprising brick, chalk, concrete, flint, ash and tarmac. (Fill)		
2.0-3.0	Medium dense, greyish-brown rounded and sub-rounded slightly clayey silty sandy, fine, medium and occasionally coarse gravel. (Fill)		
3.0-6.0	Medium dense, becoming loose, rounded and sub-rounded, slightly sandy, becoming sandy fine medium and occasionally coarse gravel. Occasional cobbles (Marine Alluvium)		
6.0-6.3	Loose/soft medium and coarse chalk gravel with black organic peat. (Alluvium)		
6.3-9.2	Loose, becoming dense fine medium and occasionally coarse, highly weathered chalk and flint gravel with some black organic peat and light brown clayey silt, becoming less gravelly with depth.		
9.2-11.0	White, medium hard to hard jointed CHALK, joints generally closed and >100mm. Apart. (MIDDLE CHALK)		

Borehole number	TWS/BH5	Grid reference	
		Ordnance datum	5.827m
Depth below ground surface	Description	Unit Number	
0.00-1.60	Excavated pit-FILL		
1.60-3.10	Dark grey sandy silt with flint, chalk, brick, tile etc.		
3.10-3.90	Moderately well rounded flint gravel with tile and brick fragments (sub-angular). Clasts are well-rounded, 2-6cms. There is very little matrix. Where it is present it consists of green-brown sand		
3.90-4.10	Large greensand blocks-angular.		
4.10-4.80	Moderately well rounded flint gravel. Poorly sorted (1-6cms) with some very large clasts (+6cms) of greensand. Matrix-grey/brown coarse flinty sand. Becomes sandier with depth.		
4.50-4.80-5.00	Well rounded flint gravel with angular greensand blocks and occasional slate fragments. Matrix consists of rose sand.		
5.00-5.40	Dark grey sandy gravel. Matrix comprises grey sand (coarse) with flint chips. Clasts are well rounded and poorly sorted (<10cms). Frequent shell fragments.		
5.40-5.70	As above and rounded clasts of armoured silt. Small flint chips and chalk fragments on outside. Clasts consist of mid-grey, to brown silt in places, possibly organic		
5.70-5.95	Moderately well sorted tufa pellet gravel (<1cm) with rare to well rounded flint clasts (<4cms). Frequent shell and organic (roots?) present.		
5.95-6.48	Dark brown, moderately compact, organic rich silt. Frequent root/stem fragments. Fibrous and homogenous.		
6.48-6.48-7.05	Large pieces of wood and shell present. Tufa pellet gravel with patches of organic rich silt containing roots. Tufa appears rooted by vegetation. In situ? Loose, unconsolidated.		
7.05-7.13	Dark brown silt with frequent organic fragments- roots/stems, shell and CaCO ₃ (tufa?) fragments. Compact and structureless. Tufa percentage increases towards the base		
7.13-7.20	Tufa pellet gravel with brown organic silty matrix. Roots present. Dry and structureless.		
7.20-7.50	Coarse tufa pellet gravel (clast<5cms). Occasional angular flint clasts.		
7.50-8.00	Coarse, angular flint gravel (<2 to +6cms) - poorly sorted. Matrix of tufa pellets (<1cms).		
8.00-8.40	Coarse, angular flint gravel.		
	BASE OF BOREHOLE AT 8.4m (-2.573m0.D.)		



Borehole number		TWS/BH5g	Grid reference		
			Ordnance datum	5.827m	
Depth below ground surface	Description				Unit Number
0.00-1.60	Pit				
1.60-3.10	Fill- brick, small medium rounded and angular stones, chalk, dark grey clay.				
3.10-4.20	Gravel, brick, small medium rounded and angular stones, coarse sand. As above and green sand stone.				
4.20-5.00	Black flints, gravel- small medium rounded and angular. Fragments green sand stone, shells. Gravel black flints – small medium and large rounded and angular, coarse gravel, shells				
5.00-5.70	Gravel black/light grey, small medium and large rounded and angular, fine/coarse cohesive sand clay.				
5.70-5.95	Tufa pellet gravel				
5.95-6.45	Peat, organic matter, reeds, roots, wood, shells				
6.45-7.13	Tufa pellet gravel				
7.13-7.20	Tufa pellet gravel, organic matter. Cuttings Lost sample				
7.20-7.50	Black flint, small medium and large angular, chalk pellets				
7.50-8.20	Coarse gravel				
	END OF BOREHOLE				

Borehole number		HC/BH 10	Grid reference		
			Ordnance datum		6.4m
Depth below ground surface	Description				Unit Number
0.00-1.30	Fill-tarmac and concrete.				
1.30-2.90	Fill-dirty grey sandy soil with chalk, flints, and brick.				
2.90-3.80	Dirty grey brown sandy soil with flints.				
3.80-5.30	Firm pale grey and brown mottled clay with occasional flint and chalk.				
5.30-14.10	Dense flint gravel with cobbles, some grey sand and occasional nodule of hard chalk.				
-10.20	Stiff buff chalky clay binding with numerous modules of hard chalk and occasional flint.				
-12.50	Pocket of fine gravel with flint cobbles.				
14.10-	Chalk bed-rock.				



Borehole number	DBS/BH3	Grid reference	
		Ordinance datum	5.81
Depth below ground surface	Description		Unit Number
0.00-2.95	Fill		
2.95-4.00	Orange-brown medium/coarse sand with very well rounded flint pebbles (2-3cms) and occasional sub-angular flints. Gravel becomes coarser with depth (3-12cms) and occasional brick/tile fragments occur.		
4.00-4.75	Silty sand with organic fragments, molluscs and occasional flint clasts. Moderately compact. Calcareous in places. Stratified.		
4.75-4.77/4.92	10YR 4/2 dark greyish brown medium to fine quartz sand with coarse sand sized chalk grains. High water content. Present distribution likely to be due to disruption during of after coring due to the high water content of the core as a whole.		
	---SHARP CONTACT---		
4.77/4.92-4.94	10YR 3/1 very dark grey sandy silt with rare sub-rounded chalk clasts up to 5mm mean diameter and charcoal fragments.		
	---DIFFUSE CONTACT---		
4.94-5.09m	2.5 Y 4/1 dark grey silt with fine sand intermixed with N4/dark grey fine to medium sand. Occasional sub-rounded flint clast up to 10mm mean diameter.		
	---SHARP CONTACT---		
5.09-5.26	2.5Y 4/1 dark grey fine silt matrix within a flint pebble gravels with clefts sub-rounded up to 30mm mean diameter. Sub-rounded chalk clasts up to 5mm mean diameter also visible.		
5.26-5.30	2.5 4/1 dark grey medium quartz sand with rare sub-angular flint clasts up to 5mm mean diameter. Large wood fragment at 5.26m.		
	---SHARP CONTACT---		
5.30-5.40	2.5Y 4/2 dark greyish brown fine silt with 2.5 5/2 greyish brown coarse silt laminations. Frequent woody organic and charcoal fragments visible.		
	---SHARP CONTACT---		
5.40-5.41	2.5Y 4/2 dark greyish brown fine tufa sand with woody fragments.		
	---SHARP CONTACT---		
5.41-5.51	2.5Y 4/2 dark greyish brown fine silt with some fine sandy silt discontinuous lamina. Contains rare woody fragments and charcoal.		
	---SHARP CONTACT---		
5.51-5.60	2.5 4/2 dark greyish brown thinly bedded medium tufa sand with some ceramic building material, sub-angular flint clasts and sub/rounded chalk clasts up to 4mm. Followed by a thinly bedded 2.5Y 5/2 greyish brown fine sand and 2.5 4/2 dark greyish brown fine silts with some sand. Also contains woody and charcoal fragments.		
	---SHARP CONTACT---		
5.60-5.64m	10YR 3/2 very dark greyish brown fine silt with laminations of 10YR 4/1 dark grey fine silt.		
	---SHARP CONTACT---		
5.64-5.70	2.5Y 3/2 very dark greyish brown medium silt with fine beds of 2.5Y 5/1 grey fine tufa sand. Rich in woody organics with some charcoal.		
5.85-6.12	Fine laminated 10YR 3/2 very dark greyish brown and 2.5Y 4/1 dark		



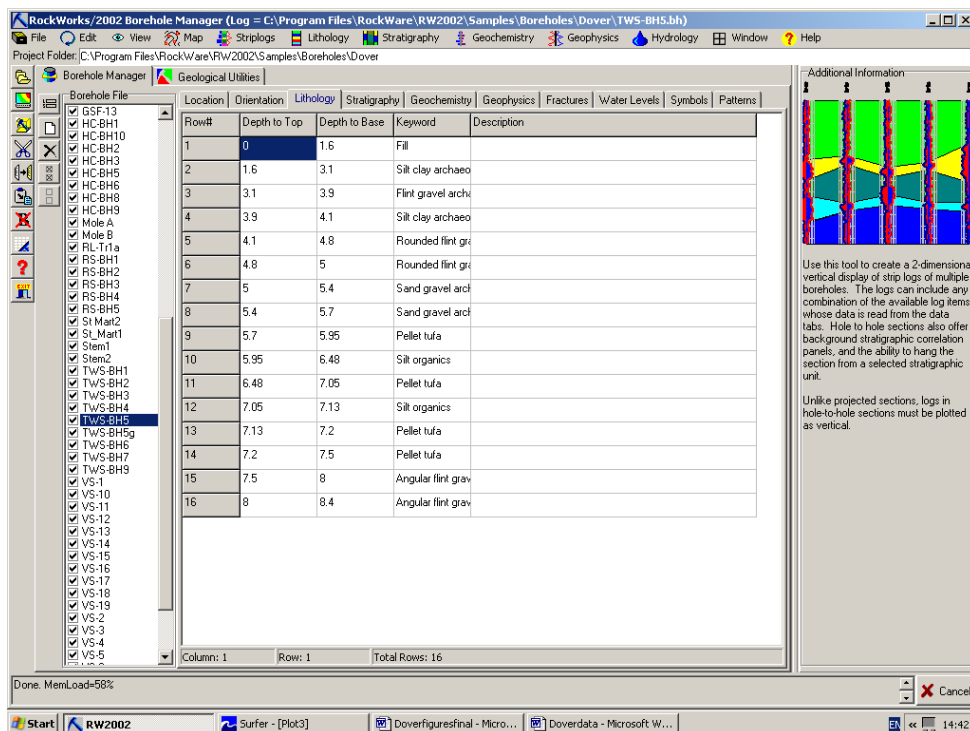
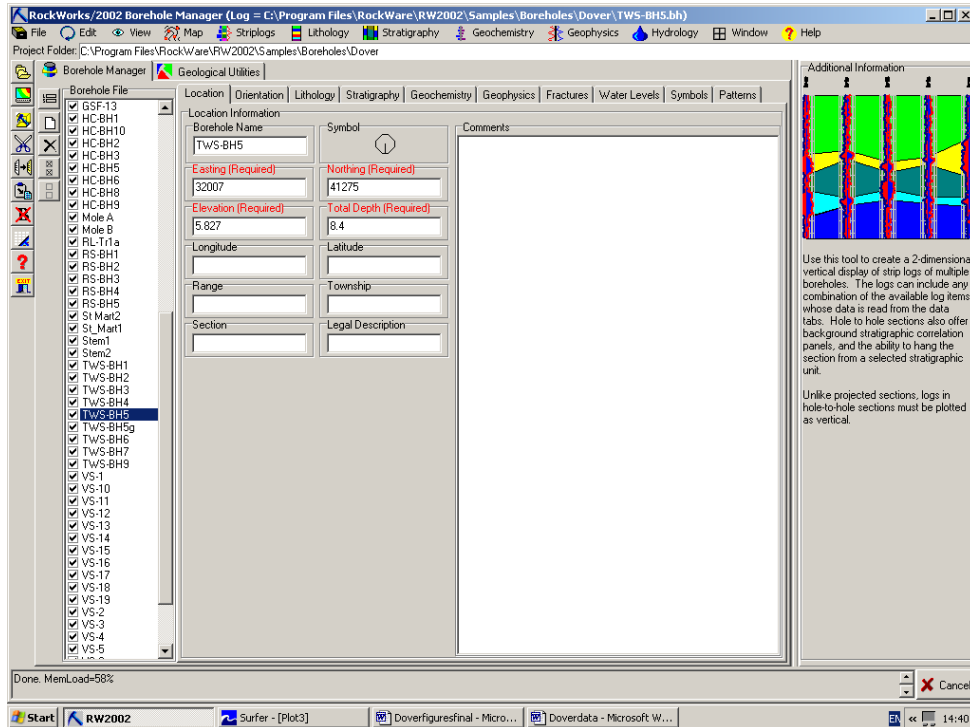
	grey fine silt with occasional N4/ dark grey fine sand. Woody fragments appear towards lower contact.	
	---DIFFUSE CONTACT---	
6.12-6.23	2.5Y 4.1 Dark grey fine silt with 2.5Y 3/2 very dark greyish brown fine silt laminated. These silts seen in between rounded flint pebbles up to 40mm long axis and patches of 2.5Y 4/2 dark greyish brown fine silt with tufa granules. Also includes woody fragments.	
	---DIFFUSE CONTACT---	
6.23-6.52	2.5Y 4/2 dark greyish brown fine quartz sand with sand sized tufa grains. Also contains a patch of 10 YR 3/1 very dark grey fine silt also with sand sized tufa grains.	
6.52/6.58-6.64	2.5Y 4/2 dark greyish brown medium to fine silty sand with some granular clasts including sub-angular flint up to 3mm, chalk up to 2mm and woody organic remains.	
	---DIFFUSE CONTACT---	
6.64-6.90	2.5Y 4/2 dark greyish brown sandy silt matrix within a poorly sorted, matrix supported, gravel. Clasts include rounded flint pebbles 30mm mean diameter, 60mm long axis, angular flint up to 20mm long axis, sub-rounded to rounded chalk clasts, and granular ceramic building material.	
6.90-7.00	Medium gravel with small fragments of brick/tile.	
7.00-8.35	Poorly sorted (2-12cm) flint gravel. Clasts sub-angular to sub-rounded.	
8.35-9.00	Flint gravel with ? chalk pebbles. Clasts > 12mm, badly damaged during drilling. Poorly sorted.	
9.00-15.00	As above but chalky silt matrix to gravel.	
12.60	Orange-brown staining	
	Base of borehole 15m (-9.19m O.D.)	

Borehole number		DBS/BH3g	Grid reference	
			Ordinance datum	5.810m
Depth below ground surface	Description	Unit Number		
0.00-0.90	Pit			
0.90-2.95	Chalk fill			
2.95-4.00	Gravel, small, medium and large rounded and angular stones, brown coarse sand.			
4.00-5.70	Dark grey/brown fine silty sand clay, small rounded and angular stones, root matter and shells			
5.70-5.85	Dark grey/brown fine silty sand, clay, small rounded and angular stones, root matter and shells. Laminated			
5.85-6.90	Flints, gravel, chalk pellets, rounded and angular stones, root matter, shells and bones.			
6.90-6.95	Flints, gravel, chalk pellets, small, medium and large flints, rounded and sub-rounded traces of chalk in a putty matrix pottery, concrete, brick, bones and shell			
6.95-7.00	Gravel, small rounded and angular flint, chalk pellets, coarse sand			
7.00-8.35	Flint, small, medium and large Rounded and angular coarse sand			
8.35-8.70	Gravel, small, medium and large Rounded and angular flints Chalk pellets			
8.70-9.00	Gravel, small, medium and large Rounded and angular flints, Chalk pellets			
9.00-12.60	As above in a weak putty matrix			
12.60-13.70	Orange, brown gravel, small, medium and large rounded and angular stones,			
13.70-15.00	Chalk, small and medium chalk pellets.			



Appendix II: Data Storage and Modelling

The data from the A20 project was obtained as paper copy information from geotechnical records and put into the geological software modelling program Rockworks 2003. Data from the records included xyz data as well as lithological information on the geological succession in individual boreholes.



This software allows cross sections to be constructed showing individual boreholes or, if correlated stratigraphic data has been input to the system as synthesised cross sections between two located end points within the area.



