SU 60 NE, SE; SU 61 SE;
SU 70 NW, NE, SW, SE; SU 71 SW;
SZ 69 NE and SZ 79 NW, NE

The south-east Hampshire district:
Havant and surrounding areas

Part of 1:50 000 sheets 316 (Fareham) and 331 (Portsmouth)

Natural Environment Research Council

BRITISH GEOLOGICAL SURVEY

Geological notes and local details for 1:10 000 sheets SU 60 NE, SE; SU 61 SE; SU 70 NW, NE, SW, SE; SU 71 SW; SZ 69 NE and SZ 79 NW, NE

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PREFACE

This report describes the geology of a group of eleven National Grid 1:10 000 sheet areas as follows: SU 60 NE, SE; SU 61 SE; SU 70 NW, NE, SW, SE; SU 71 SW; SZ 69 NE and SZ 79 NW, NE. These cover the coastal area of Portsea, Hayling and Thorney Islands, the eastern part of the Forest of Bere and the eastern part of Portsdown. The area reported on includes parts of 1:50 000 Geological Sheets 316 (Fareham) and 331 (Portsmouth).

The area was first surveyed on the one-inch scale by H.W. Bristow as part of the Old Series one-inch Geological Sheets 9 and 11, published in 1864 and 1856, respectively. Parts were resurveyed on the six-inch scale by C.E. Hawkins and C. Reid, and these results were included in the New Series one-inch Sheets 316 and 331, published in 1900 and 1893, respectively. Some minor revisions to Sheet 316 were made by F.H. Edmunds in 1928 and these were incorporated in the reprint of 1933. Descriptive memoirs were published in 1913 and 1915 respectively.

The present 1:10 000 revision survey has been undertaken with the support of the Department of the Environment. The surveyors were F.G. Berry, R.D. Lake and R.J. Wyatt, who have jointly prepared this report.

Uncoloured dye-line copies of the 1:10 000 geological sheets may be obtained through the Bookstall, Geological Museum, Exhibition Road, London SW7 2DE.

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1. INTRODUCTION

The survey area described in this report is outlined in Figure 1. The work was undertaken as part of a two-year programme to provide up-to-date geological information on the south-east Hampshire area, supported by the Department of the Environment. This report describes the area surveyed in the first year and, consequently, some of the findings should be regarded as provisional, pending completion of the programme. The geological sequence of superficial deposits and solid formations is listed in Section 2.

The area includes part of the extension of the drift-covered coastal plain of West Sussex which is extensively dissected by various inlets. To the north the dip-slope of the Chalk downland and the Portsdown ridge dominate the landscape. The intervening area of subdued relief is underlain by Tertiary sands and clays. The solid geology is depicted in Figure 2.

The coastal plain has a complex Quaternary history. Here deposits of Head Gravel and Brickearth overlie raised wave-cut platforms, on which marine deposits occur locally, at two main levels. The degraded former cliff-lines of these platforms separate areas with different sequences of drift deposits. The distribution of drift deposits is shown in Figure 3.

1.1 Previous research

The early descriptions of the Chalk and Tertiary strata in this area include the memoirs which were published after the surveys of New Series One-Inch Geological Sheets 316 and 331 (White 1913; 1915). The zonation of the Chalk outcrop in the Hampshire-Sussex border has been described by Brydone (1912), Martin (1938) and Gaster (1944). Important sections in the London Clay at Portsmouth were recorded by Meyer (1871) who proposed a tripartite subdivision of these beds. There are few descriptions of the Bracklesham Beds in this area, apart from some well records (Whitaker, 1910) and some observations by Evans (1873). More recently, however, King (1981) and his co-workers in the Tertiary Research Group have made important contributions to the study of the Tertiary deposits in the general area of south-east Hampshire.

The historical accounts of the gravels of the coastal plain include those by Godwin-Austen (1857) and Prestwich (1859). The latter referred to the raised beach deposits around Portsmouth. Codrington (1870) and Reid (1892) also described these deposits and their contained erratics at Portsea and Southsea. Palmer and Cooke (1930) showed that more than one beach was present but presented an erroneous interpretation of the environments of deposition of the lower beach. Mottershead (1976) has summarised the Quaternary history of the area.

The Flandrian deposits have few descriptions but recently Harlow (1979) has described the transport of sediment and the modes of deposition in quantitative terms. Bryant (1968) and Perraton (1953) have described the salt-marsh seres of the Hampshire-Sussex border.

2. GEOLOGICAL SEQUENCE

The solid formations and drift deposits shown on the 1:10 000 geological maps are listed below.

Superficial Deposits (Drift)

Quaternary

- Alluvium (undifferentiated)
- Blown Sand
- Marine Beach or Tidal Flat Deposits
- Estuarine Alluvium
- Storm Gravel Beach Deposits
- River Terrace Deposits
- Raised Beach Deposits (Younger)
- Raised Storm Beach Deposits (Older)
- Brickearth
- Head (undifferentiated)
- Head Gravel
- Clay-with-flints

Solid formations	Thickness m
Eocene	
Bracklesham Beds*	100+
London Clay*	112-117
Palaeocene	
Woolwich and Reading Beds	33-37
Cretaceous	
Upper Chalk	c250
Middle Chalk (proved only in boreholes)	-

*The various subdivisions of these units are described in the appropriate sections.

3. SOLID FORMATIONS

3.1 Upper Chalk

3.1.1 General account

The Upper Chalk comprises pure white microporous limestones with bands of nodular flint and, less commonly, sheet-like tabular flints. Thin marl partings are locally common within the sequence which is about 250m thick.

In this area the following zones (or modern equivalents) were recognised at outcrop (Brydone, 1912): Micraster coranguinum, Uintacrinus socialis, Marsupites testudinarius, Offaster pilula, Gonioteuthis quadrata and Belemnitella mucronata, in ascending order. Of these the lowest is only present at outcrop to the south of Chalton [732 1607][1] and only the highest four zones are present in the Portsdown outcrop. In this latter area, chalk of the Belemnitella mucronata Zone underlies the Tertiary deposits, whereas in the main crop to the north they are underlain by the Gonioteuthis quadrata Zone (Brydone, 1912).

With the exception of the two highest zones at Portsdown, the Upper Chalk is poorly exposed. The lowest of the zones noted above is known from adjacent areas to contain abundant flints (White, 1913, p. 23). A comparison of the exposed sequence in this area with that of Whitecliff Bay, Isle of Wight, indicates that nodular flints are also particularly common in the upper part of the Gonioteuthis quadrata Zone, and that marl wisps and partings characterise the lowest flinty part of the Belemnitella mucronata Zone. The boundary

[1] National Grid References are given in this form throughout. Unless otherwise stated figures with northings between 9000 and 9999 relate to places in 100-km square SZ (or 40), those with northings between 0000 and 2000 to places in 100-km square SU (or 41).

between these two zones is, however, currently under review because the zonal indicators are known to overlap slightly within the sequence (Oral communication, Dr. R.N. Mortimore, 1983). Westwards, however, in the Downend area [600 066] significant lithological changes are known to occur in the highest part of the Gonioteuthis quadrata Zone and these will be described in a later report.

3.1.2 Local details

A series of former roadside quarries [6660 0635 - 6666 0640] near the George Reservoirs expose about 25m of chalk of the Gonioteuthis quadrata Zone. The characteristic flinty chalk above the 'cave' [6660 0635] shows a sheet flint 1m above the cave roof and six regularly disposed courses (or groupings of courses) of nodular flints in the 12m of beds above. The exposure to the north shows an apparent dip of 10° at N047° (approximately 13° true dip at N012°).

The former Farlington Redoubt quarry is largely degraded but the upper part of the western face [6855 0650] exposes about 16.5m of flinty chalk with two prominent marl partings at 6 and 12.5m depth. Most of the higher beds lie in the Belemnitella mucronata Zone. The dip in this face is 10° to the north locally increasing to 16°.

The former Bedhampton Lime Works sections [697 063] expose beds at a comparable stratigraphical level to the previous quarry, dipping at 11° to the north. The highest 6m of flinty chalk contain marl partings, whereas the lower 16m of beds show only regular courses of nodular flints, some of which have a 'dispersed' aspect. There are few exposures in the main outcrop in the northern part of the area. Most of the former lime pits are degraded or overgrown. A disused pit [6655 1335] in the Gonioteuthis quadrata Zone exposes 5m of chalk with four courses of nodular flints.

3.2 Woolwich and Reading Beds

3.2.1 General account

These beds rest unconformably upon an eroded planar surface of Upper Chalk. They consist mostly of clays and silty clays, mottled in shades of bright red, orange, brown and grey. The total thickness ranges from 33m to 37m. Local lenticular bodies of fine- to medium-grained, well-sorted or loamy sands, as well as interbedded sands and clays, occur at various levels, but are more common near the top and bottom of the succession.

The mottled clays typically overlie a basal bed, analagous to the 'Bottom Bed' of the London Basin, which consists of glauconitic sand or interbedded sand and clay, the former locally cemented to form sandstone. Some borehole logs describe the occurrence of 'stone', 'rock' or 'gravel' at the base, suggesting the presence of a basal bed of flints. Fragments of chalk accompany the flints in some boreholes. This basal bed is up to 4m or 5m thick in places.

The Woolwich and Reading Beds are almost barren of fossils, the only organic remains being sporadic fragments of lignite. The environment of deposition is not fully understood but, most probably, the sediments were laid down in a brackish-water lagoon (Ellison, 1983) and were subject to intermittent exposure, leading to soil forming processes (Buurman, 1980).

3.2.2 Local details

Sands from the highest beds were formerly worked near Soake

/669 112/, where White (1913, p. 42) recorded 1.8 to 2.4m of sands with clay seams. Small exposures in a flooded pit at /6720 1115/ show interbedded finely laminated fine-grained sands and pale grey clays. Cross-bedded, medium-grained sands were also noted locally.

These sands probably persist eastwards through Cowplain. Boreholes in the Milton Road area proved up to 8m of fine-grained sands with clay partings at /6836 1110/. These beds locally pass laterally into sandy clays and sandy silts over short distances.

In the Padnell area silts and mottled clays from the highest beds were formerly dug in a brickyard /699 112/. White (1913, p. 46) recorded pale sands beneath the basal pebble bed of the London Clay hereabouts. There is no evidence for sandy beds at this horizon east of Padnell. Boreholes along the line of the A3(M) motorway south of Horndean show that most of the Woolwich and Reading Beds succession comprises varicoloured mottled clays and silty clays.

Farther east, at Rowlands Castle, the former clay pits /733 102/ are now almost wholly overgrown or degraded. White (1913, p. 43) reported up to 2.4m of yellow sand within the mottled clay sequence here. A small exposure at /7338 1025/ now shows red and grey mottled clay (1.2m) overlying varicoloured clean, well-sorted, fine-grained sand (1.6m seen). Yellow sand was thrown out of burrows adjacent to Rowland's Hill Farm /7327 1013/ at the time of the survey. This sand body is estimated to lie 10m above the base of the formation.

Near Lyel's Wood [747 102] two lenticular bodies of sand and sandstone have been mapped at the base of the Woolwich and Reading Beds. They give rise to sandy loam soils with scattered sandstone fragments. The sand is mainly brown, medium-grained, poorly sorted and rather clayey. The sandstone is bedded, medium- and coarse-grained, with seams containing granules and small pebbles of quartz; there are some thin ferruginous bands. The sands were formerly worked in shallow pits adjacent to Horsepasture Farm [7446 1022].

Between Lyel's Wood and Woodmancote [773 076] there is no evidence of sandy beds. Further east, a borehole at Hambrook (SU 70 NE 35)[1] [7893 0702] proved 6.3m of grey-brown, silty, fine-grained sand with thin silty clay layers, overlying 1.2m of silty, sandy, gravelly clay at the base of the formation. In boreholes only 200m to the west, however, sands are absent. Orange, red and grey mottled clays were exposed in shallow trenches south-east of Littlecourt Farm [796 070].

The Woolwich and Reading Beds are almost wholly concealed below drift deposits on the south side of the syncline, between Bosham and Bedhampton. Basal sands with some clay, up to 7.6m in thickness, are recorded in the logs of boreholes at Southbourne (SU 70 NE 83) [7672 0546] and (SU 70 NE 84) [7674 0540]; at Emsworth (SU 70 NE 86) [7563 0569] 4.3m of 'sand, clay and stones' were proved. Boreholes at Havant record a dominantly mottled clay succession with a few thin beds of sand and some sandy clays.

[1] Letters and numbers refer to the BGS 1:10 000 Record system in which the 1:10 000 quarter sheet is followed by the BGS Registration Number.

To the north of Portsdown Hill the Woolwich and Reading Beds crop is extensively veneered with flinty and chalky wash. The debris from pipeline excavations showed the common occurrence of red mottled clays. Fine-grained sand was augered at one locality [6665 0678] near Widley from near the middle of the formation. A site investigation borehole (SU 60 NE 11) [6944 0672] for the A3(M) road near Bedhampton proved 20.5m of this formation beneath 1.5m of Head deposits. The log records stony clay in the lowest metre, indicating that the basal bed was touched. The bulk of the sequence comprises red mottled clays, but between 5 and 11.5m depth brown and grey mottled beds predominate.

The outcrop of the Woolwich and Reading Beds south of the Portsdown Anticline forms a narrow belt trending east to west across Portsea, Hayling and Thorney Islands and the Chidham and Bosham peninsulas, and beneath Langham and Chichester harbours. For the most part the outcrop is drift covered. A well bored at Copnor (SU 60 SE 120) [6595 0198] proved a total thickness of 36.3m for these beds. This and other records show that the red and grey mottled silty clays which make up the major part of its thickness are typically replaced by sandy beds near the base and top (SU 60 SE 117, 118) and rest on beds of "stone" or pebbles near the base. No lignites have been recorded in borings although White (1915) noted that they were present locally.

On Hayling Island about 1m of orange, red and grey mottled clay can be seen beneath a thin cover of drift deposits in the low cliff WSW of Stoke /7153 0218/. Borehole logs suggest that the Woolwich and Reading Beds succession throughout the island is dominated by similar clays, with a flinty bed at the base.

On the south-western side of Thorney Island, red-mottled clays lie under the beach slope and appear at the foot of the low shore-line cliffs in a few places. Near the boundary with the Chalk /7520 0218/, firm to stiff grey-brown clays occur and on the western margin of Bosham peninsula /7975 0255/ stiff pale grey clays in a similar stratigraphical position contain small ferruginous concretions.

3.3 London Clay

3.3.1 General account

The London Clay consists mainly of grey, brown-weathering, bioturbated silty clays with intermittent seams of calcareous cementstone nodules, pyrite nodules and flint pebbles. There are also lenticular bodies of sand which, apart from the 'Basement Bed', occur at or near the top of sedimentary cycles. Certain beds with informal names, such as the 'Lingula Sands' (Meyer, 1871), have been used for the purpose of correlation. Few boreholes have penetrated the complete succession, but the total thickness of the formation is known to be in the order of 112m - 117m. The macrofauna is dominated by bivalves and gastropods, which are more common in the sandy beds. Brachiopods are also present, together with fish teeth, bones and scales. The microfauna comprises mainly foraminifera and ostracods. Dinoflagellate cysts have been used to effect a zonation of the London Clay.

In the study area the London Clay comprises a series of upward-coarsening rhythms separated by widely correlatable marker horizons (King, 1981). These horizons are represented variously by pebble beds, glauconitic concentrations or erosion surfaces. Each rhythm, where complete, has a basal pebble bed or glauconite-rich horizon and comprises a lower unit of silty clays, passing upwards into clayey silts, silts and silty sands. At the top of the sequence lenticular units of fine- to coarse-grained, cross-stratified sand or channel fills of interbedded laminated clay and sand occur. Five informal lithostratigraphical divisions, lettered A-E in ascending order, have been recognised by King in the London Basin, each representing a coarsening upward rhythm. King has correlated the Hampshire Basin succession with that of the London Basin and considers that only divisions A-C and the lower part of D are represented in the London Clay of the former area. Divisions D (upper) and E are included within the Wittering Division of the overlying Bracklesham Group (Figure 4).

Each of the rhythms was initiated by a marine transgression, followed by low-energy sedimentation in a marine environment. This was followed by shallowing of the sea floor and then by the progradation of coarser silts and sands from the margins of the depositional basin (King 1981, p. 32).

The 'Basement Bed' comprises pebbly glauconitic sands and sandy clays, and was originally (Prestwich, 1850) regarded as being the basal member of the London Clay formation. King, however, excluded it from the London Clay and considered these sandy beds to comprise a discrete unit within his underlying Oldhaven Formation. Nevertheless, recent studies of the stratigraphical distribution of dinoflagellate cysts (Knox and others, 1983) and volcanic ash (Knox, 1983) in beds of the 'Oldhaven Formation' indicate that they are contemporaneous with or, in the Hampshire Basin, younger than the clays at the base of the London Clay in the east of the London Basin. Thus, in this account the traditional view is taken that the 'Basement Bed' (i.e. Tilehurst Member of the Oldhaven Formation; King, 1981) constitutes the basal member of the London Clay formation, and represents the initial deposits of the contemporaneous transgressive sea.

A generalised London Clay succession, based largely on King's account (King, 1981 fig. 26), is given in Figure 4. The 'Basement Bed' crops out between Cowplain and Rowland's Castle and to the north of Westbourne; locally it can be recognised in boreholes. Of the other sand bodies, the Bognor Member is the most widespread and persistent; it can be traced over much of the study area, but passes into sandy clays to the east of Havant and Hayling Island and consequently has not been mapped there. Its thickness ranges up to a maximum of about 10.5m. The relatively thin Portsmouth Member, recognised in boreholes only, is apparently restricted to the Portsmouth and South Hayling areas. In these localities the Whitecliffe Member, which comprises pale coloured sands with thin clay interbeds, is also well developed and up to 12m have been proved in boreholes; elsewhere the member is either thin or absent.

Details of the London Clay succession, obtained from excavations in Portsmouth Dockyard, were reported by Meyer (1871) and were summarised by White (1915, pp. 11-17). A well record at Milton (SU 60 SE 118) [6699 0021] also provides some details of the sandy members within the sequence.

3.3.2 Local details

3.3.2.1 'Basement Bed' and adjacent overlying strata

The basal beds of the London Clay were formerly exposed in brickyards at Cowplain [6900 1108] and Padnell [699 112]. In the latter, a black flint pebble bed was recorded (White 1913, p. 46). Pebbly grey sands were logged in a number of trial boreholes in the Cowplain area but at some sites only sandy silts were noted at this level. A borehole (SU 60 NE 52) [6998 0991] near Beech Wood, which commenced near the base of the Bognor Member, proved brownish grey shelly sandy clay to overlie red mottled Woolwich and Reading Beds at 29.55m depth.

At Havant Thicket, between Horndean and Rowland's Castle, the 'Basement Bed' has a wide outcrop. Augering proved orange-brown silts, locally with flint pebbles, in most places; but near Upper Lake [7130 1015] pebbly fine-grained sands comprise the upper part of the sequence. In a stream-bed nearby [7118 0999] a bed of flaggy, fine-grained, calcareous sandstone, 0.15m thick, is present at the base of these upper sands; it contains abundant serpulid tubes and shelly partings which yield numerous bivalves and some gastropods. To the east of Upper Lake [718 100] the light silty, sandy soil is littered with well-rounded flint pebbles and cobbles up to 0.2m in diameter. These are believed to represent a pebbly band capping the 'Basement Bed'.

The 'Basement Bed' pinches out at Durrants [729 096] but is present again in Southleigh Forest [741 092] and can be traced to Westbourne Common, near Monk's Farm [753 084]. Orange-brown silts and greenish, glauconitic, fine-grained clayey sands were augered. The sands were once worked in shallow pits at Sandpit Roundell [7445 0960]. In the former brickyard at Sawmill's Farm [7525 0850] a section measured in 1891 recorded 1.2m of grey clay, overlying 3.1m of pebbles and sand, resting on red clay of the Woolwich and Reading Beds.

Between Bosham and Bedhampton the London Clay is mostly drift covered. Boreholes at Emsworth (SU 70 NE 86) [7563 0569] and Southbourne (SU 70 NE 85) [7674 0649] proved less than 0.6m of sand or 'rock' at the base of the formation. In Havant, boreholes near the railway station encountered up to 2.7m of interbedded sandy clays, fine-grained sands and shelly sandstone, with a flint pebble bed at the top.

To the north of Portsdown the base of the London Clay proved difficult to map. Clayey silts were augered locally at this level, but where buff weathered clays are present at the top of the Woolwich and Reading Beds no distinction could be made between the two lithologies.

An auger hole [7608 0135] at the southern end of Thorney Island proved the following succession:

	Depth
Grey-brown soft mottled clay with very fine-grained sand which increases gradationally downwards	0.8
Dark grey and black very fine and fine-grained sand	1.0
Pale grey very fine-grained sand	1.6
Blue grey clayey very fine-grained sand	2.0
Brown slightly clayey very fine-grained sand with grey mottling. Pebbles at base	2.7
Stiff red-grey mottled silty clay (Woolwich and Reading Beds)	3.0

The beach nearby exposes tracts of finely laminated dark grey, fine-grained sand and silty clay above this sequence. The following beds, which form a higher part of the succession, are exposed in the low cliff eastwards from this point:

	Depth
Clayey fine-grained sands, coarsely laminated, with occasional large ripple marks	3.00
Fissured silty clay with sparse ferrous concretions and occasional large ovoid black battered flint pebbles near base	4.50
Clayey fine-grained sand (Top of 'Basement Bed'?)	4.60
Pale grey clayey silt	4.63
Clayey medium- to fine-grained sands, thickly laminated, with sporadic laminae and thin beds of pale grey soft clay up to 5cm thick	5.53

Followed south, the outcrop in the cliff is cryoturbated for a distance of 15m; here the bedding locally dips sharply to the south at about 10°.

On the shoreface at low-tide, firm dark grey laminated clays with pale silty and clayey bands are exposed. These are bounded seawards and succeeded by four groups of prominent septarian reefs, trending east-west and partly covered by beach sands, restricting their outcrop to about 300m width. It is estimated from the local dip ($2\frac{1}{2}^\circ$-3°) that these septarian layers are about 25 to 30m above the Woolwich and Reading Beds and occupy about 10m of beds.

At Fleet, on Hayling Island, the 'Basement Bed' is represented by at least 2.7m of fine-grained silty sand, proved beneath drift in a shallow borehole (SU 70 SW 87) [7232 0165]. Green sand and pebbles were reported from this locality by White (1915, p. 17). In a low cliff [7132 0175] on the coastline to the west, 0.5m of rusty-brown, fine-grained silty sand with thin impersistent clay seams is overlain by grey and brown mottled clays. The lower part of the 'Basement Bed' is concealed below Estuarine Alluvium here.

3.3.2.2 Bognor Member

This member has a wide outcrop in the Creech Wood area [652 111] where it comprises silts and fine-grained sands, veneered with a pebbly wash. To the east of Furzeley Corner [658 105] the sand component is generally absent and near Old Park Farm [672 103] this member was mapped with difficulty as a clayey silt bed. Boreholes near here [677 101] indicate the presence of 5 to 6m of sandy clays and clayey silts, which are capped with a pebbly, lignitic, shelly, fine-grained sand and underlain by a thin fine-grained 'sandstone'. Boreholes in the Inhurst Wood area [6950 0945] proved a comparable sequence, but it is possible that the sandstone noted above is represented here by a calcareous siltstone. Thus 0.7 to 2.45m of silt and sand were recorded above very silty clays with a basal bed of siltstone, the total thickness being comparable to that near Old Park Farm. Other borehole logs in this area recorded only the highest sandy pebbly horizon, which is about 2m thick.

The trial boreholes for the A3(M) road near Inhurst Wood proved 2 to 6m of arenaceous beds, locally with a pebbly top. The sequence is probably comparable to those described above.

The Bognor Member occupies a broad dip-slope outcrop between the A3(M) motorway and West Leigh, giving rise to light silty and sandy soils. It forms a prominent feature and has a spring line at the base. Clayey silts at the base pass up into silts and fine-grained sands; the flint pebble bed at the top was recognised at Leigh Park /7022 0867/. A maximum thickness of about 9m is suggested by borehole data at West Leigh. The outcrop is marked by a steep bank in Southleigh Forest but pinches out at Blackbush Hanger /7420 0868/.

The member is apparently absent east of here, and similarly along the southern limb of the syncline to the east of Havant. However logs of boreholes in Havant, adjacent to the Magistrates Court /7170 0675/ and the Railway Station /7180 0660/, record up to 10.6m of grey, fine-grained sands with a bed of pebbly gravel up to 1.2m thick at the top.

The outcrop of the Bognor Member to the north of Portsdown forms a weak feature at the foot of the ridge; sands and clayey silts were augered along the outcrop. Site investigation boreholes for the A3(M) road /694 070/ near Bedhampton proved 5.4 to 5.8m of silty sands capped with a pebble bed.

To the east of Baffin's /6758 0122/ on Portsea Island, several shallow boreholes proved up to 11.7m of brown or grey, medium to fine-grained sands and "sandstone".

The Bognor Member can be traced across Hayling Island, below drift deposits, from low cliffs on the west side to Sunshine Holiday Camp on the opposite side, where it has a small drift-free outcrop. Small exposures in the cliffs, about 1km south-west of Fleet, reveal green and rusty-brown mottled, finely micaceous, clayey silts towards the base of the member. In the upper part rusty-brown, fine-grained sands are present. At outcrop brown silts appear to predominate over fine-grained sands. A borehole near Manor House (SU 70 SW 98) [7247 0068] proved 8.8m of brown and grey 'sands' beneath Brickearth.

3.3.2.3 'Lingula Sands'

Greenish-grey and rusty-brown mottled, fine-grained, silty sands seen in low cliffs north-west of Newtown on Hayling Island [7094 0034] are estimated to be 35m above the top of the Bognor Member. They are therefore believed to be equivalent to the 'Lingula Sands' of Meyer (1871).

3.3.2.4 Portsmouth Member

This subdivision has not proved to be mappable. Between Portsdown and Waterlooville a pebble bed and/or a shelly sandstone have been described in some borehole logs from the Purbrook area at a level 11 to 15m below the base of the sand unit provisionally taken as the Whitecliff Member in this area. These lithologies may represent the Portsmouth Member.

A large number of shallow boreholes throughout South Hayling penetrate sands below the drift cover. The estimated thickness of beds below the Bracklesham Group in which these sands occur is 25m which, by comparison with Southsea, is equivalent to all the beds above the base of the Portsmouth Member.

3.3.2.5 Whitecliff Member

Fine-grained sands have been mapped in the Purbrook Heath area, about 5m thick, and these are provisionally ascribed to this member. Numerous boreholes near Milton (670 000) proved a broad subcrop of sands, at least 10.7m thick. The sandy beds rest on clayey silts and sandy silty clays. The westward extension of this outcrop near Fratton cannot be defined because of the lack of borehole data.

Sands equivalent to the Whitecliff Member (and Portsmouth Member) occur at South Hayling as noted above.

3.4 <u>Bracklesham Beds (Group)</u>

3.4.1 General account

3.4.1.1 Lithostratigraphical subdivisions

In the eastern part of the Hampshire Basin this group comprises a varied succession of interbedded clays, silty and sandy clays, silts and sands, with many shelly and lignitic horizons, and some flint pebble beds. The greater part of these sediments was probably deposited in an offshore marine environment, but the presence of brackish-water molluscs and an abundance of lignite debris at some levels suggest episodes in which a coastal marsh environment prevailed.

The succession has been divided into three major units, each defined to include the deposits of a transgressive/ regressive sedimentary cycle (Curry and others, 1977). The units ('Divisions') are listed below; the lowest two of these have recently been subdivided informally into formations (King and Kemp, 1982):

	Division	Formation
Bracklesham Group	Selsey	Marsh Farm
	Earnley	Earnley
	Wittering	Cakeham
		Knowle Hill
		Allbrook

Within the study area there are up to about 90m of beds representing these three divisions. Beds of the Selsey and Earnley Divisions are restricted to a sub-drift outcrop at Southsea and are known from boreholes only. The Wittering Division is present beneath Drift at Southsea and South Hayling, and crops out in the axis of the major syncline to the south and south-west of Waterlooville.

3.4.1.2 Stratigraphy of the coastal plain

Details of the Bracklesham Group sequence within the area are poorly known because of inadequate exposure at outcrop and the paucity of borehole data elsewhere. Thus the detailed accounts of the successions at Bracklesham Bay and Selsey (Curry and others, 1977) and near Gosport (King and Kemp, 1982) have been used for the following summary which is believed to be reasonably representative of the outcrop south of the Portsdown Anticline (Figure 4).

WITTERING DIVISION

'Allbrook Formation'

This formation comprises 15 - 20m of bluish grey clays and sandy clayey silts with patches and lenses of sand. There are two prominent flint pebble beds, one at the base and the other about half-way up the sequence.

'Knowle Hill Formation'

This sequence comprises up to 7m of sands and silty sands. The upper part of the sequence is bioturbated and contains pyritised bivalves and lignitic plant debris.

'Cakeham Formation'

At Bracklesham the lowest 13m of these beds are represented by clays, silts and silty sands with many shell beds, and also a bed of vertebrate remains. The remaining 3.5m comprise a complex series of channelled lignitic silts and sands containing pebbly bands, with a vertebrate fauna at the base. The succession near Gosport totals 21m of beds, the lower half being dominantly argillaceous and comprising thin-bedded clays with laminae of fine sand. The upper half is a sequence of interbedded clays and sands at the top of which there is a thick bed of lignitic sand.

EARNLEY DIVISION

'Earnley Formation'

Bioturbated clayey and silty, glauconitic sands characterise this formation. They commonly contain a rich molluscan fauna of bivalves and gastropods, some of which give their names to marker beds. At Bracklesham there is a flint pebble bed at the base. Near the top, sands containing an abundance of the foraminifer Nummulites laevigatus form a valuable correlatable horizon. The thickness of the Earnley Formation ranges from 16m near Gosport to 21.6m at Bracklesham.

'Marsh Farm Formation'

Thinly-bedded, shelly, clayey silts and silty sands predominate at Bracklesham where a total of 13m of beds are present. Marine molluscs occur in the lower part but, towards the top, there are brackish-water forms. Near Gosport the formation is represented by 22m of fine- and medium-grained clean sands containing much plant debris, within which channel-fills are not uncommon.

SELSEY DIVISION

The highest beds represented in boreholes at Southsea comprise 3m of glauconitic sand which are thought to be at the base of the Selsey Division. As a whole this division comprises up to 25m of interbedded sands, sandy and clayey silts, and subordinate clays. Probably the greater part of the sequence is present beneath Drift at Southsea.

3.4.1.3 Stratigraphy of the Purbrook area

To the north of Portsdown the mapping has not provided a definitive stratigraphy. It is thought, however, that only beds equivalent to the Wittering Division are present. These comprise interbedded sands, silts and clays up to 25m thick. The base of the division has been taken above the lowest sand bed recognised (Whitecliff Member). In view of the uncertainties of correlation the stratigraphy outlined here should be regarded as provisional pending further studies.

3.4.2 Local details

In the area around Purbrook Heath interbedded sands and clays are present. On a local scale these lithologies appear quite persistent although significant individual thickness changes are apparent and locally the solid geology is obscured by a mantle of red mottled flinty clays. The sand beds are generally silty in character whereas the clays are typically ochreous, brown and pale grey mottled and locally pass laterally into clayey silts.

In the easternmost outliers, to the south of Purbrook, over 15m of silts with subordinate sandy silts and clayey silts are present which apparently include the Whitecliff Member at the base. A black flint pebble horizon was noted within the sequence at one exposure [6890 0742] near the South Downs College which may mark the base of the Wittering Division.

Boreholes in the Crookhorn area [685 076] proved up to 13.7m of sands with thin clay beds (about 0.3m thick). Exceptionally, one borehole [6852 0768] penetrated a gravelly clay between 1.5 and 3.7m depth. Although a surficial wash of this material has been recorded elsewhere, the significance of this bed is unclear.

A temporary excavation [6894 0826] near Frendstaple exposed the following section in basal passage beds:

	Thickness m
Loam, pebbly, buff (Wash)	1.5
Silt, clayey, sandy, buff (Bracklesham Beds or Whitecliff Member)	1.0
Silt, clayey, ochreous pale grey passing down to clay, silty, brown, holding water (London Clay)	3.0

An offshore borehole at Spit Sand Fort (SZ 69 NW 74) [6363 9716], 1km south-west of Southsea, proved the following important section within the Bracklesham Beds (Figure 4):

	Sea-bed level -4.95m	Thickness m	Depth m
	Drift	7.72	7.72
12	Clay and sandy clay	22.68	30.40
11	Shelly fine green sand	21.34	51.74
10	Clay	9.68	61.42
9	Sand with <u>Nummulites laevigatus</u>	5.36	66.78
8	Calcareous sandstones in green sandy clays	3.73	70.51
7	Sands with shells and lignite	3.05	73.56
6	Sandy clay with lignite	3.73	77.29
5	Hard clay and organic matter	0.69	77.98
4	Sandy clay and fine sand	5.87	83.85
3	Grey clay and lignite	0.23	84.08
2	Sand, pebbles and lignite	1.22	85.30
1	Laminated sandy clay	16.46	101.76

Bed 9 is an important marker because it contains N. laevigatus and correlates with similar beds at Gosport and at Bracklesham Bay. Below this level the lithologies suggest that the 'Earnley Formation' and Wittering Division are present (Beds 8-9, 1-7 respectively). Within the Wittering Division Bed 2 may be equivalent to a lignite bed at Bracklesham Bay. The clays of Bed 10 correspond to part of the 'Marsh Farm Formation'; the upper part of Bed 11 and Bed 12 represent the Selsey Division.

The thickness of the Spit Sand Fort sequence is comparable to that of the corresponding beds at Gosport and it is estimated that the total thickness of the Bracklesham Beds at Spit Sand Fort is about 130m.

Onshore, the dip calculated from the structural map indicates the presence of about 90m of Bracklesham Beds at the coast, near Southsea Pier. Several shallow trial holes (6508 9853; 6505 9815; 6534 9826; 6537 9826) made in the area north of the pier record fine-grained laminated silty sandy beds with shelly inclusions which may be equivalent to the 'Earnley Formation'.

A trial hole at Eastney (SZ 69 NE 35) (6750 9895) passed through the following beds:

		Thickness m
5	Drift and made ground	6.1
4	Laminated silty clay, with shells, pebbles and fragments of lignite	3.0
3	Fine- to coarse-grained sand and gravel with traces of lignite	1.6
2	Grey-green silty fine- to medium-grained sand	2.0
1	Laminated silty clay with shells and thin beds of grey-green silty sand	2.3

Beds 3 and 4 may be the local equivalent of the Whitecliff Bay Palaeosol at the top of the Wittering Division of Whitecliff Bay, Isle of Wight (cf. King and Kemp 1982, p. 178) or perhaps a bed lower in the sequence.

A total of about 22m of Bracklesham Beds is estimated to crop out at South Hayling, all of which can be assigned to the Wittering Formation. These beds are here confined to a narrow strip at the southern extremity of the island. For the most part they are concealed beneath Drift deposits, though there is a small outcrop at Eastoke [734 987]. Grey, brown and greenish mottled clays were augered hereabouts; in a temporary trench section [at 7336 9853] orange and green mottled, fine-grained clayey sand (0.7m) was seen to overlie orange and khaki mottled, fine-grained, well-sorted sand (0.2m). Beneath the nearby shingle storm beach, a water-well (SZ 79 NE 28) [7307 9850] proved sand and clay (4.6m), overlying hard blue clay (7.6m), in turn resting on the Whitecliff Member of the London Clay.

4. STRUCTURE

This area lies on the north-eastern limb of the Hampshire Basin, a broad assymmetrical syncline which preserves Tertiary sediments. This major structure is modified by the presence of a subordinate fold, the Portsdown Anticline, which exposes Upper Chalk in its core and which dominates the structure of this study area (Figures 5, 6). This anticline is also assymmetrical in profile with a monoclinal northern limb. The fold axis trends WNW-ESE and the structure plunges eastwards in this area. The observed dip values for this fold are typically 3° to the south and 12 to 15° to the north. North of this fold and its complementary syncline the strata dip gently at less than 3° to the south.

At outcrop the monoclinal zone of the Portsdown Anticline, which may be recognised by dip values in excess of 8°, occupies a tract, some 700m wide, between the Portsdown Hill Road (on Upper Chalk) and the outcrop of the Bognor Member to the north. It is probable that the steepest dips occur in the lowest part of the Tertiary sequence, which in consequence may have suffered internal shearing.

To the south of Portsdown the dips beneath Portsmouth and Southsea are gentle (c 3°). Only one dip-fault has been recognised, beneath Langstone Harbour, and this throws Woolwich and Reading Beds against the lowest division of the London Clay. A weak flexure modifies the outcrops of the Bracklesham Beds and sands of the Whitecliff Member between West Wittering and Hayling Island (Figure 5).

A reconnaissance of the large Chalk exposures of

Portsdown revealed that differing styles of deformation were present at each locality. Consequently it is difficult to synthesise the structural pattern for this area. It is apparent however that zones of strong sub-vertical fracturing are common at most sites. Locally these zones are associated with reduced dip values. This indicates that the Chalk was deformed in both plastic and brittle modes which commonly overlapped in space and time.

These fracture zones are strike-oriented in the Farlington Redoubt [6855 0650] and George Reservoirs [6660 0635] exposures. In the former quarry and at Bedhampton Lime Works [697 063] other joint sets are oriented at N160-170°. In the exposure near the George Reservoirs two sets of inclined joints are also present which appear to be roughly conjugate in nature, locally hading at 60°, N016° and N106°. In the Farlington Redoubt exposure, minor low angle oblique shear zones are present which consist of multiple arcuate fractures bounded by parallel shear surfaces.

The effects of bedding plane shear are difficult to assess because of the nature of the exposures. Locally, however, it has been observed that nodular flints are distended along low angle sigmoidal fractures or may pass laterally into bifurcating sheet flints, indicating a low angle shear component of deformation.

5. DRIFT DEPOSITS

In the following account the drift deposits have, as far as possible, been described in reverse order of their age.

5.1 Clay-with-flints

This residual deposit comprises stiff, reddish brown clay with many nodular and fractured flints. Locally, as at Blendworth [715 135], a significant sand fraction gives rise to a more loamy deposit. The Clay-with-flints forms extensive hill cappings on the higher part of the Chalk dip-slope between Rushmere [650 145] and Finchdean [750 135]. Downslope from these deposits an extensive veneer of flinty clay hill-wash covers the dip-slope except in the more deeply incised dry valleys. The boundary of the Clay-with-flints has been mapped therefore mainly on the evidence of features, i.e. where a prominent crestal flat is present. Locally the outcrops are rimmed with a distinctive brash of angular and shattered flints in great abundance.

Early opinions on the formation of the Clay-with-flints favoured a residual origin from the dissolution of Chalk at the surface. However, it is now considered that the bulk of the deposit represents a reworked relict of the Tertiary sediments (Hodgson, Catt and Weir, 1967). The basal surface of the drift usually approximates to the sub-Tertiary plane of unconformity, but in the Rushmere area the contour plot of the Chalk surface (Figure 5) indicates a significant lowering (by perhaps 10m) of the surface beneath the Clay-with-flints by dissolution of the Chalk.

5.2 Raised Storm Beach Deposits (Older)

The bench surface of the higher and older raised beach of the Sussex Coastal Plain ('100-foot beach' or 'Goodwood Beach'), on which marine deposits are locally preserved beneath a mantle of Head Gravel (Shephard-Thorn and others, 1982), extends westwards into the survey area (Figure 3) between Funtington and Westbourne. This feature is also evident beneath Head Gravel near Aldsworth Manor, at Southleigh Forest and at Little Leigh Farm, West Leigh. This wave-cut platform is delimited to the north by its associated cliff line, where identifiable, and to the south by the younger cliff line of the lower raised beach. It falls from a maximum elevation of about 40m O.D. at the upper cliff line to about 30m O.D. at the southern margin.

Currently no marine deposits have been proved to rest on the wave-cut platform beneath the Head Gravel in the study area. The only possible representative of such deposits is a small outcrop of flint gravel at Westbourne Common [754 088]. This gravel was once worked in shallow pits, and White (1913, p. 72) reported a large proportion of rounded flints associated with sub-angular flints and smoothly-worn Tertiary pebbles. The present small exposures reveal only well-rounded flint shingle up to 0.12m in diameter (not black-patinated like recycled Tertiary pebbles) within a sparse loamy sand matrix. The proportion of sub-angular flints is very subordinate. These sediments have a base at about 40m O.D. and may thus be regarded as storm beach deposits close to the northern margin of the inferred wave-cut platform.

5.3 Raised Beach Deposits (Younger) and River Terrace Deposits

5.3.1 General account

The literature and new field evidence relating to the younger Raised Beach Deposits of the West Sussex Coastal Plain have been reviewed by Hodgson (1964). It is now widely recognised that these deposits, which rest on an extensive wave-cut platform some 15km wide at maximum, correlate broadly with those of the well known cliff section at Black Rock, Brighton. A '50-foot raised beach' (at c 15m O.D.), intermediate in height between the higher and lower raised beaches recognised in this account, was described by Palmer and Cooke (1923) in the Portsmouth area, but this is not generally accepted as valid.

The former cliff at the back of the lower wave-cut platform is cut in soft Tertiary clays and is consequently highly degraded and locally draped by Head deposits. Nevertheless, it can be located fairly accurately from Havant eastwards, at the foot of a slope which separates the lower from the upper platforms; the position of this feature is shown in Figure 3. For the most part the line approximates to the northern limit of the Brickearth deposits. To the west of Havant the cliff line continues to the south of the Portsdown ridge where, in the survey area, the upper raised beach is absent. The wave-cut platform grades up from just below O.D. at the southern end of Portsea Island to a maximum elevation of about 11m O.D. at the inferred former cliff line inland.

Over the greater part of the coastal plain there is no evidence for Raised Beach Deposits beneath Head Gravel or Brickearth. It is probable that such deposits were removed by erosion or reworked prior to the deposition of the overlying sediments. However, shelly, sandy, fine-grained flint gravels are recorded in borehole records between Warblington and Emsworth, and at outcrop between Nutbourne and Bosham.

On the outlying islands of Hayling and Thorney, comparable deposits are also present, with a variable clay and cobble content. They are however only patchily preserved above the Chalk subcrop as in the Chichester and Bognor districts, further east (Hodgson, 1964; Shephard-Thorn and others, 1982). In these areas of Chalk subcrop the elevation of the wave-cut platform lies below its projected level. On Hayling Island, for example, the calculated reduction of elevation is in the order of 2m. It has been suggested (Hodgson, 1964) that this may have been caused by differential solution of the Chalk, possibly combined with the effects of frost-heaving at the interface of the Drift and the Chalk.

In the Portsea area fine to coarse gravels occur above the platform and these are thought to be related to Terrace 2 of the Solent which is present from Gosport westwards. These deposits are classified as such on the published maps although they may incorporate recycled sandier material from the raised beach deposits.

5.3.2 Local details

Between Warblington and Emsworth, up to 2.5m of fine-grained silty sands, locally with a coarse flint gravel at the base, have been proved in trial holes. In shallow footings at Brook Farm (7385 0580) about 1m of greyish-green, fine- and medium-grained, well-sorted sand, with a bed of flint cobbles at the base, was seen below 1.2m of younger drift deposits.

Small outcrops of gravelly loam have been mapped along the flanks of the Ham Brook valley at Nutbourne (780 056), and of the valley close to Prospect Farm, Bosham (799 054), as well as in a shallow depression 350m south-east of Flat Farm (792 055). The gravel content consists of well-rounded flint pebbles and cobbles up to 0.2m in diameter, together with abraded nodular flints. A scatter of flint pebbles and cobbles in the silty loam soils between the railway and Cox's Farm, Hambrook (790 062) indicates a thin cover of Brickearth on flint gravels.

In the south of Portsea Island, between Eastney and Southsea, the bedrock surface lies below Ordnance Datum, but northwards it rises to 4m O.D. and possibly to 6m O.D. at Buckland (6505 0175).

At Milton (6685 0292) a temporary section exposed 1.0m of coarse-, medium- and fine-grained sub-angular flint gravel containing wave-battered cobbles, with a matrix of clayey sand. At Fratton (6510 0046) a temporary section revealed 2m of Brickearth lying over 2m of crudely stratified coarse-, medium- and fine-grained flint gravel. The gravel contained sub-rounded flints together with large numbers of derived Tertiary and well-rounded chalk clasts, set in a matrix of coarse- to medium-grained sand. The top of the gravels was seen to be bleached, suggesting that a soil profile (podzol) had formed prior to brickearth deposition.

These deposits are locally very sandy and, at Milton Cemetery (6630 0040), they consist of fine, medium and coarse sands with few large flints and cobbles.

At Tamworth Road (6633 0093) two boreholes proved up to 2.8m of brown sand, resting on sandy gravel to 3.1m depth, above very sandy London Clay. Much fine and medium sand associated with sparse gravel was proved by augering in the built-up district just west of Baffins. The sands are probably in part derived from the sandy members of the underlying London Clay.

The greatest recorded thickness of gravel is at Eastney e.g.(6620 9915; 6673 9905) where between 8 and 9m were formerly dug; it rests on the Bracklesham Beds at about -1.4 to -4.4m O.D. In this locality the ground surface rises to form a west to east trending ridge about 8m high and about 1km in length at an altitude of 7m O.D.

At Hayling Island, Raised Beach Deposits are largely restricted to the southern part; in the northern part, where the wave-cut platform is cut in Chalk, they are typically absent. Where present, the deposits are described in borehole logs as sandy, clayey gravels. Typically, they are less than 1m in thickness but, locally, greater thicknesses are attained, for example near Newtown [720 002] where up to 6.1m of sand and gravel were recorded. These beds were worked nearby in pits just south of St. Patrick's Church [7185 0030].

Exposures in the low cliff on the west side of the island, from near Stoke [715 023] to near Newtown [708 002], reveal a thin bed from 0.1m to 0.3m thick, consisting mainly of flint gravel in a brown clayey silt matrix. A large proportion of the flints are sub-rounded to well-rounded pebbles and cobbles, up to 0.1m in diameter. The bed lies beneath Brickearth which is up to 1.2m in thickness; the junction between the two is commonly very uneven because of disturbance by cryoturbation. Outcrops of the gravel inland give rise to rather heavy soils of gravelly loam.

The elevation of the wave-cut platform on which these deposits rest lies mainly in the range 2.2m to 3.8m O.D. in the south of Hayling Island. In the north, on the Chalk subcrop, it is between Ordnance Datum and 2.1 O.D. Local variations in elevation suggest that there may be irregularities on the surface of the solid formations.

At Thorney Island [7673 0140] a shallow section exposed fine to medium gravel with subangular, subrounded and well rounded flints. Rounded clasts of vein quartz and well preserved spat of Cerastoderma spp. were also noted.

A well at West Thorney Church [7691 0241] penetrated an unusual thickness of 9.1m of gravel and sand resting on 'chalk and flints'. A trial pit at Thorney airfield nearby [7603 0290] passed through 1.4m of Brickearth above 0.6m of chalky clay and flints, which in turn rested on 1.0m of fine-grained rounded flint gravel. This preservation of Raised Beach Deposits on a Chalk subcrop is unusual and may occur in solution hollows.

5.4 Head Gravel

5.4.1 General account

In this report the broad sheet of angular flint gravel, with a clayey, silty or chalky matrix, that mantles much of the raised beach platforms of the coastal plain, is classified as Head Gravel. In the older literature and on the published One-inch Fareham (316) Sheet the material is designated as Coombe Deposits. On the lower raised beach much of this Head Gravel is concealed beneath a veneer of Brickearth (Figure 3).

The dominant component of the Head Gravel is flint, either as unbroken nodules or as angular, frost-shattered fragments. At depth there is much chalk in the matrix, but the top few metres are usually decalcified and here the groundmass typically consists of brown clayey silt. The deposit is thickest and most coarse-grained along the line of the old cliff of the upper raised beach and tends to become thinner and finer-grained as it is traced southwards over the lower raised beach. Where the Head Gravel rests on the wave-cut platform of the upper raised beach there is currently no evidence of intervening marine deposits comparable to those which occur to the east of the study area. Above the lower raised beach, marine sand and shingle have been recorded beneath Head Gravel near the coast, at Emsworth and Southbourne.

To the south and south-south-east of Hambrook the Head Gravel thins rapidly and is absent between Nutbourne and Bosham. It is also absent from the outlying islands of Portsea, Hayling and Thorney.

There is considerable variation in thickness of the Head Gravel deposits, from as little as 1m on parts of the lower raised beach, up to a maximum of about 6m adjacent to the old cliff lines.

It is thought that two major periods of Head Gravel deposition occurred over the Sussex Coastal Plain (Shephard-Thorn and others 1982, Table 1). The earlier, of presumed Wolstonian age, post-dated formation of the upper raised beach sediments. Thus, in the Chichester area, two spreads of Head Gravel, separated by a brickearth, are present on the upper raised beach; only the younger gravel occurs at the lower level. In worked pits near Funtington, in the present survey area, there is evidence of only one gravel deposit at the higher level, but its age is unknown. However, it is possible to differentiate between lower and higher Head Gravels on the basis of elevation, and to show their relationship to the two raised beaches (Figure 3).

Small tracts of Head Gravel, isolated from those that mantle raised beaches, are found at Closewood House, west of Waterlooville [660 100], at Hazleton Farm, near Horndean [719 119] and south of Rowland's Castle [732 101]. The first outcrop occupies a bench-like feature at about 35m O.D., slightly elevated above the valley floor. This deposit comprises abundant angular patinated flints in a clay matrix. At Hazleton Farm there is a flat bench, at about 62 - 65m O.D., with up to 1m of silty or clayey, fine- and medium-grained, sub-angular flint gravel resting on Woolwich and Reading Beds.

A small patch of similar gravel occupies a slightly higher bench [707 121] at just below 70m O.D. White (1913, p. 72) reported up to 1.8m of coarse gravel exposed in the brickpits at Rowlands Castle. The base of this outlying patch of Head Gravel is at c 55m O.D.

The Head Gravel is generally regarded as the result of solifluction of Chalk, Tertiary and Clay-with-flints material down the dip-slope of the South Downs during cold episodes of the Quaternary period (Reid 1887; Hodgson 1967).

5.4.2 Local details

The principal outcrop, which blankets the higher wave-cut platform, lies between the River Ems and Funtington. It occupies a gently sloping planar surface between the former cliff lines of the lower and upper raised beaches (Figure 3) and gives rise to very gravelly silty soils with an abundance of medium and coarse nodular and angular flints.

Borehole logs indicate a variable thickness of gravel, ranging from 2.7m in the southern part of the outcrop up to a maximum of about 6m in the north, adjacent to the old cliff line. They show that locally the lower part of the deposit has not been decalcified because it contains much chalk. The gravels have been worked just north of Hambrook; in a pit hereabouts [781 082], 2.8m of medium and coarse, unsorted, unbedded gravel with nodular and angular flints in a matrix of orange-brown silty clay or clayey silt was seen.

Isolated tracts of Head Gravel occur on the upper wave-cut platform near Aldsworth Manor [770 090], at Southleigh Forest [740 084] and at Little Leigh Farm [728 087]. At the last locality, the small patch of gravel which caps the hilltop contains many black flint pebbles as well as sub-angular flints. The more extensive outcrop at Southleigh Forest has been worked for gravel in a large pit to the north of Southleigh Park. In the pit face /7368 08417 2.5m of flint gravel with a sparse rusty-brown clayey silt matrix was recorded. The gravel consists mainly of medium angular flints and scattered large nodular flints, with many well-rounded, battered flint cobbles and pebbles up to 0.12m across. The whole deposit is unsorted and unbedded; its junction with the underlying London Clay was obscured.

The flint pebbles and cobbles may have been derived either from nearby outcrops of Tertiary pebble beds or from pre-existing marine beach deposits which are no longer preserved. White (1913, p. 72) recorded that up to 3.7m of ochreous clayey gravel was excavated in the older part of the pit /738 0827.

Head Gravel deposits underlie Brickearth over the greater part of the coastal plain, south of the cliff line of the lower wave-cut platform. They crop out in the valleys and in low lying tracts, and give rise to gravelly loam soils.

These deposits are of variable thickness, commonly with rapid changes over short distances. At Havant, borehole data indicate a range of thickness from 2m to 5m and show the lower part of the gravels to be locally chalky. Between Warblington and Emsworth up to about 3m of gravel have been proved, but less than 1m is not uncommon. The deposit is visible in the low cliff adjacent to Wade Court Farm /722 0527; here, up to 1.4m of variable chalk/flint gravel in a clayey silt matrix underlies about 1.8m of Brickearth. The fine to medium gravel consists of sub-angular flints and rounded chalk pebbles, but is locally much coarser and more flinty. It contains a few lenses of pale grey and orange mottled silt with some small rounded chalk pebbles.

At Westbourne [760 076] the Head Gravel outcrop is characterised by pale greyish, calcareous, gravelly soils containing an abundance of small calcareous concretions, which are composed of concentric accretionary shells of calcium carbonate. To the north-east, at Riverside Cottage, a total of 5.5m of gravel was proved to overlie chalk in a borehole (SU 70 NE 80) [7701 0822].

Boreholes along the line of the proposed new A27(M) route between Emsworth and Bosham proved up to 6m of gravel beneath the Brickearth; the thickest sequence occurs just south of Woodmancote [c 770 070].

The Head Gravel deposits associated with the lower raised beach extend inland northwards along the floor of the NNE - trending valley between Havant and Rowland's Castle, which breaches the younger cliff-line at West Leigh (Figure 3). Trial boreholes have proved up to 2.4m of coarse flint gravel to overlie Tertiary clays within this tract. The gravels underlie a conspicuous bench feature between Comley Bottom [735 088] and Rowland's Castle [739 101]. In shallow trenches near Mays Coppice Farm [735 094] medium and coarse, angular and nodular flint gravels in a reddish-brown loamy matrix were recorded; they contain a small proportion of well-rounded Tertiary flint pebbles and cobbles. Immediately south-west of the farm [734 094] the gravels are overlain by an isolated patch of Brickearth, and thus the sequence here corresponds to that of the coastal plain.

Sections south of Prinsted [7640 0485; 7718 0487] revealed bleached sub-angular, flint gravel, 0.2 to 0.4m thick; it rests on greyish-brown silts and is covered by estuarine desposits. There is a possibility that these gravels may be reworked, however, and thus form part of the estuarine alluvium sequence.

5.5 Head (undifferentiated)

5.5.1 General account

Head includes a heterogeneous group of superficial deposits which have accumulated by downslope solifluction, mainly under periglacial conditions. It incorporates weathered surface debris, the character of which reflects the variety of source materials.

On the Chalk dip-slope, Head deposits occupy the dry valley floors and comprise narrow tracts of brown, decalcified, very flinty loams overlying chalky rubbly marls. The flints are commonly large or broken into angular fragments. These tracts expand in width where they cross the outcrop of Tertiary clays and here the deposits pass into soft brown silty clays with a variable content of angular patinated flints.

To the south of Portsdown the Head consists of materials similar to those of the dry valleys to the north. Here, however, the pattern of decalcification is apparently more variable and recent chalky hill-wash may blanket the deposits on the steeper slopes.

Slope deposits derived mainly from the Woolwich and Reading Beds consist of reddish-mottled, variably flinty clays. The sub-angular flint content is derived either from the nearby Chalk outcrop or from Head Gravel deposits upslope. The materials derived from the London Clay range from clays, through silty and sandy clays, to clayey silts. The content of included clasts ranges from a few dispersed flint or sandstone chips to a substantial number of sub-angular flints. Near outcrops of Bracklesham Beds, the Head typically possesses a high content of silt.

The thickness of the Head is very variable; the greatest amounts typically occur in valley floors or towards the bottoms of slopes where they may be up to 4m thick.

5.5.2 Local details

Extensive spreads of Head are associated with the tributary valleys of the River Wallington in the area between Denmead, Waterlooville and Purbrook. Flinty clays and clayey gravels are common near Denmead but between Cutlers Farm [663 096] and Waterlooville soft silty clays overlie flinty clays: the former may be mistaken for weathered London Clay. This drift sequence is apparently up to 2.7m thick. Up to 3.0m of clayey gravel are locally present in the Lovedean valley to the north i.e. along the line of Milton Road [6770 1005 - 6835 1125].

To the south of Sheepwash Farm [657 096] soft buff clayey silts floor the broad shallow valley. Lenses of flinty clay are present locally within the sequence. In the east-west tributary valley between Potwell Farm [653 078] and Purbrook silty and sandy loams are commonly present.

In the valley floor of a stream draining south from Blendworth Common [709 110] to Leigh Park [706 086], up to 1.2m of brown clayey silt, locally with scattered flints, overlie a gravel bed of sub-angular flints and flint pebbles which, in turn, rests on London Clay. Up to 1m of stony silty clays and clayey silts overlie Tertiary clays in low-lying tracts around Middle Clearing [712 096]. They contain large numbers of flint pebbles and cobbles derived from the nearby outcrop of the London Clay 'Basement Bed'.

The Head which drapes the valley slope near Mays Coppice Farm [736 097] was seen in shallow trenches to consist of orange and grey mottled clay with angular flints and many flint pebbles and cobbles. Very flinty loams cover the valley slopes of the River Ems and a small tributary in the vicinity of Aldsworth Manor /767 087/ and Ell Bridge /776 088/. They derive from tracts of Head Gravel which occupy the interfluves. A veneer of orange and reddish gravelly clays covers much of the slope masking the lower raised beach cliff line between Woodmancote /773 077/ and Hambrook House /792 072/. Boreholes at Hambrook /787 071/ proved up to 3.5m of these clays near the foot of the slope.

The greater part of the lower ground at Leigh Park /705 078/, and in Havant, west of Hermitage Stream /706 070/, has a thin drape of silty clays containing few clasts. They become somewhat flinty in the valley floor of Hermitage Stream where up to 2.4m have been proved in trial holes.

On the southern lower slopes of Portsdown, borehole records indicate the presence of between 2 and 8m of brown sandy clay with chalk and flint gravel overlying a marly chalk rubble in places. Marked local variations in thickness may in part be due to the misidentification of the top of the weathered Chalk. Alternatively, they may reflect the dissolution and piping of the sub-Drift Chalk surface.

5.6 Brickearth

5.6.1 General account

Much of the coastal plain is mantled by Brickearth which gives rise to characteristic brown loamy soils. This deposit rests, for the most part, on the Head Gravel. However, between Nutbourne and Bosham, and also on Portsea, Hayling and Thorney Islands, it overlies terrace and raised beach gravels. Borehole data indicate that the Brickearth ranges up to about 3.5m in thickness though, exceptionally, it is thicker.

The deposit generally consists of fairly homogeneous, yellow-brown, or structureless silt, or variably clayey silt. It is locally quite stoneless, but commonly contains a few sub-angular flints, either scattered throughout or concentrated into impersistent stringers. Typically, the deposit becomes more flinty at the base. This may be a primary feature or cryoturbation may have disturbed the underlying gravel. Where it rests directly on Chalk, for example in the northern part of Hayling Island, the Brickearth is pale buff or greyish-white in colour and calcareous towards the base, with discrete chalk detritus. This deposit is generally unfossiliferous, but at Carisbrook Road near Milton Park /6615 9996/ a shallow trench in Brickearth yielded a right metacarpal of Bison priscus (Boj), of late Pleistocene age.

The various modes of origin of brickearth have been reviewed by Dines and others (1954), Hodgson (1967) and Catt (1977). It is now generally recognised (see also Young and Lake, in preparation) that there is insufficient local source material for the quantity of silt grade sediment represented by the Brickearth of the coastal plain. The overall characteristics of the deposit, including its grain size and sorting, are similar to continental loess deposits. Thus it was probably derived largely from wind-blown silt. However, features such as the local presence of flints throughout the Brickearth and the occurrence of chalk pellets and pebbles in unweathered material indicate that the deposit was later remobilised by solifluction. Loessic deposits are known to be metastable under conditions of high water table (IGS 1975, p. 22) but, to date, no metastability problems have been discovered within the area mapped.

The borehole data indicate local variations in thickness of the Brickearth, but values need to be treated with caution because many logs do not demarcate the deposit clearly from underlying stony lithologies. For the most part, the deposit ranges up to about 2.5m thickness, but greater thicknesses occur in a few places. A maximum of 7.0m was recorded at Hambrook /7893 0704/ (see below).

5.6.2 Local details

Only sporadic small exposures of typical Brickearth were seen on the coastal plain. In the cliff section at Langstone Harbour, near Wade Court Farm /723 053/, up to 1.8m of brown, homogeneous, massive silt containing few scattered small flints were seen. Locally, stringers of fine chalk or chalk/flint gravel were noted near the base.

Between Cosham and Farlington, and in Havant, the thickness varies between 1 and 2m. Between Havant and Emsworth there is usually less than 1.5m, although up to 2.3m have been recorded. East of Emsworth the Brickearth rarely exceeds 2m in thickness; exceptionally, up to 7.0m was recorded in a borehole (SU 70 NE 34) /7893 0704/ adjacent to the lower raised beach cliff line at Hambrook.

Between Nutbourne and Bosham the silty loam soils of the Brickearth outcrop contain a large number of well-rounded flint pebbles and cobbles which were presumably derived from the underlying raised beach material by cryoturbation processes.

On Portsea Island the Brickearth is generally up to 1.5m thick, but locally it reaches 2.5m and exceptionally up to 3.5m have been recorded in Southsea /6758 9965/. The deposit was formerly exploited for brick manufacture, particularly near Copnor.

The Brickearth at the airfield site /670 034/, described as "red clay" in the commercial logs, was found to be predominantly silty and sparsely micaceous. Small rounded chalk fragments, patinated angular flint chips and rare carbonate concretions were noted. Manganese occurs patchily in small voids and along fissures and may form earthy spheres about 1mm in diameter, apparently around clay cores.

In low cliffs on the west side of Hayling Island, from near Stoke /715 023/ to near Newtown /708 002/, up to 1.2m of brown, clayey, generally rather stony silt was seen to overlie thin raised beach deposits. The Brickearth is very flinty at the base with rounded pebbles derived from the underlying bed in addition to sub-angular flints. In the northern part of the island, where the Brickearth typically rests directly on the Chalk borehole logs show that the deposit ranges from 2.4 to 3.6m in thickness. Greater thicknesses, up to 5.5m, are recorded in a few places. The lower part of the deposit here is normally quite chalky. Near Stoke Common /718 035/ there is the last working brick kiln on the island. In central parts, between Stoke and Newtown, thicknesses of 1 to 2m are typical. In the south of the island the thickness is very variable, ranging up to a maximum of about 2.5m. Borehole logs indicate that the Brickearth is locally very thin or absent, but here urban development precludes detailed mapping of the small outcrops of the underlying raised beach gravels.

Over the Chalk subcrop at Thorney Island the Brickearth is up to 2.5m in thickness; the basal part contains chalk fragments and locally some medium-grained sand derived from Raised Beach deposits.

A comparable sequence on the Chalk outcrop was seen at Chidham /e.g. 7875 0370; 7893 0295/ where ditch sections showed large pinnacles of cryoturbated, frost-shattered chalk and chalk grit associated with unabraded horned flints within stony brickearth. The base of the Brickearth contained a few battered and rounded flint cobbles, possibly derived from Raised Beach Deposits.

Towards the western edge of the Bosham peninsula, at [7975 0266 and 7996 0493], the Brickearth, up to 1.6m thick, passes downwards into a residual red clay formed by decalcification of the underlying Chalk.

5.7 Estuarine Alluvium (and contained peats)

5.7.1 General account

The broad coastal plain is dissected by short inlets marking the sites of drainage lines which were drowned in the post-glacial rise of sea-level. This inundation also flooded the low-lying areas of Chalk outcrop and thus isolated the islands of Thorney, Hayling and Portsea. The deposits typically comprise brown and grey mottled soft silty clays and silts and are relatively thin except where they occupy former drainage channels as, for example, in Langstone Harbour.

At Portsea Island most of the inlets of the eastern shore-line near Langstone Harbour, which were formerly tidal and sites of alluvial deposition, have now been closed by bunds and the areas reclaimed by dumping refuse. Similarly, the tidal area between Thorney and Emsworth was closed by bunds after 1865 and the ground reclaimed for grazing.

5.7.2 Local details

The reclaimed area known as Farlington Marshes has been mapped provisionally as Estuarine Alluvium, but the greater part of the surface deposits comprises grey-brown silts which lack both fossils and sedimentary structures and weather out in peds reminiscent of brickearths.

Accretion of gravel along shore-lines has covered large tracts of estuarine sediment. At Eastney, for example, boreholes near Fort Cumberland [6806 9936; 6793 9923] proved several metres of shingle to rest on soft mud which encloses peat and extends down to below -9m O.D.

A former site of estuarine deposits is marked by the peaty fen in Southsea, once known as the "Great Morass" and subsequently reclaimed and partly obliterated by fill in the 19th Century. The fen consisted of a palmate system of steep-sided valleys or channels cut into the raised beach deposits at a time of low sea-level and formerly open to the sea. This was subsequently blocked to the south-west by deposition of the broad shingle bar now forming Southsea Common. The channels are partly filled with fine-grained soft silty clays which contain laminated detrital muds; these clays are underlain by gravel which extends down to below -15m O.D. Tracts of fibrous peat up to 6m in thickness rest on the alluvium in places. The peat locally contains gravel lenses.

The laminated silty clays are typical estuarine deposits, but the deposition of the shingle bar created ponds of lower salinity in which the peat accumulated. Evans (1873) recorded the presence of muds with Scrobicularia, which were exposed beneath 1m of gravel during sewer installations across Southsea Common.

Other deposits of peat occur at the seaward end of Canoe Lake [6542 9824] where they are covered by recent beach shingle. The depression in which Canoe Lake lies probably represents the distal end of one of the channels of the Great Morass, which was cut off by coastal recession at an early date. However, the peat surface rises to a higher altitude here (2.0 to 2.5m O.D.) compared with that of the Great Morass (near Ordnance Datum).

In a small tract of reclaimed Estuarine Alluvium at South Moor, Langstone /712 048/, up to 1.0m of soft grey and brown silty clays and clayey silts rest on gravel. The valley floor adjacent to Warblington Castle /731 054/ accommodates at least 1.2m of very silty clays. Similar sediment in a shallow valley 400m to the east contains a little flint gravel. The Ham Brook at Nutbourne drains into a reclaimed portion of the estuary where a thin veneer of alluvial clay overlies flint gravel.

On Hayling Island several tracts of reclaimed mudflats are present on the coastal fringes. They comprise mainly brown and grey mottled, laminated clayey silts and silty clays, with subordinate silts. A borehole at Stoke (SU 70 SW 47) /7217 0275/ proved 2.0m of brown and grey silty clays overlying 1.2m of peat, with Chalk below.

The Estuarine Alluvium at Thorney Island (the area of the Great and Little Deeps) varies in thickness from 0.5 to 1.2m and is locally more than 2.0m. It rests on a grey frost-shattered chalky rubble which is brown and patchily decalcified below, or on a sheet of rust-coloured rounded and sub-angular flint gravel enclosing rounded chalk cobbles. Both types of substratum contain interbedded shelly laminae, with faunas comparable to the alluvium above. The chalky deposit has clearly been reworked during the initial stages of the post-glacial transgression. At the surface the alluvium consists of a dark humose soil passing downwards into both pale and dark grey silts or silty fine sandy clay, commonly rather coarsely laminated. Laminae of organic mud are present. These sediments contain a fauna of Mollusca, including Scrobicularia, Cerastoderma spp., Ostrea, Buccinum, Littorina spp., Venerupis decussata with small numbers of Hydrobia spp. Macoma balthica, which forms a conspicuous component of the faunas described from the brackish sediments of the adjacent Selsey-Bognor tract (Berry and Shephard-Thorn 1983), is absent. A sample of the alluvium from the western end of the Great Deep [7494 0412], at a depth of 1.5m, yielded foraminifera typical of tidal flat or intertidal sedimentation, with other smaller species suggesting derivation from distant marshy areas. The occurrence of V. decussata is also more characteristic of mid-tidal levels and the environment is thought to have been in the hyposaline range (32ppth salt) and therefore beyond the salinity tolerance of Macoma balthica.

The natural erosion of the saltmarsh hummocks offshore at Thorney has provided a source of rounded clasts of organic mud, 8-12cm in diameter, which are enclosed in the shore-face sands [7605 0134], thus forming a soft conglomerate.

Just south of Prinsted [7648 0486; 7715 0490] thin tracts of pale grey silty alluvial clay overlie thin clayey gravels resting on a thick sequence of silts similar to that in Farlington Marshes. These have been proved to a depth of more than 1.5m and may be derived from nearby older drifts. Thus they may be regarded as alluvial deposits.

5.8 Alluvium

5.8.1 General account

Freshwater alluvial deposits are of very limited occurrence in the survey area, and are restricted mainly to the seaward extremities of relatively minor streams. They are, however, more extensive in the valley of the River Ems where they persist inland at least as far as Lordington [784 100]. These sediments typically comprise soft mottled clays which overlie a basal flint gravel of variable thickness.

5.8.2 Local details

At Brockhampton two small streams drain into Langstone Harbour. Boreholes in the alluvial tract of the more westerly, the Hermitage Stream, proved up to 4.6m of brown clay containing flints, overlying Chalk. Just north of the Sewage Works, a maximum of 7.9m of similar material (SU 70 NW/101C) [7050 0580] has been recorded in the floodplain of the second stream which is now partly culverted.

The Alluvium of the stream which flows south along the western fringe of Langstone is capped by a dark peaty soil, below which there are up to 2.0m of brown silty clay with some flints; this, in turn, rests on flint gravel with traces of chalk, of which up to 4.1m have been proved.

Near Aldsworth Manor [769 082], black peaty waterlogged soils rest on flint gravels. Just north of the railway at Emsworth [752 065], up to 2.8m of coarse flint gravels resting on London Clay have been proved in boreholes. Further downstream [751 059] about 1.2m of soft silty clays, which are peaty at the base, overlie up to 2.3m of flint gravel on London Clay.

5.9 Storm Gravel Beach Deposits and coastal changes

5.9.1 General account

During post-glacial times the eastern margins of the Solent have locally become shore-lines of accretion. In places wide bars of fine- to medium-grained gravel with some interstitial sand and shell debris have been built up by the long-shore drifting of material above mean high tide level. Re-curved spits of gravel flank the entrances to Langstone and Chichester Harbours and in recent times these features have shown considerable changes.

5.9.2. Local details

The accretion of shingle above high tide mark at Eastney has caused a seaward shift of the coastline by up to 120m since 1880. At the present time the rate of drift is low, with a probable accumulation of less than 2000m^3 per year (Harlow, 1979).

The gravel which underlies Southsea Common and which isolated the Great Morass, probably represents a rate of accumulation far in excess of that prevailing in the last two centuries, and is almost certainly of much greater age.

Storm Gravel Beach Deposits extend the whole length of the foreshore at South Hayling and terminate at each end in recurved spits. The shingle, which is dominantly flinty, is typically quite well sorted and fairly uniform throughout. The grade of its constituent pebbles is mainly in the range 0.03m to 0.05m. There is usually only a small component of medium-grained sand.

It has been shown by Harlow (1979) that the longshore drift of sediment occurs from east to west, except to the east of Creek Road, Eastoke [740 981] where drift is in the opposite direction. The movement of material westwards is checked just east of Langstone Channel and it is deposited at Gunnar Point. Harlow estimated that over the last 380 years an annual average of 40000^{3}m of sediment has accumulated at Gunnar Point. The progressive growth of this recurved spit is shown by the occurrence of no fewer than 25 relict shingle ridges behind the present storm beach. Since the primary 1:10 560 geological survey of 1891 the storm beach has advanced seaward about 200m to its present position. The spit continues as a narrow strand along the eastern side of Langstone Channel and terminates near the ferry [at 6823 9980].

Sediment transported eastwards at the opposite end of the foreshore is deposited at and beyond Eastoke Point as a recurved spit which terminates at Black Point [750 990].

The shingle of an older recurved spit, located near the Boat Yard about 150m to the west, is separated from it by a narrow inlet from Chichester Harbour.

5.10 Blown Sand

Wind-blown sands occur in association with Storm Gravel Beach Deposits. Stabilised dunes of medium-grained, rounded, well-sorted sand, which contains a small proportion of well-rounded fine shell detritus, are present behind the storm beach gravels at Gunnar Point /692 995/. There is a small tract of similar material adjacent to the Yacht Club at Black Point, at the eastern end of South Hayling /749 990/.

5.11 Made Ground

There are several types of artificial fill in the area. Low-lying ground within the Portsmouth area has been used since historical times for the disposal of domestic refuse; some of these areas are only poorly documented. The spoil from motorway excavations has also been dumped on poorly draining ground. Earthworks associated with the land reclamation and sea-defences are generally constructed of materials from local channel dredgings and borrow-pits. Table 1 lists the main areas of Made Ground. Many of the former small pits dug for chalk or clay have been back-filled both with domestic refuse and soil materials. These are too numerous to identify separately.

5.12 Solution Hollows

The surface of the Chalk has been subject to intense dissolution during periods of cold climate, both at outcrop and beneath relatively thin overlying drift and solid deposits. This process was most accentuated in the valleys beneath the present day Head deposits and also where the contemporary surface runoff was directed along the margins of the Tertiary outcrop. Oscillatory water table levels under freeze-thaw conditions probably enhanced this process. As a consequence of this dissolution, the fractures in the Chalk were enlarged and the ensuing voids formed conduits for surface drainage and its transported sediment. The resultant pipes, which are filled with superficial deposits, continue to provide sumps for excess surface water at the present day and these are particularly effective in areas of lowered water table. At the surface these features form circular depressions which are locally steep-sided and which may be mistaken for disused quarries. They are characteristically veneered with remobilised sediments and actively subside both in periods of high rainfall and when attempts are made to fill them for construction purposes.

There is little well-documented evidence of the depth of these hollows but many were evidently formed beneath a former cover which locally exceeded 12m in thickness. Consequently, some of the pipes may be of comparable or even greater depth. Indeed, one of several trial holes which penetrated a solution hollow west-north-west of Hazleton Farm, Horndean (7056 1242), proved 25.0m of clayey flint gravel (not bottomed). The distribution of the known solution hollows and the areas where comparable geological conditions occur are shown in Figure 7. These areas are largely confined to the margins of the Woolwich and Reading beds but some may occur to the south of and downslope from the outcrops of Clay-with-flints. In the latter case ploughing has probably obscured much of the evidence for the features.

Inactive solution hollows are probably present beneath the floors of the dry-valleys on the Chalk outcrop.
These are largely infilled with decalcified flinty clays.

6. CONCLUSIONS AND OUTSTANDING PROBLEMS

The above descriptions present the current state of knowledge of the solid and drift deposits present within the area.
The borehole data supplied by Havant Borough Council, Hampshire County Council, City of Portmouth City Engineer's Department and the Property Services Agency provided considerable lithological information, particularly in the urban areas. Much of this data relates, however, to site investigations not requiring full geotechnical appraisal (e.g. sewerage schemes) and which have an uneven distribution in both geographical and stratigraphical terms. Some of the borehole logs were of poor quality and less than 10 per cent of the data afforded reliable geotechnical parameters. Consequently it was considered unwise to derive a geotechnical synthesis for this part of the study. For similar reasons it was not possible to construct a valid contour plot of the subdrift surface of the coastal area. Further borehole information of good quality is required in order to resolve the outstanding stratigraphical problems which relate to the London Clay and Bracklesham Beds.

The present information indicates that the lower raised beach deposits do not have a mineral resource potential because they have a patchy distribution and generally a high content of fines. The Head Gravels which are present above the older raised beach platform (Section 5.4 and Figure 3) may however be of local utility for low-grade aggregates. There appear to be no deposits, for example in the Tertiary formations, that provide potential sand resources.

From a geotechnical standpoint, this survey has identified areas where particular caution should be exercised in site investigations. These areas include zones of solution subsidence (Section 5.12 and Figure 7). Extensive tracts of relatively poorly-compacted clayey Head deposits have also been mapped (Section 5.5.2). Sandy clays within the London Clay (Section 3.3), also have a variable and locally low bearing capacity particularly in the upper part of the formation. The Brickearth (Section 5.6.1) may under unusually high water table conditions behave in a metastable fashion with a consequent loss of cohesion. The distribution and composition of the Made Ground has been described in Section 5.11 and Table 1; some of the older areas of waste disposal are, however, poorly documented.

In the second part of the programme which includes the survey of the Gosport, Fareham and Bishop's Waltham area, it is anticipated that further and more definitive stratigraphical conclusions may be drawn which will also take account of the earlier BGS Surveys in the Southampton (Sheet 315) area.

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1:10 000 Sheet	N.G.R.	Type of fill	Thickness m
SU 60 NE	697 058	Spoil from motorway excavations	Variable
	c.698 086	"	Variable
SU 60 SE	653 048	(King George V playing fields) Pre-war fill	-
	670 013	(inlets of Great Salterns Lake) Clinker and domestic refuse south and north sides, respectively	up to 4
	672 008	(formerly Milton Lake) Domestic refuse	up to 3
	6755 0325	(Kendalls Wharf area) Domestic refuse	-
	670 045	Spoil from motorway excavations	-
SU 70 NW	704 057	Variable	4-11
	706 089	Not known	-
	708 051	"	-
SU 70 SW	716 034	Builders' waste	-
	727 043	"	-
	729 040	"	-
SU 70 SE	7610 0145	Brickearth and rubble	-
SU 71 SW	703 123	Spoil from motorway excavations	-
	704 127	"	c 1
	708 114	"	up to 1.5
SZ 69 NE	6700 9945	(Brambury Park) not known	Variable up to 2.4
	673 996	Not known	up to 7
	6800 9945	(The Gloryhole) Mainly post-war domestic refuse	up to 5

Table 1. Areas of made ground

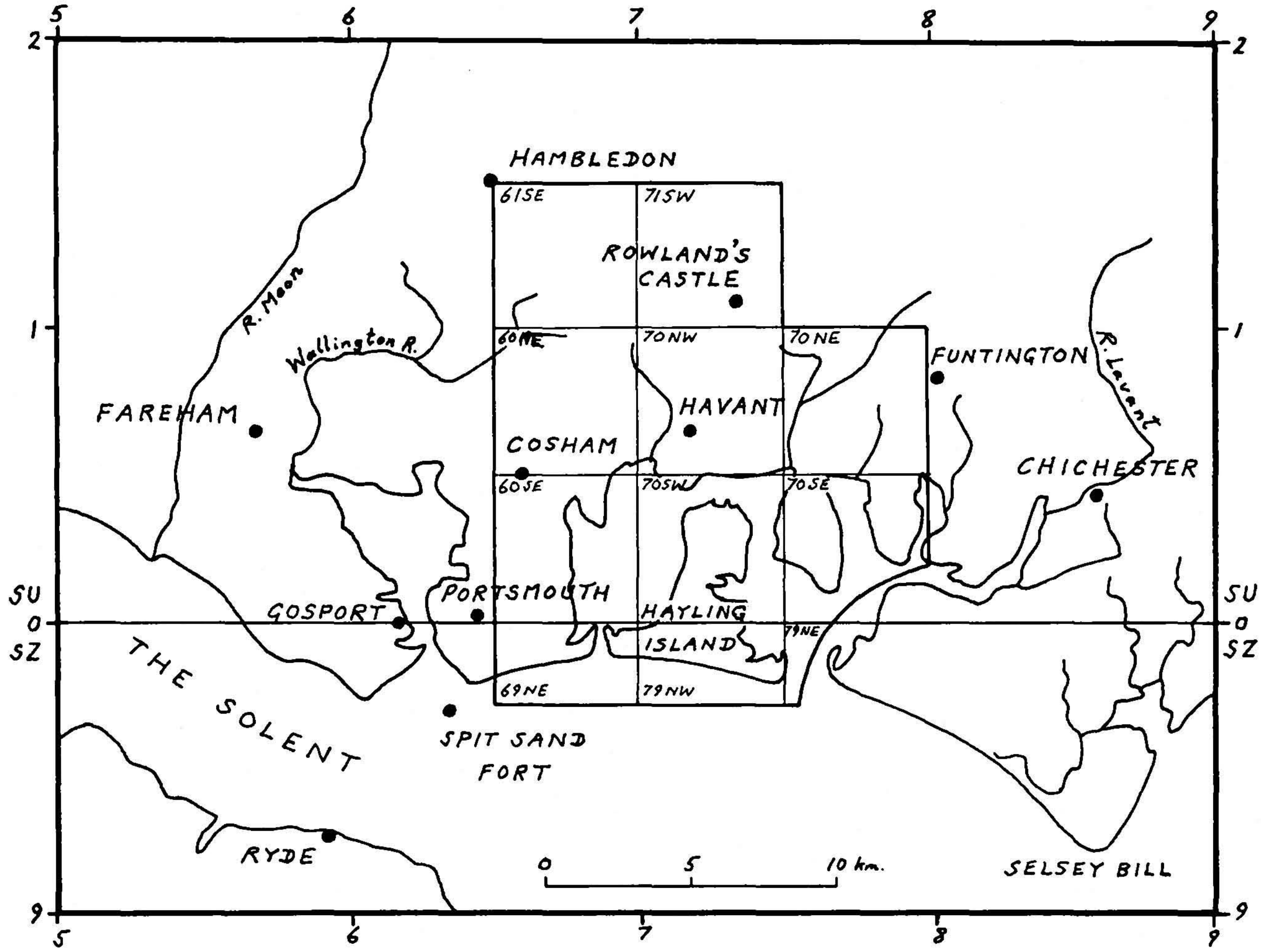

FIG. 1 LOCATION MAP SHOWING AREA OF THE 1983 SURVEY

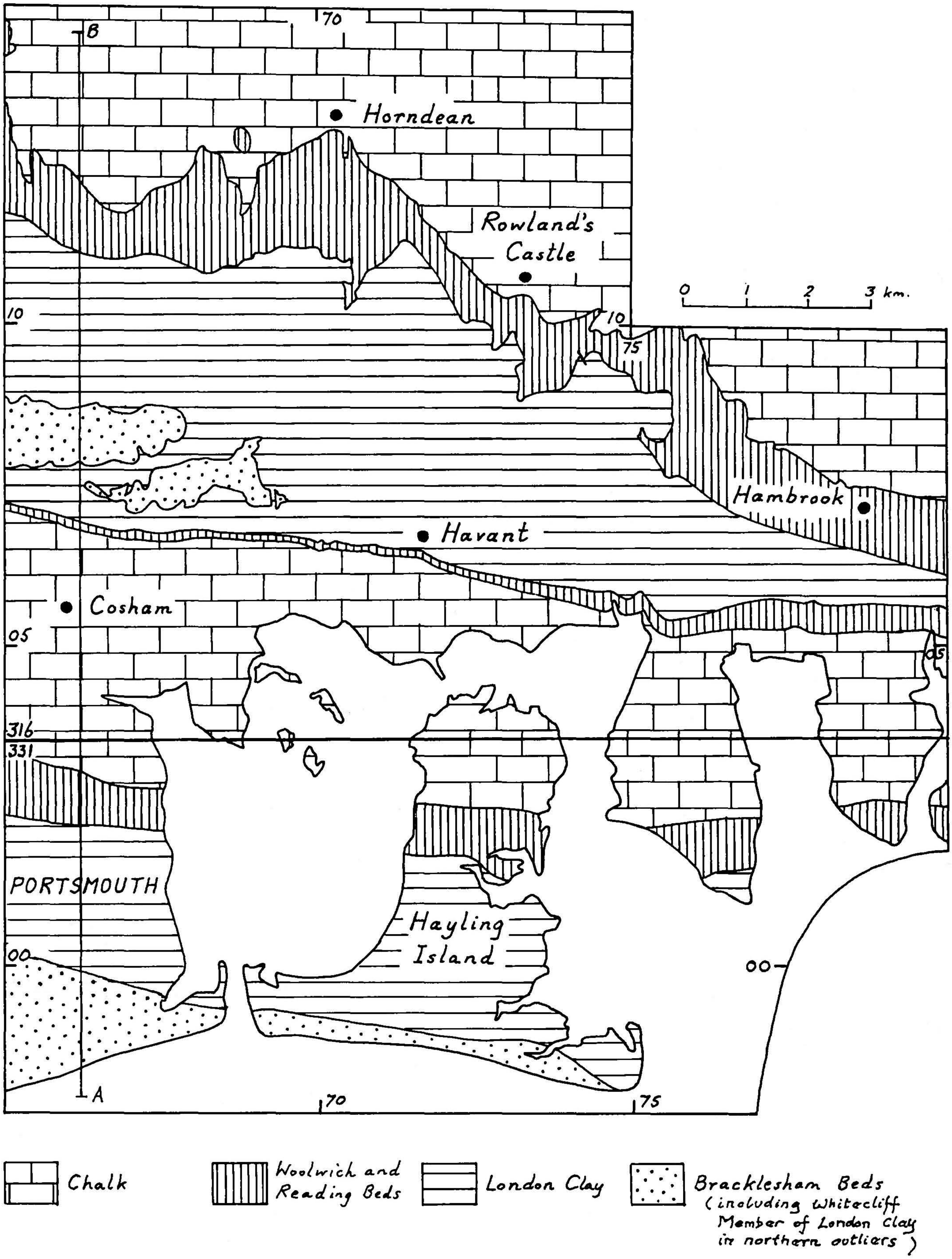

FIG. 2 DISTRIBUTION OF SOLID FORMATIONS AT OUTCROP AND BENEATH DRIFT

(See Fig. 6 for cross-section along the line A–B)

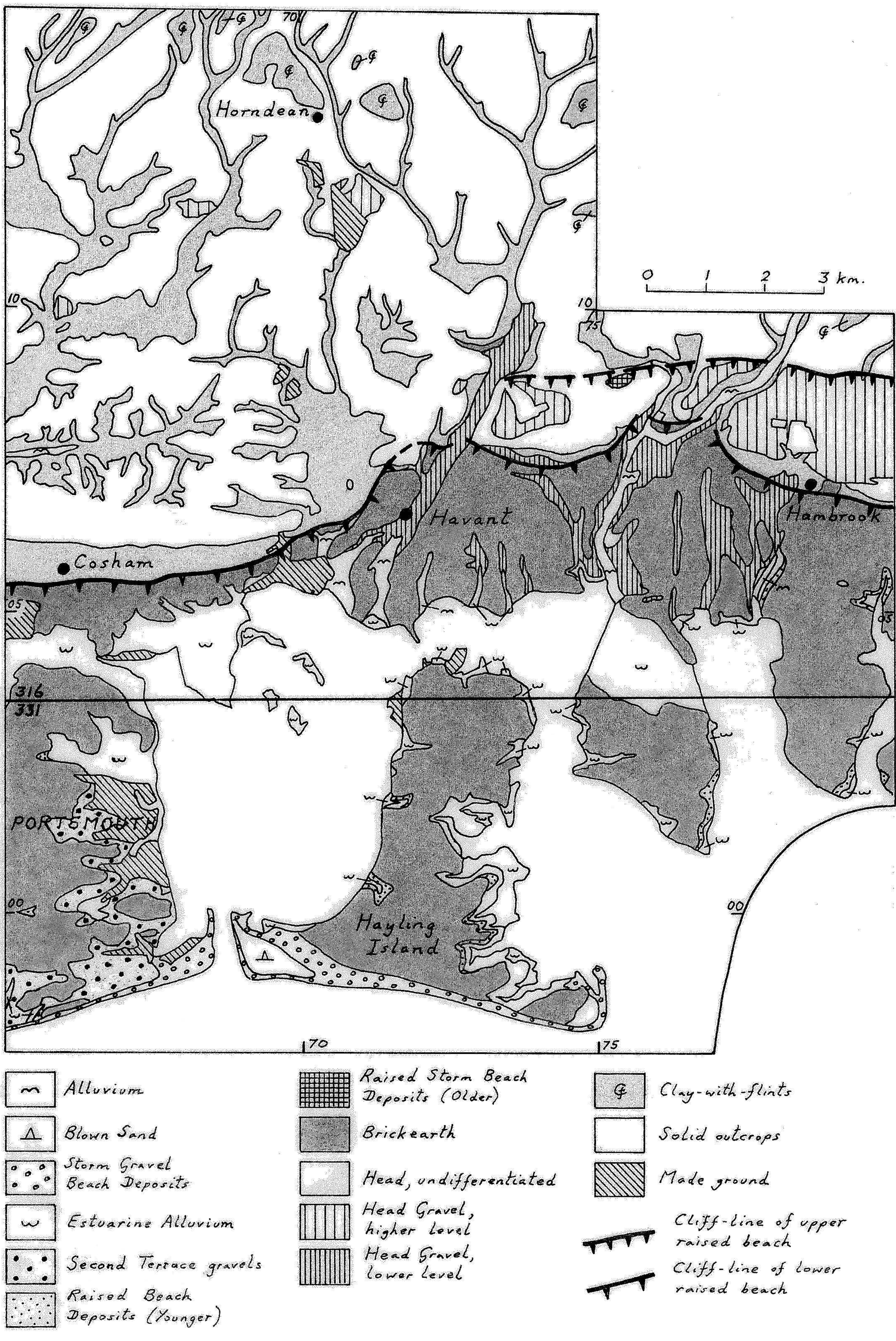

FIG. 3 GENERALISED DISTRIBUTION OF DRIFT DEPOSITS IN RELATION TO ANCIENT CLIFF-LINES

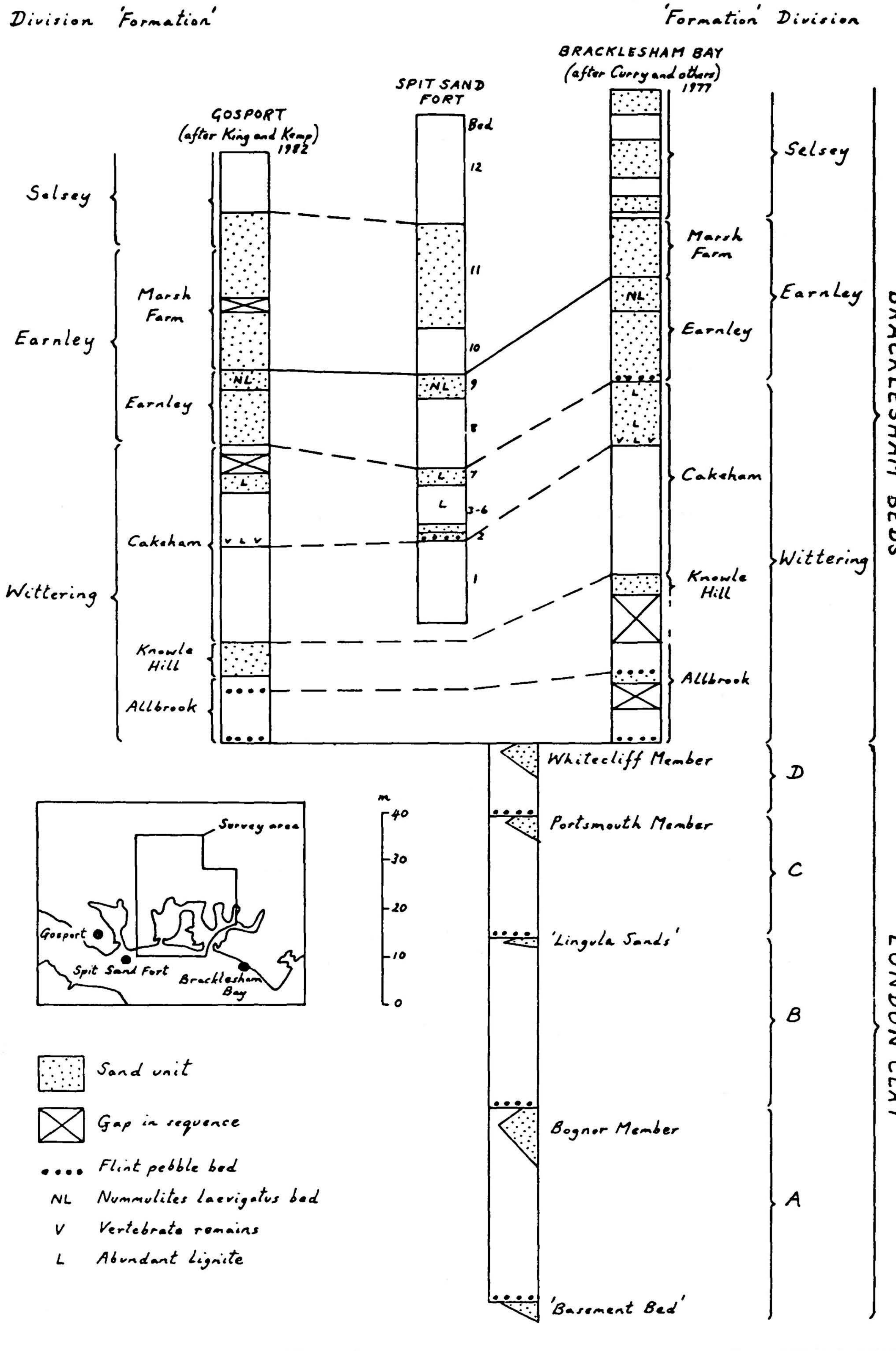

FIG. 4 SCHEMATIC SUMMARY OF LONDON CLAY SUCCESSION, AND CORRELATION OF THE BRACKLESHAM BEDS BETWEEN GOSPORT AND BRACKLESHAM BAY

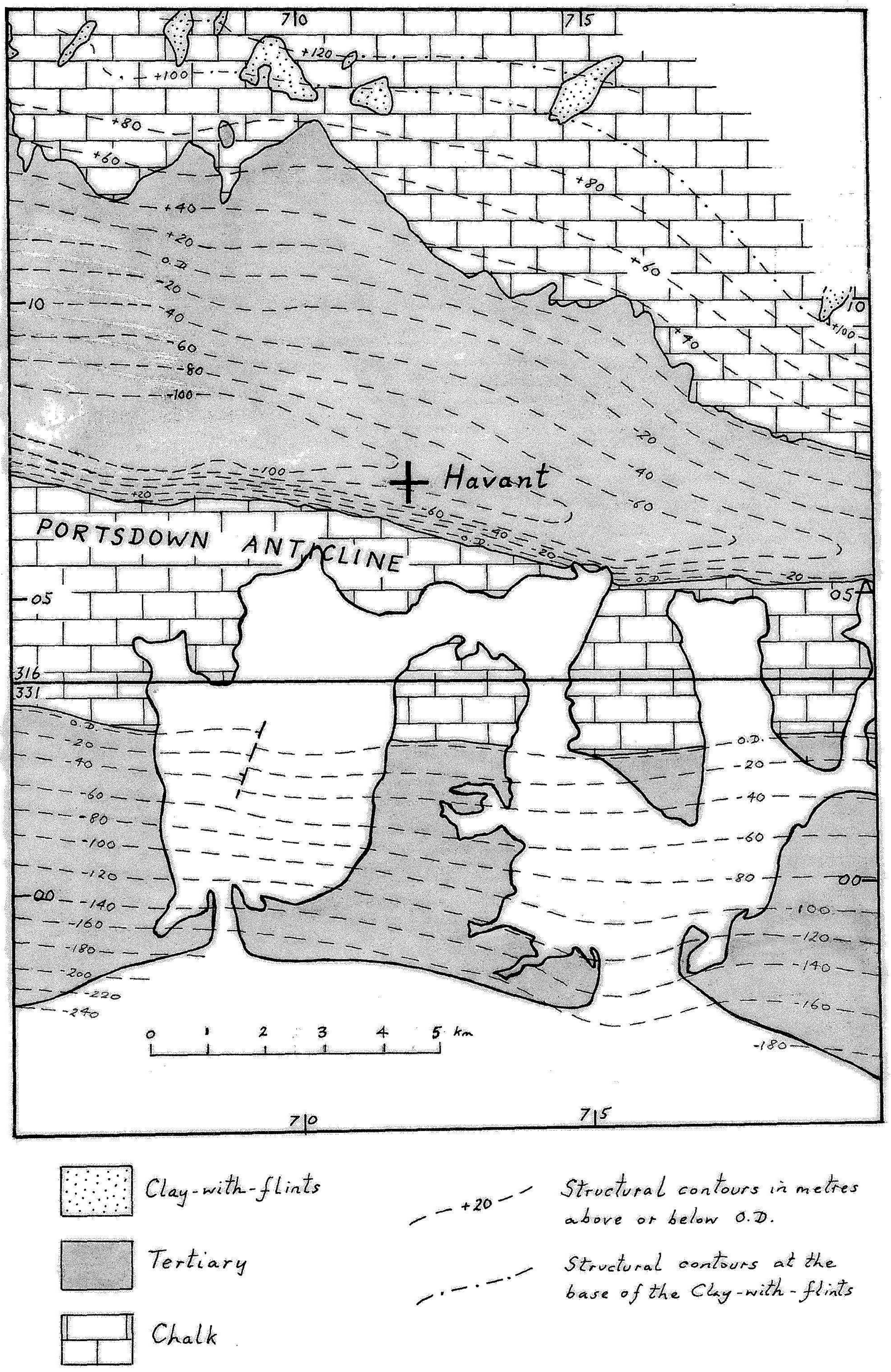

FIG. 5 STRUCTURAL CONTOURS ON THE TOP OF THE CHALK

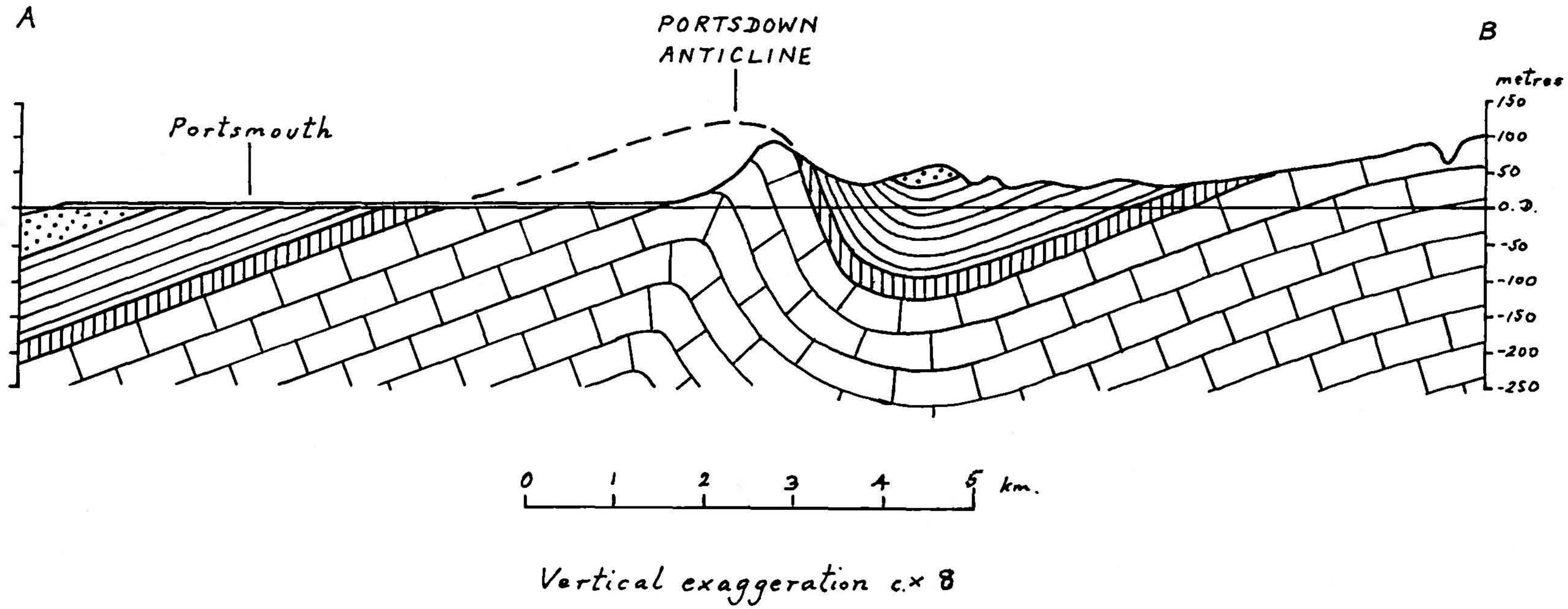

FIG. 6 CROSS SECTION SHOWING THE STRUCTURE OF THE AREA

(For line of section and key to ornament see Fig. 2)

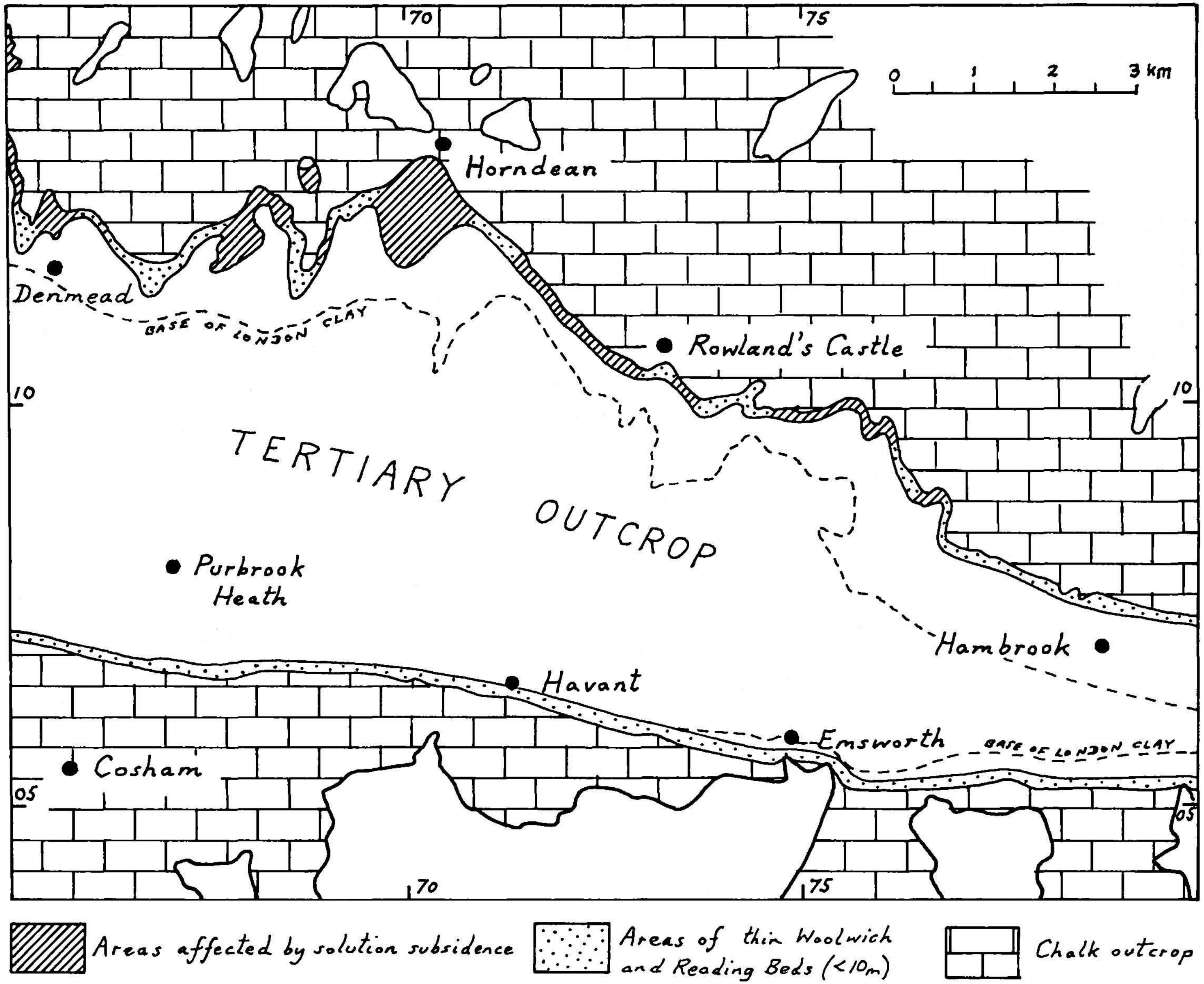

FIG. 7 MAP SHOWING AREAS OF SOLUTION SUBSIDENCE